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Landslide mechanisms along carbonate rock cliffs and their impact on sustainable development: a case study, Egypt

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Abstract

Recently, Egypt has faced unprecedented development with rapid urban and infrastructure expansion. Vast areas of Egypt are underlain by karst rocks (carbonate and evaporite). Highways and roads constructed along these karst areas are susceptible to slope stability problems. Various factors could trigger different landslides along the carbonate rock cliffs and slopes. Hence, urgent actions need to be considered to understand the landslide mechanisms that could occur along these cliffs and slopes. Carbonate rock cliffs and slopes along with some highways in Sohag-Assiut area, Egypt, were chosen as a case study in this work. Field and laboratory investigations were carried out as tools in understanding and identifying these failure mechanisms. In addition, remote sensing high-resolution images were applied to help in identifying different features, causing slope instability. Our finding indicated that five landslide mechanisms in carbonate rock cliffs and slopes were identified and categorized. These five slope instability mechanisms are including collapses of weak materials from filled caves, the breakdown of caves, instability due to differential erosions, dissolution along discontinuities, and sliding along weak surfaces. This study could help the decision-makers and planners to understand the causes of slope instability problems, to maintain the sustainability of the infrastructure, and to design appropriate prevention and remediation measures to avoid future problems.

Keywords Field and laboratory investigations · Slope stability · Carbonate slopes · Egypt

Introduction

One of the most common definitions of landslides is the movement of different materials (rocks, detritus, and/or soils) by the action of gravity leading to an observable and catastrophic event (fall, slide, topple, and/or soil movement) (Cruden and Varnes 1996; De Blasio 2011). Transportation lines (roads, highways, and railways) in the different region around the world are exposed to various types of landslides (e.g., rockfalls, rockslides, debris flows, and soil slides) wherever they cut across or skirt along mountains, posing risks to the travelers (death or injury), blocking the highway. Also, urban areas are affected by landslides, especially old buildings with inadequate foundations and new buildings that are not designed to bear displacements induced by landslides, are prone to damage and collapse (Nicodemo et al. 2017; Peduto et al. 2017). These increase the repair costs of transportation lines and the infrastructure and affected the local economies and the environment (Bateman 2003; Hungr et al. 1999; Raju et al. 1999; Ferlisi et al. 2012; Palma et al. 2012a; Youssef et al. 2012; Budetta et al. 2016, 2017). Kay et al. (2006) believed that geological structures, lithology, water, and karst are very active factors in triggering landslides. Perret et al. (2004) proved that the direction/type of discontinuities and the quantity of the overhang materials control the size, shape, and detachment position of the blocks.

Karst has a relevant role in triggering different instability phenomena, which did not receive considerable attention in previous decades. However, in recent years, several works have dealt with the different slope stability problems associated with various karst features (Ford and Williams 1989; Williams 1993; Vermeulen and Whitten 1999; Santo et al.

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Research Paper

Landslide susceptibility mapping using machine learning algorithms and comparison of their performance at Abha Basin, Asir Region, Saudi Arabia

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ABSTRACT

The current study aimed at evaluating the capabilities of seven advanced machine learning techniques (MLTs), including, Support Vector Machine (SVM), Random Forest (RF), Multivariate Adaptive Regression Spline (MARS), Artificial Neural Network (ANN), Quadratic Discriminant Analysis (QDA), Linear Discriminant Analysis (LDA), and Naive Bayes (NB), for landslide susceptibility modeling and comparison of their performances. Coupling machine learning algorithms with spatial data types for landslide susceptibility mapping is a vitally important issue. This study was carried out using GIS and R open source software at Abha Basin, Asir Region, Saudi Arabia. First, a total of 243 landslide locations were identified at Abha Basin to prepare the landslide inventory map using different data sources. All the landslide areas were randomly separated into two groups with a ratio of 70% for training and 30% for validating purposes. Twelve landslide-variables were generated for landslide susceptibility modeling, which include altitude, lithology, distance to faults, normalized difference vegetation index (NDVI), landuse/landcover (LULC), distance to roads, slope angle, distance to streams, profile curvature, plan curvature, slope length (LS), and slope-aspect. The area under curve (AUC-ROC) approach has been applied to evaluate, validate, and compare the MLTs performance. The results indicated that AUC values for seven MLTs range from 89.0% for QDA to 95.1% for RF. Our findings showed that the RF (AUC = 95.1%) and LDA (AUC = 941.7%) have produced the best performances in comparison to other MLTs. The outcome of this study and the landslide susceptibility maps would be useful for environmental protection.

1. Introduction

Landslides are the common mass wasting processes along the mountainous regions of Saudi Arabia, where many cities, highways, and roads are located along the Arabian Shield (southwestern and western parts of the kingdom territory) (Youssef et al., 2012, 2013, 2014a, b; Youssef and Maerz, 2013; Elkadiri et al., 2014; Maerz et al., 2014). Different types of landslides (e.g., rock falls, rock and soil sliding, and debris flows) in Saudi Arabia are usually triggered by intense rainstorms (Youssef et al., 2013, 2016). This problems will be augmented in the future due to urban area and highway expansion along mass wasting prone areas (rugged mountainous and steep slopes). This is especially true in Asir Region, Saudi Arabia, where thousands of people live in this mountainous region and commute along escarpment highways, which consider high-risk threat areas related to landslides. Therefore, it is essential to assess and prevent landslide disasters for this area.

Landslides represent the most damaging natural hazards in the mountainous areas of different parts of the world, causing loss of human life, property damage, and consequently economy crisis. These landslides triggered due to various external factors, including heavy rainfall, earthquakes, volcanoes, and anthropogenic activities (Guzzetti et al., 2007; Lin et al., 2007; Hadi et al., 2018; Roback et al., 2018; Strupler et al., 2018; Gordo et al., 2019; Roccati et al., 2019). To overcome these problems, landslide susceptibility maps can play a crucial role in determining the most vulnerable areas for landslides. These models can be prepared using different landslides-conditioning factors (e.g., lithology, lineaments, geomorphology, soil type and depth, slope angle, slope aspect, curvature, altitude, engineering properties of the lithological material, land use patterns, and drainage networks). Various studies have been carried out on landslide susceptibility assessment using remote sensing and GIS techniques (e.g., Saha et al., 2005; Pradhan et al., 2010a, 2010b; Pradhan and Youssef, 2010; Bednarik et al., 2012; Mohammady

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Research Article

Manipulation of optical properties in thin tetradymite layers

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ABSTRACT

Thin Bi_2Se_3 layers are promising material for many optical and optoelectronic applications. In this work, thin crystalline layers of Bi_2-chalcogenides were deposited on highly cleaned glass substrates by vacuum thermal evaporation technique. The optical properties of the concerned layers were investigated with ultraviolet–visible-near infra-red (UV–Vis–NIR) spectra. The effect of thickness reduction and the annealing treatment have been studied. Thinning the film to few nanometers resulted in a significant enhancement of light transmission through the prepared materials. Also, simultaneous reduction of layer's thickness and annealing treatment significantly improved the optical transmission. Such transmissivity enhancement opens avenues for transparent electrode applications.

1. Introduction

Not only graphene, but a lot of other layered materials can also be thinned down into two-dimensional nanostructures and monolayers [1,2]. Two-dimensional (2D) materials, which known as materials having two dimensions outside the nanometric scale, can be assembled layer by layer to form a van der Waals heterostructure [3]. Interestingly, at one-atom thick, it was found that graphene is a perfect material for electronic conduction and for thermal conduction as well. That is why graphene-based materials are suitable for many applications such as transparent conductors, thermal interfaces and barristor transistor devices [4]. As is well known, transparent electrodes are quite necessary in devices such as emitting diodes based on organic materials, thin transistor films, and solar cells. 2D materials are of great interest for theoretical and experimental research, this interest stems from the fact that all features of the material change to something uniquely and completely different from those of the initial bulk material as they are miniaturized from their bulk form to fewer and fewer layers and eventually to a single layer.

Dichalcogenides show layered structure. Layers are strongly bonded in plane, whilst they are weakly connected in interlayers via van der Waals bonds. Therefore, they can be easily exfoliated into atomically thin layers through various methods. Additionally, they show layer-dependent optical and electrical properties. When exfoliated into monolayers, the band gaps of several dichalcogenides change from indirect to direct [5], which lead to broad applications in nanoelectronics and optoelectronics [6,7].

As a member of the 2D materials family, Bi_2X_3 (X = Se, Te) has been widely investigated for thermoelectricity [8–11]. Moreover, it was discovered that Bi_2X_3 materials are topological insulators, the matter which has led to an intensive research attention on these materials [12–16]. Those materials exhibit a layered crystal structure in the form of rhombohedral structure. Each layer of that structure is composed of five covalently bonded atomic planes, X-Bi-X-Bi-X, known as a quintuple layer. The quintuple layers of Bi_2X_3 based chalcogenides are connected together with van der Waals forces to form the Bi_2X_3 crystal structure. Importantly, tunable optical transition in ultrathin layered 2-dimensional (2D) materials reveals the electronic structure of materials and provides exciting possibilities for potential applications in optics and photonics [17]. Because of the interesting optical features of 2D materials, numerous applications have been proposed for integrated photonics such as waveguide polarizers and amplifiers [18] and Q-switched

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Baseline

Microplastic distribution, abundance, and composition in the sediments, water, and fishes of the Red and Mediterranean seas, Egypt

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ABSTRACT

This study records the extent of microplastics (MPs) in the surface water, sediments, and fishes of the Mediterranean and Red seas in Egypt. In sediment and water samples, the Ras Gharib station in the Red sea and Damietta and Port Said stations in the Mediterranean sea exhibited the highest microplastic abundance, while the lowest concentration was found in the Ain Sukhna station in the Red Sea and Marsa Matruh station in the Mediterranean sea. Rayon and polyethylene terephthalate were the most frequently found polymers in fishes. The results highlighted the abundant existence of microplastics in sediments, water, and fishes of the Mediterranean and Red seas, thereby improving our understanding of the environmental risks posed by microplastics to fisheries and marine ecosystems and the need for measures to diminish the flux of plastics to the marine settings.

Plastics are produced from the polymerization of molecular monomers extracted from gas or oil for utilization in human activities (Mahat, 2017; North and Halden, 2013). The annual production of plastic has increased from 1.5 million tons in the 1950s to 359 million tons in 2018 (PlasticsEurope, 2019), with only 9% of the recycled plastics in the USA (Cessi et al., 2014). Non-recycled plastics are thrown away in landfills (Barnes et al., 2009) where they pollute the environment (Cole et al., 2011). Plastic pollution negatively affecting the marine environment has been a concern since the 1970s. Back then, the initial reports of fishes ingesting microplastics (MP) were published (Carpenter et al., 1972), and it was attributed to the fact that 80% of marine debris was plastic as it is of a durable nature (Barnes et al., 2009). However, plastic accumulation in the form of litter in the marine environment has become pervasive pollution (Frias et al., 2010), and it has been well documented that degradation and fragmentation of plastic debris create MPs (Browne et al., 2011). These small-sized (<5 mm) plastics are produced not only from the degradation of larger plastics (secondary microplastics) but also from previously used beads and fabrics used in personal care or industry products (primary microplastics). The widespread and physiological effects of MP ingestion have been reported lately (Cole et al., 2011; Rochman et al., 2015). Many types of plastic polymers were found in the environment, including polyethylene (PE), polyvinyl chloride (PVC), polystyrene, acrylic, polypropylene (PP), polyamide, polystyrene, polyethylene terephthalate, polyvinyl alcohol, and polyester fragments (Avio et al., 2017a; Mathalon and Hill, 2014).

Microplastics were detected in different animal species, for example in invertebrates, fishes, and marine mammals (Cole et al., 2011; Fossi et al., 2014; Rochman et al., 2015). MPs have toxic effects because they contain potentially dangerous chemical additives serving as vectors for persistent organic pollutants. They can increase the potential for the leaching of harmful chemicals in plastics, including cadmium, lead, and phthalates (Rochman et al., 2013; Shim and Thompson, 2015). Exposure to plastic can lead to different physiological impacts on reproductive success, biochemical alterations, behavior, growth, and histopathology (Ahrendt et al., 2020; Hamed et al., 2019 and 2020; Rochman et al., 2014).

Despite the extensive investigation of the effects of plastic litter on the marine environment and its organisms in various oceanic regions, information on the Red and Mediterranean seas is scarce. In particular, deeper investigation is required for examining plastic and MP inputs, their allocation, possible areas of accumulation, dynamics of transport, and interactions with biota and trophic web. The Mediterranean sea is a

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Microplastics induced histopathological lesions in some tissues of tilapia (*Oreochromis niloticus*) early juveniles

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ABSTRACT

Although microplastics (MPs) have received increasing focus and currently have become an emerging area of research, there is limited knowledge about their effect on whole body histology of fish. In this study, tilapia (*Oreochromis niloticus*) early juveniles were exposed to 1, 10, or 100 mg/L of MPs for 15 days and 15 days post-exposure, after which whole body histological examinations were performed. Histological analysis of kidney revealed congestion of blood capillaries, inflammatory cells, loss of basophilic cytoplasm in several tubules, vacuolated tubules, shrinking of convoluted tubules, widening of intertubular space, complete deformation, glomerular atrophy, vacuolated glomerular cells, and signs of fatty tubules. The liver tissue exhibited vacuoles, hydropic degeneration, necrotic area, severe deformation of hepatocytes, pyknotic nuclei, and dilation and congestion of blood sinusoids. The pancreatic tissue revealed shrunken and degenerated acini with pyknotic nuclei, hemorrhage, necrotic area, inflammatory cells, fatty cells, and congested blood capillaries. In the muscle tissue, fiber core dissociation, edema, necrosis, segmented fibers, and inflammatory cells were detected. The gill tissue demonstrated dilation and congestion of blood vessels, complete lamellar fusions, lifting of epithelium, shortening and degeneration of secondary lamellae, hyperplasia, and deposition of MPs between primary lamellae. In the spinal cord and notochord, the effects were degeneration and protrusion of meninges, deformation and deviation of notochord from its central axis, edema, degeneration of notochord (disappearance of vacuolar cells), deviation of spinal cord from the central axis, and loss of vacuolar cells in notochord. The intestinal tissue exhibited degeneration of basement membrane, inflammatory cells, goblet cells, atrophy of submucosa, pyknotic nuclei, hemorrhage, and vacuolization of mucosal cells. The histopathological changes in different organs were noticed even post-exposure in fish exposed to MPs compared to those in control fish and these changes were concentration dependent. In conclusion, these data together with our previous data suggest that MPs can cause different changes, ranging from biochemical alterations in single cells to lesions in the entire tissue, which can affect the vitality and life of fish.

1. Introduction

The global plastic production has increased exponentially since the 1960s, with the current annual production being more than 300 million tones (Eerkes-Medrano et al., 2015). Due to the global overuse of plastic products and their inappropriate disposal, large amounts of plastic waste are deposited in aquatic ecosystems (Karbalaei et al., 2018). There are several types (polyethylene, polystyrene, and polyvinyl chloride) and sizes of plastics such as nanoplastics (<1000 nm), small microplastics (MPs; 1–1000 μm), large MPs (1–5 mm), mesoplastics (5–20 mm), and macroplastics (>20 cm) (Andrady, 2011; Hanvey et al., 2017). Accordingly, the effects of MPs on the health of aquatic animals can be physical or chemical (Rainieri et al., 2018). In fish, exposure to plastics can cause different changes, ranging from biochemical alterations in single cells to changes in the entire tissue (Ahrendt et al., 2020; Hamed et al., 2019, 2020), where MPs can accumulate in the gut of aquatic organisms and even enter into the circulatory system and transfer to different organs (Xia et al., 2018).

Although there have been reports on the effects of MPs on fish histology with regard to different organs such as liver (da Costa Araújo et al., 2020; Espinosa et al., 2017; Jabeen et al., 2018; Karami et al., 2016; Lu et al., 2016; Rainieri et al., 2018; Rochman et al., 2013; Xia

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Microplastics-Induced Eryptosis and Poikilocytosis in Early-Juvenile Nile Tilapia (*Oreochromis niloticus*)

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This study aims to assess the impact of microplastics (MPs) on erythrocytes using eryptosis (apoptosis) and an erythron profile (poikilocytosis and nuclear abnormalities), considered to be novel biomarkers in Nile tilapia (*Oreochromis niloticus)*. In this study, four groups of fish were used: The first was the control group. In the second group, 1 mg/L of MPs was introduced to the samples. The third group was exposed to 10 mg/L of MPs. Finally, the fourth group was exposed to 100 mg/L of MPs for 15 days, following 15 days of recovery. The fish treated with MPs experienced an immense rise in the eryptosis percentage, poikilocytosis, and nuclear abnormalities of red blood cells (RBCs) compared with the control group in a concentration-dependent manner. Poikilocytosis of MP-exposed groups included sickle cell shape, schistocyte, elliptocyte, acanthocyte, and other shapes. Nuclear abnormalities of the MPs-exposed groups included micronuclei, binucleated erythrocytes, notched, lobed, blebbed, and hemolyzed nuclei. After the recovery period, a greater percentage of eryptosis, poikilocytotic cells, and nuclear abnormalities in RBCs were still evident in the groups exposed to MPs when crosschecked with the control group. The results show concerning facts regarding the toxicity of MPs in tilapia.

Keywords: microplastics, poikilocytosis, apoptosis, tilapia, *Oreochromis niloticus*, erythrocytes

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INTRODUCTION

Plastics consist of small monomers polymerized with supplements of additives, such as stabilizers, plasticizers, and pigments (Xu et al., 2019). Approximately, 300 million tons of manufactured plastics are used in industrial processes and food packing each year (PlasticsEurope., 2015). Most of the plastic wastes are discarded in aquatic ecosystems, especially in developing countries (Karbalaei et al., 2018).

There is a relatively high presence of microplastics (MPs) in freshwater bodies adjacent to the highly populated urban areas (Eriksen et al., 2013; Yonkos et al., 2014; Zhao et al., 2014; Lasee et al., 2017). Eriksen et al. (2013) found an approximate average value of MPs (mesh size 333 mm)

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Microstructural, optical, and electrical characteristics of Cu-doped CdTe nanocrystalline films for designing absorber layer in solar cell applications

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ABSTRACT

This paper reports the microstructure, optical, and electrical characteristics of undoped and Cu-doped CdTe nanostructured thin films prepared on glass substrates by electron beam evaporation technique. The crystallographic study of X-ray diffraction shows that CdTe and Cu-doped CdTe films crystallize in the form of a cubic zinc blende structure. Microstructure analysis reveals that as the Cu-doping level increases, the average crystallite size increases, while the microstrian decreases due to the improvement of the crystallinity, thereby reducing defects. XRD and AFM investigations confirmed the nanostructure characteristic of undoped and Cu-doped films. It was found that the optical band gap energy increases from 1.485 to 1.683 eV as the Cu concentration increases from 0 to 10 wt%, which may be related to the Burstein–Moss effect. The refractive index is calculated from the Swanepoel envelope method and found to decrease with the increase of the Cu doping due to the decrease in the polarizability. Similarly, the extinction coefficient decreases with the increase of Cu in the CdTe matrix. The dc electrical conductivity is found to increase with increasing Cu doping, which is attributed to the increase in the grain size, thereby reducing the scattering of the grain boundary. Furthermore, two conduction mechanisms of the carrier transport in nanostructured undoped and Cu-doped CdTe films were observed. The low-temperature dependence of the conductivity of undoped and Cu-doped CdTe nanostructured films is explained based on Mott's variable range hopping conduction mechanism model (VRH). Interestingly, the calculated values of hopping distance R, the hopping energy W, and the density of states at the Fermi level $N(E_F)$ are consistent with Mott's VRH. Finally, Hall effect measurements show that all the films have p-type conduction behavior. Besides, the results show that as the Cu doping level

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Research Article

Mn-doped molybdenum trioxide for photocatalysis and solar cell applications

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ABSTRACT

Mn-doped MoO_3 with different compositions in powder and thin film form have been prepared. The Orthorhombic (α-MoO_3) crystal structure of pure MoO_3 was revealed for $(Mn)_x(MoO_3)_{1-x}$ powdered samples, while the as-deposited films manifested an amorphous structure. FTIR spectra ensured that bonds are belonging to the vibrations of Mo═O bonds to Mo–O–Mo stretching vibrations at the optimum peaks, confirming the presence of a single phase of MoO_3. For powdered samples, the intensity of reflection has reached the maximum value (up to ≈ 85%) for $(Mn)_x(MoO_3)_{1-x}$ sample with x = 0.02 at.%, whereas the minimum value of reflection was obtained for undoped and $(Mn)_x(MoO_3)_{1-x}$ sample with x = 0.10 at.%. For thin films, the intensity of reflectance varies from 10% to 25% for all the samples. The optical energy was found to vary from 3.20 eV to 3.33 eV for the powdered samples and from 3.11 to 3.66 for as-deposited thin films. The photocatalytic properties were studied for all powdered samples by determining the absorbance of Methylene blue, using UV source as a function of illumination time. The degradation efficiency had maximum value of 48.5% at x = 0.10 at.%. The electrical conductivity study exhibited that, the maximum electrical conductivity of 3.11×10^2 $(\Omega\ m)^{-1}$ was obtained for the sample x = 0.10 at.%. It was a good match with the high degradation efficiency, minimum value of absorption, and narrow bandgap that existed due to the formation of the intermediate state of Mn.

1. Introduction

A few years ago, scientific researchers have found that MoO_3, as a transition metal oxide, is one of the important materials, which can solve these problems because it has many industrial applications such as gas sensors, energy storage devices, catalysts, smart window technology, optical switching, electronic devices, and excellent field emitters [1–11]. This is due to its brilliant properties of structural, optical, electrical, and high stability [12–16]. Besides, MoO_3 has non-toxic nature and low coast [17]. Additionally, it could be fabricated as a good P–N junction diode [6]. Moreover, MoO_3 is a very important n-type semiconductor with a wide bandgap equal to 3.2 eV in thin film [17,18], and a revealed orthorhombic (α-MoO_3) stable phase. So, it can be used as a transparent contact for organic photocatalytic [19].

More studies have been carried out on MoO_3 compounds like crystalline and electronic structures, photocatalytic, electrical, and optical properties. Inzani et al. [18] studied the electronic properties of reduced molybdenum oxides. Elkot et al. [20] studied the structure, optical, corrosion, and photocatalytic properties of thermally evaporated MoO_3 thin films deposited on different substrates and concluded that the oxygen deficiency process has a great influence on the electronic properties. Ali et al. [3]. deduced that the new energy states were formed in the forbidden bandgap by the excess of Mo atoms in MoO_{3-x}. The effects of doping could change the properties of this compound. For instance, Mahajan et al. [11]. found that lattice charge capacity, reversibility, and electrochemical stability increase with increasing in Nb content in MoO_3. But for Cu doped MoO_3 [12], there was a minimum for absorption and bandgap (2.4 eV) and maximum conductivity (1.862×10^{-11} Scm^{-1}) was achieved for Cu content 0.06 wt%. Nevertheless, the effect of the doping process on the molybdenum trioxide properties still need more studies.

Metal semiconductor heterostructures were promising visible light active photocatalysts for many chemical reactions. The catalytic properties were considerably influenced by the individual particle sizes and morphological structures [21].

Different types of preparation techniques have been used to prepare

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Mononucleating nicotinohydazone complexes with VO^{2+}, Cu^{2+}, and Ni^{2+} ions. Characteristic, catalytic, and biological assessments

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ABSTRACT

Three novel mononuclear complexes of Ni^{2+}, Cu^{2+}, and VO^{2+} ions (NiLnBu, CuLnBu, and VOLnBu, respectively) were synthesized by the chelation of a di-basic tridentate nicotinohydazone ligand (H_2LnBu) with M^{2+} ions in 1 : 1 M ratios. The ligand and its M-pincer chelates were identified and characterized using various spectroscopic tools included NMR, IR, UV–Vis. and EI-Mass spectra, beside, EI elemental analyses, and thermogravimetric analyses. The catalytic potential of NiLnBu, CuLnBu, and VOLnBu was investigated in 1,2-cyclooctene epoxidation using H_2O_2, as an efficient oxidant. Various parameters, including solvent, temperature, catalyst loading, and oxidant were investigated to identify the optimized reaction conditions. The central metal ion in their M-chelate catalysts revealed variation in the catalytic performance. The high valent metal ion (V^{4+}) catalyst (VOLnBu) exhibited slightly better catalytic potential (96% yield) over the low valent metal ions (Ni^{2+} and Cu^{2+}) complex catalysts (NiLnBu 91% yield and CuLnBu 93% yield, respectively). In addition to, the biological potential of free ligand H_2LnBu and its complexes were examined in the *ct*DNA interaction process *via* UV–Vis. spectroscopy and viscosity measurements with the aid of distinguished docking studies. The obtained results showed that M-chelates possess effective biological activities with DNA, including the antimicrobial, antioxidant, and anticancer effects against different biological targets.

1. Introduction

Coordination N,O-ligands of Schiff bases and hydrazones owning alternative donor centers form highly stable M-chelating complexes with various transition metal ions [1]. The interesting applications of such coordination ligands and their M-complexes are disclosed extensively in various important fields, *e.g.* membrane grafting, membrane sensors, biomimicry, biomass conversion, continuous-flow, COFs, and solar cell sensitizers [2]. Catalytically, the reactivity of transition metal complex catalysts is ideally influenced by the coordinated ligands backbone [3]. Steric and electronic properties are the two key factors controlling the catalyst reactivity [4]. Over the last couple of years, tremendous growth has been observed in research highlighting the aroylhydrazone derivatives syntheses and their catalytic employments (Fig. 1a) [5,6]. Due to their various possible isomeric structures [7], and their interesting coordination behavior with alternative multiple donor *O,N*-atoms, as well as, the diverse chelating modes towards transition metal ions, an uncountable number of metal-aroylhydrazone complexes have been synthesized with crucial roles in various applicable areas [8–11].

Heterocyclic aroylhydrazone derivatives, as tri-dentate chelating ligands and their complexes with varieties of transition metal ions, have shown huge potential, as effective reagents, in the catalytic organic synthesis [8–12] and in bioinorganic technologies [7]. The catalytic potential of aroylhydrazone complexes is well documented in various catalytic protocols, *e.g.* redox systems of olefins [12,13]. The chemoselective epoxidation products of olefins and their applications as epoxy paints, dyestuff, rubber promoters, and enantioselective drugs are strongly likable in the industry [8,14].

The most attractive metal based-chelates for such redox reactions are oxy-high valent biomimetic vanadates (IV)/(V) complex catalysts, as well as, non-oxy low valent copper (I)/(II) and nickel (II) chelating catalysts [9,10]. Oxo/dioxo-vanadates (IV)/(V)-chelating complexes are well reported as high reactive catalysts

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New application for TiO_2 P25 photocatalyst: A case study of photoelectrochemical sensing of nitrite ions

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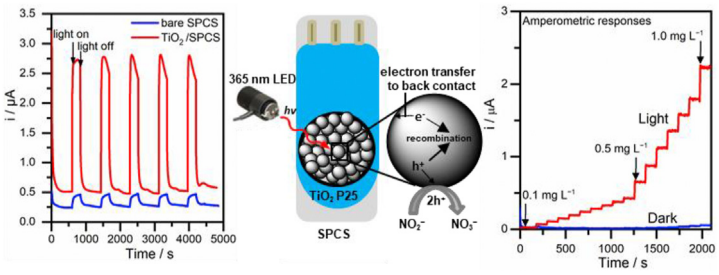
HIGHLIGHTS

- A sensitive and durable TiO_2-based photoelectrochemical (PEC) sensor has been fabricated.
- The fabricated PEC sensor exhibits high sensitivity and selectivity towards nitrite ions.
- Under UV(A) light, the detection limit was improved by 8.3-fold relative to that of the dark.
- The photo-sensitivity was increased by 37.4-fold relative to that of the dark.
- The fabricated sensor exhibits great potential for transfer from lab-to-factory.

GRAPHICAL ABSTRACT



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ABSTRACT

Developing photoelectrochemical (PEC) sensors based on photocatalytic materials has recently attracted great interest as an emerging technology for environmental monitoring. TiO_2 P25 is a well-known highly active photocatalyst, cheap, and produced commercially on a large scale. In the current work, a practical and durable TiO_2-based PEC sensor has been fabricated by immobilizing TiO_2 P25 nanoparticles at disposable screen-printed carbon substrates using drop-casting method. The fabricated PEC sensor has been applied for the anodic-detection and determination of nitrite (NO_2^-) ions under UV(A) light (LED, 365 nm) using chronoamperometry (CA) and differential pulse voltammetry (DPV). Linear calibration curves were obtained between the photocurrent responses and the concentrations of NO_2^- ions in the ranges of 0.1–5.0 and 0.5–10 mg L^{-1} for CA and DPV, respectively. Surprisingly, the detection limits (sensitivities) of the fabricated sensor towards NO_2^- ions under light were enhanced by a factor of 4.75 (4.1) and 8.3 (37.4) for CA and DPV, respectively, in comparsion with those measured in the dark. It is found that the photo-excitation of TiO_2 facilitates the photooxidation of NO_2^- ions via the photo-generated holes whereas the photogenerated electrons contribute to the enhanced photocurrent and consequently the enhanced detection limit and sensitivity. The fabricated TiO_2-based PEC sensor exhibits a good stability, durability, and satisfying selectivity for NO_2^- ions determination. These results indicate that the TiO_2-based PEC sensor fabricated by utilizing cheap and commercially available components has great potential for being transferred from lab-to-factory.

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New Cu(II) and VO(II)-O,N,O-aroylhydrazone complexes: Biological evaluation, catalytic performance, *ct*DNA interaction, DFT, pharmacophore, and docking simulation

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ABSTRACT

Polar mononuclear Cu(II) ($CuSSL{\cdot}H_2O$) and VO(II) ($VOSSL{\cdot}0.5H_2O$) complexes were prepared employing 4-hydroxy-3-((2-(4-methoxybenzoyl)hydrazineylidene)methyl)benzene sodium sulfonate ligand (H_2SSL) under green conditions. The ligand and its complexes were characterized by various spectroscopic (^1H & ^{13}C NMR, IR, UV–Visible, and Mass) and analytical tools (elemental analysis (EA), thermogravimetric analysis (TGA), conductivity, and magnetic moments). The ionic sodium sulfonate group enhanced the catalytic potential of the two complexes, as green catalysts, in the epoxidation of 1,2-cyclohexene using H_2O_2 under homogeneous reaction conditions. Interestingly, complete epoxidation (100% conversion) of 1,2-cyclohexene was observed using water as an environmentally friendly solvent. The high valent ion (V^{4+}) in the VO(II)-catalyst offered better catalytic efficiency than that of the low valent ion (Cu^{2+}) in the Cu(II) catalyst. The new compounds' biological activity was assessed using different microbes (*Staphylococcus aureus*, *Serratia Marcescence*, *Escherichia coli*, *Candida albicans, Aspergillus flavus,* and *Trichophyton rubrum*), as well as various cancer cell lines (HepG2, MCF-7, and HCT-116). Additionally, their antioxidant potential was also examined by DPPH radical scavenging and SOD assays. Moreover, the activity of the new reagents was assessed towards *ct*DNA-interaction by spectrophotometry and viscosity measurements. Both M(II)-complexes offered higher antimicrobial, anticancer, and antioxidant potential compared to that of their free ligand. Conformational and *in-silico* studies were carried out to support the newly synthesized complexes' catalytic and biological properties.

1. Introduction

Coordination compounds of aroylhydrazones with transition metals have interesting structural properties and isomeric features and also diverse variable applications [1–4].

Homogeneous and heterogeneous [5,6] catalysts of transition metal complexes with O,N,O-chelating tridentate ligands possess a fascinating potential to synthesize various chemical organic compounds [7,8]. Epoxides are versatile intermediates, which used to synthesize biologically and industrially attractive relevant candidates [5]. Within this context, the C=C double bond epoxidation is catalytically accomplished by numerous transition metal complexes, such as Mo^{6+}, $V^{4+/5+}$, $Cu^{+/2+}$, and Ni^{2+} systems [6–8].

Therefore, enormous efforts were made to develop suitable and eco-friendly homogeneous M-complex catalysts with optimized selectivity for the epoxidation systems [9,10]. Oxy and/or dioxy-$V^{(IV)/(V)}$-complexes are among the most promising catalysts used for olefins epoxidations [11], as well as alkanes, ketones, thiols, and thiophenes oxidations [12]. Copper (II) complexes are strongly preferable homogeneous catalysts in many oxidation processes of organic substrates (*e.g.*, olefins and alkanes) not only for their high oxygen accessibility but also in the context of low cytotoxicity and low cost [13,14].

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Article

Novel Cellulose Derivatives Containing Metal (Cu, Fe, Ni) Oxide Nanoparticles as Eco-Friendly Corrosion Inhibitors for C-Steel in Acidic Chloride Solutions

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Abstract: Novel environmentally-friendly corrosion inhibitors based on primary aminated modified cellulose (PAC) containing nano-oxide of some metals (MONPs), for instance iron oxide nanoparticles (Fe_3O_4NPs), copper oxide nanoparticles (CuONPs), and nickel oxide nanoparticles (NiONPs), were successfully synthesized. The as-prepared PAC/MONPs nanocomposites were categorized using Fourier transform infrared spectroscopy (FT-IR), transmission electron microscope (TEM), field-emission scanning electron microscopy (FE-SEM), energy-dispersive X-ray spectroscopy (EDX), X-ray diffraction (XRD), and selected area diffraction pattern (SAED) techniques. The data from spectroscopy indicated that successful formation of PAC/MONPs nanocomposites, as well as the TEM images, declared the synthesized PAC/Fe_3O_4NPs, PAC/CuONPs, and PAC/NiONPs with regular distribution with particle size diameters of 10, 23 and 43 nm, respectively. The protection performance of the as-prepared PAC and PAC/MONPs nanocomposites on the corrosion of C-steel in molar HCl was studied by the electrochemical and weight-loss approaches. The outcomes confirmed that the protection power increased with a rise in the [inhibitor]. The protection efficiency reached 88.1, 93.2, 96.1 and 98.6% with 250 ppm of PAC/CuONP, PAC/Fe_3O_4NPs, and PAC/NiONPs, respectively. PAC and all PAC/MONPs nanocomposites worked as mixed-kind inhibitors and their adsorption on the C-steel interface followed the isotherm Langmuir model. The findings were reinforced by FT-IR, FE-SEM and EDX analyses.

Keywords: cellulose derivatives; corrosion inhibitors; metal oxide nanoparticles; cellulose nanocomposites; Electrochemical Impedance Spectroscopy; surface morphology

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1. Introduction

Corrosion is a dangerous phenomenon devastatingly affecting mechanical and modern applications, especially in the oil and gas enterprises. Consequently, regulatory metal decomposition is a significant action of specialized, affordable, ecological, and appealing significance to spare tremendous costs in resources, hardware, and construction. The utilization of corrosion inhibitors is perhaps the most ideal choice for governing the corrosion of metals in different harsh media. Through the utilization of little particle organic and inorganic corrosion inhibitors for different issues, the utilization of corrosion inhibitors based on polymers came into the spotlight [1]. Polymers are materials that have fantastic adhesive properties on metal surfaces. A wide scope of polymers have been identified for their corrosion resistant properties as both pre-covering [2] on the metal or just as an inhibitor in an assortment of corrosive liquids [3–10]. Furthermore, the use of carbohydrate polymers in corrosion hindrance gave a course to utilize materials that are biodegradable, artificially steady, eco-friendly with the one-of-a-kind repressing property, low cost, and renewable [11,12]. The molecular weights decide the quality of carbohydrate polymers as inhibitors, the nearness of adsorption focuses, accessibility of security shaping

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Novel microwave-driven synthesis of hydrophilic polyvinylidene fluoride/polyacrylic acid (PVDF/PAA) membranes and decoration with nano zero-valent-iron (nZVI) for water treatment applications

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ABSTRACT

A novel microwave (MW)-based method was developed for *in-situ* cross-linking/polymerization of polyacrylic acid (PAA) onto hydrophilic polyvinylidene fluoride (PVDF) membrane for preparation of $PVDF_{MW}$ catalytic-membrane system. Unlike traditional thermal techniques, the use of MW radiation provided faster PAA polymerization and synthesis of $PVDF_{MW}$ membranes with excellent mechanical stability and high permeability. Air cooling and the dose-wise application of MW were the most influential parameters on the quality of PAA grafting and on the physical properties of $PVDF_{MW}$ membranes. Detailed surface characterization of $PVDF_{MW}$ revealed pores of the upper surface were occupied with PAA molecules. Nano zero-valent-iron (nZVI)-decorated $PVDF_{MW}$ membranes (nZVI-$PVDF_{MW}$) were prepared and their catalytic activities were tested for the degradation of bisphenol A (BPA) in a cross-flow system. The nZVI-$PVDF_{MW}$ system demonstrated 52% ± 0.5 of BPA removal under low permeate flux (50 L/m^2. h) in the presence of 10 mM of H_2O_2. The current study demonstrated MW is an advantageous technique for the preparation of composite membranes with ultra-fine morphology and improved physical properties for use in water treatment applications.

1. Introduction

Nanoparticle-impregnated polymeric membranes have recently gained much attention in water treatment due to their dual function of separating low molecular weight particles/organics in water and the possibility of degradation of toxic contaminants in water via catalytic processes. The impregnated nanoparticles played essential roles in improving water flux through membranes, increasing hydrophilicity, and extending the lifetime of the separation system via decreasing membrane fouling [1]. Among these nanoparticles, carbon nanotubes (CNTs), metallic silver, and metallic oxides (e.g., TiO_2, ZnO, Al_2O_3 and Fe_3O_4) are among the most used materials [1].

PVDF membranes have been reported as a suitable material for nanoparticle loading due to their properties of operation under adverse environmental conditions (e.g., various pH and salinity), as well as thermal and mechanical stability [2–4]. However, because of their hydrophobic nature, these membranes have shown low permeability that diminishes the overall efficiency of the separation process [4].

Abbreviations: Acrylic acid (AA), Bisphenol A (BPA); Ethylene glycol (EG), Hydrogen peroxide (H_2O_2); Microwave radiation (MW), *N*-Methyl-2-pyrrolidone (NMP); Nano Zero-Valent-Iron (nZVI), 2-Hydroxyterephthalic acid (OH-TPA); Propionic acid (PA), Polyacrylic acid (PAA); Polyvinylidene fluoride (PVDF), Polyvinylpyrrolidone (PVP); Scanning Electron Microscopy (SEM), Disodium terephthalate (TPA); Polyacrylic acid-functionalized PVDF membranes ($PVDF_{MW}$), Nano-Zero-Valent Iron decorated PAA/PVDF membranes (nZVI-$PVDF_{MW}$).

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Novel nanocomposites of nickel and copper oxide nanoparticles embedded in a melamine framework containing cellulose nanocrystals: Material features and corrosion protection applications

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ABSTRACT

In this work, novel metal oxide-organic frameworks (cellulose nanocrystals (CNCs)), copper oxide/melamine/cellulose nanocrystals (CuO@MEL@CNCs), and nickel oxide/melamine/cellulose nanocrystals (NiO@MEL@CNCs) were effectively fabricated using a hydrothermal method. The prepared nanocomposite CNCs, CuO@MEL@CNCs, and NiO@MEL@CNCs were described by Fourier transform infrared (FT-IR), field emission scanning electron microscopy (FE-SEM), transmission electron microscopy (TEM), Brunauer–Emmett–Teller (BET), and Raman spectroscopy. The outcomes show that the nanomaterials have high scattering and narrow size distribution. Moreover, vibrational investigations have been performed utilizing Raman spectroscopic procedures. Explicit Raman peaks were observed in the CNC, CuO@MEL@CNC, and NiO@MEL@CNC nanostructures, and the full width at half maximum (FWHM) of the peaks demonstrated the small particle size of the prepared nanocomposites. The capability of the CNC, CuO@MEL@CNC, and NiO@MEL@CNC nanocomposites to act as corrosion inhibitors of AISI360-steel in molar H_2SO_4 is described for the first time. The corrosion protection capabilities of the nanocomposites were evaluated using potentiodynamic polarization (PDP), impedance spectroscopy (EIS), and surface morphology (FE-SEM/ energy dispersive X-Ray analysis (EDX)) measurements. The protection effectiveness was found in the order NiO@MEL@CNCs (98.3%) > CuO@MEL@CNCs (96.8%) > CNCs (85.3%) at 300 mg L^{-1}. The current report shows that CNCs and metal oxide-melamine frameworks at CNCs as inexpensive and eco-friendly inhibitors could be probable candidates to protect AISI360-steel corrosion in petroleum manufacturing.

1. Introduction

Due to their excellent mechanical strength and comparatively low cost, steel alloys are commonly utilized in petroleum manufacturing as transport tubes for oil in refining, petroleum production, metal processing equipment, and chemical processing industries [1]. However, these materials are prone to corrosion, particularly in acidic solutions, and could freely be exposed to acidic media through acid pickling acid, acid descaling, and cleaning [2]. The addition of inhibitors in various corrosive media has developed an effective and popular method of protecting metallic interfaces from corrosion because it is simple to apply and comparatively low-cost. The production of environmentally friendly inhibitor materials as a substitute for toxicity-based compounds has gained much significance (particularly natural polymers) [3].

The smart characteristics of polymers are cost-effectiveness, the presence of multiple adsorption center availability, inherent stability, and eco-friendliness [4]. Natural polymers have the benefit of being biodegradable and derived from renewable sources [5]. Natural polymers have been selected for corrosion protection features, such as carboxymethyl cellulose [6], chitosan [7], starch [5], gum arabic [8], pectin [9], gellan gum [10], xanthan gum [11], and hydroxypropyl cellulose [12]. However, the major hindrance influencing the application of polymers as inhibitors for metal corrosion is that some do not easily dissolve in corrosive media. Therefore, most of them display moderate inhibiting capability.

Corrosion researchers have consequently planned some efforts to improve the stability and inhibitive characteristics of polymers. Remarkably, mixtures with materials that exert synergism, blending, copolymerization, cross-linking, and infusion of metallic substances into the macromolecule matrix are important [13,14]. Achievement seems to have been accomplished by compositing.

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Occurrence and geographical distribution of mangrove fungi

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Abstract
This is a multidimensional review of mangrove fungi occurring as saprobes, pathogens and endophytes of a wide range of host substrates and those isolated from the water columns and sediments in mangroves. Eight-hundred and fifty taxa including 658 that are supported by both morphology and molecular data and 192 with only morphological data are listed. These constitute Ascomycota, the dominant group with 773 species, and 58 Basidiomycota, one Blastocladiomycota, five Chytridiomycota, and 13 Mucoromycota. This study also includes data on mangrove yeasts 103 Ascomycota, 39 Basidiomycota and 193 taxa isolated from sediments. Endophytes isolated from submerged parts of mangrove plants total 38. The most specious orders of mangrove fungi are Pleosporales 133, Saccharomycetales 102, Microascales 101, Eurotiales 87, Hypocreales 60 and Xylariales 54. Speciose genera include *Candida* 39, *Aspergillus* 53, *Penicillium* 17 and *Corollospora* 16. The highest number of mangrove fungi have been recorded from the Pacific Ocean 553, which is the largest ocean, followed by Indian 408 and Atlantic Oceans 259. Geographical distribution of mangrove fungi varied from ocean to ocean with only 109 taxa common to the Atlantic, Indian and Pacific Oceans. Of the various countries reported for mangrove fungi, India accommodates the highest number (339) followed by Thailand 303, Malaysia 171, Florida Everglades, USA 134 and Brunei 134. A total of 60 different mangrove plants and their associates have been surveyed for mangrove fungi. These results are discussed and compared with previous studies.

Keywords Host preference · Marine ecology · Marine fungi · World distribution

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On the dissipativity property of negative imaginary systems

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KEYWORDS

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Passivity;
Negative imaginary systems

Abstract This paper extends the concept of dissipativity to a new class of dynamical systems known as negative imaginary systems. The paper also introduce a new definition for nonlinear negative imaginary systems to extend the existent definition. Two different quadratic dynamic supply rates are introduced to allow for extending the dissipativity concept to cover the negative imaginary systems. One of which is a differential operator and the other is an integral operator. Both supply rates are used in order to formulate the class of negative imaginary systems as dissipative systems. This extension allows for wider class of dynamical systems to be considered in the negative imaginary framework. We also show how the new definition extends the negative imaginary system to analyze a class of higher order evolutionary dynamics. In particular, we show that the second order replicator dynamics satisfy the negative imaginary property and hence we can conclude convergence with certain class of games. Also, a nonlinear negative imaginary lemma based on the above definitions is derived.

1. Introduction

The general theory of *dissipativity* was initially formulated and introduced by Willems [1,2] to characterize a large and important class of dynamical systems based on the behaviour of their inputs and outputs. Willems defined dissipative systems as these systems that the increase in their internal stored energy is bounded form above by the quantity of energy that is supplied to the system form the environment throughout a scalar valued function known as *supply rate* $s(u, y)$.

Two important quantities identify the dissipativity property, the *storage function* $S_f(x)$ and the supply rate $s(u, y)$. In particular, the supply rate plays an essential role in defining the stability property of the dissipative systems and their interconnections. For instance, the global stability for interconnected subsystems depends on the compatibility of their supply rates, which means that these subsystems must have

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On the theory of the fractal scaling-law elasticity

Xiao-Jun Yang · Jian-Gen Liu · Mahmoud Abdel-Aty

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Abstract In the article we invoke a new treatment of the non-traditional elasticity with use of the fractal scaling-law vector calculus. The fundamental theorems for the fractal scaling-law vector calculus are given in detail. The result presents a new insight into the descriptions for the behaviors of the solids in the Mandelbrots scaling-law phenomena.

Keywords Elasticity · Fractal · Mandelbrot's scaling-law · Vector calculus

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1 Introduction

The mathematical study of the modern elasticity theory has a long history with the great landmarks, which are the discovery of the Hooke's Law [1], the general equations of equilibrium of Navier [2, 3], the general equations of equilibrium, geometric equation and isotropic generalized Hooke's law of Cauchy [4–9], the Poisson's ratio of the velocities of waves in the isotropic elastic solid [10], and the elastic constants of Green by the conservation of energy [11] and others [12], which have been considered briefly in the tasks of Love [13], and Timoshenko [14].

The modern elasticity theory is used to describe the non-power behaviors of the solid based on the theory of the calculus due to Newton [15, 16] and Leibniz [17, 18]. However, as is reported by Mandelbrot [19], the solids in the nature have the characteristics of the fractal geometry with the self-similarity and fractional dimensions, for example, the scaling laws on strength of solids [20], the scaling-laws behaviors of the surfaces of the solids [21], the fractal structures of the solids [22, 23], the scaling-laws of the fracture systems [24], the fractal scaling laws of the microstructure [25], and so on. There are some new perspectives for the fractal vector calculus of Tarasov

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Original research article

Optical characterization and effects of iodine vapor & gaseous HCl adsorption investigation of novel synthesized organic dye based on thieno[2,3-*b*]thiophene

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ABSTRACT

Comparison of the absorption spectra of the ethanolic solution (3 ppm) of some diethyl 3,4-diaminothieno[2,3-*b*]thiophene-2,5-dicarboxylate (TT amino ester) derivatives has revealed that the azo dye derivative compound **4** manifests smaller band gap and higher absorption maximum close to solar maximum wavelength. Very good adhesive thin films to glass substrates of the azo dye compound **4** have been successfully prepared by thermal evaporation technique. The optical spectral analysis of such compound film revealed three absorption transitions corresponding to the optical gap, the electron transition between impurity levels in band gap and the fundamental band gap (HOMO to LUMO $\pi \rightarrow \pi^*$ transitions). Absorption, dielectric and dispersion parameters have been determined for as- deposited and gas treated films and discussed. This film manifested a fast response and high sensitivity toward iodine vapor with a reasonable recovery time indicating a reversibility of iodine adsorption process. In contrast, the film illustrated slow response and weak sensitivity toward HCl gas with irreversible adsorption process. Besides, the azo dye compound **4** solution manifests strong emissive properties that recommend it as promising candidate for fluorescence sensors.

1. Introduction

The interest in organic molecules with π − conjugated electron thin films has recently increased due to their promises in different optoelectronic application fields such as organic solar cells, optical sensors, light emitting diodes, laser technology and live-cell imaging [1–3], in addition to their environmental friendship and low cost fabrication. Besides, thin films of organic compounds can be easily prepared using different available techniques such as spin coating, ink-jet printing, thermal deposition and sputtering [4].

Synthesizing and optical characterization of new organic materials enriche the data base of new materials with different and may be new optoelectronic properties that provide some required essential characteristics for optoelectronic applications. From one side, the investigation of the optical absorption, identification of the electronic transitions and determination of the different optical parameters such as the band gap E_g, the absorption coefficient α and the refractive index have proved to be very useful for elucidation of electronic structure of the material as well as to specify the capability of the semiconducting material to absorb visible and other

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Optical properties of thin Bi_2Te_3 films synthesized by different techniques

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ABSTRACT

Thin films of Bi_2Te_3 alloy were grown by vacuum thermal evaporation (VTE) and pulsed laser deposition (PLD) techniques. The growth was conducted on clean substrates of non-conductive glass. X-ray diffraction (XRD) analysis was used to study the materials crystal structure. The XRD patterns revealed the crystalline nature of the prepared films. Surface morphology was investigated by the atomic force microscopy (AFM) showing that the films are formed of crystallites bounded by twin boundaries oriented in the c-axis in a way that perpendicular to the substrate plane. The samples shown to be stoichiometric and of good morphology. Transmission and reflection spectral have been obtained at room temperature using a double beam Jasco spectrophotometer. Absorption coefficient, extinction coefficient and refractive index were determined. The optical band gap was evaluated by measuring the fundamental absorption and extrapolation of the linear portion of $(\alpha h\nu)^2$ versus $h\nu$ plots. The plots indicated direct allowed transition. Comparison between all optical parameters of the films prepared by the two different methods has been performed.

1. Introduction

Experimentally and theoretically, the topological insulator Bismuth telluride (Bi_2Te_3) was shown to have metallic phase along the layer surface [1]. Bi_2Te_3 exhibited strong light absorption, single Dirac cone at the surface and low saturable optical intensity [2–5]. As proven, materials with single Dirac cone along the layer surface are interesting potential candidates for optoelectronic applications [6–8]. Moreover, the chalcogenide Bi_2Te_3 is interesting system for electrochemical and optoelectronic applications such as in solar cells and in infrared sensors [9]. Although numerous studies were conducted on Bi_2Te_3, most of them were devoted to investigate its potentiality of converting thermal energy to electrical energy. Optical and optoelectronic properties of Bi_2Te_3 are scarcely studied.

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Research Article

Optical properties upon ZnS film thickness in ZnS/ITO/glass multilayer films by ellipsometric and spectrophotometric investigations for solar cell and optoelectronic applications

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ABSTRACT

ZnS film with various thicknesses (d ≈ 100–350 nm) deposited on the ITO coated glass substrate (ZnS/ITO/glass) by an electron beam evaporation process was examined structurally and optically. Different techniques were used to specify and analyze the optical characteristics of the film, such as spectroscopic ellipsometric (SE) and spectrophotometric (SP). The ZnS/ITO/glass films exhibit a wurtzite hexagonal type structure entrenched in the crystalline background of ITO film. XRD analysis revealed changes in structural and microstructural parameters, such as a decrease in lattice parameters, a reduction in microstrain, and a raise in crystallite size. The optical constants and the optical energy gap were extracted from SE by constructing an ellipsometric optical model, while the optical constants were calculated from SP by using Murmann's exact equations. It was seen that the overall behaviour of the refractive index *n* of the ZnS/ITO/glass films obtained from SE and SP increases with an increase in ZnS layer thickness, which is attributed to the increment of the size of the grain. It was additionally found that, the overall behaviour of the extinction coefficient *k* of the ZnS/ITO/glass films increases, when the thickness of the ZnS layer increments. Also, the direct optical transition was observed with energy band gap diminishes from 3.423 (d = 100 nm) eV to 3.287 eV (d = 350 nm) that is because of the rise in grain size, the decrease in microstrain, and reduction in lattice constants. Furthermore, it was found that the deposition of ZnS on ITO coated glass substrate increases the absorption compared with the ZnS/glass film and then reduces the transmittance and energy band gap. It was concluded that as the ZnS thickness increases, the optical constants of ZnS/ITO/glass films enhance. Finally, the overall behaviour of the optical constants within the experimental error range of the ZnS/ITO/glass films with different ZnS layer thicknesses obtained by SE was found to be consistent with that calculated from SP measurement.

1. Introduction

N-type wide band gap semiconductor ZnS is formed with two polymorphic crystal type structures e.g. cubic zinc blende and wurtzite hexagonal [1,2]. A wide band gap ZnS semiconductor property (3.7–4.1 eV) enables the incident photons with high energy to arrive at the absorber layer in solar cells and improve the performance of solar cells and photovoltaic devices [3]. Interestingly, ZnS thin films have many advantages compared to other II-VI semiconductors, such as low electrical resistivity, high transparency in VS to NIR region, high refractive index, and high effective dielectric constant and better lattice-matching over CIGS thin-film absorber layer, and high mechanical hardiness [4–6]. These properties of ZnS make it a potential applicant in the industry of optical and optoelectronic technology such as thin film solar cells [7,8], heterojunction solar cells as an antireflection coating [9], optoelectronic devices [10,11], light-emitting diodes [12], liquid crystal display [13], and transparent dielectric materials [14,15]. Notably, that the optical properties of semiconductors thin film depend on the preparation factors e.g., the thickness of the prepared film and substrate type. The growth of the film is controlled by matching the lattice constants of

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Optical solitons in birefringent fibers with quadratic-cubic nonlinearity using three integration architectures

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ABSTRACT

In this work, the nonlinear Schrödinger's equation is studied for birefringent fibers incorporating four-wave mixing. The improved $\tan\left(\frac{\phi(\xi)}{2}\right)$-expansion, first integral, and $\frac{G'}{G^2}$-expansion methods are used to extract a novel class of optical solitons in the quadratic-cubic nonlinear medium. The extracted solutions are dark, periodic, singular, and dark-singular, along with other soliton solutions. These solutions are listed with their respective existence criteria. The recommended computational methods here are uncomplicated, outspoken, and consistent and minimize the computational work size, which give it a wide range of applicability. A detailed comparison with the results that already exist is also presented.

I. INTRODUCTION

Optical solitons are a valuable accretion in the field of fiber optic communications.[1–3] The nonlinear Schrödinger's equation (NLSE) is the governing model that describes the propagation of optical solitons with different forms of nonlinear media.[4–14] The nonlinear media based on the Kerr law have been extensively studied through various research papers.[12–15] Nowadays, a growing interest to study optical solitons in the non-Kerr law medium can be observed. There are various forms of nonlinearities that are studied in the context of the non-Kerr law, i.e., polynomial law, parabolic law, power law, dual-power law, saturable law, triple power law, among others.[16–20] For more than a couple of decades, the study of optical solitons has been carried out with quadratic-cubic (QC) nonlinearity. This form of nonlinearity first appeared during 1994.[21] Later, interest was rekindled with this model during 2011.[22] There are several results with a variety of mathematical methods that are reported.[23–33] These include the traveling wave hypothesis, semi-inverse variational principle, method of undetermined coefficients, conservation laws, the unified method and its generalized technique, and various other aspects.[34–48]

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Optimized thermoelectric performance in thin $(Bi_2Se_3)_{1-x}(Bi_2Te_3)_x$ alloyed films

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ABSTRACT

Herein, thin films of $(Bi_2Se_3)_{1-x}(Bi_2Te_3)_x$ were synthesized by thermal evaporation in high vacuum using highly crystalline bulk samples of Bi_2Se_3 alloyed with Bi_2Te_3. Preparation and characterization together with probing the thermoelectric properties of thin $(Bi_2Se_3)_{1-x}(Bi_2Te_3)_x$ films are discussed in this article. Crystal structure, surface morphology, roughness and lattice features of the deposited films were probed via XRD, SEM and HRTEM techniques, which confirmed the perfect crystallinity and the nano-scalability of the prepared thin films. Thermoelectric measurements were carried out for the as-deposited films within a temperature range of 300–473 K. Seebeck coefficient of the studied samples is about two times larger than that of the previously reported bulk samples. The highest power factor was recorded at 131 μW/m K^2 at 473 K. The high value of the power factor shows that the materials under the study are promising for applications such as resource recovery of waste and also as nanomaterials for environmental applications. Very low electronic thermal conductivity was obtained due to the small electrical conductivity and due to the scattering of carriers by the tiny grains constituting the prepared films.

1. Introduction

Direct conversion of thermal energy to electricity can be achieved by solid-state thermoelectric technologies. Thermoelectric technology provides the advantages of being reliable, scalable and eco-friendly. With such advantages, thermoelectric technology-based materials can play an important role in confrontation the global energy and environmental challenges [1].

Efficiency of a thermoelectric modules is described usually through a parameter known as figure of merit (ZT) given as: $ZT = \frac{S^2\sigma}{K}T$, where S is the Seebeck coefficient, σ, κ are the material's electrical and thermal conductivity, respectively and T is the absolute temperature [2].

Thin films of Bi_2Se_3 and Bi_2Te_3 have attracted considerable interest, in recent years, for their potential applications in various fields including thermoelectric, photo-electrochemical cells and other applications [3–7]. Also, they are extensively used in thermoelectric power refrigeration and other thermoelectric devices [8]. Intensive studies showed that Bi_2Te_3 and based alloys are the most preferred thermoelectric materials because of their high room-temperature ZT values [9]. For long time, Bi_2Te_3 is one of the most interesting materials for low-temperature waste heat recovery. However, the low natural abundance of tellurium guides us to synthesize the material in the form of thin film. Additionally, low dimensionality is a key factor in achieving quantum confinement which is quite efficient strategy for enhancing the material's power factor and suppressing the phonon thermal conductivity simultaneously [10].

Due to the fact that Bi_2Se_3, Bi_2Te_3 and Sb_2Te_3 are the best room temperature thermoelectric materials, and they are three-dimensional (3D) topological insulators characterized with inverted bulk band structure and topologically protected metallic surface states [11],

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Optoelectronic characteristics of as-deposited, annealed and I_2 – Treated thin films of newly synthesized organic dye based on pyrrolo[2,3-*b*]pyrrole

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ABSTRACT

Novel heterocyclic dyes were synthesized by attaching different electron-rich aromatics to the pyrrolo[2,3-*b*] pyrrole system by microwave irradiation system provided with condensation unit. The final push-pull conjugated dyes were yielded by azo coupling of PPY with aniline, 1-naphthylamine and N,N-dimethylaniline. Thin films of compound **3** have been chosen and prepared using thermal evaporation technique and investigated by FTIR and UV – VIS – NIR spectroscopy. Annealing out of PPY films at relatively low temperature (≤100 °C) for 3–6 min has been proved to notably reduce the energy gap and enhance both absorption and refractive indices. They manifested a fast response and high sensitivity toward iodine vapor with a low recovery time indicating a reversibility of iodine adsorption process.

1. Introduction

The average annual global consumption of energy has continuously increased due to the quick increases in population and their life activities. Up to now the most of energy production comes from the consumption of the traditional sources such as oil derivatives and coal as well as from nuclear reactors accompanied by noxious pollutants and emissions. In order to moderate the global reliance on such harmful pollution and emissions more scientific efforts should be oriented towards the reducing of energy production cost by exploiting the environmental friendly renewable energy technologies in the form of solid state devices that convert the energy from one form to another. Conjugation organic compounds can play an active role in that field due to their intrinsic technological advantages over inorganic semiconductors. They are characterized by compatibility with large area, low cost, and low temperature manufacturing techniques. Besides, there is an increasing concern in the chemistry of heteropentalenes, which are comprised of two pyrrole units since their compounds are marked by straight forward preparation method, good electron chemical properties and thermal stability [1,2]. These organic materials are characterized by a high absorption coefficient, large bandgap, tunable physical properties and mechanical flexibility [3]. Therefore, they are promising as solar cell absorbers [4], laser dyes [5], gas sensors [6], organic light emitters [7], fluorescent sensors [8] and organic recording materials [9–11].

Besides, synthesized new organic molecular materials with push-pull structure can illustrate a broad spectral response and different spectral optoelectronic structures which can help to receive valuable information about the material optoelectronic properties.

Moreover, the exposure of Pyrrolo[2,3-*b*]pyrrole conjugation organic compounds to halogen molecules significantly improves their optoelectronic properties in terms of energy gap decreasing that leads to more light harvesting [12], enhancing the absorption and refractive indices which are crucial parameters in the design of optoelectronic devices [13–15].

Iodine vapor which is a volatile radioactive material, noxious to the metabolism and adverse to the environment [16,17], represents one of the nuclear and medical waste pollution components. Therefore, its detection and elimination required for public and nuclear safety may be regarded as an important application goal. Such pollutants have been widely investigated by adsorption technology that offers a reasonable way to test the material validity as toxic gases sensors. Thin films of these organic compounds can be easily prepared by spin coating, inkjet printing and roll to roll processing and thermal evaporation methods. Thermal evaporation is the preferred method for growing thin films of organic small molecules [18] resulting in good adhesive to glass substrates, good homogenous and smooth films due to accurate controlling

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ORIGINAL RESEARCH ARTICLE

Optoelectronic Properties and Surface Plasmon Polaritons of CdO/Ag/CdO Multilayer Films Deposited by DC Pulsed Magnetron Sputtering

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Abstract

The optoelectronic characteristics and surface plasmon polaritons (SPPs) of nanostructured CdO/Ag/CdO multilayer films prepared by DC pulsed magnetron sputtering were inspected**.** The multilayer films were deposited with different Ag metallic interlayer thickness ranging from 2 nm to 20 nm. It was observed that the CdO single-layer has high transmittance and it decreased from 85% to 70% in the visible range as the Ag metallic interlayer thickness increased from 2 nm to 20 nm. The CdO/Ag (20nm)/CdO multilayer film has the lowest transmittance and highest reflection in the NIR. The mobility, charge carrier concentration and the conductivity increased as the Ag metallic interlayer increased. The energy gap decreased from 2.77 eV for CdO single-layer to 2.44 eV for CdO/Ag (20nm)/CdO multilayer film. The CdO/Ag (16nm)/CdO multilayer film recorded the highest figure of merit value of $2.45 \times 10^{-3}\ \Omega^{-1}$, which acts as an electrode in optoelectronic applications. The absorption of light was interpreted by the creation of surface plasmon polaritons (SPPs) modes along Ag/CdO interface. It was found that the CdO/Ag/CdO multilayer films could be employed as SPPs nano-waveguide for telecommunication applications at excitation wavelengths of 775 nm and 1550 nm.

Keywords CdO/Ag/CdO multilayer thin films · DC pulsed magnetron sputtering · optical properties · conductivity · surface plasmon polaritons

Introduction

Transparent conducting oxide (TCO) materials are categorized as high optical transparency with high electrical conductivity and low absorption within the visible region of the electromagnetic spectrum.[1–3] Recently, multilayer films of MO_x/M/MO_x have been considered superior TCO materials.[4–7] They are used in the area of optoelectronic applications such as liquid crystal displays, light-emitting diodes, solar cells, gas sensors and touch screens.[8–12] It is well known that there are numerous parameters affecting the performance of TCO materials such as the transmittance in visible light, resistivity, carrier concentrations, mobility, surface plasmons and stability. Surface plasmons are coherent delocalized electron oscillations that exist at the dielectric–metal interface. They have garnered much consideration in the past due to their sub-wavelength spatial profile of modal field that can develop light–matter interactions.[13–16] The characteristics of surface plasmons are strongly associated with material type and structure. Metals, semiconductors and two-dimensional materials with various morphologies and structures have alternating plasmonic wavelengths extending from ultraviolet to infrared. Governing and guiding of light using surface plasmon polaritons (SPPs) on the nanometer scale reveal noteworthy advantages in nano-photonics devices with very small elements. Silver and gold have advantages over other categories of metals; they show surface plasmon resonance (SPR) bands in both visible and NIR frequencies. Moreover, the surface chemistry of the two metals are well characterized and are easily functionalized by a diversity of deposition methods.[17–19] MO/M/MO multilayers are attractive alternatives to semiconductor oxide-based NIR reflecting coatings.[20, 21] MO/M/MO films provide high transmittance in the visible range as well as high

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Performance enhancement of adsorption cooling cycle by pyrolysis of Maxsorb III activated carbon with ammonium carbonate

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ABSTRACT

Maxsorb III is the best available microporous activated carbon. The parent Maxsorb III has been modified by pyrolysis in the presence of ammonia carbonate. The adsorption isotherms and kinetics of HFC404A onto the modified Maxsorb III are experimentally measured over 25 °C to 75 °C. Tóth and Dubinin-Astakhov models are utilized to fit the experimentally measured data. The isosteric heat of adsorption is calculated by applying the Clausius-Clapeyron equation. The adsorption kinetics of the modified Maxsorb III/HFC404A are fitted using the linear driving force model and Fickian Diffusion equation. Experimental measurements indicate that the modified Maxsorb III has a maximum uptake of 2.65 kg.kg^{-1} of HFC404A at 25 °C, which is the highest reached value till today.

Additionally, the adsorption cooling system efficacy is evaluated under typical operating conditions using the modified Maxsorb III/HFC404A pair. The modified Maxsorb III/HFC404A could achieve a specific cooling power (SCP) of 747 W per kg of adsorbent along with a coefficient of performance (COP) of 0.40. Compared to the parent Maxsorb III/HFC404A pair, the pyrolyzed Maxsorb III/HFC404A pair provides the SCP and COP by a factor of 2.23 and 1.7, respectively, which are are the current benchmark.

Amélioration des performances du cycle de refroidissement par adsorption par la pyrolyse du charbon actif Maxsorb III avec du carbonate d'ammonium

Mots clés: Isotherme d'adsorption; Cinétique d'adsorption; COP; Maxsorb III; Puissance de refroidissement spécifique

1. Introduction

The global ambition of sustainable development is hampered by rapid socio-economic development and continuous population growth. This has resulted in a substantial escalation of demand in energy consumption produced mainly using fossil fuels. This puts the world on the brink of an additional pollution crisis as energy, and environmental sectors are interconnected. In response to these linked troubles, there is a continuous demand to raise the contribution of renewable energy sources in the power generation mix. Adsorption technology is considered an outstanding candidate for cooling, refrigeration, and energy storage. It can address the energy-environment nexus in an efficient and effective way because it could be run by solar, geothermal heat, or even low-grade heat sources. It does not include moving parts like pumps or compressors. However, this technology is still under the technology readiness level and suffers from low performance in terms of

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Pharmacological Evaluation of Novel Organoiron Dendrimers as Antimicrobial and Anti-Inflammatory Agents

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The synthesis of a novel and attractive class of nonsteroidal anti-inflammatory and antimicrobial organoiron dendrimers attached to the well-known drug ibuprofen is achieved. The structures of these dendrimers are established by spectroscopic and analytical techniques. The antimicrobial activity of these dendrimers is investigated and tested against five human pathogenic Gram-positive and Gram-negative bacteria, and minimum inhibitory concentrations are reported. Some of these synthesized dendrimers exhibit higher inhibitory activity against methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus faecium*, and *Staphylococcus warneri* compare to the reference drugs. As well, the in vitro and in vivo anti-inflammatory activities of these dendrimers are evaluated. The results of in vivo anti-inflammatory activity and histopathology of inflamed paws show that all dendrimers display considerable anti-inflammatory activity; however, second-generation dendrimer (G2-D6) shows the best anti-inflammatory activity, which is more potent than the commercial drug ibuprofen at the same tested dose. Results of the toxicity study reveal that G2-D6 is the safest drug on biological tissues.

1. Introduction

Recently, dendrimers are drawing exponential interest and have shown uses in numerous fields of application.[1–3] Dendrimers can be created and modified in different ways to provide hundreds of various molecules with specific properties and functionalities. Many of the physical and chemical properties associated with dendrimers such as regular structure, modifiable surface functionality, well-defined molecular weight, and the availability of internal cavities, make dendrimers unique in many applications such as drug delivery, solar cells, catalysis, and electrochemical sensors.[4–9] Over the past decade, significant applications of dendrimers for biological and drug-delivery purposes have been demonstrated.[10–17] There is a direct correlation between dendrimer generation and the functional groups in their periphery, which improves the presentation of concentrated drugs or designated molecules for therapeutic applications.[1,3,18] In recent years, there have been reports suggesting dendrimers themselves can act as anti-inflammatory agents.[19–23]

The benefit of carrying metal complexes into dendritic structures is to provide highly ordered structures with engaging magnetic, electronic, photo-optical, and bioactivity properties.[24–28] The association of organotransition metal groups within dendritic structures has yielded great interest in both organometallic and dendrimer research and has opened up a new family of organometallic macromolecules with many interesting properties.[24,29–31] Over the past few decades, our research group has been focused on the use of η^6-aryl–η^5-cyclopentadienyliron (II) in many classes of macromolecules that involve linear polymers,[32] star-shaped molecules,[25,33] dendrimers,[2,18,34–37] and hyperbranched polymers.[38]

The development of efficient dendrimer-based drug delivery systems has recently drawn great attention in the past several years. Dendrimers offer a great advantage over traditional polymers, which are the precise molecular weights obtained even at high generations. Dendrimers appeared to be suitable candidates for oral drug delivery, as they loosen the tight junctions in epithelial cells, allowing for better absorption of small molecular weight drugs. In addition, covalent attachment of the drugs to the surface groups of dendrimers is known to offer better control of drug release and hence reduction of undesirable toxic effects.[20] Nonsteroidal anti-inflammatory drugs (NSAIDs) are the most commonly used drugs in the world used for treating inflammatory diseases like osteoarthritis and other musculoskeletal conditions. However, their oral administration has been restricted by their toxicity. Further, oral drug delivery is usually associated with prompt release of the drug causing toxicity in clinical practice. The clinical side effects of NSAIDs include gastrointestinal side effects like ulceration, bleeding or

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Plant biodiversity and soils in the Jebel Marra region of Darfur, Sudan

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ABSTRACT

Jebel Marra, a volcanic complex in western Sudan, is an important site of early settled agriculture, with high plant diversity, supported by orographic rainfall. Vegetation types were examined in relation to habitat, altitude, soils, and land management. In 52 sites, 274 species, predominantly Fabaceae and Poaceae, were recorded (with 17 new records). Sites were clustered using TWINSPAN, and Detrended Correspondence Analysis (DCA), generating eight vegetation types, six new since the 1970s. Changes in the dominant species show that the savanna has become sparser, with annuals displacing perennials. Soils were mostly "sandy clay loams," so vegetation types did not directly correspond to soil types, although Type VIII vegetation grew in soils with a higher clay content. The sand fraction that predominated in soils of all other vegetation types was, mainly (87%) "soft" or aeolian sand. Canonical Correspondence Analysis (CCA) separated communities and species along a first axis, associated with finer soil textures, higher Fe, and lower elevations. The second axis was positively associated with elevated phosphorus, and negatively with sandy loams. CCA showed that rainfall alone was less pertinent than soil texture, which determines plant-available water capacity. The region's vegetation was not uniformly diverse; instead, a mosaic of patches of diverse terrain, associated with different vegetation "types," collectively generates a diverse flora. Besides climate change, overgrazing and increasing human pressures due to conflict, local population growth and an influx of refugees place these (already stressed) plant resources at risk. Our survey provides a baseline to track changes and develop adaptive management strategies.

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Chorotype; climate change; Darfur; environmental factors; more sparse (diffuse) savanna; ordination; overgrazing; plant communities; refugees; soil moisture; Sudan

Introduction

There is a strong association between vegetation type and soil type, and many early soil maps were inferred from the observed surface vegetation, rather than through systematic soil sampling and analysis, particularly at the local scale. Each plant species often has a recognized range of optimal soil conditions, so this approach has worked quite

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Preparation and biological activity evaluation of some benzoylthiourea and benzoylurea compounds

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A B S T R A C T

Due to the complicated problems coming from excessive applications of insecticides, searching for safe substitutes to these insecticides has become a necessity. Thus, the insect growth regulators are candidates to be used in such concern. Comparative studies of the effects of three compounds, 2-benzoyl-*N*-phenylhydrazine-1-carbothioamide (**1**), 2-(cyanoacetyl)-*N*-phenylhydrazine-1-carboxamide (**2**) and *N*-(2-(2-cyanoacetyl)hydrazinecarbonothioyl)furan-2-carboxamide (**3**) (an insect growth regulator inhibiting chitin synthesis), were conducted on *Spodoptera littoralis* (Boisduval, 1833). The compounds, orally administered, caused larval mortality proportional to the concentrations in the food source. larvae were unable to complete the molting process and died in the old larval cuticle. Larvae contaminated by sublethal doses completed their development to adulthood. *N*-(2-(2-cyanoacetyl)hydrazinecarbonothioyl)furan-2-carboxamide (**3**) is more active than the other compounds have LC_{50} 17.082 ppm for 2nd instar larvae and 60.832 ppm for 4th instar larvae.

1. Introduction

Organic compounds are very important in nature due to their different applications.[1-17] Urea and Thiourea its derivatives constitute an important class of heterocyclic compounds which possess wide range therapeutic and pharmacological properties. Sulphonylureas become widely available in 1955 for the treatment of non-ketosis mild diabetes and are still being the drugs of choice.[18] Benzoylurea and benzoylthiourea insecticides have many attractive properties such as high selectivity,[19] high biological activity, rapid degradation in soil and water and the acute low toxicity for animals, which make them suitable for inclusion in integrated pest management programs for crops.[20] On the other hand, many Urea and Thiourea compounds have been developed into insecticide, fungicides, insecticides and other agricultural chemicals.[21] IGRs include juvenile hormone (JH), mimic and chitin synthesis inhibitors (CSIs).[22] CSIs, such as hexaflumuron, lufenuron and diflubenzuron, which inhibit the production of chitin, a major component of the insect exoskeleton. Insects treated with CSIs become unable to synthesize new cuticle, and therefore unable to successfully molt into the next stage.[23] CSIs

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Preparation and thermoelectric power properties of highly doped p-type Sb_2Te_3 thin films

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ABSTRACT

In this study, we provide facile procedures for the growth of p-type Bi-doped Sb_2Te_3 thin films on ceramic substrates using vacuum thermal evaporation technique. Crystal structure and surface morphology of the prepared films were probed via powder X-ray diffraction (PXRD) and scanning electron microscope (SEM). The thermoelectric power properties were investigated, in terms of electrical conductivity and Seebeck coefficient measurements, over the temperature range from room temperature up to 473 K. The electrical conductivity behavior showed notable transition from metallic behavior to semiconducting as a function of temperature. In addition, Seebeck coefficient measurements confirmed this transition and supported the behavior of the electrical conductivity. Importantly, power factor was estimated based on both the electrical conductivity and Seebeck coefficient values. A maximum value of 227.6 μW/m.K^2 was obtained for the $Sb_{1.85}Bi_{0.15}Te_3$ thin film sample at 428 K.

1. Introduction

Over the past few decades, thermoelectric power (TEP) materials have been extensively investigated both theoretically and experimentally as a promising technology for resolving contemporary energy and environmental issues [1–6]. These materials have also found the way towards many industrial applications such as solid-state coolers, power generators, and infrared detectors.

In principle, TEP material is a material that can convert thermal energy directly into electrical energy and vice-versa. This conversion is based on three important transport effects: the Seebeck effect, the Peltier effect and the Thomson effect. More importantly, the fabricated thermoelectric devices have the advantages of reliability, silence due to the absence of moving mechanical parts, and environmentally friendly.

Despite the advantages of the TEP materials, the efficiency of based devices is still not high enough for daily life applications. The energy conversion efficiency of a TEP material is given by the dimensionless parameter named as figure of merit (ZT), which is expressed by the equation:

$$ZT = \frac{S^2.\sigma}{(K_e + K_l)}\ T \quad (1)$$

where S is the Seebeck coefficient [mV/K], σ is the electrical conductivity [Ω^{-1} cm^{-1}] K_e and K_l are the electronic and lattice thermal conductivity [μW/cm K], respectively.

Since the past decade, smart materials such as superlattices [1,2], Skutterudites [3,4] and nano-structured films [5,6] have been produced to achieve higher values of ZT during a reduction of the lattice thermal conductivity. However, these materials usually require complex and expensive processing technology or have been optimized for use at high temperatures only.

In this context, Sb_2Te_3 is considered as one of the best thermoelectric power materials as it can achieve a relatively high figure of merit at room temperature [7]. Telluride-based alloys have witnessed great interest owing to their potential applications in thermo-power generators and coolers as well as thermal sensors [8,9]. In addition, they can be utilized in energy-related applications such as solar cells and phase-change devices [10]. In particular, thin telluride-based films

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Article

Preparation, Characterization, and Evaluation of Macrocrystalline and Nanocrystalline Cellulose as Potential Corrosion Inhibitors for SS316 Alloy during Acid Pickling Process: Experimental and Computational Methods

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Abstract: Converting low-cost bio-plant residuals into high-value reusable nanomaterials such as microcrystalline cellulose is an important technological and environmental challenge. In this report, nanocrystalline cellulose (NCC) was prepared by acid hydrolysis of macrocrystalline cellulose (CEL). The newly synthesized nanomaterials were fully characterized using spectroscopic and microscopic techniques including FE-SEM, FT-IR, TEM, Raman spectroscopy, and BET surface area. Morphological portrayal showed the rod-shaped structure for NCC with an average diameter of 10–25 nm in thickness as well as length 100–200 nm. The BET surface area of pure CEL and NCC was found to be 10.41 and 27 m^2/g, respectively. The comparative protection capacity of natural polymers CEL and NCC towards improving the SS316 alloy corrosion resistance has been assessed during the acid pickling process by electrochemical (OCP, PDP, and EIS), and weight loss (WL) measurements. The outcomes attained from the various empirical methods were matched and exhibited that the protective efficacy of these polymers augmented with the upsurge in dose in this order CEL (93.1%) < NCC (96.3%). The examined polymers display mixed-corrosion inhibition type features by hindering the active centers on the metal interface, and their adsorption followed the Langmuir isotherm model. Surface morphology analyses by SEM reinforced the adsorption of polymers on the metal substrate. The Density Functional Theory (DFT) parameters were intended and exhibited the anti-corrosive characteristics of CEL and NCC polymers. A Monte Carlo (MC) simulation study revealed that CEL and NCC polymers are resolutely adsorbed on the SS316 alloy surface and forming a powerful adsorbed protective layer.

Keywords: natural polymers; nanocrystalline cellulose; corrosion protection; DFT calculations; green synthesis

1. Introduction

SS316 steel alloy has widespread usage in chemical, automotive, petroleum, and oil production [1]. Its mechanical, physical, and structural characteristics make it appropriate for use as a suitable component, or part the SS316 steel alloy parts might corrode in acidic, alkaline, or neutral mediums [2]. SS316 steel alloy is vulnerable to harsh circumstances such as acidic or saline solutions [3]. Numerous approaches have been applied for the protection of these alloys from serious corrosion issues according to the economic aspects and service type [4–6]. The corrosion is an electrochemical process in which anodic and

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PROPERTIES OF PANCHARATNAM PHASE AND ENTANGLEMENT OF A FIVE-LEVEL ATOM INTERACTING WITH A SQUEEZED FIELD

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Abstract

We introduce a quantum scheme where a single five-level atom interacts with a single-mode cavity field by a time-dependent coupling. During the interaction, the temporal behavior of the quantum entropy in the atomic basis is compared with that of the Mandel parameter used to quantify the nonclassical properties of the field. With the field prepared in a squeezed coherent state, the atomic quantum entropy is then used to quantify the entanglement or the nonlocal correlation of the five-level atom (5 LA) – field system. The influence of one- and two-photon transitions and the atomic motion on the degree of entanglement and the Pancharatnam phase is analyzed. The analysis emphasizes that both the time dependence and photon multiplicity play an important role in the evolution of the degree of entanglement, the Pancharatnam phase, and nonclassical properties. This insight may be very useful in various applications in quantum physics and quantum optics.

Keywords: five-level atom, linear entropy, atomic motion, squeezing parameter, photon multiplicity.

1. Introduction

Essential features in quantum mechanics, namely, the Pancharatnam phase (PP) and the geometric phase (GP) have been studied by many physicists [1–5]. Michael Berry demonstrated that the quantum object – the wave function (WF) – maintains its evolution in the complex-valued argument of the WF, namely, the GP factor. In regard to its dynamical influence, the GP factor depends on the path geometry of the scheme that the quantum object traverses [6]. This factor is stable despite the uncertainties in control and environmental perturbations. Therefore, researchers pay it close attention while conducting fault-tolerant quantum computations. Focusing on the generalized Heisenberg algebra coherent state (CS), we have recently explored the PP and the purity of the field for several quantum systems [7,8].

In this context, the link between the GP and field purity is highly sensitive to the photon transition number and the initial atomic state. In regard to the atomic motion, the influence of a time-dependent

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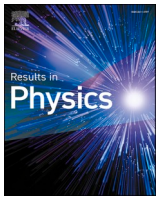

Properties of transient spectrum and field purity for a qubit system in squeezed states

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ABSTRACT

The present study investigates the transient spectrum (TS) of a two-level system that interacts with a generalized squeezed state without using the rotating wave approximation (RWA). We consider the purity of the optical field, which is developed in a generalized squeezed state, utilizing the linear entropy. The analytic expressions of the TS and field purity (FP) of the bipartite system are evaluated. Moreover, the study exhibits the influence of the squeezed parameter and some photons transition on the TS and FP. We obtain that the control of the FP may be generated based on an adequate choice of the photons transition and squeezed parameter. Such results can be utilized in the understanding and development of various tasks of quantum physics and optics.

Introduction

The abrupt radiation is considered as a primary reason of energy relaxation in an environmentally-coupled quantum system. However, it can be controlled by changing the field affects the quantum system [1], referred to as the Purcell effect. Enclosing the qubits in a cavity resonator that is detuned from the qubit frequency has resulted in improving the qubit lifetime while keeping qubit control [2–4]. Such dispersive coupling amid the qubit and the resonator plays a role in reducing the channels of decay close to the qubit frequency. However, these channels should undergo additional suppression. Contemporary authors have benefited from these techniques in the mismatches of engineering impedance in the Purcell decay channels existing in the resonator [5,6].

The photon, as a concept, in the quantum theory pertaining to a radiation field relied on the number (Fock) state. Nonetheless, the coherent states are also significant, which are defined as a linear superposition of the Fock states with choosing coefficients. In this case, the states can be generated by acting the displacement operator on the vacuum state [7–9]. Recently, squeezed states have played an important role in the development of various tasks of quantum technology. These states are classified as non-classical states in quantum optics that can be generated by using the operation of the squeezed operator [10]. Squeezed displaced Fock states were developed and their various features, including squeezing and photon statistics were explored [11,12]. They extend two-photon coherent states [13] (squeezed coherent states), squeezed number states [14] and displaced Fock states [15]. Lately, authors have reported the development of motion of a trapped ion in nonclassical states, e.g. Fock states, coherent states, squeezed states and Schrödinger-cat states [16,17].

The JCM (Jaynes Cummings model) has fulfilled the foundation of the nonclassical states through the conditional measurement method [16]. Dakna, Knoll and Welsch (1998) have provided a review for further details relevant to JCM [17]. The development of coherent states with JCM is a significant issue because it provides the information about the non-classical effects that depend on the kinds of the interaction between atoms and fields, including the cases of Schrödinger-cat states [18], displaced number states [19] and squeezed coherent states [20]. It has been shown that the squeezed parameter significantly affects the dynamical properties of the field primarily in the squeezed coherent state [21]. Recent works have shown the effect of the squeezed parameter on the entanglement for a system of two 3LAs (three-level atoms) interacting with a squeezed field [22]. The dynamical properties of a 3LA coupled to a field mode primarily developed in the squeezed coherent state without using the RWA have investigated [23,24]. The effect of the atomic motion within center-of-mass wave functions and atom nanolithography has examined [25]. Recently, the emission spectrum of an optical radiation field interacting with a 2LA when this field is initially in the coherent states (CSs) of added photons associated with pseudo-harmonic oscillators has discussed [26]. Moreover, it has found that the emission spectrum is extremely sensitive to the deformed field and detuning parameters [27]. More recently, a link between the emission spectrum and quantum state fidelity for an atomic system

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