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2	Chitosan mediated layer-by-layer assembly based graphene oxide decorated surface plasmon resonance biosensor for highly sensitive detection of β-amyloid	**SN Nangare,** PO Patil	International Journal of Biological Macromolecules
3	Design of graphene quantum dots decorated MnO2 nanosheet based fluorescence turn "On-Off-On" nanoprobe for highly sensitive detection of lactoferrin	**SN Nangare, S Patil,** S Patil, ZG Khan, A Patil, PO Patil	Inorganic Chemistry Communication
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6	Fabrication of poly (aspartic) acid functionalized graphene quantum dots based FRET sensor for selective and sensitive detection of MAGE-A11 antigen	**RS Tade**, PO Patil	Microchemical Journal
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8	Nanosuspension: A New Horizon in the Drug Delivery Systerm	GS Patil, NR Shirsath, PS Bafna, LR Zawar	International Journal of Pharmaceutical Sciences and Nanotechnology
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	reduced glutathione in real sample		
10	Bovine serum albumin-derived poly-l-glutamic acid-functionalized graphene quantum dots embedded UiO-66-NH2 MOFs as a fluorescence 'On-Off-On' magic gate for para-aminohippuric acid sensing	**SN Nangare, S Patil,** A Patil, PK Deshmukh, PO Patil	Journal of Photochemistry and Photobiology A: Chemistry
11	Development of amino acid salt-based curcumin@ lysine acetate co-amorphous system using liquid-assisted grinding for improved solubility and dissolution	U Patil, S Rawal, J Pantwalawalkar, **SN Nangare,** D Dagade, PO Patil, NR Jadhav	Thai Journal of Pharmaceutical Sciences
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Scientific paper

Design of "Turn-Off" Fluorescent Nanoprobe for Highly Sensitive Detection of Uric Acid using Green Synthesized Nitrogen-Doped Graphene Quantum Dots

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Abstract

Green synthesized graphene quantum dots (GQD) have been doped with nitrogen in an attempt to boost their optical characteristics and application sectors. In the present investigation, the blue luminescent nitrogen-doped GQDs (N-GQDs) were synthesized by single-step hydrothermal synthesis using tamarind shell powder as a precursor. The particle size and zeta potential of N-GQDs were found to be 11.40 nm and be –35.53 mV, respectively. A quantum yield as high as 23.78 % was accomplished at an excitation wavelength of 330 nm at neutral pH. It gets quenched sensitively in the existence of uric acid (UA) combining static quenching, electron transfer, and an inner filter effect mechanism. A linear range was obtained for UA from 10 μM to 100 μM, with a limit of detection (LOD) of 401.72 ± 0.04 pM. Additionally, the N-GQDs were selective toward UA in presence of metal ions and biomolecules that indicated its impending use to monitor UA in clinical samples. In conclusion, this work demonstrates that the N-GQDs as a sensing probe for UA recognition with notable advantages including socioeconomic, simple, and less time-consuming methods as compared to other methods. In the future, it can be potentially explored as a biosensor for UA detection in clinical samples.

Keywords: Graphene Quantum Dots; N-GQDs; Uric acid; Biosensor; Tamarind Shell Powder

1. Introduction

Principally, UA (2.6,8-trihydroxypurine) is the primary product of purine synthesis.[1] As per literature, in the general population, UA is referred to between 0.13 mM to 0.46 mM and 2.49 mM to 4.46 mM in serum and urine, respectively.[2] As we know, the abnormal levels of such metabolites in body fluids can cause several diseases.[3] Plentiful literature revealed that the increased UA levels in body samples are indicative of hypertension, gout, cardiovascular disease, kidney disease, high cholesterol, and many more.[4] In comparison, low concentrations of UA are also connected with multiple sclerosis and oxidative stress.[5,6] In diagnosis and healthcare, it is crucial to quantify metabolites in blood or other biological samples. Therefore, a rapid, responsive, precise, and cheap method of assessment must be developed to track such metabolites in body fluids including serum and urine.[5]

Literature survey reported that electrochemical sensing,[7] a colorimetric method,[8] a chromatographic method,[9] etc. are currently engaged detection techniques for UA in different body fluid samples. However, some in-conveniences such as complicated synthesis or challenging extraction, advanced equipment, expensive and tedious limiting their practical uses, are present in these approaches.[5] There are no exceptions for benefit of fluorescence. It is highly sensitive, and it shows a fast reaction, and operative simplicity in contrast to the oth-

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Chitosan mediated layer-by-layer assembly based graphene oxide decorated surface plasmon resonance biosensor for highly sensitive detection of β-amyloid

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ABSTRACT

Alzheimer's disease (AD), and its consequent effect primarily clinical dementia, Parkinson's disease dementia, etc. currently bring potential avenues for diagnosis centered on identification of beta-amyloid$_{1-42}$ (Aβ_{1-42}). Unfortunately, techniques engaged in AD core biomarker (Aβ_{1-42}) detection are majorly suffering from poor sensitivity and selectivity. Thus, we fabricated graphene oxide (GO) surface decorated chitosan (CS) mediated layer-by-layer (LbL) assembly based surface plasmon resonance (SPR) biosensor for highly sensitive and selective recognition of Aβ_{1-42}. Briefly, silver nanoparticles (AgNPs) and GO synthesis were achieved through a greener approach. LbL assembly was designed using CS and polystyrene sulphonate (PSS) on surface of AgNPs (AgNPs-CS-PSS-CS) and then antibodies of Aβ (anti-Aβ) were fixed on LbL assembly (AgNPs-CS-PSS-CS@anti-Aβ). Herein, amine functionality of CS offers a plethora of sites for anti-Aβ antibody immobilization that gives specific direction, high selectivity, and an adequate amount of antibody immobilization. For fabrication, synthesized GO was immobilized on an amine-modified gold-coated sensor chip via carbodiimide chemistry followed by AgNPs-CS-PSS-CS@anti-Aβ immobilization on an activated GO surface. Inimitable features of LbL assembly showed improved selectivity towards Aβ peptide whereas utilization of affinity biotransducer with a combination of plasmonic and non-plasmonic nanomaterial improved sensitivity and selectivity. Consequently, linearity range and limit of detection (LOD) of Aβ_{1-42} antigens were found to be 2 fg/mL to 400 ng/mL and 1.21 fg/mL, respectively. Moreover, analysis of Aβ_{1-42} in AD-induced rats confirmed the real-time-applicability of the designed SPR biosensor. Hence, GO surface decorated AgNPs-CS-PSS-CS@anti-Aβ mediated SPR biosensor would provide a novel approach for exceptionally sensitive and selective Aβ detection.

1. Introduction

Alzheimer's disease (AD) is a progressive, and irreversible neurodegenerative disease [1]. Subsequently, continuous progress in AD results in clinical dementia [2]. Importantly, AD is defined biologically by the presence of β -amyloid (Aβ) plaques and tau-containing neurofibrillary tangles in the brain [3]. It causes amnestic cognitive impairment in the prototypical form and non-amnestic cognitive impairment in the less common variants [3,4]. Literature divulged that AD is perhaps the leading prevalent form of dementia among individuals over the age of 65. It affects approximately 5 million individuals in the United States (US). As the population ages, the number of AD cases in the US is expected to climb to 16 million by 2050 [5]. Conventional diagnostic methods including imaging, laboratory analysis, examination, and initial history of the patient have been preferred to diagnose AD [5,6]. Such methods are suffering from plenteous demerits including less detection accuracy, extremely expensive, time-consuming, etc. Moreover, there is no promising treatment existed for the management of AD whereas symptomatic treatment can endow with a short period of relief. As a result, there is necessary to establish a newish solution to diagnose AD and clinical dementia at an early stage, which can contribute to the improvement of individual life [6,7].

Merely on AD phenotype, it is complicated to determine the fundamental disease process concerned in AD. Herein, assorted biomarkers might be of considerable assistance in expediting the early recognition of AD [8]. As per literature, biomarkers are quantitative signals that are expressed within a certain stage of the ailment. It renders them essential for both diagnosis and tracking therapy response [9]. In the case of AD,

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Short communication

Design of graphene quantum dots decorated MnO_2 nanosheet based fluorescence turn "On-Off-On" nanoprobe for highly sensitive detection of lactoferrin

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ABSTRACT

Lactoferrin estimation is increasingly acquiring prominence as a novel biomarker for the diagnosis of periodontal disease. To date, diverse lactoferrin detection methods which include electrochemical, surface-enhanced Raman scattering, colorimetric, and others have been extensively portrayed. Unfortunately, these systems have significant shortcomings including low sensitivity, selectivity, high cost, arduous and time-consuming technique, and so forth. Recently, the fluorescence-based method shows remarkable uniqueness that overcomes the demerits of traditionally reported techniques. Therefore, graphene quantum dots (GQDs) and manganese dioxide nanosheets (MnO_2-NS) based simplistic, highly sensitive, and selective fluorescent turn 'Off-On' mediated GQDs@MnO_2-NS nanoprobe was designed. Herein, MnO_2-NS addition demonstrated the quenching of GQDs containing fluorescence through inner filter effects (IFE) and strong interaction between GQDs and MnO_2-NS. The lactoferrin addition destroyed the MnO_2-NS and fluorescence emission of GQDs reappeared which may be because of redox reaction between lactoferrin and prepared MnO_2-NS. Herein, nanoprobe offers a wide concentration range and low limit of detection of 5 to 1600 ng/mL and 1.69 ng/mL, respectively. As fabricated GQDs@MnO_2-NS nanoprobe sensor demonstrated high selectivity, good stability, and reproducibility towards lactoferrin that assuring applicability of biosensor. Therefore, the GQDs@MnO_2-NS nanoprobe will offer a simplistic sensor with adequate sensitivity to achieve highly responsive and selective detection of lactoferrin.

1. Introduction

Periodontal disease is common in many countries [1], and is frequently produced by microbial infection. It stimulates the adherence of connective tissue and the prevention of bone surrounding the teeth at the onset of illness [2,3]. Despite this, its following inflammatory response adds to the loss of periodontal tissues in a patient. As a result, it is a prolonged inflammatory illness in people that causes not only regional mouth diseases but also systemic organ abnormalities [3]. Importantly, periodontal disease if remain untreated, the illness progresses to gradual bone damage, resulting in tooth movement and eventual tooth loss. As per literature, periodontal disease affects more than half of the grownup people in the United States, with around 10% suffering from serious disease those results in earlier tooth loss [4]. To prevent additional severances of periodontal disease, it is critical to accurately diagnose it. In this regard, biomarker detection is essential in the prediction of health difficulties, and scientists are presently investigating novel biomarkers for sickness diagnosis. In latest days, advances in the science of diagnosing oral as well as periodontal illness have evolved into ways for measuring periodontal threats employing quantifiable evidence kind of as biomarkers [5].

Lactoferrin (family: transferrin) is an iron-binding glycoprotein found in secondary neutrophil granulocytes [6]. As per literature, it demonstrates responsiveness to acute inflammation [3]. In addition, lactoferrin is observed in tears and saliva [6]. Lactoferrin estimation has received a lot of attention during the last two decades as a new biomarker [7] for the diagnosis of periodontal disease. Furthermore, it may be recommended for the diagnosis of various inflammatory illnesses [8]. Several identification studies have proposed various approaches for lactoferrin detection. Mainly, single radial

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Biofabricated functionalized graphene quantum dots (fGQDs): unraveling its fluorescence sensing mechanism of human telomerase reverse transcriptase (hTERT) antigen and *in vitro* bioimaging application

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Keywords: functionalized graphene quantum dots, hTERT, fluorescence quenching, turn 'On-off-On' biosensing, bioimaging

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Abstract

Lung cancer (LC) is a deadly malignancy that is posing a serious threat to human health. Therefore, early detection of LC biomarkers is the key to reducing LC-related fatalities. Herein, we present the first fluorescent-based selective detection of LC biomarker human telomerase reverse transcriptase (hTERT) using polyethyleneimine (PEI) functionalized graphene quantum dots (fGQDs). One-pot *in situ* synthesis of amine-functionalized GQDs was accomplished by hydrothermal carbonization of biowaste-derived cellulose and PEI. Synthesized fGQDs were characterized by various analytical techniques. Synthesized fGQDs not only exhibited enhanced fluorescence life-time but also excellent stability in the different solvents compared to bare GQDs. The surface activation of hTERT-Ab by carbodiimide chemistry (EDC-NHS) resulted in stacking interactions with fGQDs, involving adsorption-desorption as well as competitive mechanisms. The higher inherent affinity of hTERT-Ag (hTERT antigen) for hTERT-Ab (hTERT antibody) resulted in complex formation and recovery of fGQD fluorescence. As a result, this fluorescence sensing demonstrated a greater linear detection range (0.01 ng ml^{-1}–100 μg ml^{-1}) as well as a notable low detection limit (36.3 pg ml^{-1}). Furthermore, the fabricated immunosensor (Ab@fGQDs) has excellent stability and performance in real samples, with an average recovery of 97.32%. The results of cytotoxicity and cellular bioimaging study in A549 cells show that fGQDs can be used for additional nanotherapeutics and biological applications.

1. Introduction

Among all cancer-related deaths worldwide, lung cancer (LC) is accounted for the highest mortality rate on a global scale [1]. The global pattern of LC incidence and mortality rates is changing every day, with experts predicting that the general population will be at a higher risk of developing LC [2]. According to recent reports, LC is the most commonly diagnosed cancer (11.4%) and has the highest death rate (18%) of all cancers [3]. The literature revealed that a variety of LC biomarkers have been studied independently viz. cancer antigen 125 (CA125) [4], cytokeratin fragment (CYFRA21-1) [5], neuron-specific enolase (NSE) [6, 7], melanoma-associated antigens (MAGE A2, MAGE A11) [8], carcinoembryonic antigen (CEA) [9], heterogeneous nuclear ribonucleoprotein (hnRNP A2-B1) [10] and fibrin degradation product (D-dimers) [11], including human telomerase reverse transcriptase (hTERT) [12–14].

The hTERT is a ribonucleoprotein polymerase (RNP), which adds the TTAGGG repeating units to the telomere by which it performs its characteristic functions [15]. Telomerase is mostly found in fetal tissues, mature germ cells, and tumor cells about 70%–90%. Telomerase expression is critical for cellular immortalization and cellular senescence. The ectopic expression of hTERT plays an important role in the

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Design of zero-dimensional graphene quantum dots based nanostructures for the detection of organophosphorus pesticides in food and water: A review

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ABSTRACT

From its inception, traditional analytical approaches have been the primary strategies for sensing organophosphorus pesticides (OPPs). Unfortunately, traditionally reported methods are suffering from plentiful limitations that include their cost factor, poor responsiveness, low specificity, tedious, etc. Recently, graphene quantum dots (GQDs) have been widely applied to researchers' recognition of OPPs sensing in water and food samples, due to their outstanding and versatile attributes. Moreover, the combination of other nanomaterials like inorganic and organic materials, along with surface tuning of GQDs such as doping and functionalization, shows the potential to boost the performance of the sensing system. Despite this indubitable development, there is no detailed report on the design of zero-dimensional GQD-based nanostructures for the detection of OPPs in food and water. Therefore, we have addressed the GQDs-centered nanostructures for the recognition of OPPs in water and food. Importantly, it covers the consumption of OPPs and their impact on human health, while the synthesis and properties of nanosized GQDs have been reviewed. Besides, GQDs based on fluorescent, electrochemical, and colorimetric nanoprobe for monitoring OPPs have been illustrated. Moreover, sensing mechanisms, anti-interference potential, current challenges, and future research have been described. Fascinatingly, modification of GQDs enabled sensors exhibits supreme responsiveness and specificity for recognition of OPPs in provided samples. Accordingly, existing architectured GQDs mediated nanoprobes furnish the lower detection limit for OPPs up to a picogram. In near future, the nano-design of GQD-centered sensors will open up a new door for sensing OPPs in real-time samples.

1. Introduction

Pesticides are increasingly being utilized in crop management and pest control in advanced agricultural practices. Surprisingly, the world food demand rises, leading to increased pesticide utilization [1]. Pesticides have been categorized into rodenticides, insecticides, fungicides, and herbicides [2]. As well, pesticides such as organochlorines, organophosphorus, carbamates, pyrethrin, and pyrethroids are often chemically categorized [3]. Among reported pesticides, organophosphorus pesticides (OPPs) are most widely employed in agriculture due to the relatively long half-life, low persistence, cheaper price, high insecticidal efficacy, and high effectiveness [4,5]. Principally, OPPs are phosphoric acid ester, thiol, or amides derivatives with a diverse range of carbon, oxygen, sulfur, and nitrogen bonded compositions [6]. There are hundreds of OPPs in use due to the enormous number of chemical combinations. Moreover, most extensively OPFs used in agriculture are malathion, parathion, methyl parathion, azamethiphos azinphos-methyl, chlorpyrifos, diazinon, dichlorvos, disulfoton, fenitrothion, fonofos, phosmet, tetrachlorvinphos, terbufos, etc [7]. Owning to lethal effect on the target pests and easy accessibility, OPPs are extensively utilized over the globe [8]. Likewise, organochlorine pesticides such as dichlorodiphenyltrichloroethane (DDT), aldrin, and dieldrin have been phased out due to lack of effectiveness and environmental persistence. OPPs are usually soluble in water and rapidly degrade via hydrolysis once introduced into the air, sunlight, and soil [9]. Moreover, the extensive use and non-persistent nature of OPPs remain for a longer period in the environment. It leads to environmental contamination and has gradually evolved into the food supply chain via water, air, and soil [10]. Surprisingly, OPPs residues accumulate in the body even at very low concentrations, triggering serious health issues [11].

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Fabrication of poly (aspartic) acid functionalized graphene quantum dots based FRET sensor for selective and sensitive detection of MAGE-A11 antigen

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Fluorescence resonance energy transfer
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Bioimaging

ABSTRACT

In the present work, we investigated a label-free fluorescence resonance energy transfer (FRET) based poly (aspartic) acid (PAsP) functionalized graphene quantum dot (PAsP-GQDs) immunosensor for the selective and sensitive sensing of MAGE-A11 antigen.

Synthesis of GQDs was accomplished with hydrothermal carbonization of Onion hull (ONI-GQDs). Synthesized PAsP-GQDs were characterized for fluorescence performance, functional compositions and morphological analysis. To form a typical FRET system, functionalized GQDs conjugated with anti-MAGE-A11 (antibody) using EDC/NHS chemistry served as an energy donor, while graphene nanosheets served as energy acceptors (quenchers). The fabricated PAsP-GQDs@M−A11−Ab immunosensor demonstrated high selectivity to MAGE-A11 with a broader detection range about of 0.05 ng mL^{-1} – 5 μg mL^{-1} (R^2 = 0.9906) and a detection limit of about of 5.6 pg mL^{-1}, with a rapid response time of 12 min. The performance of the developed immunosensor was established using real sample analysis, which showed an average recovery of 96.8 % with % RSD 0.71 indicating the high precision and reproducibility of the method. Furthermore, to implicate the post-functionalization modifications, cellular bioimaging potential and cytotoxicity studies were conducted as a comparative assessment. The present immunosensing strategies can be utilized as an analytical tool for detecting MAGE-A11 in various cancers.

1. Introduction:

The global cancer risk is growing steadily, with a high fatality rate per year. The most recent epidemiological survey statistics raised concerns about the possibility of imposing cancer cases [1]. Among the various types of cancer, lung cancer (LC) is the most frequently diagnosed cancer worldwide next to breast cancer [2]. With precise early detection testing, the stages of LC can be identified. In that, identification of different tumor markers could be the key finding to arrest at the proper stage with desirable treatment. Different types of tumor marker (protein) were identified as an indication of the LC such as carcinoembryonic antigen (CEA), cancer antigen-125, pro-gastrin-releasing peptide (proGRP), cytokeratin fragment (CYFRA 21–1), Melanoma-associated antigen family proteins (MAGE's) and neuron-specific enolase (NSE) etc. [3,4]. Amongst these, MAGEs are often observed in the fetal keratinocytes, placenta, and male germ cells as well as different human malignancies. Melanoma-associated antigen-A11 (MAGE-A11) is an X-linked gene that is expressed at a lower rate specifically in the placenta, testis, endometrium and ovary of humans [5]. The MAGEs family protein plays a vital role in physiology as well as pathology of germ cell development embryogenesis, neurogenetic, cell cycle progression, apoptosis, etc. MAGE-A11 antigen expression is also found at differential levels in lung cancer, breast cancer and prostate cancer [6]. Surprisingly, it was found at higher levels in adenocarcinoma than in squamous cell carcinoma of lungs. Hence, MAGE family antigens are considered ideal target markers for immunotherapy as well as early diagnosis and management [7,8].

Accordingly, the use of different methods such as Southern blotting with reproductive tract fluid (RTF), polymerase chain reaction-based (PCR) based methods, high-resolution telomere length analysis (STELA), DNA-Microarrays, enzyme-linked immunosorbent assay (ELISA), etc. being investigated as supportive methods [9]. Though the systematic estimation methodology of MAGEs is limited, there is growing interest in researchers for the assessment of their interactions

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Formulation, optimization, and *in-vitro-ex-vivo* evaluation of dual-crosslinked zinc pectinate-neem gum-interpenetrating polymer network mediated lansoprazole loaded floating microbeads

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ABSTRACT

Low methoxy pectin (LM pectin) suffers from burst release owing to its high swellability and solubility in water. Consequently, in ways to design an ideal drug delivery system, these obstacles must be surmounted. Therefore, the work aimed to design dual crosslinked LM pectin -neem gum (NG) mediated interpenetrating polymer network (IPN) floating mucoadhesive microbeads for lansoprazole (LNZ) gastro-retentive delivery. In short, LNZ-loaded floating microbeads were achieved by using the ionic gelation method wherein zinc acetate was preferred as a crosslinking agent. The optimization of IPN microbeads was performed employing a 3^2factorial design wherein concentration of pectin and NG was considered as independent factors whereas dependant factors are entrapment efficiency and drug release. Importantly, carboxylic functionality of low methoxy (LM) pectin and hydroxylic functionality NG cross-linked with Zn^{+2} forms a 3D network. Diffractogram and thermogram revealed that conversion of drug from crystalline to amorphous form because of entrapment of drug within polymeric network. Anticipated floating microbeads showed that polymer concentration had considerable effect on drug encapsulation efficiency and drug release. Briefly, optimizing floating microbeads (Batch B:5) showed maximum drug entrapment (87.47 %) with a delayed drug release (69.20 %, at 8 h) due to formation of strong IPN. Moreover, it showed good mucoadhesive aptitude with goat stomach mucosa because of entanglement between gum and mucus layer. In addition, use of calcium silicate assists to modulate floating profile of IPN microbeads. Therefore, designing dual crosslinked zinc-pectinate-NG mediated IPN floating mucoadhesive microbeads will offer a new substitute for floating delivery.

1. Introduction

Gastro-retentive drug delivery system (GRDDS) one of the oral drug delivery systems gained popularity due to various qualities, such as decreased therapy costs, easy administration, self-medication, greater patient compliance, and acceptability [1]. It is an approach that overcomes the problems in drug absorption due to the short residence time in the stomach faced by conventional drug delivery. It can markedly extend the residence time of drugs in the stomach, increasing bioavailability and decreasing drug waste. Therefore, it is possible to achieve site-specific drug delivery specifically to the stomach and upper small intestine [2,3]. Floating drug delivery is one of the major approaches of GRDDS to achieving prolonged gastric retention to attain appropriate drug bioavailability and drug targeting [2]. These devices release the medicine gradually at a predetermined and controlled rate without influencing the gastric emptying rate [4,5]. At the moment, dual-functioning systems that combine floating and mucoadhesive processes are getting a lot of interest since they can greatly boost the performance of traditional GRDDS [6,7]. Additionally, the multiple-unit GRDDS demonstrates its advantage over the single-unit forms by ensuring uniform dispersion across the gastrointestinal tract [8].

Nowadays, Recent trends incline toward the use of natural products derived from plant materials [9,10] to minimize and restrict the use of synthetic additives because the former is biodegradable, found in abundance in nature, non-toxic, and provides ease in working and at low cost [11,12]. In the current scenario, due to their outstanding

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REVIEW ARTICLE

Nanosuspension: A New Horizon in the Drug Delivery System

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ABSTRACT

Solubility is one of the major concerns in various drug formulations. Since the majority of new drug molecules belong to the BCS II (Biopharmaceutical Classification of Drug) they often lead to poor bioavailability and ultimately affect the drug's effectiveness. The majority of new drug molecules are insoluble and hence poorly bioavailable. Because of these limitations, the proportion of newly discovered drugs reaching the market is decreasing. Nano-suspension emerges as one of the novel solutions for these problems. As it helps in delivering poorly water-soluble drugs, due to their all-around features and unique advantages. The distinctive features of nanosuspensions allow them to be used in a variety of dosage forms, including mucoadhesive hydrogels, nanogels, etc. The present review article provides information regarding the introduction to nanosuspensions, the advantages, and disadvantages of nanosuspensions, different methods of their preparations, and numerous practical applications in drug delivery.

Keywords

Nanosupension, Dissolution, Surfactant, Solubility, Bioavailability.

Introduction

Nanosuspension is a biphasic dispersion of superficially stabilized micron-sized drug particles. Therapeutic nanosuspensions seem to be very tiny solid particles of a drug suspended in an aqueous carrier for administration via oral, local, parenteral, or pulmonary routes. Dispersed particles in nanosuspensions are in the size range of 200 to 600 nm (Èller et al., n.d.). The drug maintains the ideal crystalline state with smaller particles in nanosuspension technology, enhancing the rate of dissolving and penetration and improving bioavailability. Higher solubility and micronized particle penetration (particle size <10 μm) is associated with increased surface area and thus dissolution rate. Nano-sized particles can increase the dissolution rate and solubility. Except; as the diffusion distance on the drug nanoparticle surface decreases, the concentration gradient increases (Mü & Peters, 1998). The stability of nanosuspension is affected by the size of the particles produced by the various manufacturing processes. Crystal development and consequent fine particle production are caused by Ostwald ripening. The difference in dissolution rate between fine and coarse particles is due to the availability of surface area. Molecules diffuse from a zone of greater concentration to a region of lower drug concentration. As a result, a supersaturated solution forms surrounding the large particles, causing the medication to crystallize and huge particles to proliferate. Sedimentation, high-pressure homogenization, emulsification, and milling processes can all be used to make nanosuspensions. Nanosuspensions can be made in one of two ways.

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ORIGINAL ARTICLE

Fabrication of polyaspartic acid surface-modified highly fluorescent carbon quantum dot nanoprobe for sensing of reduced glutathione in real sample

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Received: 26 July 2022 / Accepted: 4 November 2022

Abstract
The goal of this study was to create a polyaspartic acid (PAA) surface-modified blue luminescent carbon quantum dots (CDs)-based biosensor (PAA-CDs) that could detect calcium (II) ions and glutathione (GSH) with excellent sensitivity and selectivity. Herein, the hydrothermal approach was adopted to produce blue luminescent CDs from mint plant stalks. To improve surface irregularities, quantum confinement effects, and to impart recognition sites for the analyte sensing, the CDs were surface-functionalized with PAA. Spectroscopic techniques like UV, FT-IR, XPS, and other techniques were used to sanction the synthesis and surface functionalization of PAA-CDs. The probe PAA-CDs was utilized for the detection of Ca (II) ions via a quenching process (turn-off) and subsequently, restoration in fluorescence intensity (turn-on) was accomplished by incorporation of GSH, forming a novel probe for sensing of biothiol. For a linearity range of 0–45 µM concentration of Ca (II), the LOD was obtained as 25 nM in phosphate-buffered saline solutions (PBS, pH 7.4). Similarly, for a linearity range of 0–40 µM concentration of GSH, LOD was obtained as 64 nM. The surface-modified PAA-CDs exhibited stronger affinity towards Ca (II) ions via the FRET mechanism, which formed the Ca (II)@PAA-CDs complex that was unable to emit photons when excited. Thereafter, thiol (-SH) group of GSH offered selective attraction with Ca (II) ions among the various biomolecules; this caused the breaking of Ca (II) from Ca(II)@PAA-CDs complex. So, the detachment of Ca (II) from the complex re-established the fluorescence intensity of PAA-CDs in linear fashion. In addition, the cytotoxicity study of the PAA-CDs revealed their biocompatible nature, and the methodology was effectively practical to estimate the GSH concentration in human serum samples.

Keywords Carbon quantum dots · Polyaspartic acid · Functionalized carbon quantum dots · Calcium (II) ions sensing · Glutathione sensing · Fluorescent probe

Introduction

The reduced glutathione (GSH), homocysteine (Hcys), and cysteine (Cys) are major biothiols playing noteworthy functions in the conservation of pathological and physiological processes (Ballatori et al. 2009). The distinguished biothiol, GSH, is an important biological stuff that could be monitored to diagnose a number of diseases (Staal and Ela 1992).

The GSH is a putative antioxidant that performs a variety of important biological tasks such as maintaining biological redox status, modulating cell growth, gene regulation, decontamination, and metabolic activity (Yoo et al. 2019). GSH is reportedly found in normal cells (1–10 mM) and plasma (1–6 µM) (Khan and Patil 2020). Abnormal levels of GSH are linked to numerous diseases and disorders. According to the study, increasing GSH levels boosted antioxidant levels and oxidative stress resistance in cancer cells (Lucero and Chan 2021). Reduced GSH levels, on the other hand, indicate the loss of immune system functions as well as the possibility of an aging problem. Similarly, its shortage may lead to enhanced levels of oxidative stress, causing cancer (Bottino et al. 2021).

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Bovine serum albumin-derived poly-L-glutamic acid-functionalized graphene quantum dots embedded UiO-66-NH_2 MOFs as a fluorescence 'On-Off-On' magic gate for *para*-aminohippuric acid sensing

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Bovine serum albumin
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ABSTRACT

Evaluating *para*-aminohippuric acid (PAH) is emerging as a promising biomarker for the diagnostics of renal disease and other kidney-related illnesses. The present study aims to develop novel bovine serum albumin-derived poly-L-glutamic acid (PLGA) functionalized graphene quantum dots (PLGA-fGQDs) embedded in UiO-66-NH_2 metal–organic frameworks (PLGA-fGQDs@UiO-66-NH_2 MOFs) for monitoring of PAH. Initially, GQDs were achieved from bovine serum albumin (green precursor) via the single-step hydrothermal method. Here, functionalization with PLGA offers a tremendous increment in optical properties of GQDs. Then, highly luminescent UiO-66-NH_2 MOFs were achieved using zirconium tetrachloride ($ZrCl_4$) and 2-Aminoterephthalic acid (2-ATA) as a metal ion source and organic linker. Here, surface modification of GQDs with PLGA offered high quantum yield (QY), and responsiveness. Also, luminous UiO-66-NH_2 MOFs afford a wide surface area for decorating of PLGA-fGQDs. The addition of gallium ions (Ga^{3+}) into the probe solution resulted in fluorescence quenching (Turn-Off) whereas the incorporation of PAH resulted in fluorescence recovery (Turn-On). It is because of interaction with carboxylic functionality of PAH to Ga^{3+} followed by Ga-PAH complex formation. Herein, the wide concentration range and lowest limit of detection (LOD) were found to be 10 ng/mL to 900 ng/mL and 15.88 ng/mL, respectively. The specificity and real-time analysis in artificial urine validated the real-time adoption of a sensor for PAH detection. As well, it demonstrated good intraday/interday precision, stability analysis, and repeatability. In near future, the bundled illuminating PLGA-fGQDs@UiO-66-NH_2 MOFs nanoprobe will be an attractive preference for tracking PAH in clinical specimens.

1. Introduction

Renal diseases have already been considered a major public health concern around the globe. In this shade, the scientific community constantly committed to the advancement of screening methods [1]. In this ray, *para*-amino hippuric acid (PAH, 4-amino derivative of hippuric acid) is utilized in the assessment of renal plasma flow (RPF) as a diagnostic agent [2]. Hence, PAH is a valuable agent for accurately measuring effective renal plasma flow (ERPF) in clinical and laboratory research to evaluate renal functioning [3,4]. Basically, PAH is an amide derivative of glycine and *para*-aminobenzoic acid. It doesn't naturally occur in humans. As a result, it must be injected via intravenous (IV) prior to diagnosis. As an outcome, at low plasma concentrations (1 mg to 2 mg/100 mL), the kidneys can remove 90 % of aminohippurate from the renal circulating blood in a single circulation. As a function, PAH can be exploited to examine renal function as an essential indicator [5]. The renal extraction ratio of PAH in a normal individual is between 0.92 and 1.65 mL/min/kg [6]. Traditionally acknowledged indications of renal dysfunction encompass high uric acid levels and an imbalance in PAH levels [7]. In this regard, numerous analytical techniques, such as HPLC with UV detection [6], colorimetric detection [8], tandem mass spectrometry [9], and electrochemical detection [10], have been proposed

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Original Article

Thai Journal of Pharmaceutical Sciences

Development of amino acid salt-based curcumin@lysine acetate co-amorphous system using liquid-assisted grinding for improved solubility and dissolution

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ABSTRACT

Curcumin, multivalued phytoceutical, exhibits appreciable safety. However, its therapeutic utility is significantly compromised due to low aqueous solubility, and thus, poor absorption and low bioavailability become apparent. To surpass this limitation, the present work aims to develop amino acid salt-based curcumin@lysine acetate co-amorphous system for improved solubility and dissolution. Initially, screening of curcumin-amino acid mixtures was performed for saturation solubility assessment. Considering the outcome, lysine acetate was formulated to generate a co-amorphous mixture (COAM) by liquid-assisted grinding and evaluated for saturation solubility and different spectroscopical characterizations. Curcumin-lysine acetate COAM tablet formulation was developed by direct compression method and evaluated for appearance, thickness, hardness, weight variation, friability, drug content, disintegration, and *in vitro* dissolution studies. Further, curcumin-lysine acetate COAM and tablet formulation were screened for the accelerated stability study. Resultantly, curcumin-lysine acetate binary mixture demonstrated the highest saturation solubility among screened curcumin-amino acid binary mixtures that might be ascribed to the hydrotropic properties of lysine acetate. Moreover, 476-fold solubility enhancement in water was observed by curcumin-lysine acetate COAM. Later, the amorphization of the curcumin-lysine acetate COAM was confirmed using Fourier-transform infrared spectroscopy, differential scanning calorimetry, and powder X-ray diffraction. COAM tablet formulation showed optimum evaluation characteristics with improved drug dissolution. Therefore, the amino acid salt-based co-amorphous system can be used for solubility and dissolution improvement of curcumin and other multivalued phytoceutical.

Keywords: Amino acid, co-amorphism, curcumin, dissolution, lysine acetate, solubility

Graphical Abstract

Development of lysine acetate-based curcumin co-amorphous system using liquid-assisted grinding for improved solubility and dissolution.

INTRODUCTION

Co-amorphism has been widely attempted for improving the physicochemical and technological properties of actives.[1,2] The co-amorphous mixture (COAM)

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Design of polyacrylamide grafted sesbania gum-mediated pH-responsive IPN-based microbeads for delivery of diclofenac sodium: *In-vitro-in-vivo* characterizations

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Sesbania gum
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pH-sensitive microbeads, diclofenac sodium

ABSTRACT

Microwave-assisted grafting of polyacrylamide on sesbania gum (PAAM-g-SG) was implemented employing a 3^2 full factorial experimental design and was hydrolyzed using sodium hydroxide (NaOH) to form H-PAAM-g-SG. Further, the diclofenac sodium-loaded novel pH-sensitive interpenetrating polymeric network (IPN) microbeads were designed using an optimized H-PAAM-g-SG and sodium alginate (SA). Different spectroscopic analysis including FTIR spectroscopy, ^{1}H NMR spectroscopy, elemental analysis, thermal analysis, *etc.* was performed to confirm the synthesis of PAAM-g-SG and diclofenac-loaded pH-sensitive IPN H-PAAM-g-SG-SA microbeads. Here, Ca^{+2} ions combine with two strands of SA and form a round-shape structure that encloses uncross-linked H-PAAM-g-SG polymer and diclofenac sodium. As well, glutaraldehyde (GL) addition improved the mechanical strength due to acetal structure between hydroxyl of H-PAAM-g-SG and aldehyde of GL. The drug entrapment was confirmed proportional relationship to the Ca^{+2} ions concentration whereas an increase in GL concentration resulted in a reduced drug entrapment. The pH pulsatile study assured the reversible swelling-shrinkage behavior of IPN microbeads due to the carboxyl group of PAAM-g-SG. The drug release from H-PAAM-g-SG-SA microbeads (batch: S9) was found to be 84.21 % (12*h*) which was non-significant ($p > 0.05$; f2 = 79 ~ 90) over marketed formulation (83.31 %). Moreover, it follows the Korsmeyer Peppas ($R^2 = 0.996$) as the best-fit release kinetic model. The pH-sensitive release of diclofenac sodium from IPN H-PAAM-g-SG-SA microbeads was assured based on *in vivo* anti-inflammatory activity ($p < 0.05$). Therefore, developed novel pH-sensitive IPN microbeads based on H-PAAM-g-SG are a promising polymeric carrier substitute for delivery of drugs actuated by a pH stimulus.

1. Introduction

Sesbania gum is a natural polysaccharide obtained from the annual legume seeds (biological source: *Sesbania grandiflora*; family: Leguminosae). Importantly, it contains a synthetic framework similar to guar gum. The constituent of SG is α (1–6) glycosidic bond to galactose as well as β (1–4) glycosidic bond to mannose. Hence, it is composed of mannose and galactose with a proportion of 2:1. In pharmaceutical dosage form, it has been reported as a thickening agent, floating agent, cosmetics, *etc.* [1,2]. Literature reported that SG can be a suitable alternative for the development of advanced pharmaceutical dosage forms [3,4] such as hydrogels, beads, *etc.* It ensured that limited consideration was given to the utilization of SG as a potential replacement for excipients in pharmaceutical applications. Regardless of these benefits, there are issues with natural polysaccharides like uncontrolled hydration, lower shelf life, pH-dependent solubility, change in viscosity during storage, and terrific swellability. For the development of pharmaceutical dosage, there is a design to overcome the demerits of natural polysaccharides [5]. A wide variety of chemically modified/grafted polysaccharides has become an essential element in various biomedical applications [6].

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Fabrication and Characterization of Curcumin-loaded Gelatin Nanoparticle Using A Two-Step Desolvation Protocol

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Abstract Recently gelatin nanoparticles (G-NPs) have been gaining substantial consideration because they offer excellent properties like low cost, biocompatibility, and biodegradability. One of the protein materials that can be utilized to make nanoparticles is gelatin. The emphasis is constructed on the datum that gelatin is non-toxic, easy to crosslink, and chemically changeable, and hence consumes a gigantic potential for colloidal drug delivery system synthesis. The surface of G-NPs can be easily cat-ionized with a variety of amine derivatives to provide targeted and sustained drug delivery. Curcumin-loaded gelatin G-NPs were manufactured using a two-step desolvation progression in this study. A glutaraldehyde cross-linker was also employed to provide G-NP with good stability. Inclusive, the ordinary size of the curcumin-loaded gelatin (CGNPs) was 112 nm, with a zeta potential of +31.80 mV. An *In-vitro* dissolution study confirmed 88 % of the drug was released from the CGNP within 24 h. In comparison, drug release showed a lower release rate, at about 66 % after 24 h. In the present work, we fabricated a curcumin-loaded gelatin nanoparticle to improve the solubility and thereby enhance the stability of a formulation, which will further encourage the progress of curcumin based on nanoformulation. Curcumin-loaded gelatin nanoparticles have a higher stability in biological fluids than colloidal carriers, allowing for the desired delimited and unrelenting release of encapsulated drug molecules. In all, the fabricated curcumin-loaded gelatin nanoparticle proved to be a sustained-release drug delivery system.

Keywords Gelatin Nanoparticle, Gelatin, Curcumin-loaded Gelatin Nanoparticles, Glutaraldehyde, Anti-Cancer, Desolvation Method

1. Background

Because of their excellent biocompatibility and biodegradability, gelatin nanoparticles (G-NPs) have been widely used as drug and gene carriers for diseased tissues such as HIV infection [1], tuberculosis, and cancer [2]. Coating with gelatin, for example, reduces cytotoxicity while also allowing G-NPs to traverse the blood-brain barrier, allowing them to better target brain problems [3]. Recently, nanoparticles (NPs) have provided enormous benefits in terms of improving drug delivery systems by

Research Article

Nano Biomed Eng

Graphene Quantum Dots Incorporated UiO-66-NH_2 Based Fluorescent Nanocomposite for Highly Sensitive Detection of Quercetin

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Abstract

Quercetin can help with a variety of health problems. Most methods for measuring quercetin in biological fluids are characterized by low sensitivity and selectivity. The employment of metal–organic frameworks in sensor applications with carbon-based materials ushers in a new era. In this study, blue fluorescent graphene quantum dots (GQDs) embedded in a UiO-66-NH_2 metal–organic framework-based nanoprobe (GQDs@UiO-66-NH_2) were constructed for quercetin sensing. Initially, maize husk was used to produce blue fluorescent GQDs, whereas zirconium tetrachloride and 2-aminoterephthalic acid were used to synthesize extremely luminous UiO-66-NH_2. The addition of quercetin to GQDs@UiO-66-NH_2 leads to fluorescence dampening due to the adsorption potential of UiO-66-NH_2. The complexation of zirconium ions with the 3-OH and 4-C=O functionalities of quercetin resulted in fluorescence quenching. The sensor has a linear concentration range and limit of detection for quercetin of 50–500 and 2.82 ng/mL, respectively. The nanoprobe's usefulness for quercetin detection was then validated by a selectivity investigation in the presence of interfering chemicals. Furthermore, the percentage relative standard deviations were 4.20% and 2.90%, respectively, indicating great stability and repeatability. Fluorescence "Turn-On–Off" nanoprobes provide a simple, quick, sensitive, and selective method for monitoring quercetin.

Keywords: quercetin; graphene quantum dots (GQDs); fluorescence; nanoprobe; metal–organic framework; GQDs@UiO-66 NH_2; sensitivity

Introduction

Quercetin is the most important flavonoid in fruits and vegetables [1]. It does not produce in human bodies [2]. Quercetin is widely reported for antioxidant, antiviral, immunomodulation, antitumor [3], and anti-inflammatory [4] applications. The literature claimed that 945 mg/m² is the safe dose for quercetin. A high dose of quercetin can produce different several health issues including hypertension, a decline in potassium levels in serum, and emesis [2]. Therefore, accurate measurement of the concentration of quercetin is essential in the biomedical field [3]. Moreover, to measure the bioavailability of quercetin, it is essential for pharmacological response [1]. In general, analysis of quercetin with a simplistic, speedy, highly selective, and sensitive method is a prime necessity [4].

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Preparation of pirfenidone loaded chitosan-polyvinyl alcohol-graphene oxide-based scaffold: Spectroscopical characterizations and antibacterial activity

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Antibacterial activity

ABSTRACT

The antibacterial activity against *Staphylococcus aureus (S. aureus)* in diabetic foot wound treatment is an appealing area for budding researchers. In this case, drug-loaded chitosan (CS)/polyvinyl alcohol (PVA)/graphene oxide (GO)-based composites can be used as an excellent option for antibacterial activity in diabetic foot wound treatment. Therefore, the present study aims to design a pirfenidone-loaded CS/PVA/GO nanocomposite (PFD-CS/PVA/GO) based scaffold via solvent casting method for improved antibacterial activity. In brief, CS with PVA forms the polyelectrolyte complex due to hydrogen bonding between amine functionality (CS) and a hydroxyl group (PVA). The GO nanosheet addition into CS/PVA resulted in covalent bonding between the amine functionality (CS) and the carboxylic functionality (GO) whereas PFD was fixed in CS/PVA/GO via π-π stacking. In this study, optimized PFD-CS/PVA/GO (6% w/w) scaffold percent entrapment efficiency, tensile strength, moisture content, % drug release, % swelling degree, % elongation at break, and water retention capacity were found to be 77.60%, 70.35 g/cm^2, 16.39%, 50.60% (7 days), 236%, 45%, and 543.47%, respectively. Release kinetics assured that the Higuchi matrix was the best-fit model ($R^2 = 0.99$). Interestingly, the GO avoids burst drug release at the beginning followed by extending the release whereas CS into PFD-CS/PVA/GO provides a good adhesive ability. Finally, antibacterial activity against *S. aureus* of PFD-CS/PVA/GO (6% w/w) shows a high (12.06 mm) zone of inhibition over a separate component of the scaffold. Concisely, optimized PFD-CS/PVA/GO (6% w/w) scaffolds provide improved antibacterial potential owing to their combined benefits of CS, and GO. In the future, anticipated PFD-CS/PVA/GO scaffolds will open a new door for antibacterial potential in diabetic foot wound healing.

1. Introduction

Diabetes mellitus (DM) is a critical condition in the healthcare sector. Epidemiological studies indicate approximately 285 million cases of DM in 2010 whereas it would be more than 360 million cases of DM in 2030. As per the literature, DM patients are susceptible to several problems wherein diabetes chronic foot wounds are one of them [1]. Unfortunately, diabetes chronic foot wounds take longer to heal because of disruptions in the process of collagen synthesis [2]. In addition, diabetic food infection is associated with poly-microbial infections. In that, *Staphylococcus aureus (S. aureus)* is the most common pathogen. Presently, with the continuous preferences for antibiotics, there are chances of antimicrobial resistance for this pathogen [3]. To treat this critical healing condition of patients, several types of advanced approaches have been revealed. Current treatment approaches incorporating active for particular tasks, such as nanoparticles, nanogels, beads, biofilms, bandages, nanofibrous membranes, and so on, are unable to provide the necessary effects [2]. In addition, available therapies including tissue transplants, bioengineered skin, growth factors, hyperbaric oxygen treatment, and negative pressure wound therapy have shown healing

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Original Article

Thai Journal of Pharmaceutical Sciences

Prevalence, distribution, treatment, and modern methods for *in vitro* diagnosis of Alzheimer's disease in India: Challenges and future prospective

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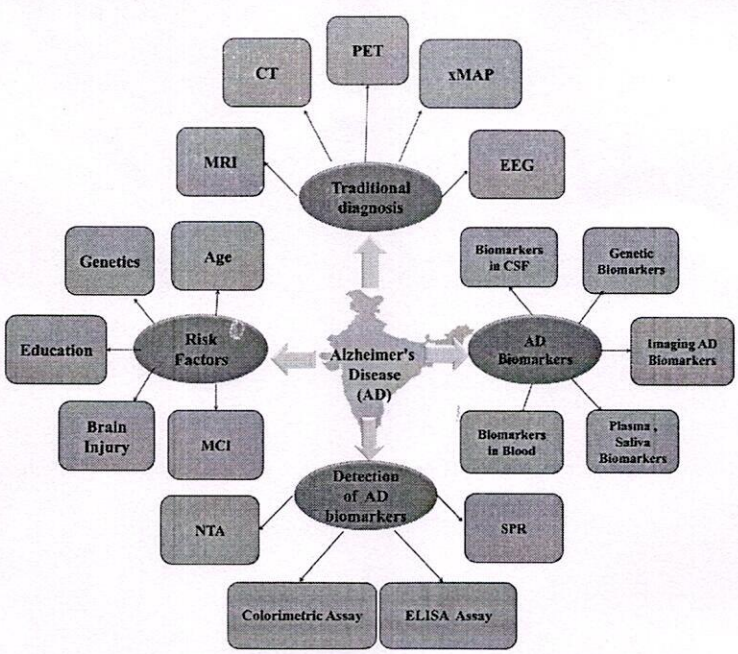
ABSTRACT

In India, the plethora of evidence indicates that neurodegenerative conditions are a significant public health issue wherein over 4 million Indian peoples have been affected. For the past two decades, the prevalence of Alzheimer's disease (AD) is growing rapidly in India that may due to the significant lack of health-care services and poor knowledge of AD and another form of dementia. Therefore, this in turn to develop ultramodern techniques for the efficient detection of AD biomarkers that helps to the prognosis and diagnosis of AD. Recently, significant progress has been observed in the area of AD that includes prognosis, and diagnosis of AD. This review article discussed different risk factors associated with AD, data on the dissemination of AD in India according to different virtues and socio-economic categories. The different standard diagnostic techniques commonly used for the identification of AD biomarkers are mentioned. This review also focuses on the new techniques established by Indian researchers such as surface plasmon resonance centered biosensors, and fluorescence-based probes that offer the enormous potential of highly sensitive and selective detection AD biomarkers. In conclusion, the present review article is providing a short overview of AD prevalence and AD-centered research in India.

Keywords: Alzheimer's disease, biomarkers, biosensing, *in vitro* diagnosis, India



Graphical Abstract: Alzheimer's disease friendly India: Prevalence, distribution, treatment, and modern methods for *in vitro* diagnosis of AD

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Poly(allylamine) coated layer-by-layer assembly decorated 2D carbon backbone for highly sensitive and selective detection of Tau-441 using surface plasmon resonance biosensor

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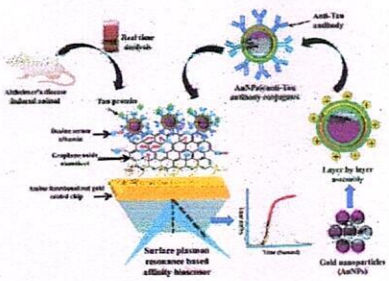
HIGHLIGHTS

- The first-time layer-by-layer (LbL) approach was preferred for selective and sensitive recognition of Tau-441 antigen.
- Antibody immobilization on poly(allylamine) coated gold nanoparticles (AuNPs) LbL assembly gives affinity biotransducer.
- Graphene oxide (GO) layered surface plasmon resonance (SPR) biosensor provides detection limit up to femtogram level.
- Spiked sample and preclinical studies assured the feasibility of GO@LbL-AuNPs-Anti-Tau SPR biosensor for Tau-441 sensing.
- Report on label-free, highly sensitive, and selective detection of Tau-441 using GO@LbL-AuNPs-Anti-Tau SPR biosensor.

GRAPHICAL ABSTRACT



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Surface plasmon resonance
LbL assembly
Gold nanoparticles

ABSTRACT

The determination of clinically significant amounts of tau protein in bodily fluids is a major problem in Alzheimer's disease (AD) diagnosis. As a result, the present work aims to develop a simple, label-free, fast, highly sensitive, and selective 2D carbon backbone graphene oxide (GO) patterned surface plasmon resonance (SPR) mediated affinity biosensor for Tau-441 monitoring. Initially, non-plasmonic nanosized GO was made using a modified Hummers' method, whereas green synthesized gold nanoparticles (AuNPs) were subjected to a layer-by-layer (LbL) design employing anionic and cationic polyelectrolytes. Several spectroscopical evaluations were carried out to ensure the synthesis of GO, AuNPs, and LbL assembly. Following that, the Anti-Tau rabbit antibody was immobilized on the designed LbL assembly using carbodiimide chemistry, and various studies such as sensitivity, selectivity, stability, repeatability, spiked sample analysis, etc., were conducted using the constructed affinity GO@LbL-AuNPs-Anti-Tau SPR biosensor. As an output, it shows a broad concentration range and a very low detection limit of 150 ng/mL to 5 fg/mL and 13.25 fg/mL, respectively. The remarkable sensitivity of this SPR biosensor represents the merits of a combination of plasmonic AuNPs and a non-plasmonic GO.

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Research Publications 2021-22

Sr.	Title of the Publication	Author/s	Name of the Journal
1	Purification and modification of neem gum for enhancement of its suspending property	MG Kalaskar, RE Mutha, AU Tatiya, SD Firke, SJ Surana, KA Dhoka, K Heda	Future Journal of Pharmaceutical Sciences
2	Electrostatic deposition assisted preparation, characterization and evaluation of chrysin liposomes for breast cancer treatment	PK Deshmukh, RE Mutha, SJ Surana	Drug Development and Industrial Pharmacy
3	Cissus quadrangularis L: A comprehensive multidisciplinary review	PS Bafna, PH Patil, SK Maru, RE Mutha	Journal of Ethnopharmacology
4	Surface architectured metal organic frameworks-based biosensor for ultrasensitive detection of uric acid: Recent advancement and future perspectives	**SN Nangare, PM Sangale,** AG Patil, SHS Boddu, PK Deshmukh, NR Jadhav, RS Tade, DR Patil, A Pandey, S Mutalik, JK Patel, AM Patil, SB Bari, PO Patil	Microchemical Journal
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7	Green synthesis of Fe-doped Ag-loaded reduced graphene oxide ternary nanocomposite for efficient photocatalytic degradation of toxic dyes	**SN Nangare, S Landge**, AG Patil, RS Tade, PK Deshmukh, PO Patil	Advances in Natural Sciences: Nanoscience and Nanotechnology
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11	Graphene quantum dots (GQDs) nanoarchitectonics for theranostic application in lung cancer	**RS Tade, MP More, SN Nangare,** PO Patil	Journal of Drug Targeting
12	Synthesis, molecular modeling study of the methaqualone analogues as anti-convulsant agent with improved cognition activity and minimized neurotoxicity	I Ahmad, SR Akand, **M Shaikh,** R Pawara, SN Manjula, HM Patel	Journal of Molecular Structure
13	Development and Evaluation of Lyophilized Methotrexate Nanosuspension using Quality by Design Approach	T Power, A Hajare, R Jarag, **S Nangare**	Acta Chimica Slovenica
14	Fabrication of Poly-l-lysine-Functionalized Graphene Quantum Dots for the Label-Free Fluorescent-Based Detection of Carcinoembryonic Antigen	RS Tade, PO Patil	ACS Biomaterials Science and Engineering
15	Comparative Phytochemical Investigation Antioxidant and Antimicrobial Activity of Leaves, Bark and Stem Extract of Muntingia calabura	RN Chaudhari, AK Jain, VK Chatap	Journal of the Maharaja Sayajirao University of Baroda
16	Pharmacognostic Studies on *Anisomeles*	RE Mutha, KJ	Journal of the Maharaja

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19	Nanostructured metal-organic frameworks based luminescent sensor for chemical sensing: Current Challenges and future prospects	**SN Nangare,** AG Patil, SM Chandankar, PO Patil	Journal of Nanostructure in Chemistry
20	Formulation of silk fibroin-based single polymeric floating microspheres for sustained release of lafutidine	J Pantwalawalkar, S Nangare	Indian Journal of Pharmaceutical Education and Research
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22	Surface nanoarchitectured metal-organic frameworks-based sensor for reduced glutathione sensing: A review	**ZG Khan, MR Patil, SN Nangare,** AG Patil, S HS Boddu, RS Tade, PO Patil	Journal of Nanostructure in Chemistry
23	Formulation, optimization, and in vitro evaluation of anastrozole-loaded nanostructured lipid carrier for improved anticancer activity	D Ghadge, **S Nangare,** N Jadhav	Journal of Drug Delivery Science and Technology

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Fabrication of polyethyleneimine surface-functionalized fluorescent carbon dots and its applications towards highly sensitive and selective detection of glutathione in aqueous medium and in vitro cell imaging of HeLa cells

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ABSTRACT

The present study aimed to synthesize polyethyleneimine (PEI) surface-functionalized fluorescent carbon dots (CDs)-based biosensor (GP-PEI-CDs) for highly sensitive and selective detection of glutathione (GSH). In brief, green pea (GP) shells were utilized for green synthesis of blue luminescent GP-CDs through hydrothermal method. The obtained GP-CDs were surface functionalized with PEI to improve surface defects and quantum confinement effects. The surface functionalization of GP-PEI-CDs was confirmed by different spectroscopic techniques, including FTIR, XPS, etc. Switch "on" of GP-PEI-CDs was quenched by Cu(II) ions (turn "off"), and the limit of detection (LOD) of Cu(II) was found to be 23 nM along with a linearity range as 0 μM to 50 μM. Then, turn "On" process enabled the restoration in fluorescence of surface-functionalized GP-PEI-CDs when different concentrations of GSH in phosphate buffer saline (PBS, pH 7.4) was added. This could be due to split up of Cu(II) from Cu(II)@GP-PEI-CDs complex by presenting selective affinity with thiol (–SH) group of GSH among the various biomolecules. The LOD of GSH was found to be 38 nM and linearity in the range of 0 to 25 μM. The cytotoxicity study confirmed the biocompatibility of surface-functionalized GP-PEI-CDs. Furthermore, a confocal analysis indicated exceptional penetrations of GP-PEI-CDs into the cell cytoplasm and nucleus, demonstrating the created probe's suitability for GSH sensing at the cellular level. The method was successfully applied to determine GSH in in human serum sample.

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Green synthesis of Fe-doped Ag-loaded reduced graphene oxide ternary nanocomposite for efficient photocatalytic degradation of toxic dyes

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Abstract

The green synthesis of iron nanoparticles (FeNPs) doped and silver nanoparticles (AgNPs) loaded reduced graphene oxide (rGO) (Fe-Ag@rGO) nanocomposite and its applications in methylene blue (MB), malachite green (MG), rhodamine B (RB) degradation were reported. Initially, AgNPs loaded rGO (Ag@rGO) nanocomposites were synthesised simultaneously by an ecological method using *Tamarindus indica* shell extract as a green reducing agent. Then, the doping of FeNPs into rGO@Ag nanocomposites afforded Fe-Ag@rGO nanocomposite. Interestingly, the finding of this study confirmed that the Fe-Ag@rGO nanocomposites exhibited countless stupendous features in terms of dye degradation. Briefly, the UV-visible spectroscopy and Fourier-transform infrared spectroscopy (FTIR) study confirmed the synthesis of Fe-Ag@rGO nanocomposite. The scanning electron microscopy (SEM) images showed the spherical shape with cross-linked network structures that confirmed the surface modification and synthesis of Fe-Ag@rGO nanocomposite. Finally, the dye degradation potential of the photocatalyst was found to be 97.20%, 98.43%, and 97.33%, for MB, MG, RB, respectively. Herein, the improved photocatalytic performance of the Fe-Ag@rGO was found due to the larger surface area, porous nature, high electron mobility, and synergistic effect of the Fe-Ag@rGO nanocomposite. Additionally, the effective interfacial hybridisation of 'Ag', and doping of 'Fe' on the rGO sheet extended the duration of the photogenerated electron (e^-) hole pairs that can also be contributing to dye degradation. Conclusively, the present experiment provides the new Fe-Ag@rGO nanocomposite to the dye degradation, which could be improved environmental remediation.

Keywords: dye degradation, nanocomposite, Fe-Ag@rGO, Tamarindus indica shells, graphene oxide, Green synthesisClassification numbers, 2.00, 5.00, 5.11

1. Introduction

Today is the era of accelerated industrialisation, which has seen rapid developments and has played an essential role in

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Crystallinity modulated silk fibroin electrospun nanofibers based floating scaffold as a candidate for controlled release of felodipine

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ABSTRACT

Floating gastro-retentive delivery approach provides a significant pathway for controlled release of drug with increase gastric residence. In this study, we report crystallinity modulated electrospun silk fibroin nanofibers (SF-NFs) floating scaffolds for the controlled release of felodipine (FD). The alteration in the crystallinity behavior due to changes in the structural conformation of SF helps to customize the release kinetics of FD-loaded SF-NFs scaffolds. Additionally, FD-loaded SF scaffolds system having a density less than the acidic gastric fluid explore as a new tactic for floating drug delivery system. The prepared FD-loaded SF nanofibers (FD-loaded SF-NFs) were characterized by spectral, thermal, and diffractometric techniques, scanning electron microscopy, floating profile, *in-vitro* degradation, mucoadhesion, and *in-vitro* dissolution studies, etc. The optimized batch had the least porosity and swelling, was annealed with ethanol and water for crystallinity modulation of SF-NFs to get controlled release of FD. Spectral, thermal, and diffractometric analyses could unveil the molecular dispersion of FD, coupled with amorphous form stabilization in NF. Excellent floating profile and satisfactory mucoadhesion of FD-SF-NFs also endorsed the formation of a novel floating drug delivery system. Temporal control over FD release was elucidated by *in-vitro* dissolution, demonstrating controlled release due to crystallinity modulation of SF-NFs. In conclusion, crystallinity-modulated electrospun NFs fabricated from SF waste could be used as a customizable carrier for drug delivery to the gastric region.

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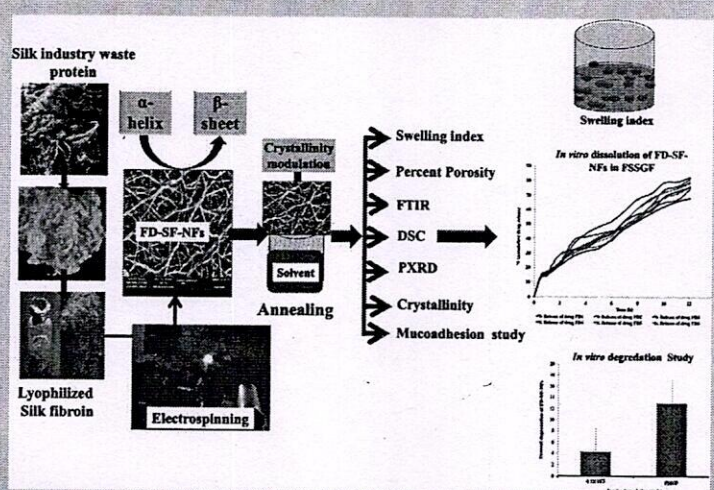
KEYWORDS
Silk fibroin; electrospun nanofibers; crystallinity modulation; felodipine; floating drug delivery; controlled release

GRAPHICAL ABSTRACT



Crystallinity modulated silk fibroin electrospun nanofibers based floating scaffold as a candidate for controlled release of felodipine

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REVIEW

Structural design of nanosize-metal–organic framework-based sensors for detection of organophosphorus pesticides in food and water samples: current challenges and future prospects

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Abstract
Organophosphorus pesticide (OPP) is regarded as an important food-chain and environmental contaminant that causes primary acute toxicity and numerous severe health issues. Therefore, the minute concentration of OPP present in food materials and environments needs to be identified before it causes any brutal harm to lives. Despite the plenty of merits of qualitative and quantitative sensing methods, the lower sensitivity, poor selectivity, detection speed, etc. towards the interest OPP are major drawbacks. Nanoparticles have attracted a lot of attention because of their unique and intriguing features, which have a variety of applications including sensor development as compared to their bulk counterparts. Recently, the structural design of nanosize-metal–organic framework (MOF) is gaining huge consideration from researchers for sensing applications owing to their versatile and tunable properties. Additionally, MOF-based sensors offer the rapid, simplistic, selective, and sensitive sensing of interest analyte. The present review provides brief information about OPPs and their toxicities. The emerging trends of structural design of nanosize-MOF including their properties have been summarized. Finally, nanosize-MOF-based fluorescent sensors, electrochemical sensors, and colorimetric sensors have been discussed with central focus on sensitivity and selectivity to OPPs. Due to the higher surface area, rich topology, ease of structural tunability and functionalization, tunable pore size, plenty of binding sites, good adsorption potential, excellent charge conductivity, and chemical stability, etc., MOF based sensors are endowed with the ability of OPPs detection upto aM. Hence, MOF as nanoporous sensors can be preferred as an excellent alternative for highly sensitive and selective recognition of OPPs in food and water samples.

Sopan N. Nangare and Sayali R. Patil contributed equally as a first author.

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Design and synthesis of poly-L-lysine-functionalized graphene quantum dots sensor for specific detection of cysteine and homocysteine

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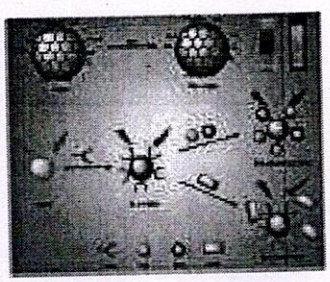
HIGHLIGHTS

- Waste material (pistachio shells) used for synthesis of graphene quantum dots (GQDs).
- Novel poly-L-lysine (PLL) surface functionalized GQDs (PLL-GQDs) based sensor was developed.
- The fabricated probe (PLL-GQDs) exhibited low cytotoxicity and excellent biocompatibility.
- The probe demonstrated highly sensitive and selective detection of cysteine (cys) and homocysteine (hcys) in real samples.

GRAPHICAL ABSTRACT



ARTICLE INFO

Keywords:
Poly-lysine surface functionalized graphene quantum dots
Poly-lysine
Functionalized graphene quantum dots
Cysteine and homocysteine
Sensing
Fluorescent probe

ABSTRACT

In this paper, a novel poly-L-lysine (PLL) surface functionalized graphene quantum dots (GQDs) based sensor was developed for detection of cysteine (cys) and homo cysteine (hcys). A fluorescent probe (PLL-GQDs) was then fabricated by surface functionalizing GQDs with PLL, a biodegradable polycationic electrolyte to improve the sensitivity and selectivity towards cys and hcys. The detection was based on the specific binding of cys and hcys to PLL at the PLL-GQDs surfaces, which enabled dynamic quenching via electrostatic and hydrophobic interactions. This fluorescent probe provided good linearity for the tested biothiols, ranging from 0 to 150 nM for cys, from 0 to 100 nM for hcys, with limit of detections (LODs) of 2.38 and 1.94 nM, respectively in BPS (pH 7.4). Interestingly, fabricated probe was also able to display a significant selectivity towards cys and hcys against known interfering molecules. The cytotoxicity study confirmed the biocompatibility of PLL-GQDs, enabling its future scope for cell adhesion and other biomedical applications. Besides, confocal study revealed the excellent penetrations of PLL-GQDs into cell cytoplasm and nucleus that validate the practical application of developed probe to detect cys and hcys at cellular level. The method was successfully applied for detection of cys and hcys in human serum sample. We expect the design concept presented here would be broadly used for selective and sensitive estimation of cys and hcys.

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REVIEW ARTICLE

Graphene quantum dots (GQDs) nanoarchitectonics for theranostic application in lung cancer

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ABSTRACT

Lung cancer (LC) is heading up as a substantial cause of mortality worldwide. Despite enormous progress in cancer management, LC remains a crucial problem for oncologists due to the lack of early diagnosis and precise treatment. In this context, numerous early diagnosis and treatment approaches for LC at the cellular level have been developed using advanced nanomaterials in the last decades. Amongst this, graphene quantum dots (GQDs) as a novel fluorescent material overwhelmed the horizons of materials science and biomedical fields due to their multifunctional attributes. Considering the complex nature of LC, emerging diagnostic and therapeutic (Theranostics) strategies using GQDs proved to be an effective way for the current practice in LC. In this line, we have abridged various approaches used in the LC theranostics using GQDs and its surface-engineered motif. The admirable photophysical attributes of GQDs realised in photolytic therapy (PLT), hyperthermia therapy (HTT), and drug delivery have been discussed. Furthermore, we have engrossed the impasse and its effects on the use of GQDs in cancer treatments from cellular level (*in vivo-in vitro*) to clinical. Inclusively, this review will be an embodiment for the scientific fraternity to design and magnify their view for the theranostic application of GQDs in LC treatment.

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KEYWORDS
Lung cancer; graphene quantum dots; theranostics; photolytic/hyperthermia therapy; drug delivery

Introduction

Global cancer risk is elevating gradually and results in a greater mortality rate per year. As per the fresh report of GLOBOCAN 2020, about 19.3 million cases and nearly 10.0 million deaths by cancer were recorded in 2020. Epidemiologists suggested that there would be probable 28.4 million new cases of cancer to befall nearly in 2040. Amongst all cancers, lung cancer (LC) has positioned on second diagnostic occurrence followed by breast cancer (11.7%) and crossed about 11.4% mortality rate, led by 1.8 million deaths (18%) in 2018 [1]. Besides, LC mortality is probable to reach 2.45 million globally by 2030. Principally, LC is a complex form of (adenocarcinoma) which increasing worldwide as an utmost cause of mortality. Generally, adenocarcinoma is known as the cancer of glandular mucus-producing cells (especially lungs). As per literature, LC is classified into four types: invasive adenocarcinoma (IA), adenocarcinoma in-situ (AIS), and minimally invasive adenocarcinoma (MIA) and other variants (e.g. lipidic) (Figure 1(A)). Besides this, the World Health Organisation (WHO) gives a sub-classification of lung adenocarcinomas as per their cellular origin. It includes acinar cells, papillary cells, bronchoalveolar, and mucus-secreting [2]. Literature survey advocated that there is a scarcity in our current knowledge of cancer statistics due to changing epidemiological trends of LC amongst developing countries [3]. In this context, it is observed that there is a vital role of the Human Development Index (HDI) in cancer mortality and morbidity in several countries. Both developed and developing countries experiencing an evident rise in the augmented effects of cancer risk factors. Moreover, there is an alarming rise in LC incidents in non-smokers as well. Notably, some major risk factors associated with the LC are smoking, exposure to second-hand smoke, previous radiation therapy, exposure to radon gas, exposure to asbestos and other carcinogens, and hereditary history of LC. Besides, the world is evidenced by the residual burden of different respiratory infections associated with LC. For example, Coronavirus disease 2019 (COVID-19), its emergence in 2020, and recurrence in 2021 have been overwhelmed the global healthcare systems. At this juncture, COVID-19 is becoming a major risk factor for LC patient's treatment. However, an extensive survey regarding the precise impact of COVID-19 associated with a patient suffering from LC is not available to date [4,5].

Current diagnostics and management strategies for LC

Despite the significant development in cancer therapeutics, several risk factors escalating in front of the developed and developing nations. Recently, Sung et al. reviewed the global cancer prevalence, which suggested the frequent diagnostic appearance as well as morbidity of LC up to 2020 which raised significantly after 2018 (Figure 1(B)) [1,6].

The traditional methods including X-ray, magnetic resonance imaging (MRI), Computed tomography (CT), or positron-electron microscopy (PET) scanning are commonly used for the diagnosis of cancer. Primary screening of LC by traditional methods is dependent on the severity and phases of LC. Unfortunately, the lack of site-specific localisation or inability to detect micrometer-sized tumours becomes inconclusive in the early detection of LC. Apart from this, sputum cytology, biopsy, and bronchoscopy methods are commonly used for the diagnosis of LC.

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Scientific paper

Development and Evaluation of Lyophilized Methotrexate Nanosuspension using Quality by Design Approach

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Abstract

With the application of the quality by design (QbD) approach, a high-pressure homogenizer (HPH) methodology was employed to develop methotrexate nanosuspension (MTX-NS) to boost bioavailability. The Ishikawa diagram was used to analyze potential risk factors in formulation development. To screen and study the impact of various formulation and process factors on the critical quality attributes (CQA), the Placket–Burman design and central composite design were utilized. The number of HPH cycles, poloxamer 188 concentration, and tween 80 concentration were shown to be significant parameters ($P<0.05$), that were further optimized using Central Composite Design. The zeta potential of optimized lyophilized MTX-NS was determined to be −11.6 ± 7.52 mV and the average particle size was 260 ± 0.25 nm. In vitro cytotoxicity experiments revealed a greater than 80% inhibition, with apoptotic cells shrinking, fragmentation, and cell death. Furthermore, the C_{max} and AUC_{0-t} were increased by 2.53 and 8.83 folds, respectively. The relative bioavailability of MTX-NS was found to be 8.83 times higher than that of MTX-aqueous dispersion. As a result, the QbD method resulted in the development of a lyophilized MTX-NS with process understanding and control based on quality risk management.

Keywords: Nanosuspension; Lyophilized, QbD approach; Central Composite Design; Plackett– Burman Design; *In-vivo* study.

1. Introduction

Pharmaceutical experts have long struggled with the formulation and development of poorly water-soluble drugs, and these challenges are projected to worsen since more than 40% of new chemical entities discovered by drug discovery are poorly aqueous soluble.[1] Whereas, it is more problematic in the case of poorly soluble drugs with poor absorption profile, and bioavailability because it is dissolution rate-limited and can be affected by patient fed or fasted state condition[2]. Traditional approaches including solubilization by surfactant, surfactant dispersion, micronization, use of the oily solution, permeation enhancers, which evolved too earlier, that address the challenges of formulation and have limited use.[2,3] The major milestone has been achieved in the development of poorly water-soluble drugs using various newer technology, but to date, there is no universal thumb approach applicable to all active pharmaceutical ingredients.[3] Consequently, a new approach has been progressively required to deal with formulation issues that are associated with the delivery of poorly soluble drugs, to enhance their therapeutic efficacy and maximize their pharmacodynamics therapy.[2]

A drug delivery aims to deliver a sufficient amount of drug to a proper side in the body such that, the optimal concentration of the drug is reached rapidly and then sustained. The development of a proper dosage form is an essential element to achieve this objective.[4] From its inception, oral drug delivery is the most commonly used route of administering the drug in various dosage forms due to

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Research Publications 2020-21

Sr.	Title of the Publication	Author/s	Name of the Journal
1	Green synthesis of fluorescent graphene quantum dots and its application in selective curcumin detection	**RS Tade,** PO Patil	Current Applied Physics
2	Green Synthesis of Silver Nanoparticles: An Eco-Friendly Approach	**SN Nangare,** PO Patil	Nano Biomedicine and Engineering
3	Silk industry waste protein: Isolation, purification and fabrication of electrospun silk protein nanofibers as a possible nanocarrier for floating drug delivery	**SN Nangare,** SS Dugam, PO Patil, RS Tade, NR Jadhav	Nanotechnology
4	Theranostic prospects of graphene quantum dots in breast cancer	**RS Tade,** PO Patil	ACS Biomaterials Science and Engineering
5	Affinity-based nanoarchitectured biotransducer for sensitivity enhancement of surface plasmon resonance for in vitro diagnosis: A review	**SN Nangare,** PO Patil	ACS Biomaterials Science and Engineering
6	One-pot development of spray dried cationic proliposomal dry powder insufflation: Optimization, characterization and bio-interactions	AB Shreya, A Pandey, **AN Nikam,** PO Patil, R Sonawane, P Deshmukh, S Mutalik	Journal of Drug Delivery Science and Technology
7	Black phosphorus as multifaceted advanced material nanoplatforms for potential biomedical applications	**A Pande, AN Nikam**, G Fernandes, S Kulkarni, BS Pandya, R Prassl, S Das, A Joseph, PK Deshmukh, PO Patil, S Mutalik	Nanomaterials
8	Carbon dots: A novel trend in pharmaceutical applications	S Dugam, **S Nangare,** P Patil, N Jadhav	Annales Pharmaceutiques Francaises
9	Nanoarchitectured bioconjugates and bioreceptors mediated surface plasmon resonance biosensor for in vitro diagnosis	**S Nangare**, P Patil	Critical Reviews in Analytical Chemistry

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10	One-pot in situ synthesis of eco-friendly cellulose magnetic nanocomposite (Cf-MNCs) for dye adsorption application	**RS Tade,** PO Patil, VK Chatap	Functional Composites and Structures
11	Fundamental aspects of graphene and its biosensing applications	**RS Tade, SN Nangare,** PO Patil	Functional Composites and Structures
12	Pharmaceutical applications of citric acid	**S Nangare, Y Vispute, R Tade**, S Dugam, P P Patil	Future Journal of Pharmaceutical Sciences
13	Eco-friendly synthesis of surface grafted carbon nanotubes from sugarcane cubes for the development of prolonged release of drug delivery platform	R Narkhede, M More, S Patil, P Patil, A Patil, P Deshmukh	International Journal of Nano Dimension
14	Fabrication of N-doped grapheme@TiO2 nanocomposites for its adsorption and absorbing performance with facile recycling	PO Patil, **SN Nangare, PM Patil,** AG Patil, DR Patil, RS Tade, AM Patil, PK Deshmukh, SB Bari	Nano Biomedicine and Engineering
15	Black phosphorus nanostructure based highly sensitive and selective surface plasmon resonance sensor for biological and chemical sensing: A review	**SN Nangare,** PO Patil	Critical Reviews in Analytical Chemistry

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Green synthesis of fluorescent graphene quantum dots and its application in selective curcumin detection

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ABSTRACT

Herein, we present a facile low-cost and eco-friendly approach for conversion of bamboo timber waste (Bf) derived cellulose nanocrystals (Bf-CNCs) into strong blue luminescent graphene quantum dots (Bf-GQDs) by hydrothermal route. The various properties of synthesized Bf-GQDs were investigated using different spectroscopic techniques. The probable mechanism of Bf-GQDs formation from Bf-CNCs and the effect of pH, particle size on the fluorescent properties of Bf-GQDs also executed. Furthermore, Bf-GQDs were used for the detection of curcumin in an aqueous environment which is the major prerequisite of the present study. The Bf-GQDs showed remarkable photoluminescence (PL) quenching kinetics toward the curcumin (LOD 30.0 nM L^{-1}) assessed by Stern-Volmer plot. The practicability of the method assessed using ginger rhizome juice, while the selectivity of the Bf-GQDs evaluated against different metal ions and different biochemicals. The proposed method will support to establish the strategies for the detection of biochemicals from the aqueous system.

1. Introduction

Graphene based materials, especially graphene quantum dots (GQDs) accolades by researchers amongst the different nanomaterials due to its exceptional properties. Since a scalable GQDs production method still stands as a serious obstacle due to its broad application in numerous areas. For example, bottom-up synthesis from graphene and its native precursors demands costly and potentially hazardous chemicals. Moreover, these methods are tedious and required multiple steps to the obtained purified final product (GQDs), which ultimately results in low production yield. Several endeavors have been made worldwide for the conversion of natural waste precursors (NPs) such as weathered leaves [1], coffee grounds [2], etc. Into graphene-like materials and GQDs [3]. It was observed that GQDs from aforementioned precursors has the greatest biocompatibility and stability as compared to the GQDs from pristine graphene as they obtained from a series of hazardous chemical treatment. Moreover, these biomass-derived GQDs are superior to semiconductor quantum dots in terms of solubility, aqueous stability, chemical modification, and high resistance to photo bleaching [4]. These ideal properties have now been subjugated for numerous applications such as fluorescent probes for solar cells [5], biochemical sensing [6] or detection [7,8], bioimaging [9], etc. Apart from the use of available biomaterials such as citric acid [10], sucrose [11], for obtaining GQDs or graphitic materials one can use waste biomass for gaining one or more active materials of interest. For instance, corn agro waste can be converted into cellulosic derivatives [12], wood waste into quality graphene [13]. The research fraternity well realized that to achieve the 'sustainable green synthesis goals' it is necessary to look after the abundant waste biomass to be utilized for the synthesis of graphene-like materials [3,14,15]. It is well known that cellulose-based biomass hitting the top list as abundant waste at agricultural as well as domestic levels. Cellulose-based polymers had been utilized for the fabrication of numerous materials like nanocomposites in many biomedical and pharmaceutical applications, etc. [16]. A huge amount of bamboo timber waste produces at the various sawmills which further expelled as waste or used as domestic fuel. Bamboo fibers mostly used as a natural composite reinforcing material because of its high strength-to-weight ratio and high hydrophilicity. Cellulose is the major component of the bamboo fibers which plays a crucial role as reinforcing materials in composites while hemicelluloses after the efficient conversion accomplish biofuels and multifunctional by-products. In addition to this hemicellulose on hydrolytic undergoes cleavage of glycosidic bonds between two anhydrous glucose which is the most significant rout of cellulose degradation [17]. Inspired by these facts, we choose the bamboo timber waste for the GQDs synthesis. The stepwise processing of bamboo timber waste yields us cellulose nanocrystals as well as GQDs

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Review

Green Synthesis of Silver Nanoparticles: An Eco-Friendly Approach

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Abstract

Eco-friendly synthesis of nanoparticles is an upcoming discipline of nanoscience. Green synthesis of Ag NPs has gained immense importance and much awareness in developed nations. Fascinatingly, such an environmental friendly synthesis of Ag NPs gives a green chemistry-based non-toxic and economical route to nanotechnology. This review article gives insight into the bioinspired synthesis of Ag NPs and mechanisms involved in the synthesis of Ag NPs. In this review, we have summarized the scientific reports in the eco-friendly synthesis arena of Ag NPs and their applications in the biomedical field. Especially, we have focused on plant materials, fungi, algae, and bacterial potential towards the eco-friendly synthesis of Ag NPs. For future perception, there is a need for in silico and in vitro, in vivo research to authenticate the outcomes.

Keywords: Silver nanoparticles, Green synthesis, Plant extract, Eco-friendly, Nanotechnology

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Silk industry waste protein: isolation, purification and fabrication of electrospun silk protein nanofibers as a possible nanocarrier for floating drug delivery

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Abstract

Amongst assorted regio-selective and targeted oral drug delivery strategies accepted for the gastro-retentive drug delivery system (GRDDS), the floating drug delivery system (FDDS) holds a major share as clinically accepted formulations. The major objective of the present investigation was to explore the silk industry waste protein, silk fibroin (SF) as a possible electrospun nanocarrier for the FDDS. In a nutshell, electrospinning (ES) is one of the flexible and astonishing strategies for the fabrication of porous electrospun nanofibers (NFs), which offers the potential to amend the floating profile, dissolution rate, solubility, and release patterns of the drug, etc as per compendial requirements. Looking at the prospects of floating SF-NFs preparation, we have isolated and lyophilized the SF from industrial waste cocoons and prepared drug-loaded SF single polymer nanofibers (SPN). Lafutidine (LF) being a good candidate for GRDDS selected as a model drug, which is an excellent proton pump inhibitor, mainly used in the treatment of gastric ulcers. Finally, the obtained LF loaded SF-NFs (LF-SF-NFs) were successfully analyzed for physicochemical characteristics, porosity, swelling index, antioxidant activity, mucoadhesion strength, floating properties, enzymatic degradation, and accelerated stability study, etc. Further, these LF-SF-NFs were evaluated for percent drug content, weight variation, *in-vitro* dissolution in 0.1 N hydrochloric acid (HCl, pH:1.2) and fasted state simulated gastric fluid (FSSGF), and accelerated stability study. It has shown significant floating time >18 h, about 99% ± 0.58% floating buoyancy with sustained release up to 24 h. LF-SF-NFs showed good compatibility, entrapment efficiency, antioxidant activity, mucoadhesion strength, enzymatic degradation, and long term stability. Soon, the essential floating and drug release profiles can claim single polymer (SF) based electrospun protein NFs as a possible novel oral nanocarrier for FDDS.

Keywords: processing industrial waste cocoons, silk fibroin, electrospun nanofibers, lafutidine, floating drug delivery system

(Some figures may appear in colour only in the online journal)

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Review

Theranostic Prospects of Graphene Quantum Dots in Breast Cancer

Rahul S. Tade and Pravin O. Patil*

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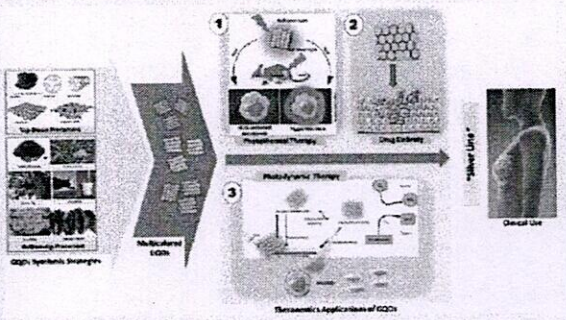
ABSTRACT: Breast cancer (BC) is increasing as a significant cause of mortality among women. In this context, early diagnosis and treatment strategies for BC are being developed by researchers at the cellular level using advanced nanomaterials. However, immaculate etiquette is the prerequisite for their implementation in clinical practice. Considering the stolid nature of cancer, combining diagnosis and therapy (theranostics) using graphene quantum dots (GQDs) is a prime focus and challenge for researchers. In a nutshell, GQDs is a new shining star among various fluorescent materials, which has acclaimed fame in a short duration in materials science and the biomedical field as well. From this perspective, we review various strategies in BC treatment using GQDs alone or in combination. In addition, the photophysical properties of GQDs explored in photothermal therapy, hyperthermia therapy, and photodynamic therapy are also discussed. Moreover, we also focus on the strategic use of GQDs both as drug carriers and as combinatorial-guided drug delivery motifs. This Review provides an update for the scientific community to plan and expand advanced theranostic horizons in BC using GQDs.



KEYWORDS: *breast cancer, triple-negative breast cancer, graphene quantum dots, theranostics, photodynamic/photothermal therapy, drug delivery*

1. INTRODUCTION

Cancer is now the second leading cause of death worldwide, with its horrific existence commonly a manner of mortality.[1] In 2018, it was estimated that 9.6 million deaths (i.e., 1 in every 6 deaths) were due to cancer. According to the World Health Organization (WHO), roughly 70% of deaths from cancer occur in low- to middle-income countries (LMICs). Research experts are worried that by the year 2030, 16−18 million additional cases of cancer will be added every year, and 60% of these will be in developing countries. WHO has claimed that by 2030, merely 12 countries are likely to reach a one-third drop in premature cancer mortality.[2,3] In order to reach sustainable development goals, there is a need for greater investment in the treatment of cancer and other non-communicable diseases.[4] The growing cancer burden globally exerts huge physical, emotional, as well as financial tensions on individuals, families, and consequently the overall health systems. Health organizations in LMICs are least equipped to handle this burden, and for that reason many cancer patients worldwide cannot receive diagnosis and treatment in a timely manner. While the overall cost of cancer treatment in 2010 was estimated at US$1.16 trillion, only 1 out of every 5 LMICs has the necessary data to drive cancer treatment and mitigation policy.[3] Reports suggest that about 30−50% of all cancer cases are predictable, that can be addressed by a cost-effective long-term strategy.[5] In many countries, the survival rates of patients diagnosed with cancer are improving owing to prognosis quality treatment and survivorship care.[6]

1.1. Breast Cancer. Every year, breast cancer (BC) affects 2.1 million women, and it is recognized as the most prevalent cancer in women. About 627 000 women died of BC in 2018, which accounts for 15% of all the cancer-associated deaths in women.[7] Usually, BC is categorized on the basis of its ability to spread, such as *in situ* ductal carcinoma (DCIS). DCIS starts in a milk duct and has no further growth into the rest of the breast tissue. Invasive or infiltrating types of BC can spread in the surrounding breast tissue. Invasive BC is comprised of two forms: invasive ductal carcinoma (IDC) and invasive lobular carcinoma (ILC). IDC accounts for 70−80% of all BCs.[8] Different forms of BC and global statistics on BC in women are depicted in Figure 1. Invasive BCs have distinct features, which affect their treatment and outlooks. Though invasive BCs are more serious than other types of BC, their occurrence is less common. Invasive BCs are further comprised of inflammatory breast cancer (IBC) and triple-negative breast cancer (TNBC).

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Review

Affinity-Based Nanoarchitectured Biotransducer for Sensitivity Enhancement of Surface Plasmon Resonance Sensors for *In Vitro* Diagnosis: A Review

Sopan N. Nangare and Pravin O. Patil*

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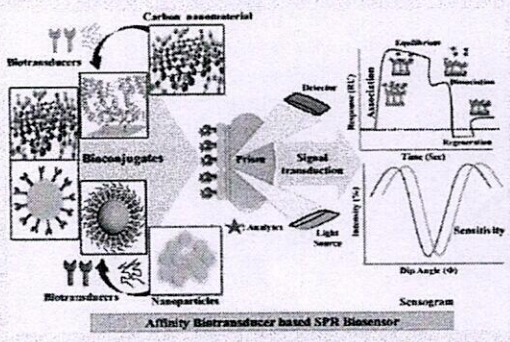
ABSTRACT: Despite the indisputable benefits and advancement of science, technology, and civilization, early diagnosis of healthcare is still a challenging field for the scientific fraternity. The detection of biomarkers is a crucial attribute of prognosis and diagnosis of disease. Out of numerous techniques, surface plasmon resonance (SPR) bestows countless benefits, including *in situ*, label-free, and real-time assessment, etc., which authorizes the analysis of molecular binding occurrences between biotransducers and biomarkers. In addition, SPR with low-molecular-weight biomarkers lacks selectivity and sensitivity, which ultimately affects binding kinetics. This, in turn, leads to the remarkable development and implementation of numerous selectivity and sensitivity enhancement methods. Among the various noticeable strategies, because of selectivity and sensitivity enrichment substrate for SPR biosensors, affinity-based nanoarchitectured biotransducers stand out as being the best substitute. The present review elaborates significant advances made in the research based on affinity biotransducers for *in vitro* diagnosis using SPR biosensors for biomarker sensing. Moreover, most recent trends and challenges in designing and application of nanoarchitectured affinity biotransducer-based SPR biosensors for detecting low-concentration biomarkers have been reviewed comprehensively. This present review may assist the scientific fraternity in designing an ultramodern novel SPR approach based on affinity biotransducers, along with improved selectivity and sensitivity of SPR biosensors for *in vitro* and real-time diagnostic applications.



KEYWORDS: *Affinity biotransducer, surface plasmon sensor, in vitro diagnosis, antibody, aptamer, nanoparticles*

1. INTRODUCTION

In addition to the indisputable benefits of research, industry, and technology, unfortunately, some impetuous shifts in the natural world have started to endanger the lives of peoples and other entities directly.[1] In the last couple of decades, a key feature to achieving rapid diagnosis of much pathology is the insistence for early, economical, and reliable analytical instruments for *in vitro* diagnosis.[2] Initially, the scientific fraternity has fixed the general criterion for *in vitro* diagnostic devices, which includes the utilization condition and risk factors of the device/machine. In addition, the device should be proficient to provide relevant information for careful diagnosis of particular health issues. Furthermore, the result of analytical techniques or devices should notably affect the public or individual negatively or positively.[3] The literature survey revealed that the emerging *in vitro* diagnostic devices are offering rapid screening and early detection ability, precise information, and real-time monitoring of several diseases and disorders.[4] Unfortunately, official analytical strategies (commonly employed for diagnostic applications) are plagued by numerous drawbacks, viz, selectivity, sensitivity, time-consuming process, the cost of analysis, need of expert and trained staff for its laborious process, and having limited availability as a point of health care system, etc. Moreover, the luminous technological expansion within assorted sectors and fields (viz, nanotechnology, biotechnology, and electronics) necessitates impetuous, user-friendly, sensitive tools, which leads to a tremendous expansion of analytical methods in the last decades.[5] More precisely, the biosensor is an advanced analytical tool in which a biotransducer (example: antibodies, aptamers, tissues, DNA, enzymes, etc.) is united through a physicochemical transducer (viz, optical, magnetic, electrochemical, piezoelectric).[1] The interaction between the interest/target biomarker (or analyte) and the specific

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One- Pot Development of Spray Dried Cationic Proliposomal Dry Powder Insufflation: Optimization, Characterization and Bio-interactions

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Review

Black Phosphorus as Multifaceted Advanced Material Nanoplatforms for Potential Biomedical Applications

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Abstract: Black phosphorus is one of the emerging members of two-dimensional (2D) materials which has recently entered the biomedical field. Its anisotropic properties and infrared bandgap have enabled researchers to discover its applicability in several fields including optoelectronics, 3D printing, bioimaging, and others. Characterization techniques such as Raman spectroscopy have revealed the structural information of Black phosphorus (BP) along with its fundamental properties, such as the behavior of its photons and electrons. The present review provides an overview of synthetic approaches and properties of BP, in addition to a detailed discussion about various types of surface modifications available for overcoming the stability-related drawbacks and for imparting targeting ability to synthesized nanoplatforms. The review further gives an overview of multiple characterization techniques such as spectroscopic, thermal, optical, and electron microscopic techniques for providing an insight into its fundamental properties. These characterization techniques are not only important for the analysis of the synthesized BP but also play a vital role in assessing the doping as well as the structural integrity of BP-based nanocomposites. The potential role of BP and BP-based nanocomposites for biomedical applications specifically, in the fields of drug delivery, 3D printing, and wound dressing, have been discussed in detail to provide an insight into the multifunctional role of BP-based nanoplatforms for the management of various diseases, including cancer therapy. The review further sheds light on the role of BP-based 2D platforms such as BP nanosheets along with BP-based 0D platforms—i.e., BP quantum dots in the field of therapy and bioimaging of cancer using techniques such as photoacoustic imaging and fluorescence imaging. Although the review inculcates the multimodal therapeutic as well as imaging role of BP, there is still research going on in this field which will help in the development of BP-based theranostic platforms not only for cancer therapy, but various other diseases.

Keywords: bioimaging; wound healing; 3D printing; surface modification; characterization

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1. Introduction

The discovery of Black Phosphorus (BP) dates back to a hundred years ago. It all began with Bridgman [1], who brought about the conversion of white phosphorus to black phosphorus under a high temperature and pressure. Later, Hultgren et al. [2] demonstrated

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GENERAL REVIEW

Carbon dots: A novel trend in pharmaceutical applications

Carbon dots : *une nouvelle tendance dans les applications pharmaceutiques*

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HIGHLIGHTS

- Presents basic concepts, advantages, synthesis approach of CDs.
- Numerous CDs based pharmaceutical applications of were reviewed.
- CDs were used in gene therapy and nanomedicine.
- CDs were used in bioimaging and biosensing.

KEYWORDS
Carbon dots;
Pharmaceutical applications;
Bioimaging;
Sustained drug delivery;
Targeted drug delivery

Summary Carbon quantum dots (CQDs, C-dots, or CDs), are generally small carbon nanoparticles having a size less than 10 nm. Carbon dots (CDs) were accidentally discovered during the purification of single-walled carbon nanotubes through preparative electrophoresis in 2004. Carbon is an organic material having poor water solubility that emits less fluorescence. However, CDs have good aqueous solubility and excellent fluorescent property, hence more attention has been given to the synthesis of CDs and their applications in chemistry and allied sciences. CDs being easily accessible for in-house synthesis, simpler fabrication as per compendial requirements are wisely accepted. In addition, since CDs are biocompatible, of low toxicity, and of biodegradable nature, they appear as a promising tool for the health care sector. Furthermore, owing to their capabilities of expressing significant interaction with biological materials, and their excellent photoluminescence (PL), CDs have been emerging as novel pioneered nanoparticles useful for pharmaceutical and theranostic applications. Also, CDs are more eco-friendly in synthesis and therefore can be favorably consumed as alternatives in the further development

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Nanoarchitectured Bioconjugates and Bioreceptors Mediated Surface Plasmon Resonance Biosensor for *In Vitro* Diagnosis of Alzheimer's Disease: Development and Future Prospects

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ABSTRACT

Alzheimer's disease (AD) is an obvious neurological disorder characterized by progressive brain cell death that resulted in memory loss, cognitive decline, and finally dementia. Besides, AD is also affected by a multifunctional pathway, which leads to alteration in the biomolecular level as AD steps forward. Notwithstanding numerous diagnosis techniques, the conventionally engaged technology permits the detection of AD biomarkers with low sensitivity and poor selectivity. Concerning this, in recent years bioconjugates and bioreceptors based AD biomarkers recognition is gaining huge prospective to improved selectivity and sensitivity of AD at the molecular level. The present review deals with the recent progress in bioreceptors and bioconjugates mediated surface plasmon resonance (SPR) biosensor for *in vitro* diagnosis of AD. Fascinatingly, this review inculcates the information of assorted important AD biomarkers viz. beta-amyloid (Aβ), Tau protein, apolipoprotein (apoE4), 17-β-hydroxysteroid dehydrogenase type 10 (17β-HSD-10), acetylcholine, etc. In addition, this review sheds light on the utmost and unique methods of bioconjugates synthesis, which is holding the huge attention of researchers for AD biomarker detection and contributed to the development of simplistic, rapid, and socioeconomic sensitivity enhancement methods. Concisely, this review gives insight into the analytical performance of nanoarchitectured bioconjugate and bioreceptor-mediated SPR biosensor and their revolutionary benefits in terms of selectivity and sensitivity for *in vitro* diagnosis of AD biomarkers. Overall, this review gives a detailed overview of research done to date in the meadow of SPR biosensors in the *in vitro* diagnosis of AD, which paves the new pathway for futuristic biomedical applications.

KEYWORDS

Alzheimer's disease; surface plasmon resonance; bioconjugates; bioreceptors; *in vitro* diagnosis

HIGHLIGHTS

- AD recent updates and its biomarkers reviewed.
- There is no leading technology to rapidly sense and monitor AD.
- Bioconjugates as potential biosensing elements.
- Conjugation methods to link bioreceptors to nanomaterials have been highlighted.
- Role of bioconjugates and bioreceptors in AD biosensing through SPR biosensor have been discussed.

GRAPHICAL ABSTRACT

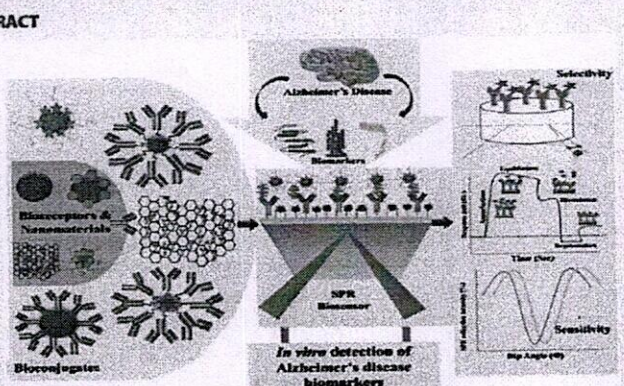

Figure 1. Nano-architectured bioconjugates and bioreceptors mediated SPR biosensor for highly sensitive and selective in vitro diagnosis of AD biomarkers.

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Functional Composites and Structures

PAPER

One-pot *in situ* synthesis of eco-friendly cellulose magnetic nanocomposite (Cf-MNCs) for dye adsorption application

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Abstract

Cellulose-based magnetic nanocomposites (Cf-MNCs) have been introduced using a modified one-pot *in situ* co-precipitation method using iron salts with various concentrations in the alkali solution. Fabricated nanocomposites investigated for structural and functional properties with different spectroscopic characterization techniques prior to use in dye degradation study. The scanning electron microscopy revealed the morphological structure of the synthesized nanofibers and nanocomposites. The elemental analysis and vibrating sample magnetometry emphasized the presence of Fe elements attributed to the iron salts. The HRTEM analysis showed a destructed cellulose fiber network indicating its arrangement into nanocomposites. Moreover, the crystal properties of the Cf-MNCs were accomplished using x-ray powder diffraction (79.3% crystallinity). The Fourier transform infrared analysis and differential scanning calorimetry gives the idea about the structural and functional changes in the cellulose fibers loaded with iron oxide nanoparticles. The functional adsorption properties of the prepared nanocomposites have been evaluated using methylene blue and Alizarin red S carcinogenic dyes. The dye adsorption of the fabricated Cf-MNCs nanocomposites was found to be 93%. We affirmed that this novel eco-friendly degradable polymer-based nanocomposite has great potential in the field of catalyst fabrication for the degradation of organic pollutants in wastewater.

1. Introduction

In recent years, nanocellulose has exploited for abundant applications in materials chemistry, nano-biomedicine, drug delivery, and green composite materials. Cellulose-based nanocomposites (CbNCs) combine the distinct features of cellulose with specific nanomaterials incorporated in it with high specific surface area and add-on characteristics. Commonly, cellulose nanofibers (CNFs) and cellulose nanocrystals (CNC) have been used for the fabrication of CbNCs [1]. Nanocellulose can be obtained from native fibers by acid hydrolysis, high pressure homogenization (HPH) or different methods [2, 3]. Amongst all methods, acid hydrolysis results in highly crystalline and rigid nanofibers, ranging in size from 100 nm to 1 μm than that of the HPH route. Recently, the use of cellulose-based magnetic nanocomposites (Cf-MNCs), acclaimed fame in a short duration of time in the catalytic and different allied applications. The length-to-diameter (L/d) is a major factor that controls the mechanical properties of nanocomposites and determines the percolation threshold value called 'geometrical aspect ratio', which further benefits the reinforcing effect [4]. As mentioned earlier, the large surface area, high porosity and biodegradability allowed investigators too many customary modifications in their structures can be availed using cellulose nanofibers (CNF). The use of iron oxide nanoparticles (IONPs) was realized for magnetodielectric properties and ease of separation [5]. To develop the ideal Cf-MNCs, the IONPs should be well dispersed in the fibrils either as an over-attached form or in the lumen. The dispersion of IONPs in the cellulose matrix can be monitored by setting the process parameters, like temperature, pH, solvent properties and other process attributes. The Cf-MNCs can be prepared by *in situ* as well as *ex-situ* methods such as microwave reflux, co-precipitation, hydrothermal treatment, etc. These reinforced Cf-MNCs can be explored for *in vivo* MRI as superparamagnetic or negative

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Functional Composites and Structures

TOPICAL REVIEW

Fundamental aspects of graphene and its biosensing applications

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Keywords: graphene, sensor scale-up aspects, biosensing applications, immunosensing, pathogen sensing

Abstract

The worldwide frontiers of research have experienced a flood of developments in advanced nanomaterials. Among these, graphene, a member of the carbon family, has now replaced many traditional materials and broadened the horizons of material chemistry, analytical chemistry, pharmaceutics, and other multidisciplinary fields. Owing to the exceptional properties of graphene, it has been widely utilized in various nanocomposites as a reinforcing material and for biosensing components. The present review serves as a familiarization for budding researchers in the materials science and analytical fields, where the use of graphene in biosensing-related applications had long been foreseen. Furthermore, we also offer a brief review of graphene's tunable properties for biosensing. This article describes the actual mechanisms of interfaces that interact with graphene, such as immunogenic agents, bacteria, and other biomolecules. We also discuss the application of graphene-based materials to the biosensing of a range of analytes, and the challenges and future perspectives of graphene. Thus, this review gives a detailed insight into biosensing with graphene, graphene's fundamental properties, and application perspectives.

1. Introduction

Over the last couple of decades, graphene-based materials (GBMs) have gained tremendous research interest owing to their excellent physicochemical properties [1]. Interestingly, graphene exists in many forms, and can be customized in numerous ways as per the application requirements [2]. Common to all graphene forms, the lattice-configured nanostructure of graphene, i.e. graphene oxide (GO) has been thoroughly investigated for several biomedical and pharmaceutical applications [3], possibly due to its very tunable properties. Because of this, it offers several benefits for the fabrication of biosensing elements or parts thereof [4]. The fascinating characteristics of graphene or GO including a large specific area, abundant surface functional groups viz. carboxyl, epoxy, etc, offer a choice of materials for the immobilization of various important biomolecules (e.g. enzymes). Moreover, the high chemical stability and remarkable optical properties of GO are suitable for electrochemical (ECL) biosensing [5]. Moreover, its electrical properties, high conductivity, and superb electron mobility help in the fabrication of thin films and plasmonic biosensors for the detection of various biomolecules. From 2010 onwards, several research groups have been engaged in the design, fabrication, and analysis of various types of biosensors based on graphene platforms for heavy metal detection [6, 7], ferric ion detection, DNA detection [8], antibody detection [9, 10] as well as many biological metabolite detections [11], etc.

Graphene has an electrical conductivity of the order of 1000 mho m^{-1} and thermal conductivities of between 1500 and 2500 W m^{-1} K^{-1}. It is the strongest material ever tested, with a tensile strength of around 130 GPa [12, 13]. Graphene exhibits a broad ECL window of approximately 2.5 V in a 0.1 mol l^{-1} when tested in phosphate-buffered saline. It offers a low charge-transfer resistance of around 6.5 MΩ cm^2. These properties prove that graphene is an ideal material for use in multifunctional fast sensors.

Since graphene was discovered, it has started to emerge and be developed in many scientific studies. Despite these advances, the fundamental science behind graphene is, unfortunately, not completely explained. More work is needed on this problem in areas such as graphene surface absorption mechanisms, biomolecular orientations, and the way in which these interactions affect graphene's transport properties, etc

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Future Journal of Pharmaceutical Sciences

REVIEW Open Access

Pharmaceutical applications of citric acid

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Abstract

Background: Citric acid (CA) is a universal plant and animal-metabolism intermediate. It is a commodity chemical processed and widely used around the world as an excellent pharmaceutical excipient. Notably, CA is offering assorted significant properties viz. biodegradability, biocompatibility, hydrophilicity, safety, etc. Therefore, CA is broadly employed in many sectors including foodstuffs, beverages, pharmaceuticals, nutraceuticals, and cosmetics as a flavoring agent, sequestering agent, buffering agent, etc. From the beginning, CA is a regular ingredient for cosmetic pH-adjustment and as a metallic ion chelator in antioxidant systems. In addition, it is used to improve the taste of pharmaceuticals such as syrups, solutions, elixirs, etc. Furthermore, free CA is also employed as an acidulant in mild astringent preparations.

Main text: In essence, it is estimated that the functionality present in CA provides excellent assets in pharmaceutical applications such as cross-linking, release-modifying capacity, interaction with molecules, capping and coating agent, branched polymer nanoconjugates, gas generating agent, etc. Mainly, the center of attention of the review is to deliver an impression of the CA-based pharmaceutical applications.

Conclusion: In conclusion, CA is reconnoitered for multiple novels pharmaceutical and biomedical/applications including as a green crosslinker, release modifier, monomer/branched polymer, capping and coating agent, novel disintegrant, absorption enhancer, etc. In the future, CA can be utilized as an excellent substitute for pharmaceutical and biomedical applications.

Keywords: Citric acid, Pharmaceutical applications, green crosslinkers, Fluorescent materials, Absorption enhancer

Background

Citric acid (CA, 2-hydroxy2, 3-propanetricarboxylic acid, tricarboxylic acid) is the largest organic acid contained in the tonnage. Generally, it is a universal plant-and animal-metabolism intermediate. CA is a commodity chemical processed and widely used around the world for plentiful pharmaceutical applications (Fig. 1) [1]. To begin with 1784, Carl Scheele (a Swedish chemist) isolated the CA (Molecular Weight: 210.14 Da) from the lemon juice. Whereas in1893, at the first time Wehmer demonstrated the culture medium includes sugars and inorganic salts, *Penicillium glaucum* (*Citromyces*) accumulating CA. Amusingly, CA was first commercially manufactured in England from the imported Italian lemons. In 1917, Currie discovered that some of the *Aspergillus niger* strain generated CA into adequate nutrient mediums that contain high levels of sugar plus mineral salts and along with that preliminary medium pH (2.5–3.5). Despite these notable findings, lemon juice was still a commercial source for the manufacturing of CA until 1919. This provided the foundation for industrial CA production with *Aspergillus niger* [2]. As per literature, CA has been unrevealed by Krebs in the late 1930s as a key ingredient in the metabolism of all aerobe species [3, 4]. The developmental stages of the discovery and manufacture of CA from 1784 to 2020 [4] are represented in Fig. 2.

From its inception, plenty of literature reported that CA is a major component in the processing of several products, mainly as an acidulant in the food, chemical, and pharmaceutical industries. Natural resources, such as fruit sugar, become more and more essential for CA

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ORIGINAL ARTICLE

Eco-friendly synthesis of surface grafted Carbon nanotubes from sugarcane cubes for the development of prolonged release drug delivery platform

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Abstract

Surface grafting of nanocarriers could modulate their properties and characteristics. As carbon nanotubes synthesis is a very tricky process and requires high-end methods, hence the present investigation was aimed to develop an eco-friendly method for synthesis carbon nanotubes (CNTs) and subsequent surface grafting for enhanced drug delivery application. The present study elaborates two-step chemical modifications; wherein the first step is catalytic cleavage of natural precursor in the presence of ferrocene and the second step involve chemical grafting of Acyclovir (ACV) as a model drug to understand the drug release behaviour. The catalytic cleavage of sugarcane cubes (natural precursor) was carried out in a closed copper tube, which prevents oxidation and results in a conversion of tubular nanostructures to amorphous carbon. The covalent attachment of ACV on purified CNTs (fCNTs) was done using carbodiimide chemistry. The preliminary Uv-Vis absorbance spectra defined at 260 nm was arised due to π-π^* stacking of aromatic C-C bonds. The Fourier Transforms Infrared Spectroscopy (FTIR) indicates the hydroxyl stretch at 3300 cm-1 while amide I bond formation was observed at 1672 cm^{-1}. The XRD spectra confirmed successful synthesis of CNTs. The calculated average crystallite size (Scherer equation) of synthesized CNTs was found to be 42.84 and 44.45 nm; it was also in accordance with the morphological observation as confirmed simultaneously using SEM analysis. The covalently attached ACV was released up to 80% during 8h of *in vitro* drug release study. The surface grafting potential of CNTs was found to be promising compared to other nanomaterials.

Keywords: *Acyclovir; Amorphous Carbon; Carbodiimide Chemistry; Natural Precursor; Purification.*

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INTRODUCTION

Even though the investigation on allotropic forms of carbon was begun before 1990, but the most intuitive form of carbon allotrope i.e. carbon nanotubes (CNTs) were reported in 1991[1]. Numerous classical approaches for the synthesis of CNTs are reported by academic researchers and industry experts for their promising physicochemical properties. In case of CNTs, the

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Research Article

Fabrication of N-Doped Graphene@TiO_2 Nanocomposites for Its Adsorption and Absorbing Performance with Facile Recycling

Pravin Onkar Patil[1], Sopan Namdev Nangare[1], Pratiksha Pramod Patil[1], Ashwini Ghanashyam Patil[2], Dilip Ramsing Patil[2], Rahul Shankar Tade[1], Arun Madhukar Patil[2], Prashant Krishnarao Deshmukh[3], Sanjay Baburao Bari[1]

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Abstract

The present work aims to synthesize nitrogen-doped reduced graphene oxide-titanium dioxide nanocomposite (N-rGO@TiO_2) using a simple, eco-friendly method and its applications in spectroscopic detection of heavy metal ions such as lead (Pb^{2+}), mercury (Hg^{2+}), and chromium-VI [Cr(VI)] in potable water. Initially, TiO_2 nanoparticles loaded N doped rGO sheets were fabricated by an ecological method using *Gossypium hirsutum* (cotton) seeds extract as a green reducing agent. Then, the N-rGO@TiO_2 nanocomposites were subjected for characterizations such as spectroscopic techniques, particle size analysis, zeta potential analysis, and spectroscopic sensing. Notably, the results of this study confirmed that N-rGO@TiO_2 exhibited countless stupendous features in terms of sensing of an analyte. Briefly, the UV-visible spectroscopy and Fourier transform infrared (FTIR) spectroscopy confirmed the successful synthesis of N-rGO@TiO_2. The SEM images showed the wrinkled, folded, and cross-linked network structures that confirmed the surface modification and nitrogen doping in the rGO sheet and synthesis of N-rGO@TiO_2. The EDAX study confirmed the elemental composition of the N-rGO@TiO_2 nanocomposite. Finally, due to the larger surface area, porous nature, high electron mobility, etc. the N-rGO@TiO_2 probe provides the lower detection limit for Pb^{2+}, Hg^{2+}, and Cr (VI) as low as 50 nM, 15 µM, and 25 nM, respectively. Concisely, our study affirms the admirable sensitivity of N-rGO@TiO_2 nanocomposite to the Pb^{2+}, Hg^{2+}, and Cr (VI) in potable water can provide better environmental remediation.

Keywords: Graphene oxide, N-rGO@TiO_2, Nanocomposite, Cotton-seed, Heavy metals, Biodegradable, Sensing

Introduction

Over the past two decades, graphene-based materials are gaining tremendous attention from a scientific fraternity in various fields [1-3]. It may because of its astonishing properties and potential to revolutionize the scientific sector [3-5]. Graphene can be used to fabricate several dimension materials such as 1D nanostructure [6], 2D layer stacked films [7], 3D graphene hydrogel [7-9], and aerogel [10-13], etc. Out

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Black Phosphorus Nanostructure Based Highly Sensitive and Selective Surface Plasmon Resonance Sensor for Biological and Chemical Sensing: A Review

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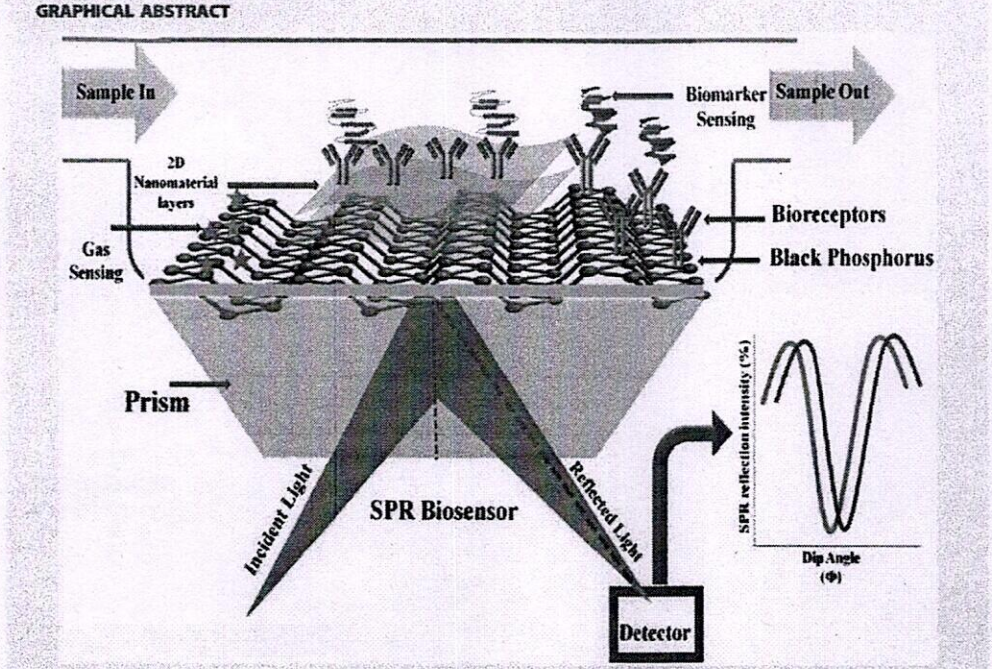
ABSTRACT

Surface plasmon resonance (SPR) is an attention-grabbing sensor type, which offers the sensitive and selective detection of biomolecules and environmentally toxic substances. Notably, the SPR sensor gives excellent rewards including real-time, *in-situ*, and label-free measuring capability as compared to existing sensing technologies. As a result, these noteworthy merits of the SPR sensor make it straightforward to investigate the molecular events and chemical/gas molecule interaction. Unfortunately, there are different binding events including smaller molecular mass substances, which cannot be detected at the SPR sensor. Accordingly, this downside of the SPR sensor eventually led to the design and implementation of new approaches for sensitivity and selectivity improvement for sensing applications in different fields. Recently, the black phosphorus (BP) derived 2D nanomaterial is stand out as a distinctive nanostructure in comparison to recently reported other 2D nanomaterials. Substantial and functional characteristics of BP including simplicity of operation, optical properties, high carrier mobility, stronger immobilization of receptors and biomolecules, electronic bridging playing important role in the highly selective and sensitive assessment of analyte. The designed BP nanostructures are mostly serving to accelerate the plasmon material signals followed by improved molecular sensing that may due to 40-times faster-sensing responses of BP nanostructure than reported 2D nanomaterials. Therefore, the present review article sheds light on the latest significant advances in biological and toxic gas detection through 2D BP nanostructures based SPR sensors. In the future, this review will facilitate detailed insights into the development of BP-based groundbreaking frameworks for highly sensitive and selective recognition of biomolecules and environmental pollutants.

KEYWORDS

Black phosphorus; biosensing; in-vitro diagnosis; sensitivity enhancement; surface plasmon resonance

GRAPHICAL ABSTRACT



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Research Publications 2021-22

Sr.	Title of the Publication	Author/s	Name of the Journal
1	Purification and modification of neem gum for enhancement of its suspending property	MG Kalaskar, RE Mutha, AU Tatiya, SD Firke, SJ Surana, KA Dhoka, K Heda	Future Journal of Pharmaceutical Sciences
2	Electrostatic deposition assisted preparation, characterization and evaluation of chrysin liposomes for breast cancer treatment	PK Deshmukh, RE Mutha, SJ Surana	Drug Development and Industrial Pharmacy
3	Cissus quadrangularis L: A comprehensive multidisciplinary review	PS Bafna, PH Patil, SK Maru, RE Mutha	Journal of Ethnopharmacology
4	Surface architectured metal organic frameworks-based biosensor for ultrasensitive detection of uric acid: Recent advancement and future perspectives	**SN Nangare, PM Sangale,** AG Patil, SHS Boddu, PK Deshmukh, NR Jadhav, RS Tade, DR Patil, A Pandey, S Mutalik, JK Patel, AM Patil, SB Bari, PO Patil	Microchemical Journal
5	Emerging Approaches to Overcome Acquired Drug ResistanceObstacles to Osimertinib in Non-Small-Cell Lung Cancer	**M Shaikh**, Y Shinde, R Pawara, M Noolvi, S Surana, I Ahmad, H Patel	Journal of Medicinal Chemistry
6	Fabrication of polyethyleneimine surface-functionalized fluorescent carbon dots and its applications towards highly sensitive and selective detection of glutathione in aqueous medium and *in vitro* cell imaging of *HeLa* cells	**ZG Khan,** PO Patil,	Journal of Materials Science: Materials in Electronics

7	Green synthesis of Fe-doped Ag-loaded reduced graphene oxide ternary nanocomposite for efficient photocatalytic degradation of toxic dyes	**SN Nangare, S Landge**, AG Patil, RS Tade, PK Deshmukh, PO Patil	Advances in Natural Sciences: Nanoscience and Nanotechnology
8	Crystallinity modulated silk fibroin electrospun nanofibers based floating scaffold as a candidate for controlled release of felodipine	**S Dugam, S Nangare,** A Gore, S Wairkar, P Patil, L Choudary, N Jadhav	International Journal of Polymeric Materials and Polymeric Biomaterials
9	Structural design of nanosize-metal-organic framework-based sensors for ultrasensitive detection of organophosphorus pesticides in food and water samples: Current challenges and future prospects	SB Bari **SN Nangare, SR Patil,** AG Patil, ZG Khan, PK Deshmukh, RS Tade, MR Mahajan	Journal of Nanostructures in Chemistry
10	Design and Synthesis of Poly-L-Lysine-Functionalized Graphene Quantum Dots Sensor for Specific Detection of Cysteine and Homocysteine	**ZG Khan**, PO Patil	Materials Chemistry and Physics
11	Graphene quantum dots (GQDs) nanoarchitectonics for theranostic application in lung cancer	**RS Tade, MP More, SN Nangare,** PO Patil	Journal of Drug Targeting
12	Synthesis, molecular modeling study of the methaqualone analogues as anti-convulsant agent with improved cognition activity and minimized neurotoxicity	I Ahmad, SR Akand, **M Shaikh,** R Pawara, SN Manjula, HM Patel	Journal of Molecular Structure
13	Development and Evaluation of Lyophilized Methotrexate Nanosuspension using Quality by Design Approach	T Power, A Hajare, R Jarag, **S Nangare**	Acta Chimica Slovenica
14	Fabrication of Poly-l-lysine-Functionalized Graphene Quantum Dots for the Label-Free Fluorescent-Based Detection of Carcinoembryonic Antigen	RS Tade, PO Patil	ACS Biomaterials Science and Engineering
15	Comparative Phytochemical Investigation Antioxidant and Antimicrobial Activity of Leaves, Bark and Stem Extract of Muntingia calabura	RN Chaudhari, AK Jain, VK Chatap	Journal of the Maharaja Sayajirao University of Baroda
16	Pharmacognostic Studies on *Anisomeles*	RE Mutha, KJ	Journal of the Maharaja

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17	A 3 factorial design approach for formulation and optimization of azilsartan medoxomil nanosuspension for solubility enhancement	NR Shirsath, **D Marathe, P Jaiswal,** LR Zawar	Indian Journal of Pharmaceutical Education and Research
18	An insight into prodrug strategy for the treatment of Alzheimer's disease	NV Bhilare, VS Marulkar, D Kumar, VK Chatap, KS Patil, PJ Shirote	Medicinal Chemistry Research
19	Nanostructured metal-organic frameworks based luminescent sensor for chemical sensing: Current Challenges and future prospects	**SN Nangare,** AG Patil, SM Chandankar, PO Patil	Journal of Nanostructure in Chemistry
20	Formulation of silk fibroin-based single polymeric floating microspheres for sustained release of lafutidine	J Pantwalawalkar, S Nangare	Indian Journal of Pharmaceutical Education and Research
21	Neuroprotective properties of medicinal plants: a comprehensive review	A Mhaiskar, V Bagul, S Patil	Journal of the Maharaja Sayajirao University of Baroda
22	Surface nanoarchitectured metal-organic frameworks-based sensor for reduced glutathione sensing: A review	**ZG Khan, MR Patil, SN Nangare,** AG Patil, S HS Boddu, RS Tade, PO Patil	Journal of Nanostructure in Chemistry
23	Formulation, optimization, and in vitro evaluation of anastrozole-loaded nanostructured lipid carrier for improved anticancer activity	D Ghadge, **S Nangare,** N Jadhav	Journal of Drug Delivery Science and Technology

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Fabrication of polyethyleneimine surface-functionalized fluorescent carbon dots and its applications towards highly sensitive and selective detection of glutathione in aqueous medium and in vitro cell imaging of HeLa cells

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ABSTRACT

The present study aimed to synthesize polyethyleneimine (PEI) surface-functionalized fluorescent carbon dots (CDs)-based biosensor (GP-PEI-CDs) for highly sensitive and selective detection of glutathione (GSH). In brief, green pea (GP) shells were utilized for green synthesis of blue luminescent GP-CDs through hydrothermal method. The obtained GP-CDs were surface functionalized with PEI to improve surface defects and quantum confinement effects. The surface functionalization of GP-PEI-CDs was confirmed by different spectroscopic techniques, including FTIR, XPS, etc. Switch "on" of GP-PEI-CDs was quenched by Cu(II) ions (turn "off"), and the limit of detection (LOD) of Cu(II) was found to be 23 nM along with a linearity range as 0 μM to 50 μM. Then, turn "On" process enabled the restoration in fluorescence of surface-functionalized GP-PEI-CDs when different concentrations of GSH in phosphate buffer saline (PBS, pH 7.4) was added. This could be due to split up of Cu(II) from Cu(II)@GP-PEI-CDs complex by presenting selective affinity with thiol (–SH) group of GSH among the various biomolecules. The LOD of GSH was found to be 38 nM and linearity in the range of 0 to 25 μM. The cytotoxicity study confirmed the biocompatibility of surface-functionalized GP-PEI-CDs. Furthermore, a confocal analysis indicated exceptional penetrations of GP-PEI-CDs into the cell cytoplasm and nucleus, demonstrating the created probe's suitability for GSH sensing at the cellular level. The method was successfully applied to determine GSH in in human serum sample.

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Green synthesis of Fe-doped Ag-loaded reduced graphene oxide ternary nanocomposite for efficient photocatalytic degradation of toxic dyes

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Abstract

The green synthesis of iron nanoparticles (FeNPs) doped and silver nanoparticles (AgNPs) loaded reduced graphene oxide (rGO) (Fe-Ag@rGO) nanocomposite and its applications in methylene blue (MB), malachite green (MG), rhodamine B (RB) degradation were reported. Initially, AgNPs loaded rGO (Ag@rGO) nanocomposites were synthesised simultaneously by an ecological method using *Tamarindus indica* shell extract as a green reducing agent. Then, the doping of FeNPs into rGO@Ag nanocomposites afforded Fe-Ag@rGO nanocomposite. Interestingly, the finding of this study confirmed that the Fe-Ag@rGO nanocomposites exhibited countless stupendous features in terms of dye degradation. Briefly, the UV-visible spectroscopy and Fourier-transform infrared spectroscopy (FTIR) study confirmed the synthesis of Fe-Ag@rGO nanocomposite. The scanning electron microscopy (SEM) images showed the spherical shape with cross-linked network structures that confirmed the surface modification and synthesis of Fe-Ag@rGO nanocomposite. Finally, the dye degradation potential of the photocatalyst was found to be 97.20%, 98.43%, and 97.33%, for MB, MG, RB, respectively. Herein, the improved photocatalytic performance of the Fe-Ag@rGO was found due to the larger surface area, porous nature, high electron mobility, and synergistic effect of the Fe-Ag@rGO nanocomposite. Additionally, the effective interfacial hybridisation of 'Ag', and doping of 'Fe' on the rGO sheet extended the duration of the photogenerated electron (e^-) hole pairs that can also be contributing to dye degradation. Conclusively, the present experiment provides the new Fe-Ag@rGO nanocomposite to the dye degradation, which could be improved environmental remediation.

Keywords: dye degradation, nanocomposite, Fe-Ag@rGO, Tamarindus indica shells, graphene oxide, Green synthesisClassification numbers, 2.00, 5.00, 5.11

1. Introduction

Today is the era of accelerated industrialisation, which has seen rapid developments and has played an essential role in

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Crystallinity modulated silk fibroin electrospun nanofibers based floating scaffold as a candidate for controlled release of felodipine

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ABSTRACT

Floating gastro-retentive delivery approach provides a significant pathway for controlled release of drug with increase gastric residence. In this study, we report crystallinity modulated electrospun silk fibroin nanofibers (SF-NFs) floating scaffolds for the controlled release of felodipine (FD). The alteration in the crystallinity behavior due to changes in the structural conformation of SF helps to customize the release kinetics of FD-loaded SF-NFs scaffolds. Additionally, FD-loaded SF scaffolds system having a density less than the acidic gastric fluid explore as a new tactic for floating drug delivery system. The prepared FD-loaded SF nanofibers (FD-loaded SF-NFs) were characterized by spectral, thermal, and diffractometric techniques, scanning electron microscopy, floating profile, *in-vitro* degradation, mucoadhesion, and *in-vitro* dissolution studies, etc. The optimized batch had the least porosity and swelling, was annealed with ethanol and water for crystallinity modulation of SF-NFs to get controlled release of FD. Spectral, thermal, and diffractometric analyses could unveil the molecular dispersion of FD, coupled with amorphous form stabilization in NF. Excellent floating profile and satisfactory mucoadhesion of FD-SF-NFs also endorsed the formation of a novel floating drug delivery system. Temporal control over FD release was elucidated by *in-vitro* dissolution, demonstrating controlled release due to crystallinity modulation of SF-NFs. In conclusion, crystallinity-modulated electrospun NFs fabricated from SF waste could be used as a customizable carrier for drug delivery to the gastric region.

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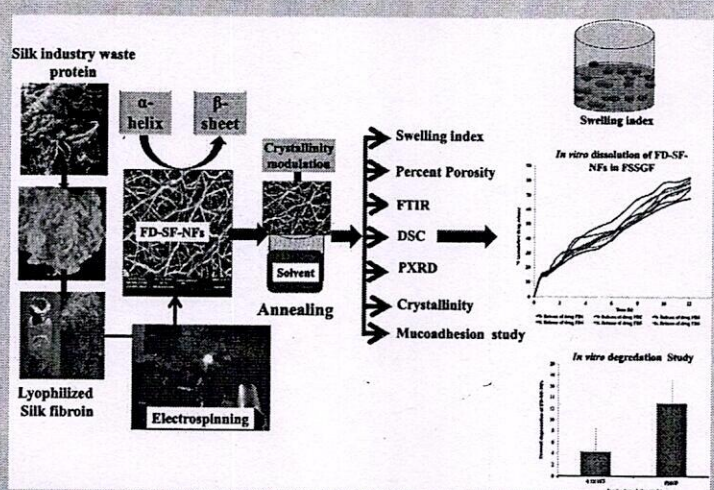
KEYWORDS
Silk fibroin; electrospun nanofibers; crystallinity modulation; felodipine; floating drug delivery; controlled release

GRAPHICAL ABSTRACT



Crystallinity modulated silk fibroin electrospun nanofibers based floating scaffold as a candidate for controlled release of felodipine

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REVIEW

Structural design of nanosize-metal–organic framework-based sensors for detection of organophosphorus pesticides in food and water samples: current challenges and future prospects

Sopan N. Nangare[1] · Sayali R. Patil[1] · Ashwini G. Patil[2] · Zamir G. Khan[1] · Prashant K. Deshmukh[3] · Rahul S. Tade[1] · Mahendra R. Mahajan[1] · Sanjaykumar B. Bari[1] · Pravin O. Patil[1]

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Abstract
Organophosphorus pesticide (OPP) is regarded as an important food-chain and environmental contaminant that causes primary acute toxicity and numerous severe health issues. Therefore, the minute concentration of OPP present in food materials and environments needs to be identified before it causes any brutal harm to lives. Despite the plenty of merits of qualitative and quantitative sensing methods, the lower sensitivity, poor selectivity, detection speed, etc. towards the interest OPP are major drawbacks. Nanoparticles have attracted a lot of attention because of their unique and intriguing features, which have a variety of applications including sensor development as compared to their bulk counterparts. Recently, the structural design of nanosize-metal–organic framework (MOF) is gaining huge consideration from researchers for sensing applications owing to their versatile and tunable properties. Additionally, MOF-based sensors offer the rapid, simplistic, selective, and sensitive sensing of interest analyte. The present review provides brief information about OPPs and their toxicities. The emerging trends of structural design of nanosize-MOF including their properties have been summarized. Finally, nanosize-MOF-based fluorescent sensors, electrochemical sensors, and colorimetric sensors have been discussed with central focus on sensitivity and selectivity to OPPs. Due to the higher surface area, rich topology, ease of structural tunability and functionalization, tunable pore size, plenty of binding sites, good adsorption potential, excellent charge conductivity, and chemical stability, etc., MOF based sensors are endowed with the ability of OPPs detection upto aM. Hence, MOF as nanoporous sensors can be preferred as an excellent alternative for highly sensitive and selective recognition of OPPs in food and water samples.

Sopan N. Nangare and Sayali R. Patil contributed equally as a first author.

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Design and synthesis of poly-L-lysine-functionalized graphene quantum dots sensor for specific detection of cysteine and homocysteine

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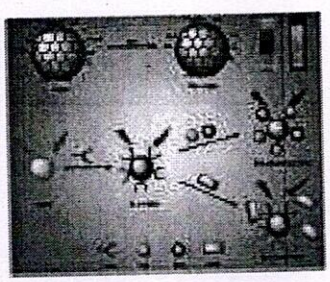
HIGHLIGHTS

- Waste material (pistachio shells) used for synthesis of graphene quantum dots (GQDs).
- Novel poly-L-lysine (PLL) surface functionalized GQDs (PLL-GQDs) based sensor was developed.
- The fabricated probe (PLL-GQDs) exhibited low cytotoxicity and excellent biocompatibility.
- The probe demonstrated highly sensitive and selective detection of cysteine (cys) and homocysteine (hcys) in real samples.

GRAPHICAL ABSTRACT



ARTICLE INFO

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Poly-lysine surface functionalized graphene quantum dots
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Functionalized graphene quantum dots
Cysteine and homocysteine
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Fluorescent probe

ABSTRACT

In this paper, a novel poly-L-lysine (PLL) surface functionalized graphene quantum dots (GQDs) based sensor was developed for detection of cysteine (cys) and homo cysteine (hcys). A fluorescent probe (PLL-GQDs) was then fabricated by surface functionalizing GQDs with PLL, a biodegradable polycationic electrolyte to improve the sensitivity and selectivity towards cys and hcys. The detection was based on the specific binding of cys and hcys to PLL at the PLL-GQDs surfaces, which enabled dynamic quenching via electrostatic and hydrophobic interactions. This fluorescent probe provided good linearity for the tested biothiols, ranging from 0 to 150 nM for cys, from 0 to 100 nM for hcys, with limit of detections (LODs) of 2.38 and 1.94 nM, respectively in BPS (pH 7.4). Interestingly, fabricated probe was also able to display a significant selectivity towards cys and hcys against known interfering molecules. The cytotoxicity study confirmed the biocompatibility of PLL-GQDs, enabling its future scope for cell adhesion and other biomedical applications. Besides, confocal study revealed the excellent penetrations of PLL-GQDs into cell cytoplasm and nucleus that validate the practical application of developed probe to detect cys and hcys at cellular level. The method was successfully applied for detection of cys and hcys in human serum sample. We expect the design concept presented here would be broadly used for selective and sensitive estimation of cys and hcys.

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REVIEW ARTICLE

Graphene quantum dots (GQDs) nanoarchitectonics for theranostic application in lung cancer

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ABSTRACT

Lung cancer (LC) is heading up as a substantial cause of mortality worldwide. Despite enormous progress in cancer management, LC remains a crucial problem for oncologists due to the lack of early diagnosis and precise treatment. In this context, numerous early diagnosis and treatment approaches for LC at the cellular level have been developed using advanced nanomaterials in the last decades. Amongst this, graphene quantum dots (GQDs) as a novel fluorescent material overwhelmed the horizons of materials science and biomedical fields due to their multifunctional attributes. Considering the complex nature of LC, emerging diagnostic and therapeutic (Theranostics) strategies using GQDs proved to be an effective way for the current practice in LC. In this line, we have abridged various approaches used in the LC theranostics using GQDs and its surface-engineered motif. The admirable photophysical attributes of GQDs realised in photolytic therapy (PLT), hyperthermia therapy (HTT), and drug delivery have been discussed. Furthermore, we have engrossed the impasse and its effects on the use of GQDs in cancer treatments from cellular level (*in vivo-in vitro*) to clinical. Inclusively, this review will be an embodiment for the scientific fraternity to design and magnify their view for the theranostic application of GQDs in LC treatment.

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KEYWORDS
Lung cancer; graphene quantum dots; theranostics; photolytic/hyperthermia therapy; drug delivery

Introduction

Global cancer risk is elevating gradually and results in a greater mortality rate per year. As per the fresh report of GLOBOCAN 2020, about 19.3 million cases and nearly 10.0 million deaths by cancer were recorded in 2020. Epidemiologists suggested that there would be probable 28.4 million new cases of cancer to befall nearly in 2040. Amongst all cancers, lung cancer (LC) has positioned on second diagnostic occurrence followed by breast cancer (11.7%) and crossed about 11.4% mortality rate, led by 1.8 million deaths (18%) in 2018 [1]. Besides, LC mortality is probable to reach 2.45 million globally by 2030. Principally, LC is a complex form of (adenocarcinoma) which increasing worldwide as an utmost cause of mortality. Generally, adenocarcinoma is known as the cancer of glandular mucus-producing cells (especially lungs). As per literature, LC is classified into four types: invasive adenocarcinoma (IA), adenocarcinoma in-situ (AIS), and minimally invasive adenocarcinoma (MIA) and other variants (e.g. lipidic) (Figure 1(A)). Besides this, the World Health Organisation (WHO) gives a sub-classification of lung adenocarcinomas as per their cellular origin. It includes acinar cells, papillary cells, bronchoalveolar, and mucus-secreting [2]. Literature survey advocated that there is a scarcity in our current knowledge of cancer statistics due to changing epidemiological trends of LC amongst developing countries [3]. In this context, it is observed that there is a vital role of the Human Development Index (HDI) in cancer mortality and morbidity in several countries. Both developed and developing countries experiencing an evident rise in the augmented effects of cancer risk factors. Moreover, there is an alarming rise in LC incidents in non-smokers as well. Notably, some major risk factors associated with the LC are smoking, exposure to second-hand smoke, previous radiation therapy, exposure to radon gas, exposure to asbestos and other carcinogens, and hereditary history of LC. Besides, the world is evidenced by the residual burden of different respiratory infections associated with LC. For example, Coronavirus disease 2019 (COVID-19), its emergence in 2020, and recurrence in 2021 have been overwhelmed the global healthcare systems. At this juncture, COVID-19 is becoming a major risk factor for LC patient's treatment. However, an extensive survey regarding the precise impact of COVID-19 associated with a patient suffering from LC is not available to date [4,5].

Current diagnostics and management strategies for LC

Despite the significant development in cancer therapeutics, several risk factors escalating in front of the developed and developing nations. Recently, Sung et al. reviewed the global cancer prevalence, which suggested the frequent diagnostic appearance as well as morbidity of LC up to 2020 which raised significantly after 2018 (Figure 1(B)) [1,6].

The traditional methods including X-ray, magnetic resonance imaging (MRI), Computed tomography (CT), or positron-electron microscopy (PET) scanning are commonly used for the diagnosis of cancer. Primary screening of LC by traditional methods is dependent on the severity and phases of LC. Unfortunately, the lack of site-specific localisation or inability to detect micrometer-sized tumours becomes inconclusive in the early detection of LC. Apart from this, sputum cytology, biopsy, and bronchoscopy methods are commonly used for the diagnosis of LC.

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Scientific paper

Development and Evaluation of Lyophilized Methotrexate Nanosuspension using Quality by Design Approach

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Abstract

With the application of the quality by design (QbD) approach, a high-pressure homogenizer (HPH) methodology was employed to develop methotrexate nanosuspension (MTX-NS) to boost bioavailability. The Ishikawa diagram was used to analyze potential risk factors in formulation development. To screen and study the impact of various formulation and process factors on the critical quality attributes (CQA), the Placket–Burman design and central composite design were utilized. The number of HPH cycles, poloxamer 188 concentration, and tween 80 concentration were shown to be significant parameters ($P<0.05$), that were further optimized using Central Composite Design. The zeta potential of optimized lyophilized MTX-NS was determined to be −11.6 ± 7.52 mV and the average particle size was 260 ± 0.25 nm. In vitro cytotoxicity experiments revealed a greater than 80% inhibition, with apoptotic cells shrinking, fragmentation, and cell death. Furthermore, the C_{max} and AUC_{0-t} were increased by 2.53 and 8.83 folds, respectively. The relative bioavailability of MTX-NS was found to be 8.83 times higher than that of MTX-aqueous dispersion. As a result, the QbD method resulted in the development of a lyophilized MTX-NS with process understanding and control based on quality risk management.

Keywords: Nanosuspension; Lyophilized, QbD approach; Central Composite Design; Plackett– Burman Design; *In-vivo* study.

1. Introduction

Pharmaceutical experts have long struggled with the formulation and development of poorly water-soluble drugs, and these challenges are projected to worsen since more than 40% of new chemical entities discovered by drug discovery are poorly aqueous soluble.[1] Whereas, it is more problematic in the case of poorly soluble drugs with poor absorption profile, and bioavailability because it is dissolution rate-limited and can be affected by patient fed or fasted state condition[2]. Traditional approaches including solubilization by surfactant, surfactant dispersion, micronization, use of the oily solution, permeation enhancers, which evolved too earlier, that address the challenges of formulation and have limited use.[2,3] The major milestone has been achieved in the development of poorly water-soluble drugs using various newer technology, but to date, there is no universal thumb approach applicable to all active pharmaceutical ingredients.[3] Consequently, a new approach has been progressively required to deal with formulation issues that are associated with the delivery of poorly soluble drugs, to enhance their therapeutic efficacy and maximize their pharmacodynamics therapy.[2]

A drug delivery aims to deliver a sufficient amount of drug to a proper side in the body such that, the optimal concentration of the drug is reached rapidly and then sustained. The development of a proper dosage form is an essential element to achieve this objective.[4] From its inception, oral drug delivery is the most commonly used route of administering the drug in various dosage forms due to

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Research Publications 2020-21

Sr.	Title of the Publication	Author/s	Name of the Journal
1	Green synthesis of fluorescent graphene quantum dots and its application in selective curcumin detection	**RS Tade,** PO Patil	Current Applied Physics
2	Green Synthesis of Silver Nanoparticles: An Eco-Friendly Approach	**SN Nangare,** PO Patil	Nano Biomedicine and Engineering
3	Silk industry waste protein: Isolation, purification and fabrication of electrospun silk protein nanofibers as a possible nanocarrier for floating drug delivery	**SN Nangare,** SS Dugam, PO Patil, RS Tade, NR Jadhav	Nanotechnology
4	Theranostic prospects of graphene quantum dots in breast cancer	**RS Tade,** PO Patil	ACS Biomaterials Science and Engineering
5	Affinity-based nanoarchitectured biotransducer for sensitivity enhancement of surface plasmon resonance for in vitro diagnosis: A review	**SN Nangare,** PO Patil	ACS Biomaterials Science and Engineering
6	One-pot development of spray dried cationic proliposomal dry powder insufflation: Optimization, characterization and bio-interactions	AB Shreya, A Pandey, **AN Nikam,** PO Patil, R Sonawane, P Deshmukh, S Mutalik	Journal of Drug Delivery Science and Technology
7	Black phosphorus as multifaceted advanced material nanoplatforms for potential biomedical applications	**A Pande, AN Nikam**, G Fernandes, S Kulkarni, BS Pandya, R Prassl, S Das, A Joseph, PK Deshmukh, PO Patil, S Mutalik	Nanomaterials
8	Carbon dots: A novel trend in pharmaceutical applications	S Dugam, **S Nangare,** P Patil, N Jadhav	Annales Pharmaceutiques Francaises
9	Nanoarchitectured bioconjugates and bioreceptors mediated surface plasmon resonance biosensor for in vitro diagnosis	**S Nangare**, P Patil	Critical Reviews in Analytical Chemistry

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Green synthesis of fluorescent graphene quantum dots and its application in selective curcumin detection

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ABSTRACT

Herein, we present a facile low-cost and eco-friendly approach for conversion of bamboo timber waste (Bf) derived cellulose nanocrystals (Bf-CNCs) into strong blue luminescent graphene quantum dots (Bf-GQDs) by hydrothermal route. The various properties of synthesized Bf-GQDs were investigated using different spectroscopic techniques. The probable mechanism of Bf-GQDs formation from Bf-CNCs and the effect of pH, particle size on the fluorescent properties of Bf-GQDs also executed. Furthermore, Bf-GQDs were used for the detection of curcumin in an aqueous environment which is the major prerequisite of the present study. The Bf-GQDs showed remarkable photoluminescence (PL) quenching kinetics toward the curcumin (LOD 30.0 nM L^{-1}) assessed by Stern-Volmer plot. The practicability of the method assessed using ginger rhizome juice, while the selectivity of the Bf-GQDs evaluated against different metal ions and different biochemicals. The proposed method will support to establish the strategies for the detection of biochemicals from the aqueous system.

1. Introduction

Graphene based materials, especially graphene quantum dots (GQDs) accolades by researchers amongst the different nanomaterials due to its exceptional properties. Since a scalable GQDs production method still stands as a serious obstacle due to its broad application in numerous areas. For example, bottom-up synthesis from graphene and its native precursors demands costly and potentially hazardous chemicals. Moreover, these methods are tedious and required multiple steps to the obtained purified final product (GQDs), which ultimately results in low production yield. Several endeavors have been made worldwide for the conversion of natural waste precursors (NPs) such as weathered leaves [1], coffee grounds [2], etc. Into graphene-like materials and GQDs [3]. It was observed that GQDs from aforementioned precursors has the greatest biocompatibility and stability as compared to the GQDs from pristine graphene as they obtained from a series of hazardous chemical treatment. Moreover, these biomass-derived GQDs are superior to semiconductor quantum dots in terms of solubility, aqueous stability, chemical modification, and high resistance to photo bleaching [4]. These ideal properties have now been subjugated for numerous applications such as fluorescent probes for solar cells [5], biochemical sensing [6] or detection [7,8], bioimaging [9], etc. Apart from the use of available biomaterials such as citric acid [10], sucrose [11], for obtaining GQDs or graphitic materials one can use waste biomass for gaining one or more active materials of interest. For instance, corn agro waste can be converted into cellulosic derivatives [12], wood waste into quality graphene [13]. The research fraternity well realized that to achieve the 'sustainable green synthesis goals' it is necessary to look after the abundant waste biomass to be utilized for the synthesis of graphene-like materials [3,14,15]. It is well known that cellulose-based biomass hitting the top list as abundant waste at agricultural as well as domestic levels. Cellulose-based polymers had been utilized for the fabrication of numerous materials like nanocomposites in many biomedical and pharmaceutical applications, etc. [16]. A huge amount of bamboo timber waste produces at the various sawmills which further expelled as waste or used as domestic fuel. Bamboo fibers mostly used as a natural composite reinforcing material because of its high strength-to-weight ratio and high hydrophilicity. Cellulose is the major component of the bamboo fibers which plays a crucial role as reinforcing materials in composites while hemicelluloses after the efficient conversion accomplish biofuels and multifunctional by-products. In addition to this hemicellulose on hydrolytic undergoes cleavage of glycosidic bonds between two anhydrous glucose which is the most significant rout of cellulose degradation [17]. Inspired by these facts, we choose the bamboo timber waste for the GQDs synthesis. The stepwise processing of bamboo timber waste yields us cellulose nanocrystals as well as GQDs

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Review

Green Synthesis of Silver Nanoparticles: An Eco-Friendly Approach

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Sopan Namdev Nangare is currently a senior research fellow (Indian Council of Medical Research) at HRPIPER, Shirpur. He has completed his M. Pharm from Bharati Vidyapeeth College of Pharmacy, Kolhapur. He has presented many research papers at various national and international conferences and symposiums. He has been awarded with "Best Outgoing Student" by Bharati Vidyapeeth College of Pharmacy, Kolhapur. He has more than 15 research papers and reviews articles published in national and international journals of repute. His research focuses on the green synthesis of nanocomposites, biosensing, natural polymer-carriers for drug delivery, etc.

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Abstract

Eco-friendly synthesis of nanoparticles is an upcoming discipline of nanoscience. Green synthesis of Ag NPs has gained immense importance and much awareness in developed nations. Fascinatingly, such an environmental friendly synthesis of Ag NPs gives a green chemistry-based non-toxic and economical route to nanotechnology. This review article gives insight into the bioinspired synthesis of Ag NPs and mechanisms involved in the synthesis of Ag NPs. In this review, we have summarized the scientific reports in the eco-friendly synthesis arena of Ag NPs and their applications in the biomedical field. Especially, we have focused on plant materials, fungi, algae, and bacterial potential towards the eco-friendly synthesis of Ag NPs. For future perception, there is a need for in silico and in vitro, in vivo research to authenticate the outcomes.

Keywords: Silver nanoparticles, Green synthesis, Plant extract, Eco-friendly, Nanotechnology

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Silk industry waste protein: isolation, purification and fabrication of electrospun silk protein nanofibers as a possible nanocarrier for floating drug delivery

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Abstract

Amongst assorted regio-selective and targeted oral drug delivery strategies accepted for the gastro-retentive drug delivery system (GRDDS), the floating drug delivery system (FDDS) holds a major share as clinically accepted formulations. The major objective of the present investigation was to explore the silk industry waste protein, silk fibroin (SF) as a possible electrospun nanocarrier for the FDDS. In a nutshell, electrospinning (ES) is one of the flexible and astonishing strategies for the fabrication of porous electrospun nanofibers (NFs), which offers the potential to amend the floating profile, dissolution rate, solubility, and release patterns of the drug, etc as per compendial requirements. Looking at the prospects of floating SF-NFs preparation, we have isolated and lyophilized the SF from industrial waste cocoons and prepared drug-loaded SF single polymer nanofibers (SPN). Lafutidine (LF) being a good candidate for GRDDS selected as a model drug, which is an excellent proton pump inhibitor, mainly used in the treatment of gastric ulcers. Finally, the obtained LF loaded SF-NFs (LF-SF-NFs) were successfully analyzed for physicochemical characteristics, porosity, swelling index, antioxidant activity, mucoadhesion strength, floating properties, enzymatic degradation, and accelerated stability study, etc. Further, these LF-SF-NFs were evaluated for percent drug content, weight variation, *in-vitro* dissolution in 0.1 N hydrochloric acid (HCl, pH:1.2) and fasted state simulated gastric fluid (FSSGF), and accelerated stability study. It has shown significant floating time >18 h, about 99% ± 0.58% floating buoyancy with sustained release up to 24 h. LF-SF-NFs showed good compatibility, entrapment efficiency, antioxidant activity, mucoadhesion strength, enzymatic degradation, and long term stability. Soon, the essential floating and drug release profiles can claim single polymer (SF) based electrospun protein NFs as a possible novel oral nanocarrier for FDDS.

Keywords: processing industrial waste cocoons, silk fibroin, electrospun nanofibers, lafutidine, floating drug delivery system

(Some figures may appear in colour only in the online journal)

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Review

Theranostic Prospects of Graphene Quantum Dots in Breast Cancer

Rahul S. Tade and Pravin O. Patil*

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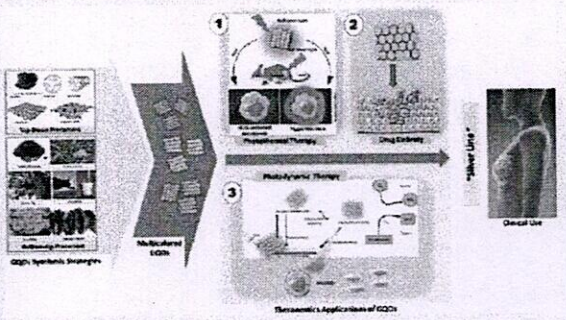
ABSTRACT: Breast cancer (BC) is increasing as a significant cause of mortality among women. In this context, early diagnosis and treatment strategies for BC are being developed by researchers at the cellular level using advanced nanomaterials. However, immaculate etiquette is the prerequisite for their implementation in clinical practice. Considering the stolid nature of cancer, combining diagnosis and therapy (theranostics) using graphene quantum dots (GQDs) is a prime focus and challenge for researchers. In a nutshell, GQDs is a new shining star among various fluorescent materials, which has acclaimed fame in a short duration in materials science and the biomedical field as well. From this perspective, we review various strategies in BC treatment using GQDs alone or in combination. In addition, the photophysical properties of GQDs explored in photothermal therapy, hyperthermia therapy, and photodynamic therapy are also discussed. Moreover, we also focus on the strategic use of GQDs both as drug carriers and as combinatorial-guided drug delivery motifs. This Review provides an update for the scientific community to plan and expand advanced theranostic horizons in BC using GQDs.



KEYWORDS: *breast cancer, triple-negative breast cancer, graphene quantum dots, theranostics, photodynamic/photothermal therapy, drug delivery*

1. INTRODUCTION

Cancer is now the second leading cause of death worldwide, with its horrific existence commonly a manner of mortality.[1] In 2018, it was estimated that 9.6 million deaths (i.e., 1 in every 6 deaths) were due to cancer. According to the World Health Organization (WHO), roughly 70% of deaths from cancer occur in low- to middle-income countries (LMICs). Research experts are worried that by the year 2030, 16−18 million additional cases of cancer will be added every year, and 60% of these will be in developing countries. WHO has claimed that by 2030, merely 12 countries are likely to reach a one-third drop in premature cancer mortality.[2,3] In order to reach sustainable development goals, there is a need for greater investment in the treatment of cancer and other non-communicable diseases.[4] The growing cancer burden globally exerts huge physical, emotional, as well as financial tensions on individuals, families, and consequently the overall health systems. Health organizations in LMICs are least equipped to handle this burden, and for that reason many cancer patients worldwide cannot receive diagnosis and treatment in a timely manner. While the overall cost of cancer treatment in 2010 was estimated at US$1.16 trillion, only 1 out of every 5 LMICs has the necessary data to drive cancer treatment and mitigation policy.[3] Reports suggest that about 30−50% of all cancer cases are predictable, that can be addressed by a cost-effective long-term strategy.[5] In many countries, the survival rates of patients diagnosed with cancer are improving owing to prognosis quality treatment and survivorship care.[6]

1.1. Breast Cancer. Every year, breast cancer (BC) affects 2.1 million women, and it is recognized as the most prevalent cancer in women. About 627 000 women died of BC in 2018, which accounts for 15% of all the cancer-associated deaths in women.[7] Usually, BC is categorized on the basis of its ability to spread, such as *in situ* ductal carcinoma (DCIS). DCIS starts in a milk duct and has no further growth into the rest of the breast tissue. Invasive or infiltrating types of BC can spread in the surrounding breast tissue. Invasive BC is comprised of two forms: invasive ductal carcinoma (IDC) and invasive lobular carcinoma (ILC). IDC accounts for 70−80% of all BCs.[8] Different forms of BC and global statistics on BC in women are depicted in Figure 1. Invasive BCs have distinct features, which affect their treatment and outlooks. Though invasive BCs are more serious than other types of BC, their occurrence is less common. Invasive BCs are further comprised of inflammatory breast cancer (IBC) and triple-negative breast cancer (TNBC).

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Review

Affinity-Based Nanoarchitectured Biotransducer for Sensitivity Enhancement of Surface Plasmon Resonance Sensors for *In Vitro* Diagnosis: A Review

Sopan N. Nangare and Pravin O. Patil*

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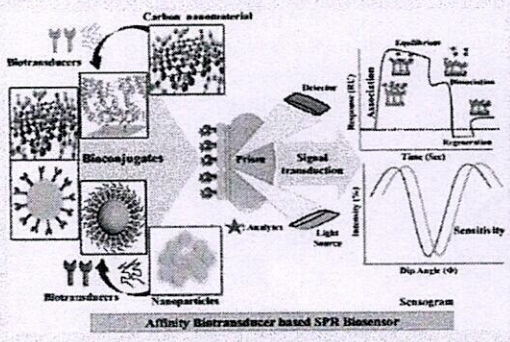
ABSTRACT: Despite the indisputable benefits and advancement of science, technology, and civilization, early diagnosis of healthcare is still a challenging field for the scientific fraternity. The detection of biomarkers is a crucial attribute of prognosis and diagnosis of disease. Out of numerous techniques, surface plasmon resonance (SPR) bestows countless benefits, including *in situ*, label-free, and real-time assessment, etc., which authorizes the analysis of molecular binding occurrences between biotransducers and biomarkers. In addition, SPR with low-molecular-weight biomarkers lacks selectivity and sensitivity, which ultimately affects binding kinetics. This, in turn, leads to the remarkable development and implementation of numerous selectivity and sensitivity enhancement methods. Among the various noticeable strategies, because of selectivity and sensitivity enrichment substrate for SPR biosensors, affinity-based nanoarchitectured biotransducers stand out as being the best substitute. The present review elaborates significant advances made in the research based on affinity biotransducers for *in vitro* diagnosis using SPR biosensors for biomarker sensing. Moreover, most recent trends and challenges in designing and application of nanoarchitectured affinity biotransducer-based SPR biosensors for detecting low-concentration biomarkers have been reviewed comprehensively. This present review may assist the scientific fraternity in designing an ultramodern novel SPR approach based on affinity biotransducers, along with improved selectivity and sensitivity of SPR biosensors for *in vitro* and real-time diagnostic applications.



KEYWORDS: *Affinity biotransducer, surface plasmon sensor, in vitro diagnosis, antibody, aptamer, nanoparticles*

1. INTRODUCTION

In addition to the indisputable benefits of research, industry, and technology, unfortunately, some impetuous shifts in the natural world have started to endanger the lives of peoples and other entities directly.[1] In the last couple of decades, a key feature to achieving rapid diagnosis of much pathology is the insistence for early, economical, and reliable analytical instruments for *in vitro* diagnosis.[2] Initially, the scientific fraternity has fixed the general criterion for *in vitro* diagnostic devices, which includes the utilization condition and risk factors of the device/machine. In addition, the device should be proficient to provide relevant information for careful diagnosis of particular health issues. Furthermore, the result of analytical techniques or devices should notably affect the public or individual negatively or positively.[3] The literature survey revealed that the emerging *in vitro* diagnostic devices are offering rapid screening and early detection ability, precise information, and real-time monitoring of several diseases and disorders.[4] Unfortunately, official analytical strategies (commonly employed for diagnostic applications) are plagued by numerous drawbacks, viz, selectivity, sensitivity, time-consuming process, the cost of analysis, need of expert and trained staff for its laborious process, and having limited availability as a point of health care system, etc. Moreover, the luminous technological expansion within assorted sectors and fields (viz, nanotechnology, biotechnology, and electronics) necessitates impetuous, user-friendly, sensitive tools, which leads to a tremendous expansion of analytical methods in the last decades.[5] More precisely, the biosensor is an advanced analytical tool in which a biotransducer (example: antibodies, aptamers, tissues, DNA, enzymes, etc.) is united through a physicochemical transducer (viz, optical, magnetic, electrochemical, piezoelectric).[1] The interaction between the interest/target biomarker (or analyte) and the specific

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One- Pot Development of Spray Dried Cationic Proliposomal Dry Powder Insufflation: Optimization, Characterization and Bio-interactions

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nanomaterials

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Review

Black Phosphorus as Multifaceted Advanced Material Nanoplatforms for Potential Biomedical Applications

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Abstract: Black phosphorus is one of the emerging members of two-dimensional (2D) materials which has recently entered the biomedical field. Its anisotropic properties and infrared bandgap have enabled researchers to discover its applicability in several fields including optoelectronics, 3D printing, bioimaging, and others. Characterization techniques such as Raman spectroscopy have revealed the structural information of Black phosphorus (BP) along with its fundamental properties, such as the behavior of its photons and electrons. The present review provides an overview of synthetic approaches and properties of BP, in addition to a detailed discussion about various types of surface modifications available for overcoming the stability-related drawbacks and for imparting targeting ability to synthesized nanoplatforms. The review further gives an overview of multiple characterization techniques such as spectroscopic, thermal, optical, and electron microscopic techniques for providing an insight into its fundamental properties. These characterization techniques are not only important for the analysis of the synthesized BP but also play a vital role in assessing the doping as well as the structural integrity of BP-based nanocomposites. The potential role of BP and BP-based nanocomposites for biomedical applications specifically, in the fields of drug delivery, 3D printing, and wound dressing, have been discussed in detail to provide an insight into the multifunctional role of BP-based nanoplatforms for the management of various diseases, including cancer therapy. The review further sheds light on the role of BP-based 2D platforms such as BP nanosheets along with BP-based 0D platforms—i.e., BP quantum dots in the field of therapy and bioimaging of cancer using techniques such as photoacoustic imaging and fluorescence imaging. Although the review inculcates the multimodal therapeutic as well as imaging role of BP, there is still research going on in this field which will help in the development of BP-based theranostic platforms not only for cancer therapy, but various other diseases.

Keywords: bioimaging; wound healing; 3D printing; surface modification; characterization

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1. Introduction

The discovery of Black Phosphorus (BP) dates back to a hundred years ago. It all began with Bridgman [1], who brought about the conversion of white phosphorus to black phosphorus under a high temperature and pressure. Later, Hultgren et al. [2] demonstrated

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GENERAL REVIEW

Carbon dots: A novel trend in pharmaceutical applications

Carbon dots : *une nouvelle tendance dans les applications pharmaceutiques*

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HIGHLIGHTS

- Presents basic concepts, advantages, synthesis approach of CDs.
- Numerous CDs based pharmaceutical applications of were reviewed.
- CDs were used in gene therapy and nanomedicine.
- CDs were used in bioimaging and biosensing.

KEYWORDS
Carbon dots;
Pharmaceutical applications;
Bioimaging;
Sustained drug delivery;
Targeted drug delivery

Summary Carbon quantum dots (CQDs, C-dots, or CDs), are generally small carbon nanoparticles having a size less than 10 nm. Carbon dots (CDs) were accidentally discovered during the purification of single-walled carbon nanotubes through preparative electrophoresis in 2004. Carbon is an organic material having poor water solubility that emits less fluorescence. However, CDs have good aqueous solubility and excellent fluorescent property, hence more attention has been given to the synthesis of CDs and their applications in chemistry and allied sciences. CDs being easily accessible for in-house synthesis, simpler fabrication as per compendial requirements are wisely accepted. In addition, since CDs are biocompatible, of low toxicity, and of biodegradable nature, they appear as a promising tool for the health care sector. Furthermore, owing to their capabilities of expressing significant interaction with biological materials, and their excellent photoluminescence (PL), CDs have been emerging as novel pioneered nanoparticles useful for pharmaceutical and theranostic applications. Also, CDs are more eco-friendly in synthesis and therefore can be favorably consumed as alternatives in the further development

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CRITICAL REVIEWS IN ANALYTICAL CHEMISTRY
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Nanoarchitectured Bioconjugates and Bioreceptors Mediated Surface Plasmon Resonance Biosensor for *In Vitro* Diagnosis of Alzheimer's Disease: Development and Future Prospects

Sopan Nangare and Pravin Patil

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ABSTRACT

Alzheimer's disease (AD) is an obvious neurological disorder characterized by progressive brain cell death that resulted in memory loss, cognitive decline, and finally dementia. Besides, AD is also affected by a multifunctional pathway, which leads to alteration in the biomolecular level as AD steps forward. Notwithstanding numerous diagnosis techniques, the conventionally engaged technology permits the detection of AD biomarkers with low sensitivity and poor selectivity. Concerning this, in recent years bioconjugates and bioreceptors based AD biomarkers recognition is gaining huge prospective to improved selectivity and sensitivity of AD at the molecular level. The present review deals with the recent progress in bioreceptors and bioconjugates mediated surface plasmon resonance (SPR) biosensor for *in vitro* diagnosis of AD. Fascinatingly, this review inculcates the information of assorted important AD biomarkers viz. beta-amyloid (Aβ), Tau protein, apolipoprotein (apoE4), 17-β-hydroxysteroid dehydrogenase type 10 (17β-HSD-10), acetylcholine, etc. In addition, this review sheds light on the utmost and unique methods of bioconjugates synthesis, which is holding the huge attention of researchers for AD biomarker detection and contributed to the development of simplistic, rapid, and socioeconomic sensitivity enhancement methods. Concisely, this review gives insight into the analytical performance of nanoarchitectured bioconjugate and bioreceptor-mediated SPR biosensor and their revolutionary benefits in terms of selectivity and sensitivity for *in vitro* diagnosis of AD biomarkers. Overall, this review gives a detailed overview of research done to date in the meadow of SPR biosensors in the *in vitro* diagnosis of AD, which paves the new pathway for futuristic biomedical applications.

KEYWORDS

Alzheimer's disease; surface plasmon resonance; bioconjugates; bioreceptors; *in vitro* diagnosis

HIGHLIGHTS

- AD recent updates and its biomarkers reviewed.
- There is no leading technology to rapidly sense and monitor AD.
- Bioconjugates as potential biosensing elements.
- Conjugation methods to link bioreceptors to nanomaterials have been highlighted.
- Role of bioconjugates and bioreceptors in AD biosensing through SPR biosensor have been discussed.

GRAPHICAL ABSTRACT

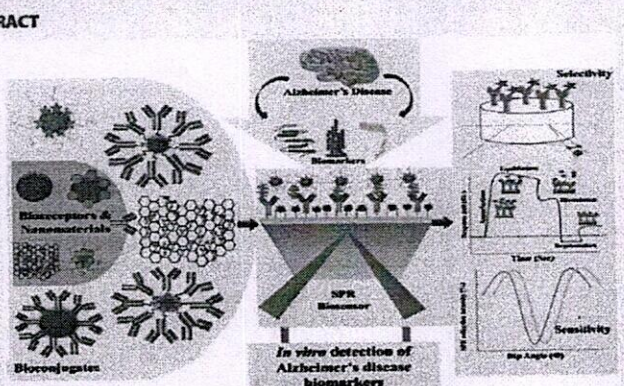

Figure 1. Nano-architectured bioconjugates and bioreceptors mediated SPR biosensor for highly sensitive and selective in vitro diagnosis of AD biomarkers.

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Functional Composites and Structures

PAPER

One-pot *in situ* synthesis of eco-friendly cellulose magnetic nanocomposite (Cf-MNCs) for dye adsorption application

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Abstract

Cellulose-based magnetic nanocomposites (Cf-MNCs) have been introduced using a modified one-pot *in situ* co-precipitation method using iron salts with various concentrations in the alkali solution. Fabricated nanocomposites investigated for structural and functional properties with different spectroscopic characterization techniques prior to use in dye degradation study. The scanning electron microscopy revealed the morphological structure of the synthesized nanofibers and nanocomposites. The elemental analysis and vibrating sample magnetometry emphasized the presence of Fe elements attributed to the iron salts. The HRTEM analysis showed a destructed cellulose fiber network indicating its arrangement into nanocomposites. Moreover, the crystal properties of the Cf-MNCs were accomplished using x-ray powder diffraction (79.3% crystallinity). The Fourier transform infrared analysis and differential scanning calorimetry gives the idea about the structural and functional changes in the cellulose fibers loaded with iron oxide nanoparticles. The functional adsorption properties of the prepared nanocomposites have been evaluated using methylene blue and Alizarin red S carcinogenic dyes. The dye adsorption of the fabricated Cf-MNCs nanocomposites was found to be 93%. We affirmed that this novel eco-friendly degradable polymer-based nanocomposite has great potential in the field of catalyst fabrication for the degradation of organic pollutants in wastewater.

1. Introduction

In recent years, nanocellulose has exploited for abundant applications in materials chemistry, nano-biomedicine, drug delivery, and green composite materials. Cellulose-based nanocomposites (CbNCs) combine the distinct features of cellulose with specific nanomaterials incorporated in it with high specific surface area and add-on characteristics. Commonly, cellulose nanofibers (CNFs) and cellulose nanocrystals (CNC) have been used for the fabrication of CbNCs [1]. Nanocellulose can be obtained from native fibers by acid hydrolysis, high pressure homogenization (HPH) or different methods [2, 3]. Amongst all methods, acid hydrolysis results in highly crystalline and rigid nanofibers, ranging in size from 100 nm to 1 μm than that of the HPH route. Recently, the use of cellulose-based magnetic nanocomposites (Cf-MNCs), acclaimed fame in a short duration of time in the catalytic and different allied applications. The length-to-diameter (L/d) is a major factor that controls the mechanical properties of nanocomposites and determines the percolation threshold value called 'geometrical aspect ratio', which further benefits the reinforcing effect [4]. As mentioned earlier, the large surface area, high porosity and biodegradability allowed investigators too many customary modifications in their structures can be availed using cellulose nanofibers (CNF). The use of iron oxide nanoparticles (IONPs) was realized for magnetodielectric properties and ease of separation [5]. To develop the ideal Cf-MNCs, the IONPs should be well dispersed in the fibrils either as an over-attached form or in the lumen. The dispersion of IONPs in the cellulose matrix can be monitored by setting the process parameters, like temperature, pH, solvent properties and other process attributes. The Cf-MNCs can be prepared by *in situ* as well as *ex-situ* methods such as microwave reflux, co-precipitation, hydrothermal treatment, etc. These reinforced Cf-MNCs can be explored for *in vivo* MRI as superparamagnetic or negative

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Functional Composites and Structures

TOPICAL REVIEW

Fundamental aspects of graphene and its biosensing applications

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Keywords: graphene, sensor scale-up aspects, biosensing applications, immunosensing, pathogen sensing

Abstract

The worldwide frontiers of research have experienced a flood of developments in advanced nanomaterials. Among these, graphene, a member of the carbon family, has now replaced many traditional materials and broadened the horizons of material chemistry, analytical chemistry, pharmaceutics, and other multidisciplinary fields. Owing to the exceptional properties of graphene, it has been widely utilized in various nanocomposites as a reinforcing material and for biosensing components. The present review serves as a familiarization for budding researchers in the materials science and analytical fields, where the use of graphene in biosensing-related applications had long been foreseen. Furthermore, we also offer a brief review of graphene's tunable properties for biosensing. This article describes the actual mechanisms of interfaces that interact with graphene, such as immunogenic agents, bacteria, and other biomolecules. We also discuss the application of graphene-based materials to the biosensing of a range of analytes, and the challenges and future perspectives of graphene. Thus, this review gives a detailed insight into biosensing with graphene, graphene's fundamental properties, and application perspectives.

1. Introduction

Over the last couple of decades, graphene-based materials (GBMs) have gained tremendous research interest owing to their excellent physicochemical properties [1]. Interestingly, graphene exists in many forms, and can be customized in numerous ways as per the application requirements [2]. Common to all graphene forms, the lattice-configured nanostructure of graphene, i.e. graphene oxide (GO) has been thoroughly investigated for several biomedical and pharmaceutical applications [3], possibly due to its very tunable properties. Because of this, it offers several benefits for the fabrication of biosensing elements or parts thereof [4]. The fascinating characteristics of graphene or GO including a large specific area, abundant surface functional groups viz. carboxyl, epoxy, etc, offer a choice of materials for the immobilization of various important biomolecules (e.g. enzymes). Moreover, the high chemical stability and remarkable optical properties of GO are suitable for electrochemical (ECL) biosensing [5]. Moreover, its electrical properties, high conductivity, and superb electron mobility help in the fabrication of thin films and plasmonic biosensors for the detection of various biomolecules. From 2010 onwards, several research groups have been engaged in the design, fabrication, and analysis of various types of biosensors based on graphene platforms for heavy metal detection [6, 7], ferric ion detection, DNA detection [8], antibody detection [9, 10] as well as many biological metabolite detections [11], etc.

Graphene has an electrical conductivity of the order of 1000 mho m^{-1} and thermal conductivities of between 1500 and 2500 W m^{-1} K^{-1}. It is the strongest material ever tested, with a tensile strength of around 130 GPa [12, 13]. Graphene exhibits a broad ECL window of approximately 2.5 V in a 0.1 mol l^{-1} when tested in phosphate-buffered saline. It offers a low charge-transfer resistance of around 6.5 MΩ cm^2. These properties prove that graphene is an ideal material for use in multifunctional fast sensors.

Since graphene was discovered, it has started to emerge and be developed in many scientific studies. Despite these advances, the fundamental science behind graphene is, unfortunately, not completely explained. More work is needed on this problem in areas such as graphene surface absorption mechanisms, biomolecular orientations, and the way in which these interactions affect graphene's transport properties, etc

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Future Journal of Pharmaceutical Sciences

REVIEW Open Access

Pharmaceutical applications of citric acid

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Abstract

Background: Citric acid (CA) is a universal plant and animal-metabolism intermediate. It is a commodity chemical processed and widely used around the world as an excellent pharmaceutical excipient. Notably, CA is offering assorted significant properties viz. biodegradability, biocompatibility, hydrophilicity, safety, etc. Therefore, CA is broadly employed in many sectors including foodstuffs, beverages, pharmaceuticals, nutraceuticals, and cosmetics as a flavoring agent, sequestering agent, buffering agent, etc. From the beginning, CA is a regular ingredient for cosmetic pH-adjustment and as a metallic ion chelator in antioxidant systems. In addition, it is used to improve the taste of pharmaceuticals such as syrups, solutions, elixirs, etc. Furthermore, free CA is also employed as an acidulant in mild astringent preparations.

Main text: In essence, it is estimated that the functionality present in CA provides excellent assets in pharmaceutical applications such as cross-linking, release-modifying capacity, interaction with molecules, capping and coating agent, branched polymer nanoconjugates, gas generating agent, etc. Mainly, the center of attention of the review is to deliver an impression of the CA-based pharmaceutical applications.

Conclusion: In conclusion, CA is reconnoitered for multiple novels pharmaceutical and biomedical/applications including as a green crosslinker, release modifier, monomer/branched polymer, capping and coating agent, novel disintegrant, absorption enhancer, etc. In the future, CA can be utilized as an excellent substitute for pharmaceutical and biomedical applications.

Keywords: Citric acid, Pharmaceutical applications, green crosslinkers, Fluorescent materials, Absorption enhancer

Background

Citric acid (CA, 2-hydroxy2, 3-propanetricarboxylic acid, tricarboxylic acid) is the largest organic acid contained in the tonnage. Generally, it is a universal plant-and animal-metabolism intermediate. CA is a commodity chemical processed and widely used around the world for plentiful pharmaceutical applications (Fig. 1) [1]. To begin with 1784, Carl Scheele (a Swedish chemist) isolated the CA (Molecular Weight: 210.14 Da) from the lemon juice. Whereas in1893, at the first time Wehmer demonstrated the culture medium includes sugars and inorganic salts, *Penicillium glaucum* (*Citromyces*) accumulating CA. Amusingly, CA was first commercially manufactured in England from the imported Italian lemons. In 1917, Currie discovered that some of the *Aspergillus niger* strain generated CA into adequate nutrient mediums that contain high levels of sugar plus mineral salts and along with that preliminary medium pH (2.5–3.5). Despite these notable findings, lemon juice was still a commercial source for the manufacturing of CA until 1919. This provided the foundation for industrial CA production with *Aspergillus niger* [2]. As per literature, CA has been unrevealed by Krebs in the late 1930s as a key ingredient in the metabolism of all aerobe species [3, 4]. The developmental stages of the discovery and manufacture of CA from 1784 to 2020 [4] are represented in Fig. 2.

From its inception, plenty of literature reported that CA is a major component in the processing of several products, mainly as an acidulant in the food, chemical, and pharmaceutical industries. Natural resources, such as fruit sugar, become more and more essential for CA

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ORIGINAL ARTICLE

Eco-friendly synthesis of surface grafted Carbon nanotubes from sugarcane cubes for the development of prolonged release drug delivery platform

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Abstract

Surface grafting of nanocarriers could modulate their properties and characteristics. As carbon nanotubes synthesis is a very tricky process and requires high-end methods, hence the present investigation was aimed to develop an eco-friendly method for synthesis carbon nanotubes (CNTs) and subsequent surface grafting for enhanced drug delivery application. The present study elaborates two-step chemical modifications; wherein the first step is catalytic cleavage of natural precursor in the presence of ferrocene and the second step involve chemical grafting of Acyclovir (ACV) as a model drug to understand the drug release behaviour. The catalytic cleavage of sugarcane cubes (natural precursor) was carried out in a closed copper tube, which prevents oxidation and results in a conversion of tubular nanostructures to amorphous carbon. The covalent attachment of ACV on purified CNTs (fCNTs) was done using carbodiimide chemistry. The preliminary Uv-Vis absorbance spectra defined at 260 nm was arised due to π-π^* stacking of aromatic C-C bonds. The Fourier Transforms Infrared Spectroscopy (FTIR) indicates the hydroxyl stretch at 3300 cm-1 while amide I bond formation was observed at 1672 cm^{-1}. The XRD spectra confirmed successful synthesis of CNTs. The calculated average crystallite size (Scherer equation) of synthesized CNTs was found to be 42.84 and 44.45 nm; it was also in accordance with the morphological observation as confirmed simultaneously using SEM analysis. The covalently attached ACV was released up to 80% during 8h of *in vitro* drug release study. The surface grafting potential of CNTs was found to be promising compared to other nanomaterials.

Keywords: *Acyclovir; Amorphous Carbon; Carbodiimide Chemistry; Natural Precursor; Purification.*

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INTRODUCTION

Even though the investigation on allotropic forms of carbon was begun before 1990, but the most intuitive form of carbon allotrope i.e. carbon nanotubes (CNTs) were reported in 1991[1]. Numerous classical approaches for the synthesis of CNTs are reported by academic researchers and industry experts for their promising physicochemical properties. In case of CNTs, the

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Nano Biomed Eng
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Research Article

Fabrication of N-Doped Graphene@TiO_2 Nanocomposites for Its Adsorption and Absorbing Performance with Facile Recycling

Pravin Onkar Patil[1], Sopan Namdev Nangare[1], Pratiksha Pramod Patil[1], Ashwini Ghanashyam Patil[2], Dilip Ramsing Patil[2], Rahul Shankar Tade[1], Arun Madhukar Patil[2], Prashant Krishnarao Deshmukh[3], Sanjay Baburao Bari[1]

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Abstract

The present work aims to synthesize nitrogen-doped reduced graphene oxide-titanium dioxide nanocomposite (N-rGO@TiO_2) using a simple, eco-friendly method and its applications in spectroscopic detection of heavy metal ions such as lead (Pb^{2+}), mercury (Hg^{2+}), and chromium-VI [Cr(VI)] in potable water. Initially, TiO_2 nanoparticles loaded N doped rGO sheets were fabricated by an ecological method using *Gossypium hirsutum* (cotton) seeds extract as a green reducing agent. Then, the N-rGO@TiO_2 nanocomposites were subjected for characterizations such as spectroscopic techniques, particle size analysis, zeta potential analysis, and spectroscopic sensing. Notably, the results of this study confirmed that N-rGO@TiO_2 exhibited countless stupendous features in terms of sensing of an analyte. Briefly, the UV-visible spectroscopy and Fourier transform infrared (FTIR) spectroscopy confirmed the successful synthesis of N-rGO@TiO_2. The SEM images showed the wrinkled, folded, and cross-linked network structures that confirmed the surface modification and nitrogen doping in the rGO sheet and synthesis of N-rGO@TiO_2. The EDAX study confirmed the elemental composition of the N-rGO@TiO_2 nanocomposite. Finally, due to the larger surface area, porous nature, high electron mobility, etc. the N-rGO@TiO_2 probe provides the lower detection limit for Pb^{2+}, Hg^{2+}, and Cr (VI) as low as 50 nM, 15 µM, and 25 nM, respectively. Concisely, our study affirms the admirable sensitivity of N-rGO@TiO_2 nanocomposite to the Pb^{2+}, Hg^{2+}, and Cr (VI) in potable water can provide better environmental remediation.

Keywords: Graphene oxide, N-rGO@TiO_2, Nanocomposite, Cotton-seed, Heavy metals, Biodegradable, Sensing

Introduction

Over the past two decades, graphene-based materials are gaining tremendous attention from a scientific fraternity in various fields [1-3]. It may because of its astonishing properties and potential to revolutionize the scientific sector [3-5]. Graphene can be used to fabricate several dimension materials such as 1D nanostructure [6], 2D layer stacked films [7], 3D graphene hydrogel [7-9], and aerogel [10-13], etc. Out

CRITICAL REVIEWS IN ANALYTICAL CHEMISTRY
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Black Phosphorus Nanostructure Based Highly Sensitive and Selective Surface Plasmon Resonance Sensor for Biological and Chemical Sensing: A Review

Sopan Nangare and Pravin Patil

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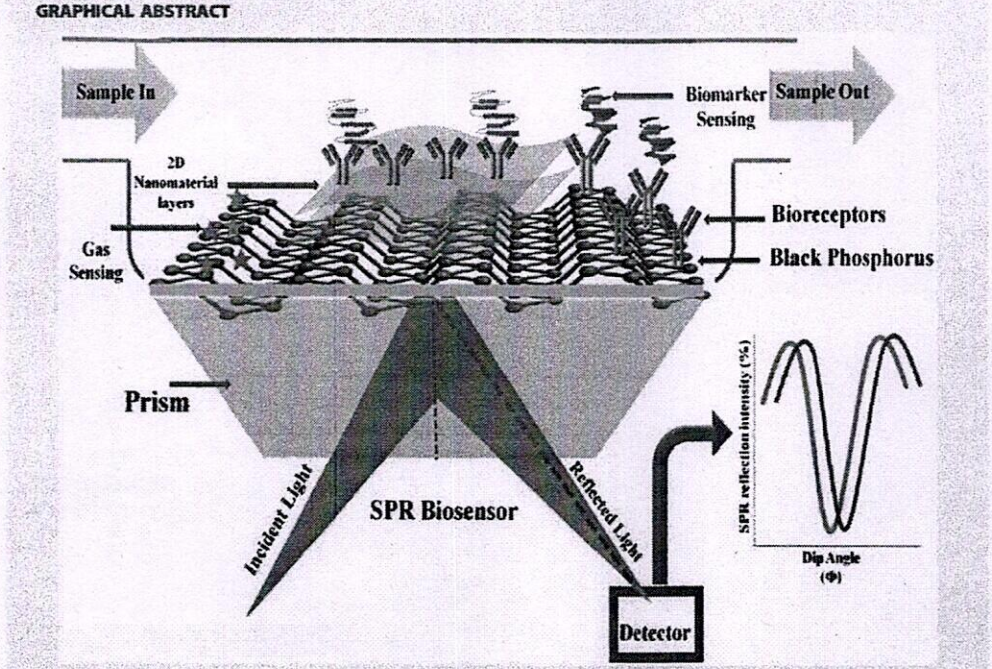
ABSTRACT

Surface plasmon resonance (SPR) is an attention-grabbing sensor type, which offers the sensitive and selective detection of biomolecules and environmentally toxic substances. Notably, the SPR sensor gives excellent rewards including real-time, *in-situ*, and label-free measuring capability as compared to existing sensing technologies. As a result, these noteworthy merits of the SPR sensor make it straightforward to investigate the molecular events and chemical/gas molecule interaction. Unfortunately, there are different binding events including smaller molecular mass substances, which cannot be detected at the SPR sensor. Accordingly, this downside of the SPR sensor eventually led to the design and implementation of new approaches for sensitivity and selectivity improvement for sensing applications in different fields. Recently, the black phosphorus (BP) derived 2D nanomaterial is stand out as a distinctive nanostructure in comparison to recently reported other 2D nanomaterials. Substantial and functional characteristics of BP including simplicity of operation, optical properties, high carrier mobility, stronger immobilization of receptors and biomolecules, electronic bridging playing important role in the highly selective and sensitive assessment of analyte. The designed BP nanostructures are mostly serving to accelerate the plasmon material signals followed by improved molecular sensing that may due to 40-times faster-sensing responses of BP nanostructure than reported 2D nanomaterials. Therefore, the present review article sheds light on the latest significant advances in biological and toxic gas detection through 2D BP nanostructures based SPR sensors. In the future, this review will facilitate detailed insights into the development of BP-based groundbreaking frameworks for highly sensitive and selective recognition of biomolecules and environmental pollutants.

KEYWORDS

Black phosphorus; biosensing; in-vitro diagnosis; sensitivity enhancement; surface plasmon resonance

GRAPHICAL ABSTRACT



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Research Publications 2019-20

Sr.	Title of the Publication	Author/s	Name of the Journal
1	Development and Characterization of Sublingual Film Containing Ropinirole Hydrochloride	PB Patil, DA Patil, LR Zawar, B Patil, GB Patil	Indian Drugs
2	Fabrication and characterization of colon specific eudragit coated graphene oxide microsphere for sustained delivery of tramadol hydrochloride	**MP More, GB Patil, SD Thakare,** PO Patil, AG Patil, PK Deshmukh	Polymer-Plastics Technology and Materials
3	Synthesis and Characterization of Thiolated Gum Kondagogu and Evaluation as Mucoadhesive Polymer	**AA Patil, KB Patil,** LR Zawar	Indian Drugs
4	Fabrication of efavirenz loaded nano-formulation using quality by design (QbD) based approach: Exploring characterization and in vivo safety	**VC Gurumukhi,** SB Bari	Journal of Drug Delivery Science and Technology
5	Heterogeneous Surface Architectured Metal Organic Frameworks for Cancer Therapy, Imaging and Biosensing: A State of Art Review	**A Pandey,** N Dhas, P Deshmukh, C Caro, P Patil, ML García Martin, B Padya, **A Nikam**, T Mehta, S Mutalik	Coordination Chemistry Reviews
6	Agro-Industrial waste-mediated green synthesis of silver nanoparticles and evaluation of its antibacterial activity	**RS Tade, SN Nangare,** PO Patil	Nano Biomedicine and Engineering
7	Development of amine functionalized super paramagnetic iron oxide nanoparticles anchored rchitec nanosheets as a possible theranostic agent in cancer metastasis	**MP More,** PK Deshmukh	Drug Delivery and Translational Research
8	Robust Analytical Method for Iron Estimation by Experimental Design Approach	**MR Mahajan,** DD Patil	Indian Journal of Pharmaceutical Education and Research
9	Recent Advancements in Bioprecursor	**RS Tade, SN**	Nanotechnology

OFFICE SEAL

	derived graphene quantum dots: Synthesis, Characterization and Toxicological Perspective	**Nangare,** AG Patil, A Pandey, PK Deshmukh, DR Patil, TN Agrawal, S Mutalik, AM Patil, MP More, SB Bari, PO Patil	
10	Perspectives of characterization and bioconjugation of gold nanoparticles and their application in lateral flow immunosensing	VB Borse, AN Konwar, RD Jayant, PO Patil	Drug Delivery and Translational Research
11	A comprehensive review on carbon dots and graphene quantum dots based fluorescent sensor for biothiols	**ZG Khan**, PO Patil	Microchemical Journal

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DEVELOPMENT AND CHARACTERIZATION OF SUBLINGUAL FILM CONTAINING ROPINIROLE HYDROCHLORIDE

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ABSTRACT

In the present work films of ropinirole hydrochloride were prepared by using polymers such as hydroxy propyl methyl cellulose (HPMC E-15) and polyethylene glycol (PEG-400) as plasticizers, by a solvent casting method, for treatment of Parkinson's disease. HPMC E-15 was used as film forming agent in the range of concentration 50 mg – 600 mg and PEG-400 was used as plasticizer in the range of concentration 0.3-1.0 mL for solvent casting method. The optimized concentration of film forming agent was 400 mg and plasticizer concentration was 0.7mL. By using optimized concentration, Ropinirole Hydrochloride mouth dissolving films (MDFs) were prepared by additionof other excipients. The formulated MDFs were evaluated for different physical characteristics like uniformity of weight, thickness, folding endurance, drug content uniformity, percentage elongation, and tensile strength, disintegration, *in vitro* drug release studies and provided agreeable results. The FTIR and DSC studies confirmed that no physicochemical interaction in between drug and excipients accured. Mouth dissolving film of Ropinirole Hydrochloride containing HPMC E-15 as polymer showed 97.66 % drug release at 30 min. Mouth dissolving films of ropinirole hydrochloride containing HPMC E-15 showed better tensile strength (70.56 ± 0.9 g/mm2), percentage elongation (33.33 ± 2.88 %), folding endurance (168± 2.081 numbers of folds), *in vitro* disintegration time (35± 3.511 sec.) and thickness (0.4± 0.17 mm).

Keywords: Ropinirole hydrochloride, Parkinson's disease, solvent casting method, tensile strength, mouth dissolving film

INTRODUCTION

Since time immemorial, oral drug administration is one of the most suitable and commonly accepted routes of delivery for most therapeutic agents. Conventionally, oral formulations refer to tablets, capsules and liquid preparations which are taken orally, swallowed and transit through the gastrointestinal tract (GIT) for post buccal absorption. For the last few years, investigators have been developing intraoral drug delivery systems (IODS) that can produce desirable drug exposure for optimum therapeutic effect. The intraoral formulations include fast dissolving dosage forms (tablets, films, wafers), sublingual tablets, buccal/ gingival patches, microparticles, Periodontal fibres, solutions and sprays, chewing gums, dry powders, topical gels, topical pastes, bioadhesive tablets, topical ointments, local injections, dissolvable lozenge etc and more[1].

New developments of orally fast dissolving dosage form such as the fast dissolving tablet or fast dissolving films have advantages of ease of dosing and convenience of dosing in the absence of any fluid and water. Most of the existing fast-dissolving drug delivery systems are in the form of tablets and designed to dissolve or disintegrate in to the mouth within a few seconds or minutes, without any need to swallow or chew. The films overcome the risk of choking and the development of a fast dissolving film also brings an opportunity for a line extension into the market place; an extensive range of drugs (e.g., neuroleptics, cardiovascular drugs, antiasthmatic, analgesics, antihistamines, and drugs for erectile dysfunction have been developed)[2].

Recently, mouth dissolving film (MDF) is one of the most extensively used marketable product because of its quick onset of action, fast dissolution, and fast disintegration in a few seconds'. Therefore Mouth dissolving film is also widely used as local anesthetics for toothaches, headache, body pain, migraine, hypertension, oral ulcers, cold sores and treatment of psychological

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Fabrication and characterization of colon specific eudragit coated graphene oxide microsphere for sustained delivery of tramadol hydrochloride

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ABSTRACT

Present investigation reports a straight forward method for synthesis of graphene oxide (GO) followed by fabrication of graphene oxide microsphere (GMS) using water in oil (w/o) emulsification technique. For colon specific drug delivery, enteric coating is desirable, which was done using Eudragit S100 and characterized by Fourier transform Infrared Spectroscopy (FTIR). The surface morphology of fabricated microsphere was confirmed using scanning electron microscopy (SEM). Drug loaded microspheres demonstrated a high payload capacity for model drug tramadol hydrochloride (TmH). The comparative *In-vitro* drug release showed around 72.37% release from uncoated microspheres, whereas eudragit coated microspheres retarded the drug release upto 10 h.

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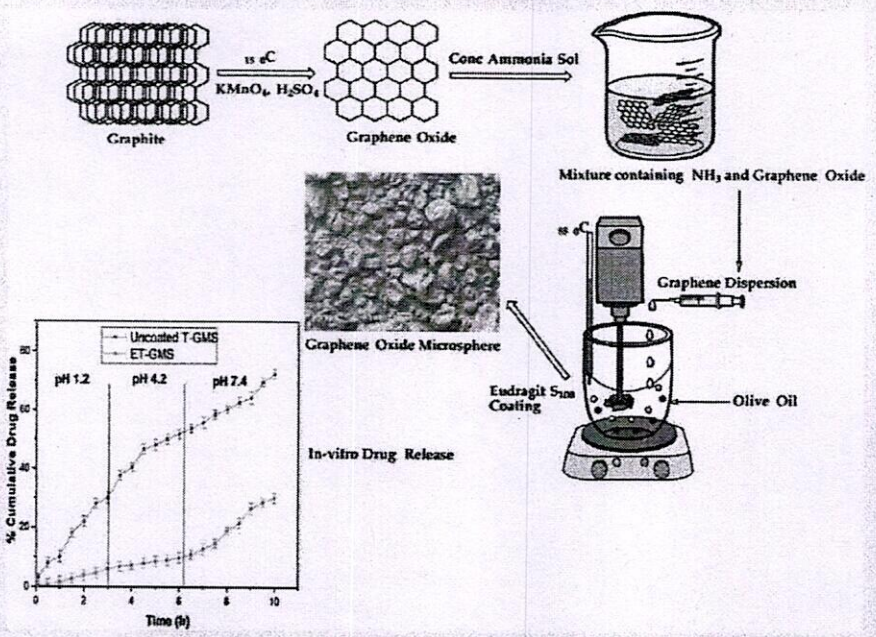
KEYWORDS
Graphene oxide; microsphere fabrication; colon targeted drug delivery system; irritable bowel disease



1. Introduction

An inflammatory Bowel disease (IBD) intensifies in many traumatic conditions such as ulcerative colitis, Crohn's disease, amebiosis, colonic cancer, etc. Specifically, IBD is most common functional disorder in colon region.[1] Due to many transportation barriers such as acid reach environment in stomach, differential pH condition and larger micro flora in small intestine, therapeutic agent is unable to reach at the colon site.[2] It seems to be very difficult for

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/lpte.

SYNTHESIS AND CHARACTERIZATION OF THIOLATED GUM KONDAGOGU AND EVALUATION AS MUCOADHESIVE POLYMER

Patil Ashwin A.[a], Patil Ketan B.[a] and Zawar Laxmikant R.[a]*

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ABSTRACT

Present work focused on thiolation for enhancing the mucoadhesive potential of Gum kondagogu (GK). Thiolation of GK was done by esterification process with 80 % thioglycolic acid in presence of 7N HCl. Thiolated Gum kondagogu (ThioGK) was determined to possess 1.59 ±0.04 mmol of thiol groups/g of the polymer by Ellman's method. ThioGK was characterized by FTIR, NMR, DSC, XRD, and FE-SEM. The tablets were prepared by direct compression using 75 mg of ThioGK and GK. Tablets containing ThioGK (F1) and GK (F2) were subjected to evaluation of weight variation, hardness and friability and show enhanced disintegration time, swelling behavior, drug release and mucoadhesion. *In vitro* drug release of batch F1 exhibits complete release of drug in 24 hr with zero order release kinetics. Comparative mucoadhesive strength was studied using chicken ileum by texture analyzer and revealed higher mucoadhesion of tablet containing ThioGK. From the above study, ThioGK was suitability exploited as mucoadhesive sustained release matrix tablet.

Keywords: Thiolated gum kondagogu, Mucoadhesive study, Diclofenac sodium, Ellman's method.

INTRODUCTION

Tree gums are natural polymers and are, in recent times receiving consideration as biopolymers since they are non-toxic, inexpensive, simply obtainable, readily improved, environmentally friendly and biocompatible[1]. In the food and pharmaceutical industry, these natural polymers have a number of applications[2]. Gum kondagogu (GK) is an important forest produce of Andhra Pradesh, India, which is collected by tribals by tapping from the tree of *Cochlospermum gossypium* DC (Family: Bixaceae). GK is belonging to substituted rhamnogalacturonans class, which is an anionic polysaccharide. It includes rhamnose, galacturonic acid, glucuronic acid, β-d-galactopyranose, α-d-glucose, β-d-glucose, galactose, arabinose, mannose and fructose with sugar linkage of (1→2) β-d-Gal p, (1→6) β-d-Gal p, (1→4) β-d-Glc p, 4-O-Me-α-d-Glc p, (1→2) α-l-Rha[3]. It absorbs a large quantity of water by developing thixotropic gels and in the course of previous studies, for it has been discovered as sustained release matrix tablets[4], as emulsifying agent[5], as a completely green synthesis of noble metal nanoparticles[6], for the green synthesis of silver nanoparticles with antibacterial application[7], for the mucoadhesive microcapsule preparation in combination with sodium alginate[8], Modification of release behavior of gum kondagogu has been executed by carboxylation on gum kondagogu polymeric backbone[9]. GK has been used with other polymers in combination, such as gum olibanum and guar gum as a mucoadhesive polymer since it alone cannot promise residence of a drug delivery system (DDs) at the desired site[10]. Till date, several drug delivery systems have been designed using mucoadhesive polymers.

The adhesive property of these natural polymers is the cause of their capability to form noncovalent bonds such as van der Waal's interaction, hydrogen bond and ionic interaction. But, because of such weak interaction, DDs cannot remain at a target site for an extensive period of time[2,11]. This demands the exploration of novel mucoadhesive polymers. Thiolated polymers have been show to form a class of novel mucoadhesive polymers. Various natural polymers such as karaya gum[2], chitosan[12-14], pectin[15], xyloglucan[16], tamarind seed polysaccharide[1], hyaluronic acid[17] and xanthan gum[18] have been improved by thiol immobilization on polymer to increase their mucoadhesive properties.

In the current study, the chemical modification of gum kondagogu has been carried out by thiolation. The characterization of thiolated gum kondagogu was carried

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Fabrication of efavirenz loaded nano-formulation using quality by design (QbD) based approach: Exploring characterizations and *in vivo* safety

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ABSTRACT

Quality by design (QbD) approach was practically applied in fabrication of nanostructured lipid carrier (NLC) encapsulating efavirenz (EF) to ensure the quality in product. Initially, risk factors were categorized based on risk priority number (RPN) using risk identification and assessment tools. A central composite rotatable design (CCRD) was employed to assess the influence of critical process parameter (CPP) (pressure of high pressure homogenizer) and critical material attributes (CMAs) (combination of solid lipid and oil; combination of stabilizers) on responses such as particle size, dispersity and entrapment efficiency. ANOVA was applied to evaluate the data for confirmation of statistical significance ($p < 0.05$). The optimum formulation was decided by setting criteria of responses to achieve desired quality product. This formulation was subsequently lyophilized to evaluate solid state characterization. TEM shows spherical particle shape of NLC. The transformation in amorphous state of NLC from crystalline EF was observed by DSC and PXRD. Lack of molecular interactions and intermolecular hydrogen bonding with lipidic atmosphere revealed by FTIR and ^{1}HNMR respectively. *In vitro* drug release 91.21% was obtained at the end of 24 h with Higuchi-matrix mechanism. *In vivo* pharmacokinetic studies improved relative bioavailability 2.95 fold with lower liver toxicity of EF encapsulated in NLC. In conclusion, QbD based approach clearly proved its usefulness to build quality in product resulting high drug encapsulated potential nanocarrier to enhance bioavailability and confirms safety of EF-NLC with promising acceptable criteria.

1. Introduction

Efavirenz (EF) is a leading drug molecule in the regimen of highly active antiretroviral therapy (HAART) for the treatment of human immunodeficiency virus (HIV). Orally active EF was official by FDA in 1998, belongs to the class of non-nucleoside reverse transcriptase inhibitors (NNRTIs) mostly prescribed to treat HIV-1 infection [1,2]. However, its pharmacokinetic is unpredictable when taken orally. This could be due to poor aqueous solubility, low gastro-intestinal (GI) absorption and rapid first-pass metabolism disappointing *in vivo* pharmacokinetic results [3]. Moreover, it is highly lipophilic (Log P = 5.4, intrinsic water solubility = 3–9 μg/mL) drug and categorized in biopharmaceutical classification system (BCS) class II (i.e. poor solubility and high permeability) results in low oral bioavailability of 40–45% [4,5]. The development of hepatotoxicity due to prolong administration is another increasingly important issue limiting the clinical applications [6–8].

Therefore, there is necessitate to develop a strategy which modulates to improve solubility and bioavailability issues of EF. The few works on such issues have been reported. For example, EF loaded nanoemulsion improved bioavailability with dosage adjustable formulation for HIV therapy [9]. Nanosuspension containing EF prepared and characterized β-cyclodextrin (β-CD) based polymeric nanosuspension (PNS) to enhance aqueous solubility and dissolution rate as compared to pure drug [10,11]. The optimized Eudragit E100-Efavirenz loaded polymeric nanoparticles developed to increase in dissolution, drug distribution, and bioavailability, which ultimately implies better control over the therapeutic dosing; and physicochemical evaluation confirmed the formulation stability of nanoparticles [12,13].

SLNs prepared for lymph targeting delivery system to understand chylomicron blocking mechanism approach [14], and NLCs engineered for brain targeted delivery through intranasal route [4]. However, no reports have been addressed on issues of hepatotoxicity which develops on prolong oral administration of EF. Therefore, our prime objective was to develop the EF loaded NLCs to augment biopharmaceutical properties.

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Heterogeneous surface architectured metal-organic frameworks for cancer therapy, imaging, and biosensing: A state-of-the-art review

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ABSTRACT

With recent progress in inorganic material based nanoplatforms for cancer therapy and imaging, multiple nano vehicles have been developed and evaluated. These recent advancements in material science led to the development of metal organic frameworks (MOFs) and nano MOFs (nMOFs) as the potential and versatile delivery platforms for cancer theranostic. With a vast amount of ongoing research on MOFs, various surface architectured MOFs for with variable properties have been developed and tested. The concept of subcellular targeted therapy of cancer has also been employed using MOFs which demonstrated significantly enhanced anticancer therapy. These MOFs have been developed in a way to provide them stimuli-responsive drug release property which can be utilized for externally guided therapy of cancer. Apart from cellular and subcellular targeted platforms and stimuli-responsive platforms, MOFs have also been explored in the field of bioimaging and biosensing. Multiple types of biosensing platforms based on MOFs and nMOFs have been proposed for biosensing of biomolecules related to cancer for sensing and early detection. The bioimaging probes based on MOFs have been employed for multiple diagnostic platforms. The review gives the recent updates for the abovementioned topics along with the toxicity aspects of MOFs for human use. The review overall gives a detailed overview of research done to date in the field of MOFs based nanoplatforms for cancer theranostics.

Contents

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Research Article

Agro-Industrial Waste-Mediated Green Synthesis of Silver Nanoparticles and Evaluation of Its Antibacterial Activity

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Abstract

The development of immaculate etiquette for the green and rapid synthesis of Ag NPs with a natural reducing agent is the spearhead of the expanding field of nanotechnology. Different scientific fraternity with novel natural reducing agents has been contributing numerous strategies daily. Though there is a submerging of many natural reducing agents, still there are plenty of natural precursors remained to be explored. In this research, we fruitfully attempted the synthesis of silver nanoparticles using agro-food industrial waste *Tamarindus* indica shell-husk extract (TSE) as a natural reducing agent. The prepared silver nanoparticles and their stability in different pH were investigated using ultraviolet-visible spectroscopic analysis. Morphological characters were examined using scanning electron microscope (SEM) and transmission electron microscopy (TEM) analysis. The structural and elemental compositions were depicted by Fourier-transform infrared spectroscopy (FTIR) and energy-dispersive X-ray (EDX) analysis, respectively. Moreover, we emphasized on the molecular mechanism involving in the TSE mediated synthesis of Ag NPs. The inherent antimicrobial activity was investigated using agar plate method against both gram-positive and gram-negative species with gentamycin as a control standard for comparison.

Keywords: Green synthesis of Ag NPs; Tamarinds shell-husk extract; Effect of pH; One-pot synthesis; Antimicrobial activity

Introduction

In the recent era, nanobiotechnology has benediction the advantages of the synthesis of nanostructures using living organisms such as plant and microbes. Plant-mediated synthesis of nanoparticles could be advantageous over additional environmentally benevolent biological processes as it eliminates the process involving toxic chemicals and reactants. Biosynthetic processes for nanoparticles would be more expedient if nanoparticles are produced extracellularly using plants or their extracts and in a controlled manner according to their size, dispersity, and shape [1]. Plant-mediated biological synthesis of nanoparticles is gaining significance due to its ease and eco-friendliness. Biosynthetic processes would be more useful if the silver nanoparticles (Ag NPs) were produced using plants or their extracts in a controlled approach according to their dispersity, shape, and size [2]. Although it is a well-known fact

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ORIGINAL ARTICLE

Development of amine-functionalized superparamagnetic iron oxide nanoparticles anchored graphene nanosheets as a possible theranostic agent in cancer metastasis

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Abstract
The major objective of the present investigation was to assess the targeting potential of a designed system for breast cancer at metastatic phases with imaging ability. In a nutshell, we have developed surface-engineered graphene oxide (GO) nanosheets by covalent linking with amine-functionalized iron oxide nanoparticles (IONPs) (GOIOIs). Gefitinib (Gf) was selected as a model drug and entrapped in between exfoliated GO sheets (GOIGF) via π-π* stacking before functionalization with IONPs. Preliminary characterization of GO, IONPs, GOIOI, and GOIGF was performed using UV-visible and Fourier transform infrared spectroscopy. Scanning and transmission electron microscopy studies confirmed successful surface engineering of GO with IONPs. The in vitro drug release study demonstrated sustained release of Gf. The magnetic behavior of IONPs and GOIOI demonstrated a sigmoidal-shaped hysteresis loop with superparamagnetic properties. The in vitro cell cytotoxicity assay was carried out on MDA-MB-231 breast cancer adenocarcinoma cell lines. The cell cytotoxicity assay showed 61.18% inhibition of cell growth with 30 ppm concentration containing 64% of the drug, whereas 100% of the pure drug revealed only 56% of inhibition. In the near future, GOIOI could be tailored further for theranostic research, especially for metastatic cancers.

Keywords Carbodiimide chemistry · Gefitinib · π-π* stacking · MDA-MB-231 breast cancer adenocarcinoma cell lines · Magnetic graphene · Drug delivery

Introduction

Cancer is the most devastating disease in human; one out of six deaths is because of cancer, and the estimated death count may increase up to 13.1 million by 2030. It is the major cause of morbidity and mortality at present. In females, breast cancer is the leading site of cancer followed by cancer of the cervix and uteri [1].

Chemotherapy [2], gene therapy [3], radiotherapy [4], surgery [5], photodynamic [6], photothermal therapy [7], hyperthermia [8], or a combination thereof have been used for the treatment of cancer. Unfortunately, no effective therapy could successfully eradicate cancer to date. Theranostic nanomedicine is the latest approach under investigation, which could systemically provide simultaneous diagnosis and treatment at a specific site of infection. This could avoid interaction with normal cells, and only cancer tumor cells get destroyed using suitable carrier molecules [9]. The survival rate in cancer patients was dismal from 5 to 15% from developing to developed countries, respectively. Mutation of cancer cell specifically in the epidermal growth factor can be characterized to identify 50% of adenocarcinomas [10].

With the emergence of 2D materials, graphene has gained attention for its use in various biomedical applications including cancer. Graphene is an allotrope of carbon in the form of a single layer of atoms in a two-dimensional hexagonal lattice in which one atom forms each vertex [11, 12]. There are numerous methods available for the synthesis of graphene oxide (GO), an oxidized counterpart of graphene such as mechanical

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Original Article

Robust Analytical Method for Iron Estimation by Experimental Design Approach

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ABSTRACT

Aim: To perform Iron estimation by UV-Visible spectroscopy using an Experimental design approach. **Objectives:** The robust analytical method was developed for the estimation of iron (III) using 1, 10-phenanthroline reagent. **Methods:** The analytical method is an exploration of the chemical reaction of iron with 1, 10- phenanthroline reagent to form a colored complex which was measured in the UV-Visible region at 509 nm. To monitor the effect of diverse factors like the concentration of reagent (A), volume of reagent (B), pH (C) and time (D) on the formation of iron 1, 10 – phenanthroline complex the full factorial design (two-level) was used. From the Pareto chart, Normal plot and half normal plot, it was studied that a combination of all factors was initiate to be significant. Then significant variables are optimized by response surface methodology (RSM) via Box-Behnken design. The evaluation of design was performed to study the effect on the selected response by quadratic effects and main interaction effects. The contour plot and surface plot used for the determined response of the selected factors for their optimum value. **Results:** The prime reaction state, Beer's law were obeyed in 2.0-10.0 μg/ml concentration range with a correlation coefficient of 0.998. **Conclusion:** The method was successfully applied for the estimation of iron in iron sucrose injection. The optimized method was used for the quantitative analysis of iron sucrose injection.

Key words: Iron sucrose, 1, 10- Pheanthroline, Full factorial design, Box-Behnken design.

INTRODUCTION

Iron is necessary for oxidative metabolism, wound healing, reproduction, cellular growth, execution of several metabolic processes.[1] Iron is employed in the production of oxygen-carrying hemoglobin, myoglobin and proteins which are required for the basic metabolic process in the cell.[2] Iron deficiency anemia are the most frequent forms of nutritional deficiency generally, anemia is distinct as decrease of hemoglobin value.[3] It possesses severe health complications as it causes general weakness, laziness, tiredness, sub-optimal work performance and in certain circumstances psychological obstruction, reduced aptitude and atypical immune response.[4] Optimization states to improving the routine of a method, a practice, or produce to get the highest output from it. The term optimization has been generally used in analytical chemistry as a means of determining situations at which to apply a process that creates the best probable response.[5]

The experimental design is a statistical technique utilized for planning, analyzing and statistical data obtained from primary investigational trials. The experimental design gives exhaustive information from the lowest numeral of trials. Identification of interacting variables characterized the effect of critical factors, evaluation of the effect of preparation and system factors on critical quality attributes.[6]

The conventional optimization approach, varying one variable/factor at a time (OVAT, also called OFAT).[7] One factor at a time (OFAT) does not include interactive outcomes between the variables deliberate as a consequence. OFAT does not include the comprehensive effects of a factor on

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Topical Review

Recent advancements in bioprecursor derived graphene quantum dots: synthesis, characterization and toxicological perspectives

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Abstract

Graphene quantum dots (GQDs), impressive materials with enormous future potential, are reviewed from their inception, including different precursors. Considering the increasing burden of industrial and ecological bio-waste, there is an urgency to develop techniques which will convert biowaste into active moieties of interest. Amongst the various materials explored, we selectively highlight the use of potential carbon containing bioprecursors (e.g. plant-based, amino acids, carbohydrates), and industrial waste and its conversion into GQDs with negligible use of chemicals. This review focuses on the effects of different processing parameters that affect the properties of GQDs, including the surface functionalization, paradigmatic characterization, toxicity and biocompatibility issues of bioprecursor derived GQDs. This review also examines current challenges and the ongoing exploration of potential bioprecursors for ecofriendly GQD synthesis for future applications. This review sheds further light on the electronic and optical properties of GQDs along with the effects of doping on the same. This review may aid in future design approaches and applications of GQDs in the biomedical and materials design fields.

Keywords: bioprecursor, quenching, GQDs, graphene, functionalization of GQDs, hetero-atom doping, fluorescent material

(Some figures may appear in colour only in the online journal)

1. Introduction

With recent advancements in materials sciences and advanced materials, research on the cost of the effective synthesis of materials has gained a lot of attention. Graphene is one of the most celebrated and fascinating 'wonder materials' and is investigated by many branches of science. The graphene family includes graphene, graphene oxide (GO), reduced graphene oxide (rGO) and graphene quantum dots (GQDs). Graphene-based nanomaterials generally exist as

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Central composite design-based optimization of lopinavir vitamin E-TPGS micelle: *In vitro* characterization and *in vivo* pharmacokinetic study

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ABSTRACT

This study was aimed at formulating Lopinavir loaded Vitamin E-TPGS micelles to enhance its oral bioavailability. Lopinavir is an HIV-1 protease inhibitor with low aqueous solubility leading to poor oral bioavailability and thus frequent dosing. Drug loaded micelles were fabricated using thin film hydration technique and optimized by two-factor five-level central composite design. For this purpose independent variables selected were TPGS to drug ratio and rotational speed of rotary evaporator, whereas dependent variables chosen were particle size and % entrapment efficiency. The effect of an independent variable on the dependent variable was studied by generating a quadratic polynomial model. Results of *in vitro* characterization showed that prepared lopinavir micelles exhibited particle size 91.71 nm, polydispersity index 0.129, zeta potential −24.8 mV, entrapment efficiency 99.36 ± 1.06% and drug loading 20.83 ± 1.23%. Results of DSC and P-XRD evaluation revealed that drugs were successfully encapsulated inside the Vitamin E-TPGS micelles. *In vitro* release studies displayed enhancement in drug dissolution as a result of its loading into micelles. TEM images showed that micelles were spherical. On oral administration of lopinavir micelles; the relative bioavailability was boosted by 3.17 folds compared to lopinavir suspensions. Thus, we can conclude that TPGS based micelles possess the prodigious potential to overcome the challenges of current HAART therapy.

1. Introduction

Based on statistics given by the Joint United Nations Programme on HIV and AIDS of the year 2018, nearly 3.79 crores individuals globally are surviving with HIV/AIDS. Out of these 18 lakhs were children of less than 15 years of age. With a rate of 5000 new infections per day about 17 lakhs people universally newly developed HIV infection [1]. Human immunodeficiency virus also abbreviated and commonly known as HIV is a lentivirus. It causes HIV infection which ultimately causes AIDS (Acquired Immunodeficiency Syndrome). AIDS is a condition where the human immune system progressively fails allowing life-threatening opportunistic infections and cancers to conquer the body. It is estimated that normal lifetime post-HIV infection is 9–11 years, based on the HIV subtype [2]. Therefore, an HIV patient needs constant antiretroviral therapy throughout life. This regimen of anti-HIV medication is commonly known as HAART (Highly Active Anti-Retroviral Therapy), which includes a combination of three or more different antiretroviral drugs. Although a complete cure for HIV does not exist, this treatment slows the progression of the virus in the body by reducing the viral titer in body fluids [3]. Thereby conserving the immune system strength and averting opportunistic infections that may cause death [4].

Lopinavir (LPV) is chemically designated as (2S)-N-[(1S,3S,4S)-1-benzyl-4-([(2,6-dimethyl phenoxy)acetyl]amino)-3-hydroxy-5-phenylpentyl]-3-methyl-2-(2-oxotetrahydropyrimidin1 (2H)-yl) butanamide. It is an integral part of the HAART program. But LPV suffers a major drawback *i.e.*, poor bioavailability due to its poor water solubility and cytochrome P450 as well as P-glycoprotein efflux mediated hepatic first-pass metabolism [5].Thus it is used in combination with ritonavir with the trade names Kaletra® and Aluvia®. Therefore there is a need to develop antiretroviral drug formulation with enhanced bioavailability to improve HAART therapy. Lopinavir and ritonavir both are antiretroviral drugs that are used in combination. Ritonavir is just used as a booster dose for other protease inhibitors and does not have significant antiretroviral activity against HIV and hence it is not prescribed for treatment now a day. It just helps to enhance the bioavailability of Lopinavir. Since after loading into nanocarrier bioavailability of Lopinavir will get enhanced significantly therefore there is no need to use

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Review Article

A comprehensive review on carbon dots and graphene quantum dots based fluorescent sensor for biothiols

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ABSTRACT

Fluorescent carbon-based nanomaterials such as carbon dots (CDs) and graphene quantum dots (GQDs) owing to their high aqueous solubility, stable photoluminescence and good biocompatibility are showing greater interest in sensing of biothiols. Biothiols mainly glutathione (GSH), cysteine (Cys), homocysteine (Hcys), considered to be an important tool in the clinical diagnosis of many disorders and diseases. Therefore, the development of new probes has fascinated considerable attention since they are simple, sensitive, rapid and cost effective. Although conventional sensors have been designed and widely applied in biothiols determination, but unfortunately they present many limitations and challenges. In this review, we provide a focused outline on the most recent developments concerning fluorescent based CDs and GQDs nanosensor for detection of biothiols. The most important reaction mechanisms and strategies for detection of biothiols were outlined and compared in terms of their sensitivity and selectivity against different biothiol species and other interfering substances viz. metal ions, amino acids, etc. Future research and challenges in designing of functionalized CDs and GQDs are discussed and elucidated.

1. Introduction

Nanomaterials are the candidates responsible for making breakthroughs in nanotechnology. Over the last two decades, a variety of nanomaterials have been found and evolved as, CDs and GQDs. Quantum effects provide unique features to these nanomaterials when the size of a material reduces to the nanometer range, which failed to predict at macroscopic or microscopic level. As a result, these nanomaterials enhanced the capabilities of researcher to focus on sensing of a variety of materials which could not have been possible with other conventional materials [1]. Nanoparticles are always attributed with the novel properties irrespective of origin [2]. Evolution of the unique physical, chemical and electronic properties at the nanoscale forms the essence of the various applications of nanotechnology [3].

The interplay between the nanomaterials and biological systems for human health concern is of special significance, especially for the CDs and GQDs which have diverse imaging and sensing applications. Biomedical research has become extremely important from past two decades due to human health concern. Biosensing includes qualitative/quantitative recognition of a specific type of analytes by characterizing spectroscopic, electrochemical and photoluminescence behavior of the systems. Most prominently, various biomolecules viz. proteins, nucleic acids, enzymes and chemical analytes e.g., organic metals, inorganic metals and sugars that help in monitoring the biochemical processes can be detected.

1.1. Fluorescent nanomaterials

Fluorescent nanomaterials *viz.* CDs, metallic nanoclusters, silicon, metallic nanocomposites, and GQDs immensely revolutionized the field of biosensing and bioimaging [4], however promising CDs [5] and GQDs [6] are attracting increasing attention owing to their high aqueous solubility, low cytotoxicity, stable photoluminescence and better biocompatibility.

1.2. Graphene quantum dots (GQDs)

In recent years, GQDs have gained considerable interest in biosensing and cell imaging applications with other potential applications in diverse areas of the medical and pharmaceutical field [7] owing to their distinctive and remarkable quantum confined electronic state and unique edge structure effect, physicochemical properties [8], fascinating optical properties, high photostability, non-toxicity, biocompatibility and nanometer lateral size [9]. GQDs exhibit excellent photoluminescence properties that can be influenced by structural defect and surface functionality such as heteroatom doping [10].

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Research Publications 2018-19

Sr.	Title of the Publication	Author/s	Name of the Journal
1	Preparation, characterization and in vivo assessment of repaglinide nanosuspension for oral bioavailability improvement	LR Zawar, SB Bari	Recent Patents on Drug Delivery and Formulation
2	Physicochemical characterization and anti-inflammatory activity of ayurvedic herbo-metallic Tamra bhasma in acute and chronic models of inflammation	PS Bafna, SD Patil	Materials Technology
3	Controlled synthesis of blue luminescent graphene quantum dots from carbonized citric acid: assessment of methodology, stability, and fluorescence in an aqueous environment	**MP More, PH Lohar**, AG Patil, PO Patil, PK Deshmukh	Materials Chemistry and Physics
4	Fabrication and in-vitro drug release characteristics of magnetic nanocellulose fiber composites for efficient delivery of Nystatin	**RS Tade, MP More**, VK Chatap, PO Patil, PK Deshmukh	Materials Research Express
5	Development of graphene-drug nanoparticle based supramolecular self assembled pH sensitive hydrogel as potential carrier for targeting MDR tuberculosis	**MP More, RV Chitalkar, MS Bhadane, SD Dhole,** AG Patil, PO Patil, PK Deshmukh	Materials Technology
6	Eco-friendly in situ fabrication of reduced graphene oxide gold nanocomposites for catalysis and dye degradation	PO Patil, **SC Mahale, MP More, PV Bhandari**, PK Deshmukh, SB Bari	Russian Journal of physical Chemistry A
7	Design and Development of Thiolated Graphene Oxide Nanosheets for Brain Tumor Targeting	**AN Nikam, MP More, AP Pandey**, PO Patil, AG Patil, PK Deshmukh	International Journal of Polymeric Materials and Polymeric Biomaterials
8	Graphene-based nanocomposites for sensitivity enhancement of surface plasmon resonance sensor for biological and chemical sensing: A review	PO Patil, **GR Pandey, A**G Patil, VB Borse, PK Deshmukh, DR Patil, **RS Tade, SN Nangare, ZG Khan**, AM Patil, MP More	Biosensors and Bioelectronics

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Recent Patents on Drug Delivery & Formulation 2018, *12*, 162-169

RESEARCH ARTICLE

Preparation, Characterization and *In Vivo* Assessment of Repaglinide Nanosuspension for Oral Bioavailability Improvement

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Abstract: ***Aims and Background*:** The objective of the study was to improve the bioavailability of poorly soluble repaglinide (RPG) by preparing nanosuspension with poloxamer 188 using high pressure homogenization (HPH). The recent patents on nanocrystals (US20150337006A1) facilitated selection of drug and polymer.

***Methods*:** Suspensions containing dissimilar sized particles were prepared by ultrasonication and HPH. The prepared aqueous suspensions were lyophilized and then characterized. Further, the dried aqueous suspensions were evaluated for drug content, solubility, *in vitro* dissolution, oral bioavailability study and stability study.

***Results*:** RPG nanoparticles size, polydispersity index (PDI) and zeta potential were found to be 280.8 ± 15 nm, 0.279 ± 0.04 and - 25.81 ± 1.6mV, respectively. DSC and XRD results showed that RPG particles in aqueous suspensions were present in a crystalline state; however, RPG nanoparticles exhibited decreased lattice energy due to smaller particle size. Nanoparticles prepared by HPH exhibited significant improvements in solubility and dissolution rate. Oral bioavailability was found to be enhanced by 1.93 fold in comparison with that of plain RPG. The nanosuspension was found to be stable when stored at 5°C ± 3°C.

***Conclusion*:** The outcomes of the study revealed significant enhancement in dissolution rate and oral bioavailability of RPG due to size reduction to nano range by HPH.

Keywords: Repaglinide, nanosuspension, high pressure homogenization, solubility enhancement, dissolution rate enhancement, oral bioavailability enhancement.

1. INTRODUCTION

Bioavailability and dissolution rate governs the therapeutic success of a poorly soluble drug. Dissolution is the most important constraints for pharmacological action by attaining anticipated absorption of the drug in systemic circulation [1]. Numerous restrictions like growing the dose, increase in the frequency of administration and the considerable incidences of the side effects are associated with the poorly soluble drugs. Absorption of poorly water soluble drugs in the gastro intestinal fluids is governed by the dissolution rate of such drugs. Improvement in the solubility and dissolution rate of poorly soluble drugs thus improves the oral bioavailability.

Repaglinide (RPG) is a meglitinide derivative aimed at managing type 2 diabetes mellitus [2, 3]. RPG was developed in an effort to succeed in dealing with the adverse effects such as hypoglycemia, cardiovascular side effects, and secondary failure of the existing antidiabetic compounds [4]. The blood glucose lowering mechanism by RPG involves binding to a receptor site different from that of sulfonylurea and stimulating the release of insulin. Poor solubility with relatively low and variable bioavailability of RPG is a constraint for good therapeutic prospective [2]. High inter-individual inconsistency in plasma concentrations in clinical trials has been shown by RPG [5-7]. Dissolution rate and bioavailability enhancement of RPG is thus, a valued tactic for improving its therapeutic efficacy.

During last 2 decades, a novel tool for decreasing drug particle size has been established. Pure solid drug particles with a mean particle size below 1 µm are called as drug nanocrystals. Nanosuspensions are the liquid dispersions of the drug nanocrystals stabilized with surfactants or polymeric stabilizers [8]. Enhanced bioavailability is attained by nanosuspensions by improving the saturation solubility and dissolution rate of poorly soluble drugs [9]. Drug nanosuspensions can be prepared by top down process, bottom up process and the combination of these two processes. Amongst these technologies top down process involving HPH is commonly used because of the lack of organic sol-

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Physicochemical characterisation and anti-inflammatory activity of ayurvedic herbo-metallic *Tamra bhasma* in acute and chronic models of inflammation

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ABSTRACT

Current study was aimed to validate traditional claim of *Tamra bhasma* (*TB*) as an antinflammatory agent by investigating the preclinical anti-inflammatory activity of *TB*. Initially, *TB* was characterised by some traditional and modern parameters including scanning electron microscopy (SEM), energy dispersive x-ray analysis (EDAX) and X-ray diffraction (XRD). Subsequently, its anti-inflammatory activity was evaluated in carrageenan, cotton pellet and complete Freund's adjuvant (CFA) model. The % inhibition of paw oedema and granuloma tissue, blood and tissue related pharmacological evaluations were performed for assessment of anti-inflammatory activity. The SEM, EDAX and XRD confirmed presence of nanoparticulate copper as its sulfide or oxide form in *bhasma*. The changes produced by carrageenan and CFA in animals were reversed significantly in *TB* treated animals throughout the study. The results suggest that *TB* has a potential anti-inflammatory activity.

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KEYWORDS
Tamra bhasma; anti-inflammatory activity; physicochemical characterization; *Ayurvedic bhasmas*; preclinical activity

Introduction

The growing recognition of Ayurveda worldwide in recent years has drawn the attention of budding researchers as well as patients from modern medicine to alternative therapies. *Bhasmas* (incinerated ash) are unique metal/mineral/herbal based ayurvedic medicines that have been used to treat numerous chronic ailments since ancient times without any toxicity. Adopting unique set of procedures namely *Shodhan* (purification); removal of toxicity and *Maran* (incineration); produces ash [1] which is a key to safety and maximum therapeutic effect of *bhasmas*. Although *bhasmas* have been used in clinical practice since ancient times, their use is limited in the present era because of safety concerns [2]. In this regard, several recent studies proved they are nontoxic upto certain doses [3,4]. Furthermore, preclinically *bhasmas* possess haematinic [5], antidiabetic [6], anticataleptic, antianxiety, antidepressant [7] activities.

Tamra bhasma (TB) is an ash of metallic copper. According to the ancient literature, *TB* is used to cure *Pandu* (anaemia), *Udara* (ascites), *Svasa* (asthma), *Amlapitta* (hyperacidity), liver disorders, old-age disorders, leucoderma, arthritis [8], *Sotha* (inflammation) and *Sula* (pain) [9]. Several biological studies also reported that it have antihyperlipidemic [10], free radical-scavenging [11] and hepatoprotective activity [12].

To date, only two *bhasmas*, namely Muktashoukti [13] and Raupya [14] reported to possess anti-inflammatory activity. Copper is well known for its anti-inflammatory property stated in many books belongs to ancient cultures of India, Egypt and China [15]. Several published reports suggested that copper has anti inflammatory properties [15–17] and copper complexes of non-steroidal anti-inflammatory drugs (NSAIDs) preclinically exhibit enhanced anti-inflammatory activity and improve gastric protection [18,19]. As available literature supports anti-inflammatory claim of copper, its biological evaluation needs to be performed. The current study focused on pharmacological evaluation of *TB* to check its anti-inflammatory activity.

Materials and methods

Drugs and chemicals

TB was procured from Baidyanath, Nagpur, India. CFA and λ-Carrageenan were purchased from Sigma Aldrich. Rat TNF-α and IL-1β ELISA kits were procured from Krishgen Biosystems, Mumbai, India. All the other chemicals utilized in the study were of analytical grade.

Preparation, dose, and route of TB

The study doses of *TB* were calculated from its specified clinical dose (60–120 mg/day) as per Paget and Barnes, 1964 [20]. The therapeutic equivalent dose (TED) for animal is 5.5 mg/kg. Other study doses were 2.25-(TED/

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Controlled synthesis of blue luminescent graphene quantum dots from carbonized citric acid: Assessment of methodology, stability, and fluorescence in an aqueous environment

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HIGHLIGHTS

- Carbonized Citric acid forms self assembly structure at controlled condition.
- Graphene Quantum dots (GQDs) demonstrated efficient and stable fluorescence.
- GQDs has high luminescence at variable pH and Temperature.
- Reproducible fluorescence for prolonged period of time at ambient temperature.

ARTICLE INFO

Keywords:
Graphene quantum dots
Scientific microwave
Blue luminescence
Aqueous synthesis
Carbonization

ABSTRACT

The present investigation deals with a comparative assessment of various techniques for the synthesis of blue luminescence Graphene Quantum Dots (GQDs) using various equipments like furnace, domestic microwave synthesiser and scientific microwave synthesiser using citric acid as a precursor. A bottom–up method was adapted to develop photoluminescent (PL) GQDs and assessed for luminescence intensity of GQDs at different environmental conditions. The methodology requires very less concentration of NaOH to disperse GQDs. The present approach is advantageous over other conventional organic solvent mediated synthesis, as it requires less time, easy to reproduce and disperse in water, furthermore it produces stable fluorescence for a longer period of time at ambient temperature conditions. The synthesized GQDs are primarily characterized by UV for detection of the fluorescence intensity and simultaneously Ultraviolet–Visible (UV–Vis) spectroscopy and Fourier Transform Infra Red (FTIR) Spectroscopy to assess the up conversion from the precursor molecule. Apart from these techniques, Particle Size and Zeta Potential, Scanning Electron Microscopy (SEM), Elemental Analysis (EDX), Raman Spectroscopy and Fluorescence spectrophotometry were used to characterise synthesized GQDs.

1. Introduction

From last few decades when the nanotechnology starts exploring at the edge; becoming a new area that represents small sized materials, structures, devices, and systems. Nanometer scale size ranging between 1 and 100 nm is considered the most promising application in nano-medicine and other technical approaches [1]. Novel technical aspects can be possible with help of Nanomaterials to produce an efficient system with wide range of applications such as drug delivery systems; performance based medical devices, diagnostic materials, etc. [2,3].

The demand of nanomaterials has increased in recent years, due to their unique properties and structural features. The application area is going to increase day by day with varying its phases or in different types of areas such as catalysis, biomedical, drug delivery and many more areas are still exploiting. Few of these materials includes the carbon-based luminescent nanomaterials (CLNMs), carbon quantum dots (CQDs) [4], nanodiamonds [5], Carbon nanotubes (CNTs) fragment and surface functionalized CNTs [6,7], Graphene quantum dots (GQDs) to name a few, are exploring more due to low toxicity, high luminescence, robust material, chemically inertness and ease for

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Fabrication and In-vitro Drug Release Characteristics of Magnetic Nanonanocellulose Fiber composites for efficient delivery of Nystatin

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Abstract

In the present study, one pot fabrication process was used for the synthesis of magnetic nanocellulose fiber composite (MCFNCs), wherein *In-situ* co-precipitation methodology contains reaction of iron with ammonia in controlled temperature environment and cellulose fibers acts as a capping and stabilizing agent. The crosslinked cellulose fibers helps to dissociate Fe ions and avoid aggregation during the nucleation stages. The Nystatin (Nyst) was used as a model drug for studying the release characteristics of MCFNCs. The preliminary confirmation was done by comparing the FTIR spectra of synthesized MCFNCs with its precursor. The fabricated MCFNCs was characterized by X-ray Diffraction, Vibrating Sample Magnetometry, Particle Size, etc. The surface morphology and internal structure were identified by Scanning and Transmission Electron Microscopic observation of respective samples. It shows porous aggregated structure of synthesized nanocellulose, BET surface area and BJH pore size was determined simultaneously and found to be 13.42 m^2/g and 104.48 Å respectively. Due to the porous nature of nanocellulose fiber, it has high loading capacity i.e. around 17.8% amongst porous material category. *In-vitro* drug release characteristics of Nyst loaded MCFNCs compared to pure drug showed sustained deliver for up to 8h time period. The Antifungal activity was evaluated on *Candida Albicans* and showed prominent inhibitory activity. The biocompatible nature of synthesized nanocomposites obtained from the natural nanocellulose fiber has a huge prospective in magnetically guided drug delivery in various parasitic diseases and have a potential of biomedical applications.

Keywords: Nanocellulose Nanofiber, Nanocomposites, Antifungal Activity, Controlled Release, Drug Delivery System

1. Introduction

Nanocellulose based fibers containing Iron oxide composites have gained significant interest in recent years due to interim potential pharmaceutical and bio-medical applications by virtue of their biocompatibility and biodegradability [1, 2]. Nanocellulose based magnetic composites find more promising application as antifungal and antimicrobial activity when studied in combination with silver nanoparticles [3, 4], agents for a hyperthermia based killing of parasites [5], drug delivery [6], vectors for magnetically-assisted active targeting in diseases such as cancer [7, 8], etc. The impressive characteristics of nanocellulose fibers have increased its relevance in different fields due to high specific surface areas and aspect ratio

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Development of graphene-drug nanoparticle based supramolecular self assembled pH sensitive hydrogel as potential carrier for targeting MDR tuberculosis

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ABSTRACT

The *Mycobacterium tuberculosis* (MTB) resides in mononuclear phagocytes (macrophages) hence selective targeting at the molecular level using Graphene Oxide (GO) Air Dried Hydrogel (ADH) is investigated in present investigation. The GO has capability to form supramolecular self assembly, due to $\pi - \pi$ stacking and hydrogen bonding interactions between surface groups of GO and oppositely charged drug molecule in presence of water. The hydrogel was fabricated using GO and Para-aminosalicylic acid (PAS) in solution phase. The fabricated hydrogel was lyophilized to obtain air dried hydrogel (ADH). The ADH showed potent antimicrobial activity and *in-vitro* cytotoxicity against *S. Aureus* and *E. Coli*, and MCF –7 cells respectively. The Alamar blue assay demonstrated the invasive characteristics of ADH in MTB (H37Rv). From the results obtained so far we lead to conclude that ADH is more invasive compared to the equivalent amount of pure PAS.

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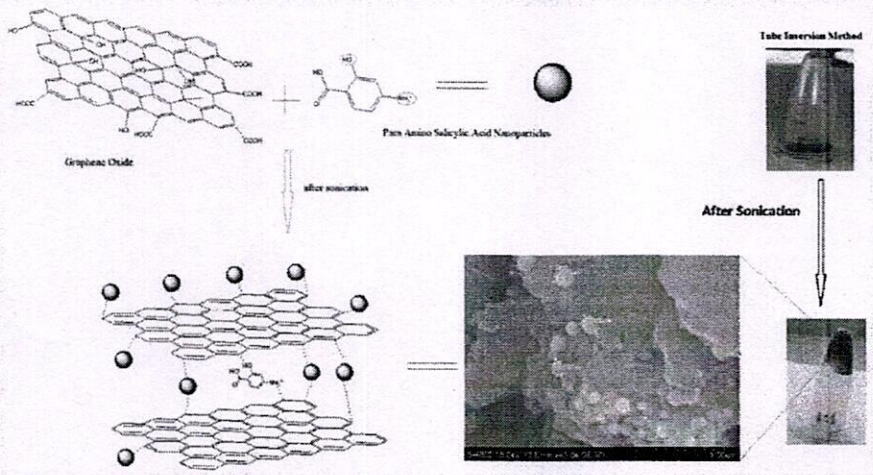
KEYWORDS
Tuberculosis; macrophages; supramolecular hydrogel; antitubercular activity; para amino salicylic acid; cytotoxicity



Introduction

Tuberculosis (TB) is contributing major cause of death amongst global health population Smith [1]. It was considered diseases of the past but eventually about 30% of the global population are affected with TB. The world wide diseases burden comprises major causes of morbidity and mortality is related to TB [2]. It is a chronic, contagious [3], airborne [4], prototypic [5] and fatal respiratory bacterial infection. TB is caused by the rod-shaped, obligate [6], non–spore-forming aerobic bacterium [7]. In 1993, World Health Organization (WHO) declared that TB is a global threat for health community [8].

'Super Carbon' denotes the potential applications of Graphene, it is one-atom thick honeycomb lattice structure, two-dimensional (2D) sheet of carbon atoms and is considered as the potential revolutionary material with electronic potential of zero band gap semimetal [9]. Graphene Oxide (GO), also known as graphitic acid, was discovered long time back [10]. The GO has large number of

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PHYSICAL CHEMISTRY OF NANOCLUSTERS AND NANOMATERIALS

Eco-Friendly In Situ Fabrication of Reduced Graphene Oxide Gold Nanocomposites for Catalysis and Dye Degradation[1]

Pravin O. Patil[a,*], Sanchita S. Mahale[a], Mahesh P. More[a], Pravin V. Bhandari[a], Prashant K. Deshmukh[a], and Sanjay B. Bari[a]

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Abstract—The invention represents a development of robust eco-friendly method use for water waste management and polluted water. The inadvertent role of peanut peels extract helps to simultaneously convert and form reduced graphene oxide gold nanocomposite (rGO@AuNCs) in single step. Fabricated nanocomposite was evaluated for its catalytic performance using reduction of 4-nitrophenol to 4-aminophenol as well as elimination of methylene blue (MB) and malachite green (MG) dyes from water. Graphene oxide (GO) and rGO@AuNCs, were synthesized using simplified approaches and preliminary characterization was done using UV–Vis spectrophotometer and Fourier transform infrared spectroscopy. Least concentration of rGO@AuNCs is required to eliminate MB and MG around 77 and 93%, respectively. Furthermore, surface morphology and elemental analysis of rGO@AuNCs confirm successful fabrication methods as well as X-ray diffraction pattern confirms the crystalline behavior of nanocomposite. The study illustrates an environment-friendly and cost effective in situ fabrication rGO@AuNCs from industrial agro waste for an environmental remediation.

Keywords: graphene oxide, industrial-agro waste, methylene blue, malachite green, 4-nitrophenol, environmental remediation

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INTRODUCTION

Single-layer of graphene oxide (GO) is usually produced by the chemical oxidation of graphite, which is a harsh chemical reaction in presence of H_2SO_4 and $KMnO_4$. Exfoliated graphite forms a stable dispersion in water and different organic solvents such as ethanol, dimethyl sulfoxide, etc. [1]. A synthesized material at nanoscale shows enormous structural and functional properties. These advancements in nanotechnology deals with the exploration and exploitation of nanomaterials with their synthesis, characterization, evaluation, etc. [2]. Conventional composite materials unable to show such efficient properties thought the nanocomposite owing to their unique desirability and surface, structural properties shows significant progress in 21st century. The significant aspect for exploring the research of the graphene-based nano composites is the yearning to combine the promising properties of graphene with other fundamental nanomaterials [3]. Applications and recent needs of energy and environmental remediation approaches as well as to check the possibilities attension has been made towards fabrication of graphene based nanocomposites [4].

Metal nanoparticles–graphene nanohybrid systems become highly important in catalysis and dye removal because of their large surface area, high electronic transport capacity and extraordinary chemical stability [5]. The interest in the use of graphene-based materials in the field of catalysis is due to the activity and stability of graphene-based catalysts through tailoring its structures/morphologies, catalytic performance, and design for synthesis, catalytic mechanisms [6]. Textile industries are using dyes in larger amount and their wastage is also been increasing, synthetic dyes are less costly but produces toxicity to aquatic animals and humans. The rate of degradation of dyes is much slower due to complex chemical structure and difficult in decomposition. Several methods have been reported previously for the treatment of dye bearing effluents, but they are generally inefficient for the complete removal of dyes. Adsorption and removal of dyes using metal nanoparticles–graphene nanohybrid is the method of choice for the treatment of waste water [7].

Peanut (*Arachis hypogaea*) is an important food crop grown in over 100 countries with a total produc-

[1] The article is published in the original.

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Design and development of thiolated graphene oxide nanosheets for brain tumor targeting

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ABSTRACT

The present investigation emphasizes on synthesis and characterization of thiol functionalized reduced graphene oxide (TrGO) as a novel platform for loading of anticancer drug methotrexate (TrGO-MTX), through amide bonding. Thiolation of graphene oxide (GO) was achieved by transesterification process. The introduction of sulfur containing chemical groups and the partial reduction of GO to TrGO were proven by analytical techniques. Thiol content was found to be 6.98 mM by Ellman's method in a quantitative manner. Furthermore, antineoplastic action of TrGO-MTX against human glioblastoma astrocytom U-373 MG cell line was studied, wherein TrGO-MTX demonstrated significant inhibition rate as compared with pure MTX.

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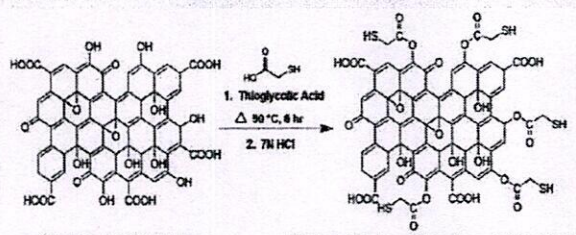
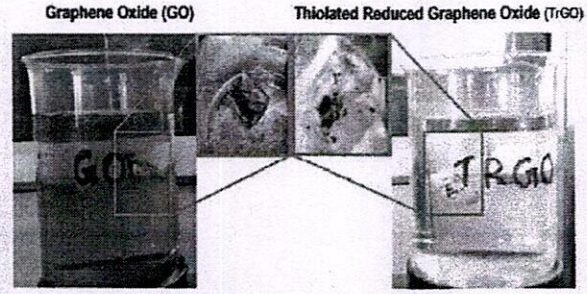
KEYWORDS
Brain tumors; graphene oxide; methotrexate; mucoadhesion; mucociliary clearance; thiolation

GRAPHICAL ABSTRACT



Graphene Oxide (GO) — Thiolated Reduced Graphene Oxide (TrGO)



Mucoadhesive Property of GO and TrGo

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/gpom.

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Graphene-based nanocomposites for sensitivity enhancement of surface plasmon resonance sensor for biological and chemical sensing: A review

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Sensitivity enhancement
Nanosensor

ABSTRACT

Surface plasmon resonance (SPR) offers exceptional advantages such as label-free, *in-situ* and real-time measurement ability that facilitates the study of molecular or chemical binding events. Besides, SPR lacks in the detection of various binding events, particularly involving low molecular weight molecules. This drawback ultimately resulted in the development of several sensitivity enhancement methodologies and their application in the various area. Among graphene materials, graphene-based nanocomposites stands out owing to its significant properties such as strong adsorption of molecules, signal amplification by optical, high carrier mobility, electronic bridging, ease of fabrication and therefore, have established as an important sensitivity enhancement substrate for SPR. Also, graphene-based nanocomposites could amplify the signal generated by plasmon material and increase the sensitivity of molecular detection up to femto to atto molar level. This review focuses on the current important developments made in the potential research avenue of SPR and fiber optics based SPR for chemical and biological sensing. Latest trends and challenges in engineering and applications of graphene-based nanocomposites enhanced sensors for detecting minute and low concentration biological and chemical analytes are reviewed comprehensively. This review may aid in futuristic designing approaches and application of grapheneous sensor platforms for sensitive plasmonic nano-sensors.

1. Introduction

From its inception, surface plasmon resonance (SPR) technique plays a prevailing role in the field of optical sensors. The SPR has evolved from a moderately impenetrable physical phenomenon to an optical tool that is widely used in chemical and biological investigations (Slavík et al., 1999; Yamamoto, 2008; Zeng et al., 2014) to study the binding events between two molecules of interest. Since its first intervention in 1990 by a Biacore group (GE Healthcare), the technology has established exponential growth in the last years, which is evident from the increase in the number of publications as well as the number of the methodology developed, till 2019, total of 24,148 papers are published as per PubMed search database (Fig. 1).

SPR technique is advantageous in terms of an *in-situ*,label-free methodwitheconomical and ease of fabrications as compared with the electrochemical and other methods (Merwe, 2001). The SPR phenomenon occurs in between the metal surface of sensorgram with specific molecule recognition element and a medium either vacuum/air or liquid.Whenever there is recognition of the particular molecule specific to the site/scaffold/receptor of this element, it results in the change of the surface of the metal, causing an angle shift as shown in Fig. 2(i).The shift resulted due to the changes in the refractive index (RI) at the surface of the metal. A usual SPR sensor either works in the angular interrogation mode or the wavelength interrogation mode. At the resonance wavelength or angle, the dispersion relation of the incident light matches with that of the surface plasmon, at which the reflectance shows a dip as seen in Fig. 2 (ii). The reflectance dip is attributed to the transfer of energy possessed by the photons incident to the surface plasmon and is more sensitive to the changes in the dielectric medium adjacent to the sensor surface (Ekgasit et al., 2004; Vasić et al., 2013).

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