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A simple method to fabricate metal doped TiO_2 nanotubes

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ARTICLE INFO

Keywords:
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ABSTRACT

A simple electrochemical method for effective doping of TiO_2 nanotubes with metals is presented here. The doping is done in a two-stage cost effective process and is found to result in uniform doping concentration, without any surface layer formation, in the nanotubes. Detailed structural, compositional, optical and electrical analyses are done on the nanotubes doped with copper metal. The cu metal doping is found to produce tuning of the electrical and optical properties. The doped tubes with increased conductivity are better suited in dye sensitized solar cells (dsscs) whereas enhanced visible light absorbing capacity makes them better candidates for photocatalytic applications. Further the success of this method in doping TiO_2 nanotubes with any metal of choice is demonstrated by testing aluminum metal doping in the nanotubes.

1. Introduction

Titanium dioxide is a versatile wide bandgap semiconducting metal oxide, which has undergone immense research studies in the past decade on account of the wide bandgap and band edge positions suitable for photochemical and photo catalytic applications [1–3]. Even though the large band gap of TiO_2 (~3 eV) is desirable for several applications, this property creates a performance barrier in the sun driven applications since only the ultra violet part of the solar spectrum can be absorbed and utilized by TiO_2. Reports indicate that the poor response of TiO_2 to the visible part of the solar radiation limits its photocatalytic applications whereas the low electrical conductivity adversely affects its use in optoelectronic devices [4–11]. An improvement in the electrical conductivity of the TiO_2 is very much relevant in applications such as dye sensitized solar cells (DSSCs), in which the titanium dioxide nanomaterials are used as electron transport pathways [12]. In DSSC, the photo excited electrons are injected into the conduction band of the titanium dioxide nanomaterials serving as electrodes and are transported to the back metal contact [4].

Improving the optical and electrical properties of the Titanium dioxide nanomaterials by doping, band gap engineering, and sensitization is a keen field of research today [13,14]. The lower level of the conduction band of the titanium dioxide is formed by Ti 3d states, while the upper level of the valence band is formed by O 2p levels. Thus, the modification of the band gap can be done by shifting the valence and conduction bands and by introduction of localized states in the band gap. But very few studies on tuning the band gap of Titanium dioxide nanotubes (TONTs) are found in literature [15,16]. This paper presents doping as an effective means of bandgap tailoring of TONTs.

Several doping methods such a high energy ion implantation, co-sputtering, annealing in dopant gas atmosphere and use of alloys have been used to modify the optoelectronic properties of titanium dioxide nanomaterials [13]. Most of these doping processes are done on a very high energy budget. Cost effective methods for metal doping of TONTs is particularly important. Here we introduce a simple two-electrode electrochemical doping method for fabricating metal doped TiO_2 nanotubes, which can modify the optical and electronic properties of the titanium dioxide nanotubes at a lower energy budget. In this paper, a novel method for metal doping of TiO_2 nanotubes and an analysis of the structural, compositional, electrical and optical properties of Cu (I

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Novel processing parameters for the extraction of cellulose nanofibres (CNF) from environmentally benign pineapple leaf fibres (PALF): Structure-property relationships

Lakshmipriya Ravindran [a], Sreekala M.S. [a], Sabu Thomas [b]

Industrial Crops and Products

Volume 130, April 2019, Pages 398-408

Physicochemical, mechanical, barrier and antibacterial properties of starch nanocomposites crosslinked with pre-oxidised sucrose

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Effect of starch reduced graphene oxide on thermal and mechanical properties of phenol formaldehyde resin nanocomposites

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ARTICLE INFO

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Potato starch
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ABSTRACT

Phenol formaldehyde (PF) resins are one of the oldest synthesized and very widely used resins. Their properties can be improved with the incorporation nano-fillers even with lower loadings. Graphene materials have attracted significant attention in recent years owing to its exceptional thermal, mechanical and electrical properties. Herein, we report a very simple and effective way to reduce graphene oxide (GO) by using highly abundant potato starch instead of conventionally used toxic and hazardous reducing agents like hydrazine. The reduced GO (RGO) is then effectively incorporated into PF resin by optimizing various processing parameters. The reinforcing effect of RGO sheets on the PF matrix was investigated by X-ray diffraction (XRD) and Transmission Electron Microscopy (TEM). The effect of RGO on thermal properties of the polymer nanocomposites was studied using Thermogravimetric Analysis (TGA). The mechanical properties of PF/RGO composites were studied by tensile and Izod impact tests. The fracture mechanism of the composites was investigated by Scanning Electron Microscopy. Theoretical prediction of the mechanical properties of the nanocomposites using Halpin-Tsai models gave sufficient information regarding the orientation of graphene sheets in PF matrix.

1. Introduction

Phenol formaldehyde (PF) resole resin is one of the oldest synthesized low-cost resins with excellent thermal stability, mechanical properties, good solvent and weather resistance which make them excellent candidate for a wide variety of applications in the fields of thermal insulation, coatings, automotive and aerospace industries. Their FST (fire, smoke, low toxicity) properties also make them highly favorable for composite preparation [1]. In spite of these advantages only a very few studies have been made on this phenolic resin since it is known to form three-dimensional molecular structure even before it is cured. Phenolics are generally very brittle but that can be modified and varied by adding appropriate fillers or other additives into the matrix.

Graphene is well-known for its excellent mechanical properties such as high tensile strength, high Young's modulus, and fracture toughness but the lack of any reacting functionalities make it non-responsive to any composite formation. However, layered graphene oxide (GO) which we get by exfoliation of graphite possess several surface O-functionalities which can facilitate the interfacial interaction, effective dispersion and hence efficient load transfer between GO layers and the polymer matrix [2]. Therefore, GO can function as an ideal candidate for imparting many of graphene-related properties like superior mechanical, electrical and electronic properties, light weight and the high surface area nature in its nanocomposites making them versatile multifunctional materials [3]. Different methods are used for the synthesis graphene like mechanical exfoliation [4], Chemical Vapour Deposition (CVD) [5], chemical oxidation/exfoliation followed by reduction of graphene derivatives such as graphene oxide (GO) [6,7], unzipping carbon nanotubes [8], arc discharge methods [9]. Among these methods, chemical oxidation of natural graphite by Hummers method followed by reduction is the most commonly used method. Earlier, the chemical reduction of GO were performed using various reducing agents such as hydrazine and its derivatives [10–16], $NaBH_4$ [17,18], hydroquinone [19], hydroiodic acid (HI) [20–22], sulfur-containing compounds [23], metal powders [24–27] and hydroxylamine [28]. Among these the most widely adopted method for the reduction of GO was done by hydrazine which is a very hazardous chemical, both to the human health and to the environment [29]. Employing green reducing agents can therefore act as a highly favorable alternative method for such hazardous materials and for the large-scale production of graphene-like materials. The first green route for the preparation of graphene dispersions from graphite oxide was reported by Fan et al. [30].

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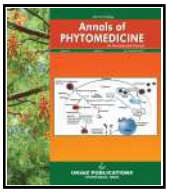

Original article: Open access

Protective effect of the polyherbal formulation, Nalpamaram against ethanol induced hepatotoxicity in rats

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Abstract

Nalpamaram which constitutes a group of four plants, *Ficus racemosa, Ficus microcarpa, Ficus benghalensis* and *Ficus religiosa* is one of the polyherbal formulations, used by ayurvedic practitioners for the treatment of a variety of health problems. In the present study, the hepatoprotective activity of aqueous extract of the barks of Nalpamaram (NMAE) against ethanol induced hepatotoxicity was studied in male albino rats. The levels of the toxicity marker enzymes aspartate transaminase (AST), alanine transaminase (ALT), alkaline phosphatase (ALP), gamma glutamyl transferase (GGT), and bilirubin showed a significant increase in the ethanol treated group indicating liver injury. On treatment with NMAE at various concentrations, the activity of the enzymes AST, ALT, ALP and GGT, and total bilirubin significantly decreased compared to the ethanol treated group. The total protein and albumin levels increased on treatment with NMAE. The hepatoprotective activity was also supported by the histopathological studies of the liver tissue. The effects of NMAE at a dose of 500 mg/kg b.wt/day were comparable to that of the standard drug silymarin.

1. Introduction

Liver is one of the most important tissues of the human body and is the primary site of metabolism, detoxification and secretion. Liver plays a major role in physiological homeostasis. It is also the site of the biochemical pathways involved in growth, immunity, the supply of nutrients and energy production (Ahsan *et al*., 2009). Liver diseases have become a worldwide health problem that accounts for a very high death rate. Hepatic damage may be caused by excess ethanol consumption, the use of high doses of paracetamol, antibiotics, environmental pollutants and microbial infection (Daniyal *et al*., 2019). Ethanol damages the liver by accumulating fat, inflammation and oxidative stress which may progress to fibrosis and cirrhosis (Osna *et al*., 2017). In recent years, plant extracts have received attention as hepatoprotective agents as the available hepatoprotective drugs often fail to restore liver functions (Kumar and Pari, 2003). In the traditional Indian system of medicine, plant extracts are used to treat a variety of diseases, including those of liver (Chattopadhyay, 2003; Gaurav *et al*., 2017). In the Ayurvedic system, combinations of plant extracts are considered to have greater therapeutic efficacy than individual extracts. Polyherbal formulations (PHF) may produce better results by acting at multiple targets at a time or one herb may nullify the deleterious side effects of the others (Parasuraman *et al*., 2014).

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Nalpamaram is one of the polyherbal formulations used by Ayurvedic practitioners for the treatment of a variety of health problems. The four trees that constitute Nalpamaram are *Ficus racemosa* (FR), *Ficus microcarpa* (FM), *Ficus benghalensis* (FB) and *Ficus religiosa* (FG). In vernacular, they are called Athi, Ithi, Peral and Arayal, respectively. They belong to family Moraceae. The aqueous extracts of the barks of FR, FM, FB and FG form an ingredient in many of the Ayurvedic medicines. Nalpamaram is credited with cooling, soothing, antiinflammatory and antipruritic properties and is used in the treatment of various diseases to relieve burning sensation, haemoptysis, wounds and ulcers (Chopra *et al*., 1992; Warrier *et al*., 1995). The leaves and bark of FR and FG are reported to have hepatoprotective and nephroprotective activities (Mandal *et al*., 1999; Channabasavaraj *et al*., 2008).

Nalpamaram which is a concoction of FR, FM, FB and FG may exhibit hepatoprotective action. However, a detailed scientific study is found to be essential to explore its hepatoprotective action. Hence, the present study focuses on the hepatoprotective activity of the aqueous extract of Nalpamaram on ethanol induced hepatotoxicity in male albino rats.

2. Materials and Methods

2.1 Preparation of the extract

The preparation of the extract was carried out as per the guidelines given in traditional Ayurvedic textbooks. Authentic samples of the barks of FR, FM, FB and FG were collected from Arya Vaidyasala, Kottakkal, Kerala. Bark powders (100 g each) of FR, FM, FB and FG

First Page of UGC approved Research Publications from Sree Sankara College, Kalady during 2020-21

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Enhancement in electrical conductivity and dynamic mechanical properties of resole resin with ZnO-RGO as nanofiller

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ABSTRACT

The present study aimed at investigating the influence of ZnO-RGO nanofiller on the electrical and dynamic mechanical properties of phenol formaldehyde (PF) resin. The nanocomposites were prepared by solution mixing method followed by compression molding and nanofillers were synthesized by refluxing graphene oxide with zinc acetate dihydrate in DMF. The maximum value of the dielectric constant is observed for composites with 1 wt% ZnO-RGO content. A comparative study on the experimental and theoretical values of effective dielectric constant was done by Maxwell Garnet equation. The theoretical modeling of DC conductivity of the nanocomposites was done by the Bueche, Scarisbrick, and Rahaman modeling. The effect of ZnO-RGO on the viscoelastic properties of PF was analyzed with DMA. About 28% increase in storage modulus is observed with the addition of 0.12 wt% ZnO-RGO. The degree of entanglement, reinforcement efficiency factor, and cross-link density were calculated from DMA analysis to understand the interaction between PF and ZnO-RGO. The nature of the drawn Cole-Cole plot shows the existence of heterogeneity in PF/ZnO-RGO nanocomposites.

1. Introduction

Phenol formaldehyde (PF) resin, a kind of macromolecular compound and it is the first synthetic resin prepared by the polycondensation of phenol and formaldehyde [1]. The characteristic features of PF resins are remarkable thermal stability, low cost, good flame retardancy, weather and chemical resistance [2,3]. While considering its applications in various fields such as flame retardant materials, automotive, aerospace, composites etc. researchers are now trying to find good solutions for improving the properties of PF resin [4]. Currently polymers and thereby achieving a synergistic reinforcing effect.

Graphene and its derivatives plays an important role as nanofiller in polymer matrices because of its ability to improve the thermal, mechanical, electrical, and multifunctional properties of the matrix at lower loadings. Graphene found applications in various fields such as automobile, aerospace, energy, and environment because of its excellent mechanical strength, thermal conductivity, chemical and temperature resistance [8]. One of the problems associated with the production of graphene is the synthesis of high-purity graphene in high amounts. Even though, there are several methods used for the produc-

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Research paper

Seasonal variability of groundwater quality in coastal aquifers of Kavaratti Island, Lakshadweep Archipelago, India

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Influence of p-n junction mechanism and alumina overlayer on the photocatalytic performance of TiO_2 nanotubes

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Abstract

Modified hybrid structures of TiO_2 nanotubes (TONT), p-Al doped TONT/n-TONT with an additional overlayer of alumina, are constructed to achieve 99.57% photodegradation of the stable organic pollutant methylene blue (MB) within 180 min, a degradation rate 17 times higher than pure TONTs. The anodization at three different temperatures 2, 28 and 40 °C followed by impregnation of Al is used for their preparation. The analyses of structure, chemical composition and morphology are completed using x-ray diffraction, x-ray photoelectron spectroscopy (XPS) and high resolution transmission microscopy, respectively, Rutherford back scattering and field emission scanning electron microscopy confirm the formation of the hybrid structure. This structure exhibits the highest photodegradation rate with TONT based catalysts to date for MB blue, by enhancing the electron—hole separation, the absorption of visible photons and the adsorption sites for the pollutant. The optical data coupled with valence band XPS is used for elucidating the energy band structure of the p-n junctions and to gain insight into the effect of the junction mechanism on photoactivity. The rectification ratios of the impregnated p-n junctions, determined by current—voltage measurements, are found to vary from 10^2 to 10^6.

Keywords: TiO_2 nanotubes, alumina, photocatalysis

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

1. Introduction

Extensive use of dyes in textile, paper, leather, plastic and cosmetic industries and their discharge into water bodies pose serious threats to life and the environment. The organic dyes are stable, carcinogenic and toxic and hence development of efficient technologies for their removal from water is of great concern to scientists [1]. Among the various techniques investigated, photocatalysis is found to be one of the most promising methods for water purification and semiconducting TiO_2 has been widely investigated as a potential photocatalyst, with the advantages of nontoxicity, low cost and high chemical stability [2, 3]. However its use is limited due to two factors: (i) the wider band gap (~3.2 eV) that responds only to the ultraviolet region of the solar spectrum and (ii) the rapid recombination of charge carriers that leads to low quantum efficiency and

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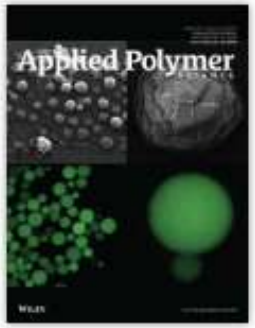

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ARTICLE

Viscoelastic and electrical properties of RGO reinforced phenol formaldehyde nanocomposites

Pattoorpady Krishnan Sandhya, M. S. Sreekala, Guijun Xian, Moothetty Padmanabhan, Nandakumar Kalarikkal, Sabu Thomas

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Abstract

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Volume 108, October 2020, 107961

Mechanical and thermal properties of ZnO anchored GO reinforced phenol formaldehyde resin

P.K. Sandhya [a], M.S. Sreekala [b], Moothetty Padmanabhan [a c], Sabu Thomas [a]

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Effect of MWCNT carboxylation on mechanical, thermal and morphological behaviour of phenol formaldehyde nanocomposites

Lakshmipriya Ravindran, MS Sreekala , [...], and Sabu Thomas +1 View all authors and affiliations

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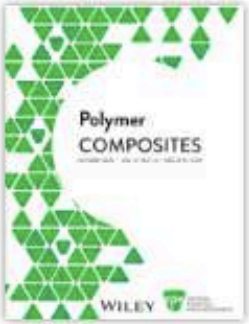

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RESEARCH ARTICLE

Thermal and electrical properties of phenol formaldehyde foams reinforcing with reduced graphene oxide

P K Sandhya, M S Sreekala, Abderrahim Boudenne, Bertrand Garnier, Didier Rouxel, Moothetty Padmanabhan, Nandakumar Kalarikkal, Sabu Thomas

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Abstract

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ORIGINAL ARTICLE

Journal of Food Safety WILEY

Antifungal activity of human gut lactic acid bacteria against aflatoxigenic *Aspergillus flavus* MTCC 2798 and their potential application as food biopreservative

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Abstract

With the enhanced use of chemical preservatives and the survival of foodborne pathogens, lactic acid bacteria and its metabolic product have received increased attention as a potential food preservative. Even though the antibacterial property of lactic acid bacteria is well known, its antifungal property and application in food preservation have not been widely exploited. Considering these facts, this study was conducted to investigate the antifungal properties of three human gut lactic acid bacterial isolates, *Lactobacillus plantarum* AL1, *Lactobacillus fermentum* AL2, and *Weissella confusa* AL3 antifungal activity of the isolates were studied against the aflatoxigenic *Aspergillus flavus* MTCC 2798, using the agar overlay method and inhibition of fungal mycelium (co-culture method). These LAB isolates were also potent producers of antimicrobial compounds like lactic acid, hydrogen peroxide, and diacetyl. GC–MS analysis of the methanolic extract of the three LAB isolates detected two antifungal bioactive compounds like cyclo (leucyloprolyl) and 1,2-benzenedicarboxylic acid in extracts. The hemolysis results provided an important insight that the human gut lactic acid bacteria can be used as protective cultures in the biopreservation. The antifungal activity of human gut LAB AL1, AL2, and AL3 against aflatoxigenic *Aspergillus flavus* MTCC 2798 and its ability extend the shelf life of peanuts prove as a natural preservative for food products.

1 | INTRODUCTION

Food spoilage is described as an alteration in the quality of food that makes it unpleasant and unfit for consumption either by spoilage microorganisms for animals and humans (Odeyemi, Alegbeleye, Strateva, & Stratev, 2020). Despite the development of technological innovation in food science and technology for many years, spoilage of food remains as a global issue and experience huge economic losses from producers to consumers (Snyder & Worobo, 2018). Apart from the complication of food humility and financial loss spoiled food also come up with food waste, which is another universal environmental problem.

Food and animal feed contamination by fungi especially by mycotoxigenic fungi, is a global concern for food manufacturers. Mycotoxins are toxic secondary metabolites produced by fungi, which in turn poses serious health concerns, some of which present considerable food safety challenges. Contamination by aflatoxin produced by *Aspergillus parasiticus*, *Aspergillus flavus*, *and Aspergillus nomius*, is one of the highest risks of stored feed. Aflatoxin has a serious impact on human and livestock causing both acute and chronic toxicity such as immunosuppression, hepatotoxicity, teratogenicity, and cancers, which threaten public health and may lead to death (Kumar, Mahato, Kamle, Mohanta, & Kang, 2017). Aflatoxin B1 is the most dangerous and categorized as class IIa carcinogen by the International Agency of Cancer Research (IACR; Shehata, Badr, El Sohaimy, Asker, & Awad, 2019).

The current trends of biopreservation have emerged as promising solution to satisfy customer demand for high quality food without

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Water sorption behavior of phenol formaldehyde resin reinforcing with reduced graphene oxide and ZnO decorated graphene oxide

P. K. Sandhya, M. S. Sreekala ✉, Moothetty Padmanabhan & Sabu Thomas

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Abstract

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A comprehensive review on cellulose, chitin, and starch as fillers in natural rubber biocomposites

Seena K. Thomas [a,b], Jyotishkumar Parameswaranpillai [c,*], Senthilkumar Krishnasamy [d], P. M. Sabura Begum [a], Debabrata Nandi [d], Suchart Siengchin [d], Jinu Jacob George [e], Nishar Hameed [f], Nisa.V. Salim [g], Natalia Sienkiewicz [h]

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Bio-nanocomposite

ABSTRACT

Biofillers based on cellulose, chitin, starch, and their composites have been topics of interest during the last few decades because of their eco-friendliness, low-cost, and good thermomechanical properties. The biofillers based on plant fibers are hydrophilic that reduce the compatibility with rubber matrix. In this manuscript, an effort has been made to review cellulose, chitin, and starch, focusing on their preparation and properties of natural rubber (NR) based composites reinforced with these fillers. The main characterization properties of NR based composites, such as mechanical, thermal, and biodegradability were discussed. The filler-NR interactions were also explored. The small size of the filler improved the physical interaction between the filler and matrix, and consequently, mechanical, thermal, sorption, crystallinity, and biodegradability of the biofillers/NR composites were found to be improved. Finally, the applications of NR-based composites reinforced with cellulose, chitin, and starch were reviewed in different areas such as medical, food packaging, footwear, sensors and water purification to study their practical uses.

1. Introduction

Currently, biodegradable and eco-friendly polymers derived from various renewable resources are preferred for a wide range of applications (Blanchard, Ogunsona, Hojabr, Berry & Mekonnen, 2020; Cesar et al., 2020; Lehman et al., 2021; Tang et al., 2021). The usage of eco-friendly materials helps to protect the environment, and these materials decompose quickly in the environment. Thus, the products produced from renewable resources are rapidly increasing in recent years. For instance, the applications of environmentally friendly products include food packaging (Varghese, Pulikkalparambil, Rangappa, Siengchin & Parameswaranpillai, 2020a, 2020b), drug delivery (Dutta, Giri & Giri, 2020; Moohan et al., 2020), tissue engineering (Bose, Koski & Vu, 2020; Dutta et al., 2020), medical implants (Rebelo, Fernandes & Fangueiro, 2017), composite technology (Rangappa, Parameswaranpillai, Yorseng, Pulikkalparambil & Siengchin, 2021), and eco-friendly sorbents (Alhwaige, Agag, Ishida & Qutubuddin, 2013, 2016; Dragan, Apopei Loghin & Cocarta, 2014). Natural rubber (NR) is one of the most

Abbreviations: TEMPO, 2,2,6,6-tetramethylpiperidine-1-oxyl; AFM, Atomic force microscopy; BC, Bacterial cellulose; CB, Carbon black; CNT, Carbon nanotube; CTE, Cashew tree exudate; CNCs, Cellulose nanocrystals; CNFs, Cellulose nanofibers; ChNFs, Chitin nanofibers; ChNCs, Chitin nanocrystals; DNR, Deproteinized natural rubber; FTIR, Fourier-transform infrared spectroscopy; FESEM, Field emission scanning electron microscope; *H. brasiliensis*, *Hevea brasiliensis*; NC, Nanocellulose; NFC, Nanofibrillated cellulose; NR, Natural rubber; OPFB, Oil palm fruit bunches; POM, Polarized optical microscopy; RC, Regenerated cellulose; TGA, Thermogravimetric analysis; TEM, Transmission electron microscopy; UV, ultraviolet; XRD, X-ray powder diffraction.

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Polypyrrole- silver nanocomposite for enhanced photocatalytic degradation of methylene blue under sunlight irradiation

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ABSTRACT

Polypyrrole (Ppy) -Silver nanocomposite samples have been synthesised by chemical oxidative polymerisation. The characteristic peaks of face centered cubic (fcc) structure of silver in XRD confirmed its presence in Ppy. Shift in N–H stretching frequency observed in FTIR spectroscopy revealed the coordination of silver into Ppy. The photocatalytic activity of the samples was studied by photocatalytic degradation of the aqueous solution of methylene blue (MB) under sunlight. The presence of Ag in polypyrrole (Ppy) enhanced its photocatalytic activity with respect to the reported values which further increased on increasing the silver concentration.

1. Introduction

Nanomaterials exhibit unique physical and chemical properties, and these unique properties of nanomaterials can be utilized by incorporating them into different materials to form composites for our specific needs. Polymer nanocomposites emerge as a special class because of their wide range of applications in a variety of fields. Among the conducting polymers, the heterocyclic polymer, polypyrrole has drawn more attention due to its unique electrical conductivity, redox property, stability, easy preparation by chemical as well as electrochemical methods [1].

The noble metals such as Au, Ag, Pt, etc. have high photocatalytic enhancing properties due to their capacity to inhibit electron-hole pair recombination [2]. Silver nanoparticles are the most promising ones to make visible light photoactive materials. The thermal and chemical stability of PPy makes it a stable photosensitizer.

An Ag-Ag_2O/TiO_2@Ppy heterojunction was used for methylene blue degradation by Rajiv Kumar et.al.[2]. Shuna Gy et.al. synthesised AgCl/Ppy composite for methyl orange degradation [3]. Ppy/Ag has not yet been explored in photocatalysis. In this work the combined photocatalytic effect of PPy and silver nanoparticles on methylene blue (MB) dye degradation under sunlight irradiation is studied for the first time. The method we adopted for synthesis of Ppy/Ag is simple and cost effective.

2. Experimental

2.1. Synthesis of PPy-Ag nanocomposite

Polypyrrole silver nanocomposite was prepared by thermal-oxidative polymerisation. For this 20 ml of pyrrole is mixed with 0.5gm of silver nitrate (5 wt%) and heated at 100 °C in a water bath for 4 h. Chloroform and ethanol were added to isolate the product by filtration. The filtered product was washed several times with distilled water and ethanol to remove unreacted Ag^+ ions. The product was dried for 12h at 45–55 °C. Different samples were prepared with 5 wt%, 7.5 wt%, and 10 wt% of silver nitrate.

In the direct way of polymerisation of pyrrole using silver nitrate, without using any other additional solvents, pyrrole was oxidised by silver ions yielding PPy. Silver can act as a strong oxidising agent since the reduction potential of silver and oxidation potential of pyrrole lie in the same region [4]. When pyrrole is heated with silver nitrate, the reaction is supposed to be considered as the reduction of silver nitrate by pyrrole. Silver ions thus formed will initiate the polymerisation and will generate polypyrrole equal to or lesser than the silver ions that might be available for polymerisation. The excess pyrrole will reduce silver ions com-

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PAPER

α-Fe_2O_3/ZnO heterostructure for enhanced photocatalytic and antibacterial activity

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REVIEW ARTICLE

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Progress in organocatalysis with hypervalent iodine catalysts

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Hypervalent iodine compounds as environmentally friendly and relatively inexpensive reagents have properties similar to transition metals. They are employed as alternatives to transition metal catalysts in organic synthesis as mild, nontoxic, selective and recyclable catalytic reagents. Formation of C–N, C–O, C–S, C–F and C–C bonds can be seamlessly accomplished by hypervalent iodine catalysed oxidative functionalisations. The aim of this review is to highlight recent developments in the utilisation of iodine(III) and iodine(V) catalysts in the synthesis of a wide range of organic compounds including chiral catalysts for stereoselective synthesis. Polymer-, magnetic nanoparticle- and metal organic framework-supported hypervalent iodine catalysts are also described.

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1. Introduction

The major challenge of synthetic organic chemistry in the 21st century is the selective synthesis of target compounds in an efficient and economical way using mild reaction conditions. The most striking approach in environmentally benign

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Fateh V. Singh

Fateh V. Singh was born in Ravani Katiry, Bulandshahr, UP, India in 1976. He completed his Masters in Chemistry at SSV College, Hapur, UP, India in 1998. He received his PhD in 2007 under the supervision of Dr Atul Goel, CSIR-CDRI, Lucknow, India. After the completion of his doctoral studies, he was in Prof. H. A. Stefani's research group at USP, São Paulo, Brazil for more than two years. In 2010, he joined as a Marie Curie postdoctoral fellow with Prof. Thomas Wirth at Cardiff University, UK and learned various new reactions regarding organoselenium and hypervalent iodine chemistry. He subsequently stayed with Prof. G. Mugesh at IISc Bangalore, India for more than one year. In 2014, he started his independent career and joined VIT Chennai as an Assistant Professor. His research group is interested in new organoselenium and hypervalent iodine catalysts for organic synthesis.

Samata E. Shetgaonkar

Samata E. Shetgaonkar was born in Morjim, Pernem, Goa, India in 1992. After completing her MSc in Chemistry at Goa University, Goa, India, in 2015, she completed her PhD at VIT Chennai under the supervision of Dr Fateh V. Singh. She has published more than 15 research papers during her doctoral research studies. Her research interest mainly involves the synthesis of novel hypervalent reagents and their application in organic synthesis.

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ORIGINAL ARTICLE

Antimicrobial compound produced by human gut lactic acid bacteria having antifungal activity against aflatoxigenic *Aspergillus flavus* MTCC 2798

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Abstract

Lactic acid bacteria (LAB) are a group of distinguished bacteria that have reserved their place in the food industry, with their probiotic properties as well as their ability to produce many antimicrobial compounds. The antagonistic microorganisms and their bioactive compounds have a potential application as natural bio preservatives as they not only inactivate but also inhibit the growth of undesired microorganisms in food. Hence, the use of LAB and their antimicrobial compounds like organic acids, hydrogen peroxide, diacetyl, bacteriocins, etc. attract considerable interest during the past years. Among the 173 human gut LAB studied 17 isolates showed antifungal activity against aflatoxigenic *Aspergillus flavus* MTCC 2798. All the seventeen isolates produced antimicrobial compounds such as lactic acid, hydrogen peroxide, diacetyl. GC–MS based metabolic profiling of the methanolic extracts of 17 isolates identified 40 metabolites. Thirteen metabolites were identified and reported to have potent antimicrobial activity. The results suggest the antagonistic potential of antimicrobial compounds produced by human gut LAB having significant application in the pharmaceutical and food industry.

Novelty impact statement:

- Antimocrobial compounds were produced by seventeen antifungal human gut Lactic acid bacteria have promising application as food preservative.
- GC–MS based metabolic profiling of the methanolic extracts of 17 isolates identified thirteen metabolites reported to have potent antimicrobial activity.
- Bioactive metabolite Cyclo(leucyl prolyl), was present in the methonolic extract of all the seventeen LAB isolates reported to have anti-aflatoxin activity, thus confirms the anti-aflatoxigenic property of the isolates.

1 | INTRODUCTION

A diverse group of safe, non-pathogenic; gram positive bacteria produce lactic acid as the metabolic end product designated as "lactic acid bacteria" and are traditionally used in the food industry which is capable of providing health benefits to both humans and animals. Nowadays, lactic acid bacteria got great interest exists in the commercial, consumer, and research communities. The human gut lactic acid bacteria play a crucial role in the health and nutritional side of the host like controlling the entry or invasion of the pathogenic microorganisms into the human body by acting as a barrier, improves the nutritional value of the fermented foods, improvement of lactose intolerance, inhibitory action

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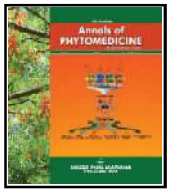

Polyherbal formulation : Open Access

Protective effect of the polyherbal formulation Nalpamaram on the oxidative stress induced by ethanol

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Abstract

Oxidative stress plays a prominent role in the pathogenesis of alcoholic liver diseases. The present study focuses on the protective effect of Nalpamaram on ethanol induced oxidative stress. Male albino rats of wistar strain weighing 200-250 g were divided into different groups. Ethanol, 20% w/v, was administered orally (3 ml/kg b.wt./day), to animals of all the groups for 120 days except normal group of animals. Aqueous extract of Nalpamaram (NMAE) at doses 100, 250 and 500 mg/kgb.wt./day and silymarin at a dose of 100 mg/kg b.wt./day were administered orally for 120 days, to the animals of different groups. After 120 days the rats were fasted overnight, sacrificed and liver was collected and used for various assays. The increased alcohol dehydrogenase levels in ethanol administered rats were found to be decreased in NMAE and silymarin treated groups. The indicators of oxidative stress, thiobarbituric acid reacting substances, conjugated dienes, conjugated trienes and hydroperoxides in the liver of ethanol treated rats were found to be decreased in ethanol + NMAE treated rats. The decreased activities of the antioxidant enzymes superoxide dismutase and catalase, and the levels of reduced glutathione in ethanol administered rats, were increased significantly in ethanol + NMAE treated rats. The activities of glutathione reductase and glutathione peroxidase decreased significantly in ethanol administered rats, when compared with pair fed controls. In ethanol + NMAE treated rats, the activities of these enzymes increased in a dose dependent manner. However, the activity of glutathione S transferase was significantly higher in ethanol-treated rats, which was brought down towards near normal values in NMAE treated rats. The hepatoprotective effect of NMAE can be attributed to the amelioration of oxidative stress induced by ethanol. The effect of NMAE at a dose of 500 mg/kg b.wt./day was comparable to that of the standard drug silymarin at a dose of 100 mg/kg b.wt./day.

1. Introduction

Free radicals have been implicated in the pathogenesis of diseases, such as Alzheimer's, Parkinson's, arthritis, rheumatism, atherosclerosis, AIDS, cataract, cancer, diabetes and degenerative diseases (Hemnani and Parihar, 1998;Venkatesh *et al*., 2001; Tiwari, 2001; Halliwell and Gutteridge, 2015). In biological systems, the highly reactive free radicals also called reactive oxygen species (ROS) are generated from molecules which possess unpaired peripheral electrons (Muriel, 2009). The term ROS refers to chemical species such as superoxide, hydrogen peroxide and hydroxyl radical, which are generated in the human body by the normal metabolic reactions. ROS are generated in the hepatocytes by the action of CYP2E1, mitochondrial respiratory chain alterations and NADPH oxidase (Jezek and Hlavata, 2005).

Oxidative stress plays an important role in the pathogenesis of alcoholic liver diseases by inducing mitochondrial injury, enhancing endoplasmic reticulum stress and lysosomal fragility, and activating the proinflammatory signalling pathways (Ambade and Mandrekar, 2012). The ROS and reactive nitrogen species (RNS) relevant in ethanol induced liver damage include superoxide radical, hydroxyl radical, hydroperoxide radical, lipid radical, peroxy lipid radical, hydrogen peroxide, peroxynitryl radical, nitrogen dioxide and nitric oxide (Galicia-Moreno and Gutiérrez-Reyes, 2014). These ROS and RNS disrupt the cellular integrity by damaging the cellular macromolecules like DNA, proteins and lipids.

Under normal physiological conditions the endogenous antioxidants of the cell balances or neutralises the toxic effect of the ROS and RNS. However, a shift in balance between the prooxidants and antioxidants create oxidative stress (Halliwell and Gutteridge, 2015). Hence, dietary or exogenous, plant derived antioxidants play a significant role in mitigating the cellular oxidative stress.

The antioxidant potential of the plant extracts and polyherbal formulations (PHF) has been reported to have a crucial role in the hepatoprotective action. Their protective effects can be attributed to the secondary metabolites such as phenolic compounds, flavonoids and terpenoids (Mukherjee *et al.*, 2015; Mahmoodzadeh *et al*., 2017; Bakr *et al*., 2018). Many of these compounds have been claimed to possess antioxidant activity due to their free radical scavenging and redox properties (Soni and Sosa, 2013; Kuntal Das *et al*., 2019; Punit *et al*., 2019).

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Phenotypic variations among strains of *Escherichia coli* O157 isolated from raw milk samples collected in Kerala, South India

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ABSTRACT

Entero-haemorrhagic *Escherichia coli* (EHEC) constitutes a heterogeneous group of foodborne pathogens. We characterize 60 *E. coli* O157 serotypes isolated from 97 raw milk samples collected from local milk retailers. The biochemical analysis of the indigenous strains revealed a significant variation from their global counterparts. The study identifies a distinct phenotypic variant of *E. coli* O157 that ferments sorbitol, is urease-positive and produces hydrogen sulphide. The observed heterogeneity points to the inconsistency in the current screening approaches, which mostly depend on biochemical features, and justifies the demand for a universally inclusive standard procedure.

Keywords: Raw milk, EHEC; *E. coli* O157:H7; Shiga-toxigenic *Escherichia coli; STEC;* Sorbitol fermentation

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ORIGINAL ARTICLE

Repetitive extragenic palindromic and enterobacterial repetitive intergenic consensus sequence-based typing of Shiga toxin-producing *Escherichia coli* from bovine samples

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Abstract

The strain typing of Shiga toxin-producing *Escherichia coli* (STEC) is challenging due to its high genetic variability. In the present study, two polymerase chain reaction (PCR)-based typing methods—repetitive extragenic palindromic sequences PCR (REP-PCR) and enterobacterial repetitive intergenic consensus sequences PCR (ERIC-PCR)—are evaluated for their efficacy in differentiating the strains. The present study used 100 strains of STEC isolated from bovine meat, bovine feces, and swabs from the chopping boards. The REP-PCR profiles showed 21 different banding patterns, whereas ERIC-PCR profiles obtained 18 patterns among the tested strains. The dendrogram prepared by the neighbor-joining method formed eight and seven clusters for REP and ERIC-PCR, respectively. The discriminatory indices for the typing methods were 87.83 and 83.03% for REP and ERIC-PCR, respectively. Thus, the clusters based on REP and ERIC-PCR fingerprints were unambiguous and thus could be useful for phylogenetic clustering and epidemiological surveillance. The nonparametric multidimensional scaling plots showed more than 75 and 60% similarities within populations of different REP and ERIC clusters, respectively, regarding its source of isolation, serogroup, and distribution virulence markers. The REP and the ERIC sequences are good molecular markers that offer rapid, cost-effective, and easy molecular typing for STEC strains.

1 | INTRODUCTION

The Shiga toxin-producing *Escherichia coli* (STEC) has been recognized as a public health hazard associated with foodborne illness worldwide (FAO and WHO, 2019). They cause diseases in humans ranging from self-limiting diarrheal diseases to fatal extraintestinal sequelae such as hemorrhagic colitis and hemolytic uremic syndrome. The pathogen colonizes in the intestine of cattle and serves as reservoirs of STEC (Fink et al., 2018), transmitting it to humans through contaminated food. The commonly implicated foods in STEC infections are undercooked beef, milk, beef products, salads, sprouts, and vegetables (FAO and WHO, 2019).

The STEC is a heterogenous group comprising hundreds of serotypes classified based on somatic O-antigen and flagellar H-antigen. The pathogen belongs to two major groups—*E. coli* O157:H7 and *E. coli* non-O157 (FAO and WHO, 2019). Heterogeneity within the species makes the detection of these pathogens difficult. The ubiquitous distribution and frequent implication in foodborne outbreaks made the subspecies level typing of STEC a paramount necessity, especially to establish source attribution and for etiological and epidemiological analysis. We could explain the quick emergence of STEC as highly virulent pathogens based on the phylogenetic analysis, which largely depended on genetic typing methods. Therefore, we require rapid and reliable typing methods for the subspecies level classification of these foodborne pathogenic bacteria.

The key characteristic of STEC pathotypes is their ability to produce prophage encoded Shigatoxins (stx), and the *stx* genes are the standard genetic marker for their detection (Kaper, Nataro, & Mobley, 2004). The widely accepted methods for screening of STEC relied on primer-based detection of *stx1*, *stx2*, intimin, and hemolysin

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Research Paper

The relationship of lipid peroxidation and antioxidant status to selected modifiable risk factors in coronary artery disease patients

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ABSTRACT

Background: Coronary artery disease (CAD) is found to be associated with a wide range of modifiable and non-modifiable risk factors.
Aim of the Study: To evaluate the relationship of lipid peroxidation and antioxidant status to selected modifiable risk factors in angiographically proven CAD patients.
Methods: 150 angiographically proven CAD patients were categorized into three, based on selected risk factors. Data was collected using proforma and from hospital records. Peroxidation and antioxidant levels in blood samples were assessed using standard procedures.
Results: In category, I, significantly higher level of lipid peroxidation and the lower enzymatic antioxidant level were observed in patients with diabetes, hypertension, and with both diabetes and hypertension, when compared with patients without these clinical characteristics ($p < 0.01$). Similar results obtained for patients following a non-vegetarian diet when compared with patients following a vegetarian diet (category II). In BMI based group (category III), patients with BMI>25kg/m2 showed a significant increase in peroxidation and low enzymatic and non-enzymatic antioxidant levels than those with normal BMI.
Conclusion: The study confirmed a strong association between selected modifiable risk factors, higher lipid peroxidation, and lower antioxidant levels in angiographically proven CAD patients. This provides leads in the management of cardiovascular events in CAD patients.

1. Introduction

Coronary artery disease (CAD) is the most prevalent disease with the highest global mortality rate. According to the World Health Organization, CAD accounted for 17.6 million deaths per year in 2016 and maybe expected to rise to 23.6 million by 2030 [1]. Lipid peroxidation is a free-radical mechanism that plays a significant role in cardiac dysfunction pathogenesis [2]. A healthy antioxidant status is therefore critical for human health, in particular, to reduce peroxides and prevent chronic diseases such as CAD.

Different environmental and genetic factors concurrently implicated in CAD [3]. Age, sex, race and family background are the non-modifiable risk factors for CAD whereas the modifiable factors include increased blood pressure, cholesterol levels, triglyceride levels, diabetes, alcohol intake, smoking, eating patterns, obesity, etc. [4]. Several studies on associating risk factors with CAD are available. Researchers have shown a consistent link of hypertension to coronary artery disease [5]. Diabetes mellitus (DM) was also reported to play a major role in the propensity to CAD [6]. Obesity is increasingly recognized as an epidemic and a modifiable risk factor for CAD [7]. Collecting evidence from a host of clinical trials and observational studies, researchers concluded that individual adopting a plant-based diet display 16–32% reduction in cardiovascular disease mortality risk.

Researchers suggested that the effects of risk factors on CAD may differ across ethnic groups [8,9]. The high prevalence of CAD in India may be due to increased genetic risks and predominance of cardiovascular risk factors. Among all Indian states, Kerala has the highest prevalence of coronary artery disease, 7.4% in rural areas and 11% in urban areas [10]. Our previous studies showed that CAD intensity is closely linked to increased lipid peroxidation and decreased antioxidant status when compared to normal healthy subjects [11,12]. Hence, the aim of this study was to examine the relationship of lipid peroxidation and

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INDIAN JOURNAL OF SCIENCE AND TECHNOLOGY

RESEARCH ARTICLE

Kurthia gibsonii Mb126 immobilised chitinase against *Aspergillus flavus*, a fungal pathogen linked to lemon postharvest deterioration

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Abstract

Background of the study: As fungi become resistant to commonly used pesticides, fungicides are becoming not only more expensive, but also less effective in controlling postharvest infections. New chitinase immobilisation techniques are urgently needed to minimize enzyme costs while enhancing bio catalytic performance, antifungal activity, enzyme stability, and reusability. **Objectives:** The objective of this study was to immobilise chitinase of *Kurthia gibsonii* Mb126 by entrapping it in calcium alginate beads and to analyse its antifungal activities against *Aspergillus flavus*. **Methods:** The optimal parameters influencing the immobilization process and the characteristics of soluble and immobilised chitinase of *K. gibsonii* Mb126 were analysed. The antifungal activities of immobilised and free chitinase of *K. gibsonii* Mb126 against *A. flavus*, which was isolated from decayed lemon fruit, were performed using the agar-disk diffusion method. Free chitinase 25.0 mL (0.8 U/mL) and immobilised chitinase 0.06 g (specific activity 124–192 U/mg) were treated on separate lemon fruits for testing antifungal activity against *A. flavus*. **Findings:** *K. gibsonii* Mb126 chitinase was immobilised perfectly in calcium alginate beads. After optimising process parameters of immobilisation (sodium alginate concentration 3%, calcium chloride 0.2 M, 120 min. curing time), the specific activity of *K. gibsonii* Mb126 immobilised chitinase improved to 11.9-fold greater than the free form of chitinase and the immobilisation yield increased to 84%. It was observed that the thermal stability and storage stability of immobilised chitinase were better than those of free enzymes. The immobilised chitinase could be reused, and it retained 78% activity even after 16 cycles. The surface morphology of immobilised chitinase was observed in a scanning electron microscope at different magnification powers. Enzyme kinetics was studied and compared with that of its chitinase soluble counterpart. An *in vitro* study demonstrated that immobilised chitinase of *K. gibsonii* Mb126 has higher antifungal activity against *A. flavus*. *In vivo* experimental study of the

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RESEARCH ARTICLE OPEN ACCESS

Deproteinization of Shrimp Shell Waste by *Kurthia gibsonii* Mb126 immobilized chitinase

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Abstract

This work was aimed at immobilization, characterization, and utilization of chitinase from *Kurthia gibsonii* Mb126. Immobilization of *Kurthia gibsonii* Mb126 chitinase on glutaraldehyde treated chitosan was carried out with immobilization yield of 106%. The optimal factors of the immobilization technique such as concentration of glutaraldehyde, chitinase concentration, and immobilization time were evaluated. After optimizing process parameters of immobilization (Glutaraldehyde concentration 4%, chitinase conc. 60mg, immobilization time 30min.), the specific activity of immobilized chitinase improved to 4.3-fold compared to the free form of chitinase. Temperature and pH optima of the immobilized chitinase and free enzyme were same i.e., 7.5 and 40°C respectively. The relative activity of immobilized chitinase remained 90% at 40°C, at 50°C, and at 60°C for 120 min. In the pH range from 5.5 to 8, the immobilized chitinase retained 100% activity. The results confirmed that the pH stability and thermal stability of chitinase increased by immobilizing chitinase on chitosan. The immobilized enzyme system maintained 90% of its efficiency even after 16 successive reaction cycles. The immobilized chitinase maintained 78% of its activity even after 20 months. Fermentation of prawn shell waste with immobilized chitinase indicated a high level of deproteinization. Deproteinization experiments were carried out with 5mL (0.4 mg/mL) of immobilized and free chitinase on 300 mg/mL of prawn shell waste for 20 days without any additional supplements at 40°C and 6.5 pH. Protein content was reduced from 38.4 to 0.8% with immobilized chitinase. Results suggests the possibility of using immobilized enzymes to remove the prawn shell waste from the environment. To the best of our knowledge there was no such study about the deproteinization of prawn shell waste using immobilized chitinase till the date.

Keywords: Kurthia gibsonii Mb126, Chitinase, Deproteinization, immobilization, chitosan

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Antifungal effects of *Kurthia gibsonii* Mb 126 chitinase as a seed treatment on seed-borne fungi of rice seed on germination percentage and seedling vigor

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PDF [1.3 MB] Article Tools

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Abstract

Soil and seed-borne phytopathogenic fungi are the main factors limiting crop yield in India's agricultural sector. They attack the root of the seed before germination or seedling after germination resulting in huge deprivation in crop yield. In this scenario, it is crucial to control phytopathogenic fungi to ensure sustainable food production to the ever-increasing world population. The antifungal property of purified chitinase of *Kurthia gibsonii* Mb 126 was investigated by isolating fungi infected with seeds of various rice samples and then studying the effect of purified chitinase of *K. gibsonii* Mb 126 on these isolated fungi. The effect of *K. gibsonii* Mb 126 purified chitinase on the germination of rice seed infested with these isolated fungi was also investigated. Eight fungi (*Aspergillus niger, Aspergillus flavus, Curvularia lunata, Fusarium moniliforme, Rhizopus oryzae, Trichoderma harzianum, Rhizoctonia solani, and Fusarium subglutinans*) were isolated and identified from the different rice varieties of Kerala, India, viz Aswathy (PTB 37), Jaya, Sabari (PTB 40), Ahalya, Onam, Makam, Triveni (PTB 38), Swarnaprabha, Kairali, Pavizham, and Ponni, The frequency of isolated fungi ranged from 46% to 100% (present in all the 20 samples). The isolated fungi *C. lunata, A. flavus, R. solani* and *A. niger* were predominated. Seeds treated with the *K.*

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ORIGINAL PAPER

Nanosilica Entrapped Alginate Beads for the Purification of Groundwater Contaminated with Bacteria

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Abstract

Nowadays the World is facing a scarcity of safe drinking water and the water sector encounters great challenges. The impact of a growing population and the change of climate on water availability and quality; public health and environmental issues related to emerging pollutants are the major challenges that need to be addressed. In drinking water, there may be a chance of having water-related diseases and health issues due to the occurrence of some pathogens. In the present study, we synthesized nanosilica from rice husk and it was encapsulated with sodium alginate beads and tested its efficiency for removal of bacteria from drinking water. These beads are novel since it is fully bio-origin, biodegradable and cost-effective. The isolated nanosilica were characterized spectroscopically and morphologically (FT-IR, XRD, FESEM, and HRTEM). The synthesized beads were characterized by FT-IR, FESEM, and EDX and antibacterial analysis. Using the Petrifilm method and column disinfection experiment, different filler loadings were optimized and found that higher content (1.25 g) of nanosilica reduced bacterial contamination of drinking water. The alginate-nanosilica beads are cost-effective compared to alginate beads incorporated with other nanomaterials. The antibacterial evaluation verified superior antibacterial efficacy against E.coli. The prepared alginate-nanosilica beads can be used in the wastewater treatment industry, as an effective antibacterial agent.

Keywords Nanosilica · Alginate · Groundwater · Bactericidal activity

1 Introduction

Owing to the increasing demand for drinking water, researchers are facing a challenging task to develop materials that should easily remove the contaminations in drinking water as well it should not make any harm to nature. Both developed and developing countries are facing this serious issue [1]. Every year water-borne diseases kill a large population. Many people in developing countries depend on water resources like rivers, ponds, wells, streams, etc. Due to bacterial contamination, the water turns unsafe to drink [2]. Researchers are focused on the decontamination of water over decades [3]. Many of the scientists are focussing on developing bio sorbents for effectively resolving water-related issues [4]. Y. Orooji, et al. [5] used two distinct methods, such as hydrothermal, co-precipitation-sonication processes and, the very active visible light photocatalysts, silver iodide-graphitic carbon nitride (AgI/g-C_3N_4) nanocomposites were synthesized and analyzed. This technique has got a lot of interest since it converts organic pollutants into innocuous inorganic chemicals (such as H_2O, CO_2) that don't cause any harmful pollution in the future. The

Highlights
- Nanosilica was extracted from Rice husk, an agro-waste.
- Nanosilica were reinforced in Alginate beads.
- The new environmentally benign beads were efficient in removing bacteria from contaminated groundwater.
- The beads have shown 92% of disinfection efficacy with 20 min of HRT, indicating that the beads can be used more extensively.
- This research can be scaled up to a low-cost water filtration system to assure clean water in contaminated locations.

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Influence of Magnesium Doping on the Photocatalytic and Antibacterial Properties of Hematite Nanostructures

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Herein, the effect of magnesium doping on hematite nanostructures prepared by a simple and cost-effective electrochemical method is reported. Photocatalytic and antibacterial studies on the undoped and doped samples suggest improved performance for the Mg-doped samples. Structural studies using X-ray diffraction, Raman spectroscopy, and X-ray photoelectron spectroscopy (XPS) in combination with field-emission scanning electron microscopy for surface morphology confirm the Mg presence in the nanostructured hematite phase of iron oxide. Analyses of the valence band (VB) XPS spectra along with optical reflectance spectra indicate a shift in VB edge, characteristic of a conductivity type conversion from n-type in hematite to p-type in Mg-doped hematite. The room temperature electrical conductivity is increased by three orders, and the optical bandgap is reduced by around 0.08 eV for moderately doped hematite nanostructures.

1. Introduction

This is an era when concerted efforts are put in by environmentalists and scientists in planning strategic techniques for restoring a clean and healthy environment for habitation. The conventional practice of discharging harmful chemicals and pollutants into water bodies and poisonous gases into the air from factories pose a serious threat to living beings. Due to the havoc produced by the pollutants and infected habitat, the research for techniques and materials for the removal of pollutants and the disinfection of pathogenic bacteria is gaining wide interest in the present world.

Photocatalysis is one of the cheapest and most eco-friendly techniques employed for the removal of dyes and other organic pollutants from water.[1,2] The significant improvement noted in the photocatalytic efficiency of the most stable oxide of iron, hematite (α-Fe_2O_3) when doped with metals such as Pt, Sn, Zn, Cr, and Ta has been previously reported.[3–7] The reason for the increased efficiency has been attributed to reduced recombination rate of e-hole carriers and increased charge separation. In this article, the effect of Mg doping on the photocatalytic and antimicrobial action of hematite is investigated. A few reports are available in the literature on the study of photoconversion and water-splitting efficiency of Mg-doped iron oxide as adsorbents of various chemicals.[8–10] A study undertaken by Ingler et al.[8] using Mg-doped iron (III) oxide thin films prepared by spray pyrolysis reported a maximum photoconversion efficiency of 0.33%. A hydrothermal method was utilized by Cai et al.[9] to prepare tin and magnesium co-doped hematite films as photoanode for water splitting that attained a maximum photocurrent density of 1.1 mA cm^{-2}, which was better than the pristine α-Fe_2O_3 by three times. The improvement in its performance was ascribed to the increase in charge injection efficiency and charge separation efficiency due to Mg doping. Li and coworkers [10] fabricated a homojunction photoelectrode by a hydrothermal method with Mg-doped α-Fe_2O_3 on phosphorous-doped α-Fe_2O_3 and studied its performance in photoelectrochemical water splitting. The higher charge separation resulted due to the formation of homojunction which created a built-in electric field. In contrast, nano-structured Mg-doped Fe_2O_3–ferrihydrite powders synthesized by co-precipitation technique were utilized by Mohapatra and group [11] for the removal of cations—Pb(II), Cd(II), Cu(II), and Co(II)—from aqueous solution. The maximum rate of adsorption of 0.024 min^{-1} was obtained by them for the cobalt cation. They also prepared Mg-doped nano-ranged hematite by surfactant cetyl trimethyl ammonium bromide (CTAB) mediation–precipitation technique for fluoride adsorption, and an adsorption rate of 0.0072 min^{-1} was achieved.[11] However, our literature survey revealed that no reports are available on the use of Mg-doped hematite for

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REVIEW ARTICLE

A comprehensive review on phenol-formaldehyde resin-based composites and foams

Lakshmipriya Ravindran, Sreekala M. S., Anil Kumar S., Sabu Thomas

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Abstract

This article covers the introduction to polymer composites, phenol formaldehyde resin, phenol formaldehyde composites, and foams along with their properties and

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RESEARCH ARTICLE OPEN ACCESS

Exoenzyme Profiling of Soil Bacteria from Thattekad Bird Sanctuary for Bioprospection

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Abstract

Thattekad bird sanctuary, located in the Western Ghats of Kerala, India, which hosts an unexplored microbial community, is selected for the present investigation. Microbes play a major role in mineral recycling and nutrient absorption by the flora and fauna in the habitat. Various bacterial extracellular enzymes facilitate all these activities. The increasing demand for microbial enzymes in favor of green technology encouraged us to focus on exoenzyme profiling of bacterial isolates from forest soil samples. The present study is aimed at the screening and identification of exoenzyme producing soil bacterial strains isolated from evergreen forests and moist deciduous forests of Thattekad bird sanctuary. In this study, only multienzyme producing bacteria were selected for detailed analysis because such bacteria are highly relevant in multi-enzyme dependent processes such as biowaste degradation. We screened for nine hydrolytic exoenzymes namely, amylase, cellulase, ligninase, pectinase, xylanase, caseinase, gelatinase, esterase and lipase, and identified 79 multienzyme-producing bacterial strains, mostly belonging to phylum *Firmicutes* and *Proteobacteria*. *Firmicutes* from evergreen forests and moist deciduous forests produced a greater number of enzymes compared to *Proteobacteria*. Also, bacterial strains isolated from evergreen forest soil produced more enzymes compared to moist deciduous forest. *Bacillus amyloliquefaciens strain TBS040* isolated from moist deciduous forest soil was found to produce all the nine enzymes screened. Enzymatic hydrolysis of biowaste using cell free crude enzyme extract from *Bacillus velezensis* strain TBS064 resulted in enhanced bioethanol production. These findings highlight the importance of screening unexplored habitats for the identification of novel strains, which can contribute to the future of green technology.

Keywords: Forest Soil, Bacterial Exoenzyme Profiling, Functional Metagenomics, Bioethanol, Biowaste

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ORIGINAL ARTICLE

Composites of resorcinol and hexamethylenetetramine modified nanocellulose whiskers as potential biofiller in natural rubber latex: synthesis, characterization and property evaluation

Seena K. Thomas[1,2] · P. M. Sabura Begum[1] · P. Dileep[3] · K. V. Neenu[1] · Deepthi Anna David[1] · Ansa Santu[1] · C. D. Midhun Dominic[4]

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Abstract

Surface modification of nanocellulose to improve its compatibility with the polymer matrix is gaining considerable attention these days. Herein, nanocellulose whiskers (NCW) extracted from *Acacia caesia* were modified with resorcinol and hexamethylenetetramine (RH) by the refluxing method. The characteristic properties of RH-modified NCW were studied using field emission scanning electron microscopy (FESEM), high-resolution transmission electron microscopy (HRTEM), energy dispersive X-ray spectroscopy (EDX), Fourier transform infrared spectroscopy (FTIR), dynamic light scattering (DLS), X-ray powder diffraction (XRD), thermogravimetric analysis (TGA) and UV–visible diffuse reflectance spectroscopy (UV-DRS). A marginal decrease in crystallinity index was observed by surface modification, whereas the thermal stability (T_{max}) of the NCW increases by 32 °C on surface modification. The potential of modified filler in improving the properties of natural rubber latex (NR) was studied by comparing its mechanical, thermal, diffusion, permeability and biodegradability properties with neat NR and NR-NCW composites. Upon 2 phr filler loading, the tensile and tear strengths of modified NCW composites increased by 26 and 38% accordingly compared to the NR-neat. The better filler matrix interaction resulted in the marginal positive shift in the glass transition temperature, transport properties and T_{max} of the modified composite. The incorporation of NCW also enhanced biodegradability and reduced the permeability of the prepared composites.

Keywords *Acacia caesia* · Hexamethylenetetramine · Nanocellulose whiskers · Natural rubber · Resorcinol

1 Introduction

Modern research is focused on biomaterial-based systems for producing fresh, eco-friendly and defensible goods due to environmental concerns and sustainability considerations [1]. To reduce the ecological problem, a biopolymer used in the elastomeric industry is natural rubber due to its high extensibility and use as a potential raw material in flexible packaging, gloves, food wraps, belts, foot wears, etc. However, the lower mechanical strength and abrasion resistance of the raw form of natural rubber limit its usefulness in diverse applications [2]. So, an effective filler should be provided to enhance the properties of natural rubber for forward looking requisites.

Lately, natural fillers like cellulose, lignin, starch, chitin, chitosan, xylose, etc. gained prominence in composite materials due to their environmental friendliness. These fillers can effectively minimize the drawbacks of petroleum based

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Research Article

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Salutary attributes of probiotic human gut lactobacilli for gut health

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Abstract

Lactobacilli are GRAS organisms and are important members of gut microbiota. They have been strongly recommended as probiotics because of many benefits provided by them to overall human health. Human gut lactobacilli with salutary properties can provide additional advantages. *Limosilactobacillus fermentum*L1 MW600457, *L. fermentum*L3 MW600480, *L. fermentum*L4 MW600464, *L. fermentum*L5 MW600493, *L. fermentum*L6 MW600495, *L. fermentum*L7 MW600496, *L. fermentum*L8 MW485761, *Lactiplantibacillus plantarum*L9 MW485746, and *Ligilactobacillus salivarius*L10 MW600498 with *in vitro* probiotic properties were explored for salutogenic characteristics. Salutary properties like β-galactosidase activity, anthelminthic property assay, anti-inflammatory assay, antidiabetic study, cholesterol assimilation assay, and biofilm assay were performed. All the isolates were positive for β-galactosidase activity. The anthelminthic property with minimum paralysis time and death time between 16–25 min was shown by *L. fermentum*L8 MW485761. Anti-inflammatory activity with bovine serum albumin was maximum at 200 μg ml^{-1} concentration. α-amylase inhibitory activity was maximum for *L. fermentum*L8 MW485761 (51%). Maximum cholesterol assimilation was reported for *L. fermentum*L6 MW600495 (76%). Strong biofilm forming ability for all isolates improved the colonization and stability as probiotics. Human gut lactobacilli with salutary properties can make an efficient probiotic.

Significance and impact of the study

The scientific evidence of beneficial effects of gut microbiota on human health has promoted novel probiotic microorganisms. Lactic acid bacteria are the most important representatives of probiotics. Lacobacilli are Gram positive rods, catalase, and oxidase negative; having generally recognized as safe status. Human gut lactobacilli as probiotic, is a safe alternative for the treatment of many gastrointestinal disorders. Our study is on the salutary attributes associated with probiotic human gut lactobacilli, which could help in prevention of many disorders and also treat many diseases.

Keywords: salutary attributes, lactobacilli, anthelminthic, antiinflammatory, antidiabetic, biofilm, probiotics

Introduction

Probiotics are live microbial feed supplements that beneficially affect the host animal by improving its intestinal microbial balance. Probiotics can be defined as live microorganisms, which then administered in adequate amounts provide health benefits to the host (FAO/WHO 2002). *Lactobacillus* spp. is a widely used probiotic bacteria and they are generally recognized as safe (GRAS) organisms (Pino et al. 2019). Lactic acid bacteria (LAB) as probiotics have been studied frequently for potentially imparting specific health benefits such as lactose-fermenting property, anti-inflammatory property, antidiabetic property, anthelminthic property, etc. to the host.

Probiotics with lactose-fermenting property can be used as a therapeutic agent for lactose intolerance, which is a common disorder of intestinal lactose indigestion. Detection of the bacterial enzyme β-galactosidase responsible for lactose fermentation in the colon can represent the presence of LAB. *Lactobacilli* mostly produce β-galactosidase, helps lactose digestion thus alleviating the symptoms of lactose intolerance (Zhong et al. 2004).

Commercially available drugs for helmintic infections are losing their effectiveness because of resistance developed by nematodes against commonly used drugs. Various organic metabolites produced by lactobacilli are responsible for the anthelminthic property. The use of *Lactobacillus* and its metabolites as anthelmintic agents have been found to be effective against helminthic infections (Bharti et al. 2016).

Probiotic bacteria play an important role in balancing the natural gut microflora and are used as an alternative approach for prevention and therapy of several intestinal inflammatory disorders (Jain and Mehta 2017). Imbalance of intestinal microflora causes intestinal inflammation and infections. The anti-inflammatory properties of probiotics include blocking of pathogenic effects by producing antibacterial compounds, competitive inhibition of pathogens and toxins by adhering to intestinal epithelium thus regulating mucosal immune responses (Menard et al. 2004).

The excessive intake of high-calorie food can lead to many chronic diseases such as obesity, type 2 diabetes mellitus, hyperlipidemia, etc. The population of obese people and the number of people with diabetes is increasing globally every year. *Lactobacillus can* reduce the absorption of intestinal carbohydrates (Rueben et al. 2019) thus showing antidiabetic property, a strain specific character.

In recent years, food with components that recommend additional health benefits such as cholesterol reduction proper-

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Thermal diffusivity study of one-pot synthesised polypyrrole silver nanocomposite by thermal lens method

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ABSTRACT

We are reporting the results of our exploration of the thermal lens method to determine the thermal diffusivity of Ppy and Ppy/Ag nanocomposites synthesised by simple, cost effective in situ chemical oxidative polymerisation. EDAX spectrum confirms the presence of silver in the samples. Raman analysis shows that the increase in the concentration of silver in composite results in an increase in the conjugation length of the samples. We have adopted the dual-beam pump-probe technique to determine the thermal diffusivity of polypyrrole and polypyrrole silver nanocomposite with varying silver concentrations. We report suppression of thermal diffusivity of polypyrrole with the addition of a small concentration of silver and an enhanced thermal diffusivity with an increase in the concentration of silver with ethanol as the base fluid. Increased thermal diffusivity of the samples makes them suitable for use as coolants.

1. Introduction

Thermal diffusivity is a material-specific thermal property represented by the ratio of its thermal conductivity to the product of specific heat and density. Different methods such as photoacoustic spectroscopy [1], laser flash technique [2], hotwire technique [3], photopyroelectric technique [4] and thermal lens (TL) technique have been used to measure thermal diffusivity. The TL technique is a highly sensitive photothermal technique used to determine thermal diffusivity. In addition, the TL technique is based on the measurement of temperature variations arising from the nonradiative relaxation of the sample molecules that get excited by energy absorbed from the pump laser source [5]. The advantages of this technique are high sensitivity since it measures absorbed optical energy directly, accuracy, applicable even with small volume of the sample, and dependency on thermo-optical properties of solvents [6–8].

Among the various polypyrrole (Ppy) metal nanocomposites, Ppy silver (Ppy/Ag) nanocomposite has attracted the attention of many researchers due to its prospective applications in various fields such as sensors, biosensors, supercapacitors, and drug delivery [9–11]. *Bharti et. al.* have reported the thermoelectric performance of Ppy/Ag films and they found out the thermal diffusivity of the film by laser flash technique [12]. Thermal diffusivity measurement by the TL technique is a more accurate and sensitive method and to the best of our knowledge, no work has yet been reported in which the thermal diffusivity of Ppy/Ag nanocomposite is measured using the TL technique. In this paper, we report the results of primary investigations of thermal diffusivity of one-pot synthesised Ppy/Ag nanocomposite by TL technique in view of exploring the possibility of using this as a material for thermoelectric power generation and also for using as coolants. For thermoelectric power generation reduction in thermal diffusivity is a favourable condition and we achieved a 59.7% reduction in the thermal diffusivity of Ppy alone by the addition of a low concentration (5 wt%) of silver nanoparticles into it.

2. TL technique - theory

The TL effect arises from the non-radiative relaxation of the excited molecules in the sample irradiated by a pump laser beam of suitable frequency that has a Gaussian intensity profile. The non-radiative relaxation of the sample molecules generates heat that leads to a refractive index gradient across the beam width producing a thermal lens. The thermal lens formed will be diverging or converging depending on the sign of refractive index gradient with temperature. Most liquids

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A model of foreground emission in UV using GALEX deep observations

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Abstract

Foreground emission, mainly airglow and zodiacal light, is a significant contributor in an ultraviolet observation especially from low earth orbit. Its careful estimation and removal are tedious yet unavoidable processes in the study of diffuse UV radiation and by extension interstellar dust studies. Our analysis of deep GALEX observations show that airglow is not only a function of Sun angle but also a strong function of Solar activity at the time of observation. We present here an empirical model of airglow emission, derived from GALEX deep observations, as a function of 10.7 cm Solar flux and Sun angle. We obtained the model by training machine learning models on the data using a variant of the regression algorithm that is both resilient toward outlier data and sensitive to the complexities of the provided data. Our model predictions across various observations show no loss in generalization as well as good agreement with the observed values. We find that the total airglow in an observation is the sum of a baseline part (AG_c) that depends on the Solar flux and Sun angle, and a variable part (AG_v) that depends on the Sun angle and the time of observation with respect to local midnight. We also find that the total airglow can vary between 85 – 390 photon units in FUV and 80 – 465 photon units in NUV.

Keywords: Solar activity; Solar cycle; Astrophysical phenomena; Upper atmosphere; Astronomical space missions and instrumentation

1. Introduction

Interstellar gas and dust play a major role in the formation and evolution of galaxies. However, its observation is difficult due to its diffuse nature and low surface brightness. Since the dust grains absorb stellar radiation field energy in Ultraviolet (UV), and emit in Infrared (IR), the diffuse UV radiations can help track this transfer of energy, making the study of diffuse UV sky an integral part of Interstellar dust studies (Bowyer, 1991; Henry, 1991).

With the launch of the Galaxy Evolution Explorer (GALEX) in 2003, the availability of high spatial-resolution (4.5–6″) observations from GALEX in large scale revolutionized the study of diffuse ultraviolet sky (Sujatha et al., 2010) in the same way that the Infrared Astronomical Satellite (IRAS) data has enabled advancements in the study of diffuse IR sky (Low et al., 1984). While analyzing GALEX data, Murthy et al. (2010) found that the intensity of diffuse emission is highest near the Galactic plane and decreases drastically towards high latitudes. In the low-to-mid latitudes, dust scattered starlight is the major contributor of diffuse UV sky while at high latitudes, the faint emissions from extra-galactic sources dominates (Burrows and Mendenhall, 1991; Henry, 2002; Murthy, 2009).

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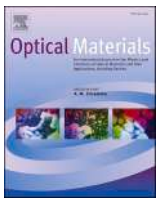

Research Article

Surface plasmon resonance induced impressive absorptive nonlinearity from C-2-phenylethenilcalix [4]resorcinarene silver hybrid system

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ABSTRACT

We experimentally demonstrate the enhanced absorptive nonlinear response from a hybrid system developed through the noncovalent interaction of C-2-phenylethenilcalix [4]resorcinarene (CPECR) with the silver nanoparticles (Ag NPs). The modified absorption spectrum and significantly reduced emission spectrum confirm the hybrid system formation. The characteristic shift in the Raman peaks ensures the charge transfer between CPECR and Ag. The absorptive nonlinearity of the hybrid system at the surface plasmon resonance (SPR) band of Ag NPs was studied by the z-scan method using a Q-switched Nd: YAG laser with nanosecond pulsed beams having a repetition rate of 10 Hz at 532 nm. The dominance of the hybrid system formation over the pure system is the emergence of impressive nonlinear response at low input intensity resulting from the synergistic effect of effective two-photon absorption, the photo-induced charge transfer between CPECR and Ag and the local field effect produced by the SPR of Ag NPs.

1. Introduction

The nonlinear optical system is a promising field for designing optoelectronic devices mainly focused on the nonlinear nature of organic materials and inorganic semiconductors [1–4]. Nonlinear optics (NLO) always pay close attention to poly-conjugated organic materials due to their rapid and significant optical response, good chemical stability, and tunable optical properties [5,6]. Donor-acceptor systems are suitable for NLO studies since intramolecular charge transfer provides extended delocalization of π electrons, resulting in increased polarizability and, thus, enhanced nonlinear response. Hybrid organic-inorganic materials have been an ever-growing field in recent decades because their revised properties find application in versatile areas such as sensors, electronics, optics, energy storage, energy conversion, etc. [7–9]. Hybrid materials with superior NLO properties are developed through the covalent or noncovalent interaction between an organic dye with nano-sized inorganic or organic matrices [10,11].

Molecular clusters formed through hydrogen bonds, electrostatic interaction, stacking interaction, charge transfer interaction, etc., are potential functional materials in optics and nonlinear optics [11,12]. Among these noncovalent interactions, hydrogen bond interactions are crucial for various applications because the properties of the subsystem involved are undisturbed compared to isolated molecules. Metal nanoparticles are essential for developing optical applications due to their unique surface plasmon resonance (SPR) band arising from the interaction of visible light with their free electrons in the conduction band, leading to intensified near-field effect. Nanoparticle-based novel materials exhibit outstanding material properties due to their size between molecular and bulk regimes, which find applications in ultrafast optical communication and optical data storage [13,14].

The primary motive of the present work is to identify the third-order nonlinearity of C-2-phenylethenilcalix [4]resorcinarene (CPECR). To enhance the identified nonlinearity of CPECR, we developed a novel hybrid system through its noncovalent interaction with silver nanoparticles (Ag NPs). Calix [4]resorcinarenes, a resorcinol-derived calix [4]arenes, provide a host lattice for versatile guest molecules [15,16]. Bredas et al. studied the second-order polarizability of different conformers of calix [4]arene [17]. The NLO polarization of calix[n]arene with many geometrical arrangements was investigated by Datta et al. [18]. Third-order nonlinear optical studies of calixarenes/ calix [4] resorcinarene are not explored well to the best of our knowledge [19].

Kongor et al. reviewed the interaction of calixarenes with metal nanoparticles and their ability to modifying, reducing, stabilizing, and functionalizing the nanoparticles [20]. Calixarenes' hollow cavities and

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