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2	Green Synthesis of Silver Nanoparticles: An Eco-Friendly Approach	SN Nangare, PO Patil	Nano Biomedicine and Engineering
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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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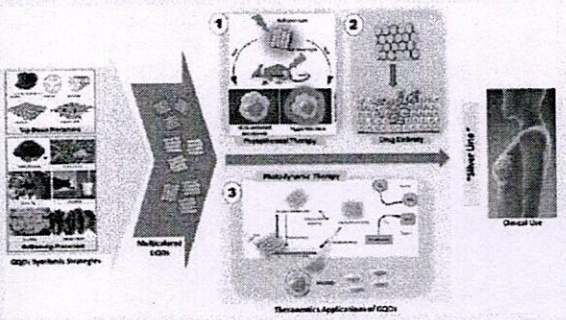
ABSTRACT: Breast cancer (BC) is increasing as a significant cause of mortality among women. In this context, early diagnosis and treatment strategies for BC are being developed by researchers at the cellular level using advanced nanomaterials. However, immaculate etiquette is the prerequisite for their 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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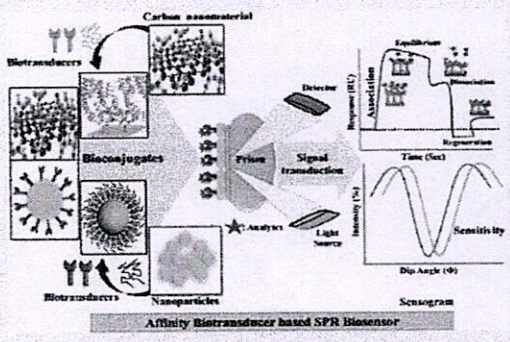
ABSTRACT: Despite the indisputable benefits and advancement of science, technology, and civilization, early diagnosis of healthcare is still a challenging field for the scientific fraternity. The detection of biomarkers is a crucial attribute of prognosis and diagnosis of disease. Out of numerous techniques, 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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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

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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

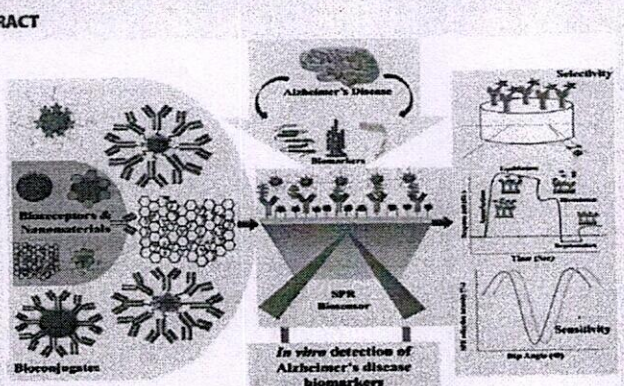

Figure 1. Nano-architectured bioconjugates and bioreceptors mediated SPR biosensor for highly sensitive and selective in vitro diagnosis of AD biomarkers.

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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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Keywords: cellulose fibers, *in-situ* synthesis, magnetic nanocomposites, dye adsorption

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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REVIEW Open Access

Flavonoids as natural phenolic compounds and their role in therapeutics: an overview

Rakesh E. Mutha*, Anilkumar U. Tatiya and Sanjay J. Surana

Abstract

Background: Natural plants and plant-derived formulations have been used by mankind from the ancient period of time. For the past few years, many investigations elaborated the therapeutic potential of various secondary chemicals present in the plants. Literature revealed that the various secondary metabolites, viz. phenolics and flavonoids, are responsible for a variety of therapeutic action in humans.

Main body: In the present review, an attempt has been made to compile the exploration of natural phenolic compounds with major emphasis on flavonoids and their therapeutic potential too. Interestingly, long-term intake of many dietary foods (rich in phenolics) proved to be protective against the development and management of diabetes, cancer, osteoporosis, cardiovascular diseases and neurodegenerative diseases, etc.

Conclusion: This review presents an overview of flavonoid compounds to use them as a potential therapeutic alternative in various diseases and disorders. In addition, the present understanding of phenolics and flavonoids will serve as the basis for the next scientific studies.

Keywords: Phenolics, Flavonoids, Secondary metabolites, Therapeutic action

Background

Polyphenols is one of the major classes of naturally occurring compounds having at least one phenol group in their structure, present in the plants, including vegetables, fruits, cereals and dry legumes [1–3]. As these compounds show multiple physiological effects, when consumed as a component or dietary supplement, polyphenolics become a subject of interest in a scientific fraternity [4]. Polyphenols are secondary metabolites consisting of polyhydroxy phytochemicals of the plant kingdom and effective defense against pathogenic aggression and ultraviolet radiation [5]. These secondary compounds are biosynthesized through shikimic acid and phenylpropanoid pathways and believed to be participative in adapting the plants in a stressed situation due to environmental changes [6]. From this extensive class of polyphenolic compounds, more than 8000 have been already isolated, identified and described in detail [7].

In food, initially, polyphenols are used to manipulate astringency, bitterness, flavor, color, odor and oxidative stability. Throughout evolution in various plant lines, the ability to synthesize phenolic compounds was selected when these compounds met unique needs, allowing plants to cope with continuously evolving environmental conditions over evolutionary time [8]. Afterward, various epidemiological research activities and accompanying meta-analyses intensely recommended protection offered against the development of diabetes, cancer, osteoporosis, cardiovascular diseases and neurodegenerative diseases by long-term intake of plant polyphenols in our daily diet [9, 10]. These compounds, based on their chemical structures, are divided into various subclasses like phenolic acids, flavonoids, tannins, coumarins, lignans, quinones, stilbenes and curcuminoids [1].

Flavonoids are ubiquitously occurring polyphenolic compounds and comprise the broad class of natural products. To date, it has documented over 8000 different flavonoids and most of them are present in the cells or surfaces of various plant tissue organs [11]. A large variety

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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

Sopan Nangare[1], Yogini Vispute[2], Rahul Tade[1], Shailesh Dugam[3] and Pravin Patil[1*]

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.*

How to cite this article

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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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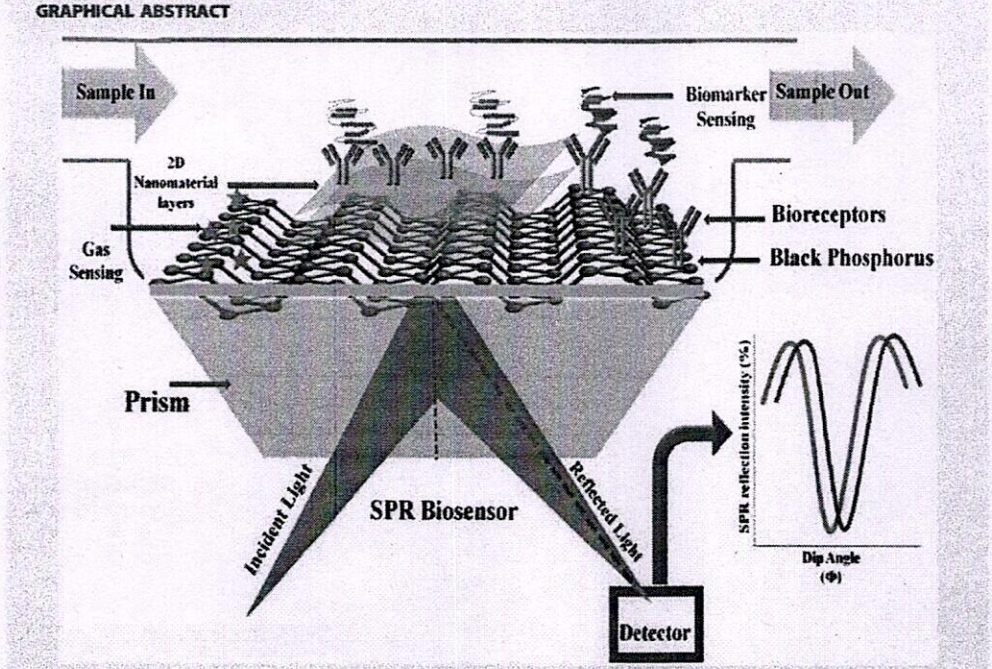
ABSTRACT

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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