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Production of biodiesel from *Cordiamyxa* bio-oil using $BaMoO_4$-Ce_2O_3 nanoparticles as an alternative fuel for diesel engine

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ABSTRACT

In recent years, the production of biodiesel has rapidly increased due to its benefits and to resolve the problem findings present in environmental pollution. In, this study barium salts doped with cerium oxide are used as a heterogeneous catalyst for the production of biodiesel from *Cordiamyxa* oil. The synthesized $BaMoO_4$-Ce_2O_3 nanocatalyst has characterized by XRD (X-ray powder diffraction) and SEM (Scanning Electron Microscope) analysis. Methanol to a molar ratio of oil from 12:1 to 16:1 has studied and got the optimized results. An optimum yield of 87.50 wt% of methyl esters collected from *Cordiamyxa* bio-oil with optimized limits of 0.5 wt% of catalyst $BaMoO_4$-Ce_2O_3 at 65 °C. The purpose of the current study investigates the analysis of biodiesel and their blends with diesel oil in four-stroke internal combustion engine (ICE) applications like unburned hydrocarbons, sulfates, particulate matter, polycyclic aromatic hydrocarbon, carbon monoxide, and nitrate aromatic hydrocarbons. *Cordiamyxa* methyl ester blend (Biodiesel-B20) with $BaMoO_4$-Ce_2O_3 nanoparticles shows a better engine performance and emission reduced compared to fossil fuels like decrease hydrocarbon particulate matters.

1. Introduction

Crude reserve decrease and concerns increase to global warming; the look for a sustainable, property and much measure of ecologically well-disposed of fuel supply needs development of biodiesel [1]. Vegetable oil, non-edible oils, and algae found to be the alternative energy source has used directly in the existing engine. The demands occur in the energy system, especially for petroleum-based products. Transesterification is nothing but a displacement of alcohol from an ester by another alcohol [2]. Advantages biodiesel over diesel fuel is its portability, higher combustion, renewable, available, efficient, lower sulfur, higher Cetane number, higher biodegradability, and aromatic content [3]. Today alternative fuels have larger markets in the world. Recently, the International energy reports have shown that energy consumption is larger and it will grow near 110 barrels per day in 2018 and 138 barrels per day in 2040. The current market price of oil has already increased to 45–55% higher than 2030 projected. Members present in the oil wealth countries, OPEC (Organization of Petroleum Exporting Countries) to supply 15.8 billion barrels per day. Due to these effects, the non-members present in OPEC the amount of oil production increased to 24.9 million barrels per day [4]. Biodiesel can use directly in diesel engines with a count of their blended petrodiesel or without petrodiesel and it easily mixes with petrodiesel at any concentrations [5]. Today, automobile sectors have to decide many of their models are suitable for biodiesel. The automobile sector prefers blended biodiesel content up to 20% for use in vehicles because it has easy lubricity and especially on ultra-low sulfur diesel [6]. The plan of this current study has to check the earliest studies in the emission and performance analysis of biodiesel in an enclosed combustion engine [7,8] The usual properties of *Cordiamyxa* biodiesel were compared to standard ASTM methods (D6751) are shown in Table 1.

2. Materials and methods

2.1. Oil recovery and chemicals

Oil has extracted by using different methods like steam distillation, solvent extraction, fractional distillation. Easiest and finest traditional wet method for oil estimation is a Soxhlet apparatus which has performed 100% of oil recovery. Solvents like methanol, acetone, hexane, chloroform, isopropanol, and toluene and chemicals like cerium trioxide, barium chloride, barium nitrate tetrahydrate, molybdic acid from SRL Chemicals Pvt Ltd Chennai. All above solvents, chemicals are in anhydrous grade and used in the

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Core/shell structures on argon ions implanted polymer based zinc ions incorporated HAp nanocomposite coatings

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ABSTRACT

Polymer-based zinc ions incorporated HAp nanocomposite coatings (ZHAp) on titanium substrate are synthesized by wet-chemical route and assisted by microwave irradiation. The surface of the nanocomposite coatings was modified by low energy (90 keV) argon (Ar^{9+}) ions with various fluences 1×10^{14}, 1×10^{15} and 1×10^{16} ions/cm^2. A significant reduction in crystallite size (19%) was observed at the lower fluence (1×10^{14} ions/cm^2). The chemical bonding of the polymer/ZHAp was confirmed by FTIR. At the higher fluence, core/shell morphology (ZHAp/PVA) was observed whereas, at the lower fluence, plates-like structures were noticed. In the pristine, agglomerated core/shell with plates-like morphology was observed. The photoluminescence intensity was enhanced at the lower fluence with blue emission. The band gap (18%) and *in vitro* bioactivity were improved at the lower fluence and drops with an increase in ion fluences. The contact angle was decreased by 38 % at the lower fluence compared to the pristine (hydrophobic surface). Implantation tailors the contact angle from hydrophilic to hydrophobic due to the variation of chemical bonding, surface morphology and surface charge/energy as a function of ion fluence. Therefore, the overall results demonstrate that the surface engineered PZHAp nanocomposite coatings could be a potential candidate for novel biomedical and new optoelectronic devices.

1. Introduction

Hydroxyapatite (HAp) is a major inorganic mineral component of bone and teeth. It belongs to a family of apatite [1]. It has been considered as an ultimate material for hard tissue replacement owing to its biocompatibility and bioactivity. The HAp in bulk form has been employed as a bone cement, protein adsorbent, and gas sensor and also as a chromatographic agent. Besides, it has been extensively used in orthopaedic field as a coating material for implants in order to enhance their biological properties [2]. The main restrictions of HAp are fragile mechanical potency and stumpy resorbability [3]. To surmount the drawbacks, metal ions like magnesium and zinc ions were incorporated in the HAp [4]. The incorporated zinc ions provide high mechanical strength, bioactivity, and antimicrobial activity [4]. Polymer such as polyvinyl alcohol (PVA) was used as a binding agent in coating of HAp composite on substrates which eventually improve the biodegradability and biocompatibility to living cells [5]. Properties like roughness, surface potential, wettability etc., of the biomedical implants play a vital role in the enhancement of adhesion to the surrounding cell environment [6]. Many techniques have been used for surface modification and to engineer the surface of the implants viz., laser irradiation [7], electron [8], plasma and ion beam based implantation [9] and ion irradiation [10]. Among the various techniques, one of the effective and efficient tools is low energy ion implantation which can alter the surface of the implants and not affecting their bulk [11–13]. The implantation (1–1.5 MeV) of nitrogen and argon ions was enhanced the mechanical properties of HAp thin films [14]. Argon ions (0.6–1.2 kV) and oxygen ions (2 MeV) implantations improved the properties like luminescence, wettability and bioactivity [15,16]. In the current work, microwave-assisted deposition technique is used to prepare novel crack free polymer based zinc ions incorporated HAp (PZHAp) nanocomposite coatings and subjected to low energy argon ion (90 keV) implantation. The ion interaction with the polymer based zinc ions incorporated HAp nanocomposites is deeply examined and the changes in

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Effects of rare earth, transition and post transition metal ions on structural and optical properties and photocatalytic activities of zirconia (ZrO_2) nanoparticles synthesized via the facile precipitation process

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ABSTRACT

This work aims to study the structural, optical and photocatalytic properties of pure and different metal ions, such as rare earth samarium, transition scandium and post transition stannic ions doped zirconia (ZrO_2) nanoparticles, synthesized via the facile precipitation process. The effects of the different metal ions on the physic-chemical properties of zirconia were analyzed by using different techniques. The structural properties of the synthesized samples were studied by the XRD and FTIR analyses, which confirm that both the pure and different metal ions doped zirconia nanoparticles reveal a tetragonal structure with an average crystallite size in the range of 9.46–4.05 nm and are in good agreement with the TEM results. The smooth spherical surface morphologies and presence of elements of the samples have been confirmed by the SEM and EDX analyses. The Optical properties of the different metal ions doped ZrO_2 nanoparticles were evaluated using UV–vis absorption and PL emission spectroscopies. Blue shifts were observed and the band gap energies of the samples found to be in the range of 5.51–5.65 eV, which are higher than that of bulk ZrO_2. The enhanced broad green emissions at 578 nm in the PL spectra correspond to the $^5D_0$–$^7F_1$ transition, which contributes to the crystallinity and presence of defects concentration in the samples. The performances of the pure and different metal ions doped zirconia nanoparticles in the photocatalytic degradation of methyl orange (MeO) dye under UV light were evaluated, and the degradation percentage (%) found to be in the range of 58.48–98.24%; the results have been comparatively discussed. The detailed mechanism for the degradation of the MeO dye by using metal ions doped ZrO_2 catalyst is discussed. The Chemical oxygen demand (COD) test has been done to confirm the total quantity of oxygen required for the oxidation of the organic MeO dye solution into mineralization.

1. Introduction

In recent years, water pollution caused by organic and toxic pollutants has aroused great attention. One of the important water sources is the river, but the river also has nowadays become much polluted because of the different dyeing factories. Maiko Sakamoto et al. reported the usage of dyes in various factories and how the factories polluted the river with the wastage of the dye solutions [1]. Dye using factories across the world are dumping millions of tons of dye effluents into the rivers. Dyes are problematic, because the families of chemical compounds that make good dyes are also toxic to humans and are considered deadly poisons [2]. In the past few years, there has been tremendous research and development in the area of photocatalysis. Photocatalysis has received much attention in recent times as a promising environmental remediation technique because of its ability to completely remove organic and inorganic toxins from water pollutants by using nanosized metal oxides as catalysts [3–5]. Various nanosized semiconductor metal oxide nanoparticles have been used for various applications including the photodegradation of dye solutions and polluted water [6–11]. Semiconductors with wide band gap materials such as titanium dioxide (TiO_2), zinc oxide (ZnO), tin oxide (SnO_2) and zirconium oxide (ZrO_2) were predominantly studied in the field of

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Electric potential and surface oxygen ion density for planar, spherical and cylindrical metal oxide grains

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ABSTRACT

In this article, the mathematical model presented by Barami and Ghafarinia (Sensors and Actuators B: Chemical 293 (2019) 31–40) for metal oxide grains is discussed. The nonlinear governing model, which is a Poisson-Boltzmann-type equation, is solved by a simple and efficient method. Analytical expressions for the electrical potential and oxygen ion density within the planar, cylindrical and spherical metal oxide grains are expressed in terms of the absolute value of the electric potential and grain thickness. In addition, an investigation of the effects of parameters such as grain diameter, grain thickness, and uniform distribution of single donors on the performance. The validity of the derived analytical expression is established by direct comparison with computer-generated numerical simulations in addition to previously available limiting cases' results (low and high oxygen adsorption on the grain).

1. Introduction

Many natural and engineered aqueous nanoparticles (NPs) are electrically charged due to the presence of certain functional groups in their polymer or crystal structure [1]. To compensate for the electrical charges, the opposite charges' counter-ions are adsorbed onto the surface. The net electric charge of NPs with counter-ions on the particle surface forms an electrochemical double layer. The distribution of electric potential and concentration profiles of ions within an electrical double layer is represented by the Poisson-Boltzmann (PB) equation.

The efficiency of the PB equation in describing the charge distribution in a solute validates its frequent appearance in many applied and theoretical fields of physics and chemistry. Finding analytical solutions of the PB equation leads to finding both the distribution of electric potential and the concentration profiles of ions within an interior electric double layer. However, finding reliable analytical or semi-analytical solutions of the PB equation for the electric double layer in planar, spherical, and cylindrical geometries is still in a premature stage except possibly in the case of small surface charge density. Duval et al. [1] discussed PB electrostatics and ionic partition equilibration of charged NPs in aqueous media and presented an analysis of their potential profiles. They provided the implications thereof in terms of counter-ion accumulation within and/or near hard, soft and core-shell NPs. Recently, Ohshima et al. [2] obtained approximate analytical solutions to the modified PB equation for planar [3], spherical [4] and cylindrical charged surface [5] for limiting cases.

The fact that the PB equation is strongly nonlinear makes it impossible for an exact solution to exist except in the case of low potentials, where the equation can be linearized. Under the assumption of low potentials, Debye-Hückel's linearization method has been the most approachable technique for solving the PB equation for planar particles [6–10]. Realizing the complexity of cylindrical and spherical operators resulting from the curvature of shells, Saboorian-Jooybari et al. [11] obtained an approximate analytical solution of the PB equation for slab-shaped particles containing an electrolyte solution. Ohshima et al. [12] derived approximate expressions for surface charge density/surface potential relationship and double-layer potential distribution in the case of spherical or cylindrical colloidal particles in an electrolyte solution. Rajni et al. [13] obtained the osmotic pressure from the modified PB equation. Prakash et al. [14] employed the Debye-Hückel linearization approach to linearize the PB equation in order to investigate the double diffusive convection in peristaltic pumping of ionic nanofluids. Ganjizade et al. [15] assumed that the electric potential is small enough to apply the Debye-Hückel approximation and neglected the relaxation effect to analytically study the effect of ion partitioning on electrophoresis of spherical soft particles. In a recent study, Barami et al. [16] obtained analytical expressions of the electric potential and surface oxygen ion density for planar and spherical metal oxide grains

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Analysis of the steady-state behavior of pseudo-first-order EC-catalytic mechanism at a rotating disk electrode

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ABSTRACT

An efficient analytical method is applied to solve a system of convection-diffusion equations in the pseudo-first-order EC-catalytic mechanism at a rotating disk electrode. A simple closed form analytical expression for the concentration of oxidized and reduced catalyst species in the electrochemical reaction is obtained and analyzed for various values of parameters. Also, closed form analytical expressions are derived for the steady-state current response and the current ratio at potential steps for various values of diffusion coefficients, rate constant, and rotation rate. The derived approximate analytical results are shown to be in satisfactory agreement with numerical simulation results.

1. Introduction

Electron transfer reactions coupled with preceding or follow-up chemical reactions have been under intensive and extensive investigation for the past four decades. In particular, The electrode reaction scheme, where the charge transfer is followed by a homogeneous chemical reaction has received a great deal of attention, not only in electrochemistry, but also in various fields of general chemistry and biochemistry, since it appears in many experimental systems of interest in biomedical science, industrial synthesis and electrochemical technologies [1–4].

Many of theoretical features of the EC, CE, ECE systems under various conditions at various electrodes are appropriately expounded in several outstanding books [5–7], theoretical studies and reviews [8–11]. The so-called electrocatalytic regenerative mechanism or EC catalytic mechanism is one of the most interesting from a theoretical point of view, since it differs in many aspects from the other two mechanisms (CE, and ECE) [12–14]. This mechanism comprises regeneration of the initial electroactive species involved in the electrode reaction via homogeneous redox reaction of the electrochemically generated product with other redox species present in the electrolyte solution [1].

In recent years, the problem of the EC catalytic mechanism at the rotating disc electrodes has received considerable attention [15]. The present work deals with a conceptually simpler pseudo-first-order EC mechanism where a reactant can be isolated by increasing the concentration of other reactants. An exclusively attractive and suitable technique known as rotating disk electrode (RDE), which has potentially critical applications in the study of catalytic reactions, is applied for the kinetic study of the EC mechanism. An RDE that is made of carbon, palladium, platinum, and gold is a device that offers a well-defined solution flow pattern, where the mass transport of the species is almost completely due to convection, which makes it possible for RDE to calculate parameters related to mass transport, such as the diffusion coefficient of the various electroactive species [16].

Rotating disk electrodes have been used to find the outcome of the electroactive nature of the electrode on the reaction rate [17]. Opekar and Beran [18] have presented an intensive theoretical review of the RDE and RRDE (Rotating Ring Disk Electrode) and their application to the study of the kinetics of electrode reactions. Other uses of RDEs include investigation of the electrochemical properties of a zinc electrode in concentrated solutions of potassium hydroxide saturated with zincates [19]. Using the method of RDE, the concentrations of Fe(II) and Fe(III) can be measured simultaneously

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