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Review

Significance of Immune Status of SARS-CoV-2 Infected Patients in Determining the Efficacy of Therapeutic Interventions

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Abstract: Coronavirus disease 2019 (COVID-19) is now being investigated for its distinctive patterns in the course of disease development which can be indicated with miscellaneous immune responses in infected individuals. Besides this series of investigations on the pathophysiology of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), significant fundamental immunological and physiological processes are indispensable to address clinical markers of COVID-19 disease and essential to identify or design effective therapeutics. Recent developments in the literature suggest that deficiency of type I interferon (IFN) in serum samples can be used to represent a severe progression of COVID-19 disease and can be used as the basis to develop combined immunotherapeutic strategies. Precise control over inflammatory response is a significant aspect of targeting viral infections. This account presents a brief review of the pathophysiological characteristics of the SARS-CoV-2 virus and the understanding of the immune status of infected patients. We further discuss the immune system's interaction with the SARS-CoV-2 virus and their subsequent involvement of dysfunctional immune responses during the progression of the disease. Finally, we highlight some of the implications of the different approaches applicable in developing promising therapeutic interventions that redirect immunoregulation and viral infection.

Keywords: coronavirus; SARS-CoV-2; immune response; therapeutic interventions; immunopathogenesis

1. Introduction

In consideration of public health emergency and global reach, on 11 March 2020, the World Health Organization (WHO) specified coronavirus disease 2019 (COVID-19) as a global pandemic outbreak of international public health concern [1]. A novel, highly transmissible enveloped RNA betacoronavirus unexpectedly emerged in December 2019 in Wuhan, China, and then was formally named as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2. The most common clinical symptoms and manifestations of SARS-CoV-2 infection are pneumonia-like, including fever, hypoxia, dyspnea (labored breathing), headache, myalgia, cough, and in some cases, intestinal symptoms [2,3]. COVID-19 is now characterized as a mild to severe respiratory disease, and its clinical presentation

materials

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Article

A Novel Synthesized 1D Nanobelt-like Cobalt Phosphate Electrode Material for Excellent Supercapacitor Applications

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Abstract: In the present report, we synthesized highly porous 1D nanobelt-like cobalt phosphate ($Co_2P_2O_7$) materials using a hydrothermal method for supercapacitor (SC) applications. The physicochemical and electrochemical properties of the synthesized 1D nanobelt-like $Co_2P_2O_7$ were investigated using X-ray diffraction (XRD), X-ray photoelectron (XPS) spectroscopy, and scanning electron microscopy (SEM). The surface morphology results indicated that the deposition temperatures affected the growth of the 1D nanobelts. The SEM revealed a significant change in morphological results of $Co_2P_2O_7$ material prepared at 150 °C deposition temperature. The 1D $Co_2P_2O_7$ nanobelt-like nanostructures provided higher electrochemical properties, because the resulting empty space promotes faster ion transfer and improves cycling stability. Moreover, the electrochemical performance indicates that the 1D nanobelt-like $Co_2P_2O_7$ electrode deposited at 150 °C deposition temperature shows the maximum specific capacitance (Cs). The $Co_2P_2O_7$ electrode prepared at a deposition temperature 150 °C provided maximum Cs of 1766 F g^{-1} at a lower scan rate of 5 mV s^{-1} in a 1 M KOH electrolyte. In addition, an asymmetric hybrid $Co_2P_2O_7$//AC supercapacitor device exhibited the highest Cs of 266 F g^{-1}, with an excellent energy density of 83.16 Wh kg^{-1}, and a power density of 9.35 kW kg^{-1}. Additionally, cycling stability results indicate that the 1D nanobelt-like $Co_2P_2O_7$ material is a better option for the electrochemical energy storage application.

Keywords: $Co_2P_2O_7$; hydrothermal method; 1D nanobelt; hybrid asymmetric supercapacitor

1. Introduction

The energy demand for industrial applications has risen steadily over the past decade [1,2], leading to the increasing exploitation of several energy sources, including solar energy, biofuels, coal, wind energy, and biomass [3,4]. However, there remain several bottlenecks in the energy industry, including limitations in the conversion and storage capacity of power plants and the transport of electricity from generation sites [2,5]. Supercapacitors (SCs) have become a vital element of the portable electronics industry to overcome these issues. Though SCs are superior to traditional batteries and capacitors in terms of their higher specific capacitance and energy

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Enhanced corrosion protection of Cu & Al in Saline media using a new PEDOT based waterborne polyurethane coating

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ABSTRACT

In the present investigation, a new nanocomposite (PGZ) viz. PEDOT (poly(3,4-ethylenedioxythiophene)/ Graphene oxide (GO)/Zirconia (ZrO_2) has been developed via in-situ chemical oxidative polymerization method. Its electrochemical response as a preventive coating for inflating the corrosion resistance of industrial alloys i.e. copper (Cu) and aluminum (Al) exposed to neutral chloride (3.5% NaCl) environment at room temperature has been analyzed using various electrochemical techniques. Both the substrates along with the nanocomposite material (PGZ) have been characterized by various surface analysis studies viz. FE-SEM, XRD, TGA, TEM, EDAX and FT-IR studies. The SEM studies showed the compact formation of coating on the substrate. Other characterization studies well established the formation of PGZ nanocomposite. The experimental electrochemical investigations on coated substrates demonstrated a significant reduction in the corrosion current density (i_{corr}) and a fascinating increase in the charge transfer resistance (R_{ct}) values in comparison to the bare metal specimens.

1. Introduction

Corrosion of industrial alloys specifically copper (Cu) and aluminum (Al) is a subject of huge concern for various industries. Their gradual depletion after coming in contact with the aggressive environment, during various industrial processes results in enormous economic loss of both direct and indirect type (Liu et al., 2015; Lokesh et al., 2012; Rickerby and Steinke, 2002; Liu et al., 2016; Kinsella et al., 2003; Lamaka et al., 2007; Zhao et al., 2001). The extensive use of aggressive electrolytes in these industrial processes triggers the destructive electrochemical corrosion reactions on the surface of these important metals (Steppan et al., 1987; Fenelon and Breslin, 2002; Cascalheira et al., 2003; Brusic et al., 1997; Beccaria and Chiaruttini, 1999). Several strategies including the use of cathodic/anodic protection (Kear et al., 2005; Li et al., 2018; Simões et al., 2007; Cecchetto et al., 2007), inhibitors (Fateh et al., 2017; Xhanari and Finšgar, 2016), paints, coatings (Kowalczyk and Luczka, 2015; Stankiewicz et al., 2013) etc. have been adopted to minimize this destructive force of corrosion. Among all these methods the most convenient and promising way to combat corrosion is the use of barrier coatings. Chromate-based anti-corrosion coatings are proven to be very effective but their toxic nature is a huge drawback for the concerned industries (Kendig et al., 1993; Bastos et al., 2005; Shi and Dalal, 1994). The organic/inorganic nanocomposite coatings comprising of sustainable components are the ideal substitute for these chromate based coating materials, which provides significant corrosion deterrence for a prolonged period of time (Nguyen-Tri et al., 2018).

Several researchers have reported the use of polymeric nanomaterials as anti-corrosion coating, R. Hasanov et al. (Hasanov and Bilgiç, 2009) explored the use of monolayer and bilayer polymer coatings, including polypyrrole (PPY) and polyaniline (PANI), on steel electrodes for corrosion protection. The coatings were deposited via electro-polymerization in oxalic acid solution, and their effectiveness in inhibiting corrosion was evaluated in 1 M H_2SO_4 solution. The study found that the bilayer coatings showed better corrosion inhibition than the monolayer coatings, with PPY/PANI offering the highest level of protection. The coatings were characterized by FTIR spectroscopy and SEM. C.K. Tan et al. (Tan and Blackwood, 2003) investigated the effectiveness of multilayered coatings consisting of polyaniline (PANI) and polypyrrole (Ppy) in providing a barrier against corrosion in chloride environments. The coatings were galvanostatically deposited on carbon steel and stainless steel, and their performance was evaluated using potentiodynamic polarization. The results showed that the multilayered coatings were significantly better at protecting against pitting corrosion than single Pani coatings on stainless steel, with films consisting of

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DFT-based theoretical model for predicting the loading and release of pH-responsive paracetamol drug

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ABSTRACT

Here, we provide a theoretical framework that integrates quantum mechanical calculations with classical pKa theory to forecast the degree of interaction of drug molecules with carrier surfaces across the whole pH range. The drug loading and release of a pH-responsive drug delivery system is demonstrated using paracetamol drug carried using mesoporous silica surface with and without trimethylammonium (TA) functional group. The model is explained on the basis of possible combinations of surface (S) and drug (D) molecules as neutral (0) and deprotonated (1) pH-dependent states. The relative probabilities of these states depend on the pKa values of the drug as well as surface and the desired pH. Paracetamol, an analgesic and antipyretic drug, is required to be absorbed in small intestine and not in the stomach. It's seen that Paracetamol is caught in the MSN-TA nano-vehicle when it goes through the acidic environment of the stomach and then released in the slightly basic pH of the intestine. The reported model from the literature is used for forecasting the loading and release pH for the Paracetamol using mesoporous silica surface.
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1. Introduction

The drug, the way it's delivered and the target location where it's delivered are of utmost importance factors in the treatment of various diseases. If the drug delivery mechanism is ineffective, even the therapeutic molecule itself may fail during the clinical trial in such circumstances. [1–2]. The process of discovering a new medicine and obtaining clinical approval is expensive and time-consuming. Numerous drug carrier molecules, including liposomes, micelles, dendrimers, polymers, microspheres and nanoparticles were reported, which were purposely developed utilising organic and inorganic compounds to avoid these issues. The intended effects of the medication molecules are obtained similarly to wearing new clothing or coating on an old medicine. Low toxicity, biodegradability, biocompatibility, good cellular absorption, sustained, and targeted distribution are requirements for an effective drug delivery system. Efficient use of drug delivery system, diseases can be prevented with little to no side effects, a low dose, and a low dosage frequency [1–2].

Nanoparticles (NPs) are one of the best candidates for the development of improved drug delivery systems because they have special qualities like being small enough to pass through cell membranes, being able to pass through tiny arterioles and endothelial without causing clotting, and stabilising the drugs [3–5]. The utilisation of liposomes, co-polymers, micelles, SiO_2, Carbon, and maghemite nanoparticles for the trapping of pharmaceutical drugs has already been extensively studied and reported for the enhancement of drug delivery [6]. Meso-porous SiO2 NPs (MSNs) (2–50 nm) have garnered a great deal of interest recently as potential drug delivery systems due to their numerous advantages, including good biocompatibility, low apparent cytotoxicity, biodegradability, good excretion, ordered and uniform size, high

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Discovery of oxazoline-triazole based hybrid molecules as DNA gyrase inhibitors: A new class of potential Anti-tubercular agents

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ABSTRACT

A library of novel oxazoline-triazole hybrid analogues (**6a-6 g** and **7a-7 m**)was designed using a molecular hybridization approach and synthesized from commercially available ethyl 2/3/4-hydroxybenzoate. The synthesized compounds were characterized by modern art instrumentation, including IR and NMR (^{1}H, ^{13}C). All the final compounds were evaluated for their *in-vitro* antibacterial (*S. aureus, B. subtilis, E. coli* and *P. aeruginosa*), antifungal (*C. neoformans, C. albicans* and *A. niger*) and anti-tubercular (*Mycobacterium tuberculosis* H_{37}Rv, MDR and XDR strains) activities. Among the series, compound **7a-7i** exhibited excellent activity (**MIC** = 1.6 µM) against H_{37}Rv strain of *M.tuberculosis*. However, antibacterial screening data (in vitro) revealed a moderate inhibition for **6e-6 g** and **7f-7 h** against gram-positive bacteria (*Bacillus subtilis*) and **7a-7i** against gram-negative bacteria with a **MIC** value of 25 µg/ml. While moderate activity was observed against fungal (*C. neoformns* and *C. albicans*) strains with **MIC** value of 25–200 µg/mL. Additionally, five compounds (**7a, 7d-7f** and **7 h**) were further evaluated for their in vitro inhibitory activity against *E-coli* DNA gyrase. These compounds displayed significant inhibitory activity against the DNA gyrase enzyme with an $\mathbf{IC_{50}}$ value of 0.08 – 0.5 µM.

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1. Introduction

The research on antimicrobial agents is a continuing process as there are many reasons like prolonged and excessive use of antibiotics resulting in drug resistance. Since the early stages of childhood, antibiotics have often been used to develop new strains of microorganisms having resistance to the antibiotic used. Therefore, continuous research would help for the development of better and more effective antimicrobial drug molecules [1,2].

Tuberculosis is an air-born contagious disease caused by mycobacterium tuberculosis (*Mtb*). In 2012, World Health Organization (WHO) reported 8.6 million infections, and among them, 1.3 million people died because of infectious diseases, and in 2016, 490,000 new cases of multidrug resistance were widely estimated. There is a growing resistance to existing drugs resulting from deadly diseases that become more deadly and difficult to treat. MDR and extensive drug resistance (XDR) *Mtb* are diseases caused by bacteria that don't respond to first-line anti-tubercular drugs. Existing treatment consists of various drugs that need to be taken for more than a year, resulting in numerous side effects and a substantial economic burden. In developing countries, pollution is the primary concern as *Mtb* can be gained through the air. In recent years the death rate was declined, but it is still a significant cause of death after AIDS. Streptomycin, Isoniazid, Ethambutol, Rifampicin, Ethionamide, Cycloserine and Kanamycin, etc., are the drugs used for the treatment. Most of these drugs have been discovered and used for the last 70 years. Hence, there is an alarming concern about the drug-resistant strains of *Mtb* [3–8]. A constant research is underway for understanding the reasons behind the evolution and existence of resistant strains of *Mtb*. Synthesis and high-throughput screenings of different derivatives with a broad spectrum of novel and known scaffolds have been carried out to obtain lead derivatives as anti-TB [9–11].

Fused oxazole and oxazoline were widely distributed in nature, and these attracted much attention due to their diverse pharmaceutical activities. These scaffolds consist of nitrogen and oxygen atoms in an aromatic five-membered ring. These heteroatoms bind with different receptors and enzymes in the body mechanism's biological system through non-covalent interactions. The structure

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Insights into the formation of multiwall carbon nanotubes using simple flame pyrolysis method

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ABSTRACT

Herein, we discuss the formation of multiwall carbon nanotubes (MWCNTs) during the simple and effective flame pyrolysis of ferrocene solution in ethanol with the help of alcohol lamp. The method is unique and simple one to prepare impure MWCNTs in the best possible way. Systematic investigations showed that the in-situ generated maghemite plays an important role in the formation and development of the MWCNTs. The growth of the maghemite impregnated MWCNTs were thoroughly studied using sophisticated instruments viz. XRD, BET, HR-SEM, and TEM analysis in details and on the basis of these, the growth mechanism is discussed.
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1. Introduction

Carbon nanotubes were extensively studied for diversified applications and were in main focus since their discovery by Ijima [1]. Carbon nanotubes possess unique structural and physical properties including high tensile strength coupled with high surface area, high electric as well as thermal conductivity [2,3], These properties made them ideal candidate for the numerous applications viz. electronic devices [4], composite materials [5–7], sensors [8], gas storing [9], catalytical supports [10–12], etc. For these extensive uses, their low cost and simple synthesis became essential. Various methods were developed to synthesis of carbon nanotubes which includes but not limited to either arc discharge [13–15] and high temperature furnaces [16–19]. Besides these methods, flame method emerged as energy efficient and is readily scalable for bulk synthesis of carbon nanotubes.

The synthesis of carbon nanotubes required three essential components, catalyst material, heat source and the carbon source [20]. Flame method is widely utilized for the synthesis of carbon nanotubes in the literature [20,21–23]. The commonly used catalyst materials includes Fe, Co and Ni containing compounds [11,24,25]. Firstly ferrocene, cobaltocene and nickelocene when used requires relatively low temperatures about 700 K [18,19] for their thermal decomposition than the threshold of soot formation which is approximately at 1300 K [20]. Secondly, the formation of carbon nanotubes requires fuel within the pyrolysis when using ferrocene or cobaltocene.

In recent years, Inamdar et al. gradually developed flame pyrolysis method using simple alcohol lamp [26–29]. In this the first report came in 2006 with the preparation of spherical 25 nm sized γ-Fe_2O_3 nanoparticles [26,27]. The next two reports came in 2012 and 2013 about preparation of faceted maghemite-carbon composite [28] and sulphur containing carbon nanoparticles [29] respectively. In a year another report came about flame synthesized N-containing turbostatic carbon nanoparticles in 2014 [30]. The latest report came last year in 2021, reporting electrochemical sensor using flame synthesized MWCNTs-iron oxide nanocomposite [8]. Herein, we discussed the insights into the formation of multiwall carbon nanotubes (MWCNTs) observed during the simple and effective flame pyrolysis of ferrocene solution in ethanol using an alcohol lamp [8]. In the present study carbon nanotubes were seen growing in the spirit lamp flame, where, ferrocene is utilized as both catalyst and carbon source. Ethanol, the fuel used in the lamp, acts as extra source of carbon.

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Synthesis of cobalt oxide nanoparticles coated with carbon and its catalytic applications in organic reactions

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ABSTRACT

Cobalt oxide nanoparticles coated with carbon were prepared by the modified flame pyrolysis method. The preparation was carried out by simply exposing the cobalt nitrate salt onto a spatula to gas flame, the flame temperature converted the cobalt nitrate into cobalt oxide, which further get coated by carbon produced from the combustion of fuel gas. The obtained product from the flame pyrolysis was characterized using techniques viz. XRD, FTIR and SEM. SEM data show that the short length rod shaped nanoparticles coated with carbon ranging from 0.3 to 1 μm μm formed during the process. XRD and FTIR data also support the formation of cobalt oxide nanoparticles coated with carbon particles. Cobalt oxide NPs were utilized for the catalytic N-formylation reaction of amines at 70–80 °C. The optimization of the catalyst as well as temperature have been done carefully. The product of the reaction were characterized by various techniques viz. FTIR, HRMS and ^{1}H NMR which confirmed the formation of the product.
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1. Introduction

Metal oxide demonstrates wide range of applications. Cobalt oxide here is the most stable phase in the Co-O system [1–4]. Cobalt oxide has been reported demonstrating wide range of applications viz. in lithium-ion batteries, heterogeneous catalysts, gas sensing, ceramic pigments, electrochemical devices etc. [5–9]. Co_3O_4 reportedly plays a vital role as selective coating material for the high-temperature solar collectors [10]. Supercapacitors are responsible for the advancement of mobile phones, digital cameras and solar cell power storage. Some electrode material which can be used in the supercapacitors is made up of metal oxides, metal sulfides etc. Co_3O_4 nanoparticles as electrode material for supercapacitors were also reported in the literature [11]. Cobalt oxide also gained very much attention in supercapacitors applications in the worldwide researchers, as it has capability to impart higher power density than normal batteries.

Various methods like sol–gel, surfactant-mediated synthesis, thermal decomposition, polymer-matrix assisted synthesis and spray-pyrolysis are well known for the synthesis of Co_3O_4 nanoparticles [12–14].

Applications of transition metal-oxide nanoparticles especially cobalt oxide are also well known in the organic reactions. Various reactions of N-formylation of aliphatic and aromatic amines have been reported. Reactions were carried out either in the broad range of solvents or under solvent free condition. Application of cobalt oxide NPs on growth of various parts of the plants are also reported in the literature [15–21]. Various biological applications of cobalt oxide have been found [22–26].

N-Formyl compounds are the main precursors as protecting groups for amines and an ideal starting material for isocynide compounds. [2–3] These compounds can also act as an intermediate for mono methylated amines from primary amines [4].

Many reports on the formylation reactions are available such as chloral,[27] activated formic acid using DCC [28] or EDCI,[29] formic esters [30–33] and ammonium formate [34]. Although these strategies have their own advantages high yield, mild reaction conditions but they are expensive and may be toxic to use. The green approach for such reactions has great importance concerning to the 'save environment campaign' run all over the world.

Here, we report a modified flame pyrolysis method to synthesis cobalt oxide nanomaterial from cobalt nitrate. We used modified

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Synthesis of cobalt oxide nanoparticles coated with carbon and its catalytic applications in organic reactions

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ABSTRACT

Cobalt oxide nanoparticles coated with carbon were prepared by the modified flame pyrolysis method. The preparation was carried out by simply exposing the cobalt nitrate salt onto a spatula to gas flame, the flame temperature converted the cobalt nitrate into cobalt oxide, which further get coated by carbon produced from the combustion of fuel gas. The obtained product from the flame pyrolysis was characterized using techniques viz. XRD, FTIR and SEM. SEM data show that the short length rod shaped nanoparticles coated with carbon ranging from 0.3 to 1 μm μm formed during the process. XRD and FTIR data also support the formation of cobalt oxide nanoparticles coated with carbon particles. Cobalt oxide NPs were utilized for the catalytic N-formylation reaction of amines at 70–80 °C. The optimization of the catalyst as well as temperature have been done carefully. The product of the reaction were characterized by various techniques viz. FTIR, HRMS and ^{1}H NMR which confirmed the formation of the product.
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1. Introduction

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Here, we report a modified flame pyrolysis method to synthesis cobalt oxide nanomaterial from cobalt nitrate. We used modified

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Research Papers

Co-precipitation synthesis of pseudocapacitive λ-MnO_2 for 2D MXene ($Ti_3C_2T_x$) based asymmetric flexible supercapacitor

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ABSTRACT

The rapid growth of wearable/portable electronics imposes a development of flexible, lightweight and highly efficient energy storage devices. In this work, we have synthesized λ-MnO_2 nanoplates through one step co-precipitation method and used for flexible asymmetric supercapacitor (SC). The structural, morphological and electrochemical properties of synthesized λ-MnO_2 were systematically investigated. The optical and electronic properties of λ-MnO_2 were studied using UV–vis spectroscopy and density functional theory (DFT) calculations. The pseudocapacitive λ-MnO_2 nanoplates-like electrode showed a maximum specific capacitance of 288.5 F g^{-1} at the scan rate of 5 mV s^{-1}. To check the practicability, symmetric (λ-MnO_2//λ-MnO_2) as well as asymmetric (λ-MnO_2//AC and λ-MnO_2//$Ti_3C_2T_x$ MXene) SCs were fabricated and their performances were compared. The asymmetric λ-MnO_2//$Ti_3C_2T_x$ MXene SC demonstrated a maximum energy density of 15.5 Wh kg^{-1} at the power density 1100 W kg^{-1} along with 86.3 % of capacitive retention after 5000 cycles. Besides, to confirm the suitability of these electrodes for flexible energy storage, a flexible λ-MnO_2//$Ti_3C_2T_x$ asymmetric SC was fabricated using PVA: Na_2SO_4 gel polymer electrolyte that operated in the potential window of 2 V and supplies high areal energy density of 39.9 μWh cm^{-2} at a power density of 8586 μW cm^{-2}. Therefore, the λ-MnO_2 prepared with a simple and scalable co-precipitation method may play a promising role in flexible energy storage.

1. Introduction

Electrical energy is prominent for technological development and its production through non-renewable resources greatly influences the world economy and ecological system [1]. Due to the expansion in the global need for energy, researchers have been focusing on exploring novel renewable energy sources and effective energy storage technologies [2]. Currently, electrochemical energy storage devices (EES) such as fuel cells, batteries and supercapacitors (SCs) have attracted great attention due to their good safety, reliability and eco-friendliness [3]. Amongst, SCs are mainly attracted due to their high power density and extended cycle life, exhibiting a wide range of applications in electric vehicles, communication technology, smart electronics, aircraft and smart grids [4]. Depending on the storage mechanism, SCs are classified into electric double-layer capacitors (EDLCs) and pseudocapacitors. EDLCs store electrical energy through ion adsorption/desorption while pseudocapacitors store charge via rapid redox reaction at the interface between electrode and electrolyte [5]. SCs are largely suffered from their poor energy density (ED), therefore, a significant amount of research is anticipated to develop novel electrodes and device configurations [6,7]. The ED of SC can be improved by enhancing capacitance and operating voltage according to the relation $E = (0.5) \times CV^2$, where C is capacitance and V is operating voltage. The operating voltage and thereby the energy performance can be effectively enlarged by fabricating asymmetric SCs (ASCs). The ASC is fabricated by combining two dissimilar electrodes mainly pseudocapacitive (positive) and EDLC

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Enhanced electrochemical performance of hybrid composite microstructure of $CuCo_2O_4$ microflowers-NiO nanosheets on 3D Ni foam as positive electrode for stable hybrid supercapacitors

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ABSTRACT

Self-assembled composite porous structures comprising $CuCo_2O_4$ microflowers and NiO hexagonal nanosheets were synthesized on a conducting 3D Ni foam surface [CCO/NO] using a simple hydrothermal method. This unique composite assembly was further characterized and electrochemically evaluated as a binder-free positive electrode for hybrid supercapacitor application. The study showed that the CCO/NO exhibited a maximum areal capacitance of 1444 mF cm^{-2}, significantly higher than the parent $CuCo_2O_4$ and NiO electrodes, with remarkable stability of 88.5% for 10,000 galvanostatic charge-discharge cycles. Key features for the enhanced electrochemical performance of CCO/NO can be related to a lowered diffusion resistance because the hybrid nanocomposite porous assembly generates short diffusion paths for electrolyte ions and more active sites for reversible faradaic transition for charge storage. The hybrid supercapacitor was assembled using activated carbon as a negative electrode and CCO/NO as a positive electrode in alkaline electrolyte, performed at an improved potential of 1.6 V. Device showed a maximum areal capacitance of 122 mF cm^{-2}, a maximum areal energy density of 43 μWh cm^{-2}, and a maximum areal power density of 5.1 mW cm^{-2}. This hybrid supercapacitor showed remarkable cyclic stability up to 98% for 10,000 cycles. This study encourages the development of low-cost, high-performance, durable electrode designs using hybrid composite for next-generation energy storage systems.

1. Introduction

Sustainable energy storage becomes crucial for developing modern technology, such as electric vehicles, miniaturized/portable electronic devices, smart grids, and medical implants, as fossil fuel is depleting and demand for CO_2 reduction is becoming inevitable. Li-ion battery technology has been focused as high energy density storage application [1,2]. Meanwhile, the efficient supercapacitors (SCs) with high energy, power output and extended lifetime have been a vital and supporting to Li-ion battery technology for the sustainable energy storage [3–5]. In SCs, electrostatic interactions or faradaic redox reactions are responsible for the electrochemical energy storage [6,7]. Electrostatic interaction involves numerous rapid kinetic interactions as the charges electrostatically accumulate on the electrode-electrolyte interface, delivering high power density to SCs. However, Faradaic storage involves reversible kinetically faster redox reactions at the electrode-electrolyte interface, producing much higher energy to SCs. Therefore, major studies use state-of-the-art design and development of SC electrodes for simplicity and sustainability by using low-cost, environmentally benign electrochemically active materials that could provide high energy and power densities [3,8–10]. SCs with the most carbon-based 1D, 2D, and 3D material electrodes have been recognized as electric double-layer capacitors (EDLCs), where electrostatic interactions can store the charge. However, SCs with Ni-, Co-, Mn-, and Cu-based metal oxide electrodes have been popular as pseudocapacitors, where faradaic reactions can store the charge [7,11,12]. In both, the electrode electrochemical performance is confined to its thin active surface, so the material overloading at the electrode surface could degrade the SC performance.

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Uniform and fully decorated novel Li-doped α-Fe_2O_3 nanoparticles for high performance supercapacitors

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ABSTRACT

Supercapacitors are considered emerging energy storage sources owing to their long-term cycling stability, high energy/power density, and rapid charge/discharge process. The performance characteristics of supercapacitors can be enhanced by devising electrodes with highly porous nanostructures through subtle hybridization of active materials and the development of current collectors with tailored nanoarchitectures. Herein, we reported the effect of Li doping on the electrochemical application of the pure α-Fe_2O_3 thin films. The preparation of nanoparticles-like nanostructures of the pure α-Fe_2O_3 and different percentages of Li-doped α-Fe_2O_3 thin films by cost effective and facile hydrothermal method for the supercapacitor application. As-synthesized pure α-Fe_2O_3 and Li doped α-Fe_2O_3 thin films were analyzed by the X-ray diffraction (XRD), and X-ray photoelectron (XPS) spectroscopy, scanning electron microscopy, transmission electron microscopy, and supercapacitor properties. The XRD results revealed the formation of the pure phase of the α-Fe_2O_3 with the rhombohedral crystal structure. XPS results confirmed the Li species existence in the 0.5% Li doped α-Fe_2O_3. The electrochemical properties indicate the 3D chain of the nanoparticle-like surface morphology of pure α-Fe_2O_3 and Li-doped α-Fe_2O_3 are more useful electrode materials for electrochemical application. The calculated values of the specific capacity (Cs) indicate the different percentages of doping of Li are affected by the electrochemical properties of the pure α-Fe_2O_3. The Cs of the optimized 0.5% Li-doped α-Fe_2O_3 (79 mAh g^{-1}) electrode was 1.3-fold higher than that of the pure α-Fe_2O_3 electrode (52 mAh g^{-1}) at a constant scan rate with excellent cycling stability upto 3000 cycles. The electrochemical and surface morphological analysis demonstrate that the 0.5% Li-doped α-Fe_2O_3 electrode is more useful than the pure α-Fe_2O_3 and other electrodes for developing high-rate hybrid supercapacitor-based energy storage devices applications.

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1. Introduction

In this present era of digitalization, the rapid growth of portable devices, wireless electronics, hybrid electric vehicles, and the aerospace industry have triggered significant developments over the past few years [1,2]. The most important electrochemical energy conversion and storage devices include batteries and supercapacitors, which stand out because of their potential use in various electrical appliances [3–8]. However, batteries have certain limitations such as high production cost, low power density, and limited life span. By contrast, the supercapacitor has huge potential as a backup power source because of its rapid charge–discharge rate, high power density, fast energy delivery, prolonged cycle life, lightweight, excellent reliability, and flexibility, which can fulfill the growing power requirements of energy storage systems [9–11]. However, supercapacitors lag batteries in terms of energy density. Hence, the idea is to fabricate supercapacitors with increased energy density, while retaining all of their other beneficial features. Supercapacitors are categorized into two types based on the underlying energy storage mechanism, namely electric double-layer capacitors (EDLCs) and pseudocapacitors. EDLCs' function based on ion-adsorption

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Synthesis of 3D nanoflower-like mesoporous $NiCo_2O_4$ N-doped CNTs nanocomposite for solid-state hybrid supercapacitor; efficient material for the positive electrode

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ABSTRACT

In this research work, we report a novel method for developing ternary $NiCo_2O_4$ compounds using deep eutectic solvents (DESs) and a strategy for improving their pseudocapacitive performance. $NiCo_2O_4$ composites with N-doped carbon nanotubes (NCNTs) were fabricated on Ni foam using a hydrothermal method. The electrochemical performance of the $NiCo_2O_4$ was altered with the change in the reaction temperature. The composite of $NiCo_2O_4$ and NCNTs demonstrated a maximum value of specific capacity of 303 mAh g^{-1} at a scan rate of 5 mV s^{-1}. The specific capacity for the composite compound was 1.3-fold greater than that of the pristine $NiCo_2O_4$ sample. For practical applications, we constructed a flexible solid-state hybrid supercapacitor comprised of $NiCo_2O_4$/NCNTs//activated carbon (AC) cells with an excellent energy density of 12.31 Wh kg^{-1}, outstanding power density of 8.96 kW kg^{-1}, and tremendous electrode stability. The three-dimensional mesoporous nanoflowers and nanotubes-like nanostructures of $NiCo_2O_4$ are well-suited for use in hybrid devices as well as convenient for flexible electronic devices.

1. Introduction

Supercapacitors are actively being investigated by researchers for extended commercial use due to the increasing demand for energy storage devices in smart-grid digital electronic gadgets [1]. However, supercapacitors are currently limited by their low energy density compared to Li-ion batteries. Therefore, improving the energy density is the fundamental goal of current supercapacitor research. To this end, many attempts have been made to develop highly efficient supercapacitive materials such as metal oxides, chalcogenides, polymers, polyoxometalates, metal-organic frameworks, Mxene, and siloxene [2,3]. The combination of two different metals to form bimetallic oxides is also an efficient approach to enhance the electrochemical performance of supercapacitors compared to bare metal oxides [1,4].

Recently, various binary and ternary metal oxides have been synthesized for supercapacitor applications including $MnCo_2O_4$, $FeCo_2O_4$, $CoFe_2O_4$, $ZnFe_2O_4$, and $ZnCo_2O_4$, $NiCo_2S_4$, $NiCo_2Se_4$, etc. Among them, the $NiCo_2O_4$ is widely used as a supercapacitor electrode because of its various properties like good electrical conductivity, excellent redox activity, long-term stability, environmental nontoxic, easily available on the earth, and simple preparation [5]. Interestingly, $NiCo_2O_4$ has been utilized for various applications in several research fields such as supercapacitors, Li-ion batteries, water splitting, solar cells, oxygen reduction, hydrogen evolution, and electrocatalysts [1,3]. Recently, many researchers focus on the ternary $NiCo_2O_4$ nanocompounds with various nanostructures for supercapacitor applications. Because, it offers good electrical conductivity and better electrochemical performance, faster redox reaction, multivalence states of Ni^{3+}/Ni^{2+} and Co^{3+}/Co^{2+}, good cycling stability as compared to the binary NiO and Co_3O_4 [3].

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Review—Mitigating Supercapacitor Self-Discharge Through Strategic Materials Modification

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A high-power density, rapid charge-discharge and long cycle life are important features of supercapacitors (SCs). However, SCs are mainly suffered from their high self-discharge (SD) which is a spontaneous decay of voltage with time under open-circuit conditions. Due to SD behavior, SCs cannot be employed or coupled with many important energy harvesting devices including piezoelectric and triboelectric nanogenerators. It is highly desired to develop different innovative strategies to mitigate the SD. This review aims at discussing a SD mechanism and reviewing different mitigation strategies based on the modification of materials and devices. We discuss design, underlying principle, mechanism of the mitigation strategies and corresponding SD performance in detail. Moreover, the summary and prospects in this field have been provided. It is recommended to test an individual electrode for SD, identify the mechanism and develop different strategies for suppression. This review will be beneficial for researchers around the world to have a better understanding of the SD mechanism and to develop innovative strategies for SD mitigation and thereby the high-performance SCs.
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As a high-performance energy storage device, supercapacitor (SC) has gained major interest owing to its rapid charging-discharging ability, high power density and long cycle life.[1–5] Based on electrode material used, SCs are classified into electric double-layer capacitors (EDLC) and pseudocapacitors.[6–9] The EDLC stores charge via physical adsorption/desorption of electrolytic ions on the electrode surface, whereas, pseudocapacitor stores charge via fast redox reaction at/near the surface of the electrode.[10–12] SCs are normally characterized by their energy density, power density and cycle life, however, one of the important parameters, such as self-discharge (SD) is often ignored by the research community.[13,14] The SD is nothing but the spontaneous voltage decay of charged SC with time in the absence of an external load. Since the energy and power densities are voltage-dependent parameters, the loss of a significant amount of energy due to SD has raised a question on the energy storage efficiency of SCs. The SD rate in SCs is greater than the batteries, in conventional SCs, the voltage reduces about 40% after 12 h.[15] This is a serious decrement since SCs are mainly utilized in the first half of their operating potential window. Owing to this limiting character, SCs cannot be employed or coupled with many important energy harvesting devices including piezoelectric and triboelectric nanogenerators.[16] Previously, different models have been developed to study and predict the SD mechanism.[17–20] The SD originates due to the higher thermodynamic state of the charged SCs from which it finds ways to naturally relax and return to the lower energy state (uncharged). In general, the main contributions to the SD are ohmic leakage, parasitic faradaic reaction and charge redistribution.[21–23] It is imperative to identify the main SD mechanism involved in a particular electrode or device and develop different strategies to mitigate it. Previously, different strategies have been developed and effectively employed on the materials and device level. However, in literature, most of the SD profiles are obtained for full cells rather than for individual electrodes. Besides, the data has been poorly analyzed and presented. Therefore, it is the need of the hour to discuss different SD mechanisms, find efficient methodologies for identifying the mechanism and recognize effective strategies from the literature. There are very few review articles focusing on SD, for instance, Ike et al.[13] emphasized understanding the SD mechanism and its suppression in electrochemical SCs and hybrid SCs. In another perceptive review, Andreas[24] touched upon some important aspects such as the theoretical background, identification of SD mechanism and future directions. Recently, the work of Liu et al.[25] have sufficiently reviewed the SD mechanism and different strategies of suppression, however, recent important developments and comprehensive description of strategies are missing.

Herein, we updated an SD mechanism by referring to recently published important contributions. Furthermore, different strategies have been reviewed and classified based on their employment made not only on materials but also on device level to mitigate the SD. We discussed mitigation strategies, their design, underlying principle, mechanism and corresponding SD performance in detail. Moreover, the summary and prospects in this field have been provided.

Self-Discharge Mechanism

The SD of a conventional capacitor is governed by the equation $V = V_{initial}e^{\frac{-t}{RC}}$ where V, $V_{initial}$, R and C are potential difference, initial voltage, ohmic resistance and capacitance, respectively. In this case, the SD process is completed within microseconds that leads to negligible retention of energy. The RC is the time constant which is the intrinsic property of the capacitor that decides the value of SD.[26] However, in SCs, the SD mechanism involves mainly three processes, (1) ohmic leakage between the electrodes of a full cell, (2) parasitic faradaic reactions on the electrode surface and (3) the charge redistribution.

Self-discharge due to ohmic leakage.—The ohmic leakage between the electrodes is the least discussed mechanism because it is originated due to the faulty construction of the cell (Fig. 1a). This can be avoided by eliminating the resistive pathways which connect the positive and negative electrodes. This can be easily identified by modeling the SD profile using the equation, $\log\left(\frac{V_t}{V_i}\right) = \frac{-t}{RC}$. As shown in Fig. 1d, if the plot of $\log\left(\frac{V_t}{V_i}\right)$ versus the time (t) is a straight line, the main contribution to SD will be due to the ohmic leakage.

Self-discharge due to parasitic faradaic reactions.—In this type, SD takes place due to the oxidation and reduction reactions on the charged electrode surface that lead to the discharge of the electrode and the overall cell (Fig. 1b). This can be easily understood by the following reactions at positive and negative carbon electrode surfaces (C) in sulfuric acid.[24]

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Impact of Annealing Temperature on the Morphological, Optical and Photoelectrochemical Properties of Cauliflower-like $CdSe_{0.6}Te_{0.4}$ Photoelectrodes; Enhanced Solar Cell Performance

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Abstract: We are reporting on the impact of air annealing temperatures on the physicochemical properties of electrochemically synthesized cadmium selenium telluride ($CdSe_{0.6}Te_{0.4}$) samples for their application in a photoelectrochemical (PEC) solar cell. The $CdSe_{0.6}Te_{0.4}$ samples were characterized with several sophisticated techniques to understand their characteristic properties. The XRD results presented the pure phase formation of the ternary $CdSe_{0.6}Te_{0.4}$ nanocompound with a hexagonal crystal structure, indicating that the annealing temperature influences the XRD peak intensity. The XPS study confirmed the existence of Cd, Se, and Te elements, indicating the formation of ternary $CdSe_{0.6}Te_{0.4}$ compounds. The FE-SEM results showed that the morphological engineering of the $CdSe_{0.6}Te_{0.4}$ samples can be achieved simply by changing the annealing temperatures from 300 to 400 °C with intervals of 50 °C. The efficiencies (η) of the $CdSe_{0.6}Te_{0.4}$ photoelectrodes were found to be 2.0% for the non-annealed and 3.1, 3.6, and 2.5% for the annealed at 300, 350, and 400 °C, respectively. Most interestingly, the PEC cell analysis indicated that the annealing temperatures played an important role in boosting the performance of the photoelectrochemical properties of the solar cells.

Keywords: electrodeposition; $CdSe_{0.6}Te_{0.4}$; thin films; XRD; EDS; DSSC; solar cell

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1. Introduction

With the rapid increase in the world's population and environmental pollution, there is limited availability of energy sources. A worldwide demand therefore exists for new energy sources that are clean, cost-effective, and simple and that do not cause environmental pollution [1,2]. Various energy storage devices available on the electronic markets include fuel cells [3], solar cells [4,5], H_2 evolution systems [6,7], light-emitting diodes (LED) [8], capacitors [9], supercapacitors [10,11], and batteries [12]. Among these, the photoelectrochemical (PEC) cell is the best electronic device because of the easy and whole-day availability of sunlight on Earth, whereas the convenience of the other sources of materials is geographically limited. To improve the electrical properties of its solar cells, the PEC has two main principal requirements, which are related to the band gap energy and the stability of the photoelectrodes. First, the photoelectrode should provide the band gap of materials whose band gap energy is nearly matched to the extreme sunlight intensity in the visible spectrum to use the solar spectrum resourcefully (1–3 eV). Second, the semiconductor photoelectrode materials need to be stable with respect to the 1 M polysulfide ($NaOH:Na_2S:S$) liquid electrolytes during the PEC measurements.

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Review

COVID-19 Pandemic: Public Health Risk Assessment and Risk Mitigation Strategies

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Abstract: A newly emerged respiratory viral disease called severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) is also known as pandemic coronavirus disease (COVID-19). This pandemic has resulted an unprecedented global health crisis and devastating impact on several sectors of human lives and economies. Fortunately, the average case fatality ratio for SARS-CoV-2 is below 2%, much lower than that estimated for MERS (34%) and SARS (11%). However, COVID-19 has a much higher transmissibility rate, as evident from the constant increase in the count of infections worldwide. This article explores the reasons behind how COVID-19 was able to cause a global pandemic crisis. The current outbreak scenario and causes of rapid global spread are examined using recent developments in the literature, epidemiological features relevant to public health awareness, and critical perspective of risk assessment and mitigation strategies. Effective pandemic risk mitigation measures have been established and amended against COVID-19 diseases, but there is still much scope for upgrading execution and coordination among authorities in terms of organizational leadership's commitment and diverse range of safety measures, including administrative control measures, engineering control measures, and personal protective equipment (PPE). The significance of containment interventions against the COVID-19 pandemic is now well established; however, there is a need for its effective execution across the globe, and for the improvement of the performance of risk mitigation practices and suppression of future pandemic crises.

Keywords: pandemic crisis; SARS-CoV-2; coronavirus; risk assessment; risk mitigation; administrative controls; engineering controls

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1. Introduction

Coronaviruses were generally not considered highly infectious to humans before 2002; however, after the occurrence of the severe acute respiratory syndrome (i.e., SARS; 2002) [1,2], Middle East respiratory syndrome (i.e., MERS; 2015) [3,4] and COVID-19 pandemic attracted serious attention of the scientific community and public health authorities. SARS-CoV-2 is the ninth known coronavirus to cause infections in humans, causes severe respiratory illness, and breathing discomfort. Its symptoms are similar to those of pneumonia and seasonal Influenza virus, as well as some other coronaviruses [5,6]. Notably, the worldwide spread of this virus was observed within a few months of its first appearance in December 2019 at Wuhan, China [7]. The SARS-CoV-2 outbreak has created a prolonged global public health and economic crisis and created confusion over the need for travel bans and border closures, the closure of educational institutions and businesses, and the implementation of preventive measures [8].

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Histidine Functionalized Gold Nanoparticles for Screening Aminoglycosides and Nanomolar Level Detection of Streptomycin in Water, Milk, and Whey

Surendra Krushna Shinde [1], Dae-Young Kim [1], Rijuta Ganesh Saratale [2], Avinash Ashok Kadam [2], Ganesh Dattatraya Saratale [3], Asad Syed [4], Ali H. Bahkali [4] and Gajanan Sampatrao Ghodake [1,*]

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Abstract: Aminoglycoside (AMG) antibiotics are being applied to treat infections caused by Gram-negative bacteria, mainly in livestock, and are prescribed only in severe cases because of their adverse impacts on human health and the environment. Monitoring antibiotic residues in dairy products relies on the accessibility of portable and efficient analytical techniques. Presently, high-throughput screening techniques have been proposed to detect several antimicrobial drugs having identical structural and functional features. The L-histidine functionalized gold nanoparticles (His@AuNPs) do not form a complex with other tested antibiotic classes but show high selectivity for AMG antibiotics. We used ligand-induced aggregation of His@AuNPs as a rapid and sensitive localized surface plasmon resonance (LSPR) assay for AMG antibiotics, producing longitudinal extinction shifts at 660 nm. Herein, we explore the practical application of His@AuNPs to detect streptomycin spiked in water, milk, and whey fraction of milk with nanomolar level sensitivity. The ability of the analytical method to recognize target analytes sensitively and rapidly is of great significance to perform monitoring, thus would certainly reassure widespread use of AMG antibiotics. The biosynthesis of hybrid organic–inorganic metal nanoparticles like His@AuNPs with desired size distribution, stability, and specific host–guest recognition proficiency, would further facilitate applications in various other fields.

Keywords: histidine; gold nanoparticles; aminoglycoside; antibiotics; colorimetric changes; spectral shift; real samples; milk samples; whey fraction

1. Introduction

Antibacterial drugs have been commonly applied as human and veterinary medicine to treat a wide range of infectious diseases [1–3]. Aminoglycosides (AMG) are broad-spectrum antibiotics, are commonly prescribed for humans and a range of livestock, mainly for infections caused by Gram-negative bacteria. Thus, there is an ever-growing concern of direct exposure of residual drugs [4] and adulteration of the food chains [4–6]. Besides this, AMG antibiotics induce adverse effects on human health include allergic reactions [7], cytotoxicity [8,9], nephrotoxicity [10], as well as negative impacts on the environment and risk of antibiotic resistance [11–13]. In this account, we target the development of an

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Review

MOFs-Graphene Composites Synthesis and Application for Electrochemical Supercapacitor: A Review

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Abstract: Today's world requires high-performance energy storage devices such as hybrid supercapacitors (HSc), which play an important role in the modern electronic market because supercapacitors (Sc) show better electrical properties for electronics devices. In the last few years, the scientific community has focused on the coupling of Sc and battery-type materials to improve energy and power density. Recently, various hybrid electrode materials have been reported in the literature; out of these, coordination polymers such as metal-organic frameworks (MOFs) are highly porous, stable, and widely explored for various applications. The poor conductivity of classical MOFs restricts their applications. The composite of MOFs with highly porous graphene (G), graphene oxide (GO), or reduced graphene oxide (rGO) nanomaterials is a promising strategy in the field of electrochemical applications. In this review, we have discussed the strategy, device structure, and function of the MOFs/G, MOFs/GO, and MOFs/rGO nanocomposites on Sc. The structural, morphological, and electrochemical performance of coordination polymers composites towards Sc application has been discussed. The reported results indicate the considerable improvement in the structural, surface morphological, and electrochemical performance of the Sc due to their positive synergistic effect. Finally, we focused on the recent development in preparation methods optimization, and the opportunities for MOFs/G based nanomaterials as electrode materials for energy storage applications have been discussed in detail.

Keywords: coordination polymers MOFs; graphene; supercapacitors; chemical method; nanomaterials; porous nanostructures

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1. Introduction

Restrictions in renewable energy resources and the rising air pollution have catalyzed the request for green and clean sustainable energy. To solve this problem, researchers from around the globe have been actively working on the development of a novel composite electrode material for the efficient environmental remediation, conversion, and storage of electrical energy in the form of electrochemical energy [1]. In the electric market, the main two systems are available batteries and supercapacitors (Scs). Among these electrochemical energy storage devices, batteries store charge via the oxidation/reduction of electrode-active materials and/or intercalation/de-intercalation of the ions into/out of the electrode

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Review

Significance of Immune Status of SARS-CoV-2 Infected Patients in Determining the Efficacy of Therapeutic Interventions

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Abstract: Coronavirus disease 2019 (COVID-19) is now being investigated for its distinctive patterns in the course of disease development which can be indicated with miscellaneous immune responses in infected individuals. Besides this series of investigations on the pathophysiology of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), significant fundamental immunological and physiological processes are indispensable to address clinical markers of COVID-19 disease and essential to identify or design effective therapeutics. Recent developments in the literature suggest that deficiency of type I interferon (IFN) in serum samples can be used to represent a severe progression of COVID-19 disease and can be used as the basis to develop combined immunotherapeutic strategies. Precise control over inflammatory response is a significant aspect of targeting viral infections. This account presents a brief review of the pathophysiological characteristics of the SARS-CoV-2 virus and the understanding of the immune status of infected patients. We further discuss the immune system's interaction with the SARS-CoV-2 virus and their subsequent involvement of dysfunctional immune responses during the progression of the disease. Finally, we highlight some of the implications of the different approaches applicable in developing promising therapeutic interventions that redirect immunoregulation and viral infection.

Keywords: coronavirus; SARS-CoV-2; immune response; therapeutic interventions; immunopathogenesis

1. Introduction

In consideration of public health emergency and global reach, on 11 March 2020, the World Health Organization (WHO) specified coronavirus disease 2019 (COVID-19) as a global pandemic outbreak of international public health concern [1]. A novel, highly transmissible enveloped RNA betacoronavirus unexpectedly emerged in December 2019 in Wuhan, China, and then was formally named as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2. The most common clinical symptoms and manifestations of SARS-CoV-2 infection are pneumonia-like, including fever, hypoxia, dyspnea (labored breathing), headache, myalgia, cough, and in some cases, intestinal symptoms [2,3]. COVID-19 is now characterized as a mild to severe respiratory disease, and its clinical presentation

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Novel and efficient hybrid supercapacitor of chemically synthesized quaternary 3D nanoflower-like $NiCuCo_2S_4$ electrode

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ABSTRACT

In this work, we employed a simple and cost-effective chemical route to obtain a highly stable and efficient quaternary mesoporous 3D nanoflower-like $NiCuCo_2S_4$ nanocomposite for supercapacitor applications. The $NiCuCo_2S_4$ composite exhibited a mixture of $NiCo_2S_4$ and $CuCo_2S_4$ phases, confirming the formation a quaternary $NiCuCo_2S_4$ thin film. A surface morphological analysis revealed the unique nanoflower-like nanostructure of the annealed composite. The electrochemical analysis of the $NiCuCo_2S_4$ electrode demonstrated a high specific capacity (Cs) of 414 mAh g^{-1} at a lower scan rate of 10 mV s^{-1} and a superior cycling stability up to 3000 cycles. A solid-state hybrid supercapacitor (SHS) was also constructed by the $NiCuCo_2S_4$ and AC powder as positive and negative electrodes, respectively. The $NiCuCo_2S_4$//AC hybrid cell produced a high Cs, energy density, and power density of 159 F g^{-1}, 35.19 Wh kg^{-1}, and 0.66 kW kg^{-1}, respectively at a current density of 10 mA with good cycling stability. The results demonstrated that the fabrication process is effective for the development of a novel quaternary transition metal sulfide (TMS) electrode.

1. Introduction

The expansion of a high-energy storage system has fascinated significant consideration due to the rising demand for efficient renewable energy sources. The capable energy storage systems such as supercapacitors (Sc) offer a high power density, energy density, cycling stability, lower resistance, and greater safety compared to batteries [1,2]. Electrochemical supercapacitors store energy either through ion adsorption (electrochemical double-layer capacitors, EDLCs) or fast, reversible, multi-electron surface redox reactions (pseudocapacitors). Highly reversible redox reactions are responsible for the high specific capacitance of pseudocapacitor devices [3–5]. Physicochemical properties of the selected materials strongly affect the performance of supercapacitor devices. For instance, the electrochemical performance can degrade during the cycling due to change in the morphology of selected materials. Therefore, it is important to improve the morphological stability of supercapacitive electrode materials to maximize their cycle life [6]. Materials with hierarchical pores and tabular or layered structures are well-known to increase the charge transport, ion diffusion, power density, and the cycling stability [1,7]. In addition to structural design, the electrode composition also have a crucial role in the performance of electroactive materials [8]. The electrochemical performance can be tuned by optimizing the ratio of metal ions.

Several nanomaterials with desirable properties fabricated from carbonaceous materials and metal oxides have been employed in supercapacitor applications. In particular, metal chalcogenides exhibit excellent physiochemical properties that are suitable for supercapacitor applications. Ni, Co, and Cu-based materials have attracted significant attention in various fields, the oxides and sulfides of these metals have been proven to be useful for electrochemical energy storage applications [9]. These metals are an important strategic resources which are mostly suitable in electrochemical energy storage systems, catalysis, and other fields due to their unusual structural, optical, and electronic properties [10]. Ni, Co, and Cu-based battery materials in aqueous and alkaline electrolytes have been reported to facilitate fast Faradaic reactions on or near their surface, thus offering both high energy storage and power

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A review on electrodeposited layered double hydroxides for energy and environmental applications

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ABSTRACT

The great demand for efficient and low-cost materials for energy and environmental applications has been inspiring researchers to develop novel and advanced materials. Recently, layered double hydroxides (LDHs) are found to be admirable materials for various applications owing to their tunable elemental composition and diverse nanostructures. The preparation of binder-free LDHs thin-film electrodes has attracted great attention in the field of supercapacitors, electrocatalysts and sensors. The electrodeposition method exhibits the capability of fabricating binder-free, uniform and well-oriented thin films with tunable elemental composition. In the present review, we provide a detailed electrodeposition mechanism behind the formation of LDHs with nucleation and growth processes. Also, we summarize the literature on electrodeposited LDHs based electrode materials for energy and environmental applications. In energy storage applications, a loading amount of active materials on the substrate is crucial to improve the areal and volumetric capacities. Therefore, the utilization of low-cost and scalable scaffold materials such as carbon nanofibers, graphene foam, etc. is highly recommended.

1. Introduction

Layered double hydroxides (LDHs), often called hydrotalcite-like systems or anionic clays have attracted great attention owing to their tunable chemical and metal-anion compositions. The general formula for LDHs can be written as $[M^{II}_{1-x}M^{III}_{x}(OH)_2]^{x+}[A^{n-}_{x/n}\cdot yH_2O]^{x-}$ (where M^{II} and M^{III} represent the divalent and trivalent metal cations, A^{n-} represents n-valent anions). Depending upon the nature of cations and M^{II}/M^{III} molar ratios, LDHs can be prepared with a wide range of layered structures [1]. The tunability of the molar ratio of metal cations and the nature of interlaying compensating anions lead to the formation of different nanoarchitectures with versatile physical and chemical properties, extending their applicability in diverse fields [2]. LDHs have been reported for different energy and environmental applications such as electrochemical energy storage, electrocatalyst, sensors, etc. These applications demand well-oriented, uniform and high conducting thin films [3,4]. Previously, LDHs have been prepared by different chemical methods such as co-precipitation [5], hydrothermal [6], sol-gel [7] and urea hydrolysis [8], either in thin film or powder form. These chemical methods are time-consuming and complex. Also, the powdered materials need to be combined with binders and conducting additives to be applied for many energy and environment-related applications, imposing additional inactive mass to the electrode [9]. In order to overcome these disadvantages, a binder-free LDHs can be prepared using electrodeposition method. The electrodeposition is rapid, facile, and scalable method which deposits well oriented and high quality thin film materials on the conducting support with enhanced conductivity and electrochemically active sites [10]. Recently, variety of different LDHs thin films have been prepared using electrodeposition method. Fig. 1 shows the number of publications and number of citations received by the research papers published in the field of electrodeposited LDHs, indicating the influence of the field.

Recently, some review articles have been published in the field of LDHs [1,11–13]. However, they mainly focus on general synthesis methods and their different applications. To the best of our knowledge, there is no review article published that emphasizes the detailed electrodeposition mechanism behind the formation of LDHs and review of electrodeposited LDHs for energy and environmental applications. It is important to understand the detailed electrodeposition mechanism in preparing LDHs for a variety of applications to fabricate efficient materials by overcoming present difficulties. Therefore, in this review, we have discussed the fundamentals of electrodeposition methods with

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Green synthesis of novel $CuCo_2O_4$ nanocomposite for stable hybrid supercapacitors by deep eutectic solvents

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ABSTRACT

Currently, many transition metal oxides (TMOs) have been demonstrated as attractive nanomaterials for application in supercapacitors for energy storage/conversion systems. Among TMOs, $CuCo_2O_4$ has presented excellent electrochemical properties, including higher electrical behavior. Also, they are readily accessible in earth, ecofriendly and cost effective compared to other nanocompunds. In this research, we have for the first time synthesized $CuCo_2O_4$ (CCO) nanomaterials using a deep eutectic solvents (DES) method for supercapacitor (SC) applications. We systematically studied the effect of annealing temperature of CCO on its structural, morphological, and electrical properties. The CCO was annealed at different temperature of 150, 200, 250, and 300 °C for 3 h. CCO annealed at 250 °C exhibited the superior performance compared to other as-synthesized and annealed samples. The optimized CCO electrode shows outstanding supercapacitive properties with specific capacity 421 mAh g^{-1} at 10 mV s^{-1}, excellent GCD capability, and super cycling stability. This indicates that the DES-prepared CCO shows better electrochemical performance due to highly porous nanostructure providing more active sites for easy transformation of the ions.

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1. Introduction

Supercapacitors (SCs) are the core component in the development of sustainable energy storage systems with high power density, high energy density, fast charge–discharge, long life, cycling stability, and low cost [1–4]. SCs can be classified into two categories based on the charge storage mechanism: electrical double layer capacitors (EDLCs), which consist of electrostatic charge accumulation at the electrode/electrolyte interfaces, and pseudocapacitors, which comprise reversible Faradic reactions. Pseudocapacitors deliver much higher specific capacitance and energy density than the EDLC [5–7] Metal oxides of copper, nickel, cobalt, and manganese have gained increasing attention in SCs research because of their electrochemical properties [8,9]. Copper oxide and cobalt oxide has many potential applications in various scientific technologies. Among numerous metal oxides, binary transition metal oxides (TMOs) of copper and cobalt showed excellent electrochemical properties, such as specific capacitance, conductivity, cycling performance, and structural stability [10].

The earth abundant spinel type cobalt oxide and its derived compounds offer a promising alternative cheap material for electrochemical energy storage application because of its high theoretical capacitance ~ 3600 F g^{-1}, electrochemical reversibility, and stability. However, the electrochemical performance was slightly lower than expected due to the internal low conductivity, morphology, surface area, chemical composition, and crystallinity [11,12]. Recently, many efforts have been devoted to overcoming these obstacles by designing mixed-metal oxides, controlling morphology, size, and structural properties. Previous reports found that the introduction of Cu in the host cobalt oxide could be beneficial towards improving conductivity and electrochemical properties. Therefore, copper cobalt-based oxides have been highlighted because of their natural abundance, excellent stability, and low cost. Furthermore, amalgamation of metal oxides is a promising way to boost electrical conductivity, electro-chemical properties, and structural stability.

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Probing the electrochemical properties of $NiMn_2O_4$ nanoparticles as prominent electrode materials for supercapacitor applications

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ABSTRACT

$NiMn_2O_4$ (NMO) powders have been prepared by facile sol–gel route, and the effect of annealing temperature and the concentration of KOH electrolyte on its electrochemical performance has been investigated. The electrochemical performance of the NMO electrodes is tested via a three electrode arrangement in KOH electrolyte. The NMO electrode (NMO1) prepared from the powder synthesized at a temperature of 500 °C with an approximate crystallite size of 10 nm exhibits maximum specific capacitance of 571 Fg^{-1} at a scan rate of 5 mVs^{-1} in 1 M KOH electrolyte. The specific capacitance of the NMO1 electrode is found to be improved from 571 Fg^{-1} in 1 M KOH to 762 Fg^{-1} in 6 M KOH electrolyte. The improvement in the specific capacitance of the NMO1 working electrode in 6 M KOH electrolyte can be attributed to good electrochemical utilization and an effective charge storage mechanism.

1. Introduction

Supercapacitors (SCs) have attracted much attention because of the fast rechargeability, higher power density over the batteries, and more energy storage ability as compared to conventional capacitors. The SCs have enormous energy storage capacity besides possessing the combined property of both conventional capacitor and battery [1]. Based on the charge-storage mechanism, electrochemical SCs can be classified into three categories: viz, pseudocapacitors, electrical double-layer capacitors (EDLCs), and hybrid capacitors. The conducting polymers and various metal oxides are utilized as the active electrode materials in pseudocapacitors, whereas in EDLCs carbon-based materials such as activated carbon, graphene, and carbon nanotubes are used as active electrodes. One more type of SCs is a mixture of both pseudocapacitors and EDLCs, known as a hybrid capacitor. To construct these types of SCs, the active electrode materials are made by combining either two or three distinct elements which give very large specific capacitance and enhanced energy density than pseudocapacitors or EDLCs [2]. However, all the above-mentioned SCs still suffer from some significant disadvantages such as poor cyclic life span of conductive polymers, the low capacitance of carbon-based materials and high cost of typical transition metal oxides like RuO_2 [3]. RuO_2 has been extensively investigated as a promising material due to its high specific capacitance and excellent cycling stability, but rareness and the high cost of ruthenium element are putting significant barriers to its commercialization [4]. To overcome these significant disadvantages, it is necessary to explore other alternative materials for the fabrication of supercapacitors.

Mixed transition metal oxides (MTMOs) are preferred to fabricate electrode materials for supercapacitor application over the single transition metal oxide component due to its enhanced chemical stability and electrochemical properties [5]. Out of the different MTMOs, considerable attention has been centered towards the synthesis of cubic spinel $NiMn_2O_4$ (NMO) as it offers high conductivity, outstanding electrochemical capacitance, high redox-active sites, and exceptional chemical

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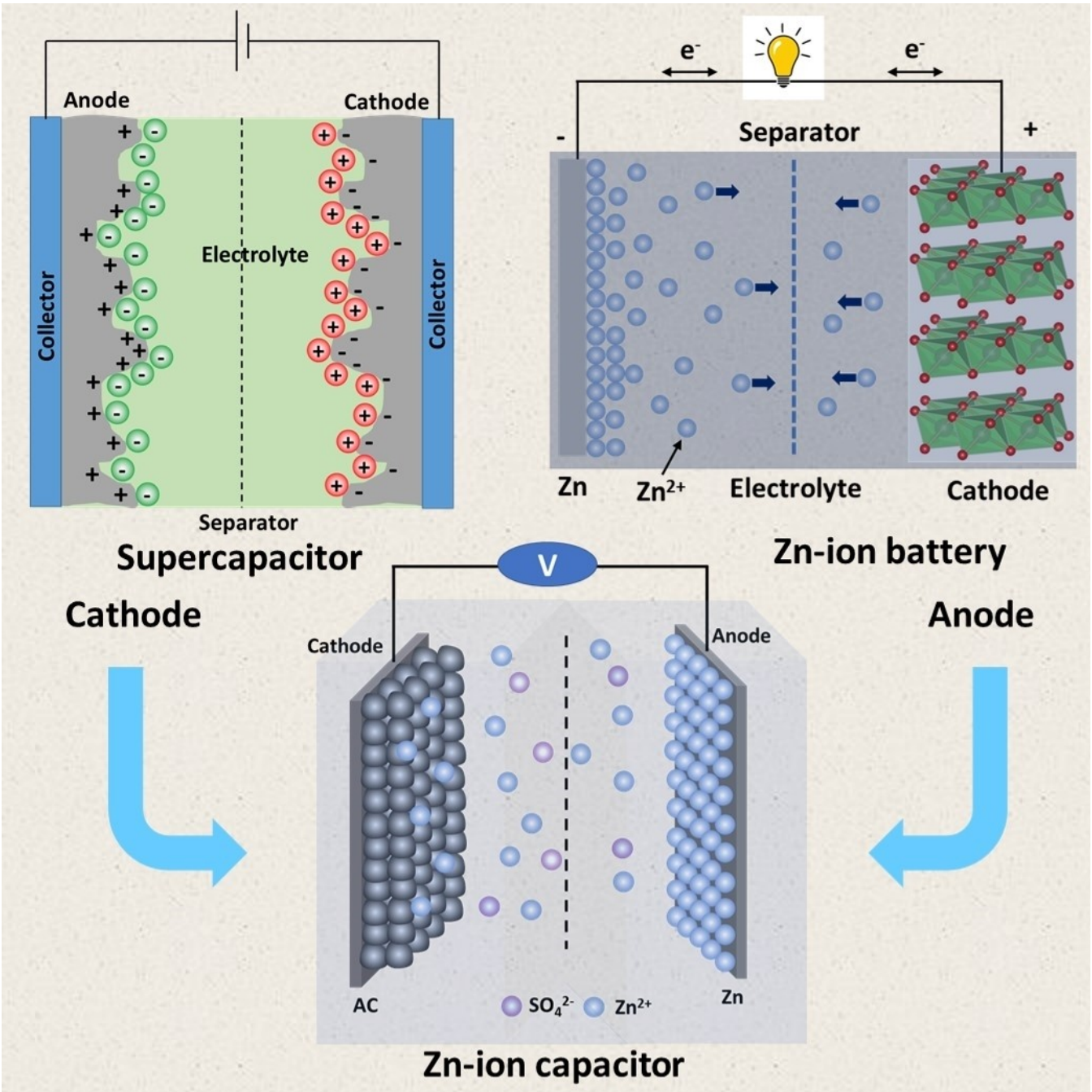
CHEMNANOMAT
Minireview

Materials Development in Hybrid Zinc-Ion Capacitors

Ajay Dattu Jagadale,*[a] Ravichandran Chitra Rohit,[a] Surendra Krushna Shinde,[b] and Dae-Young Kim[b]



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Discovery of oxazole-dehydrozingerone based hybrid molecules as potential anti-tubercular agents and their docking for M*tb* DNA gyrase

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ABSTRACT

The oxazole-dehydrozingerone hybrid molecules (4a-j) and oxazole-dehydrozingerone-thiophene derivatives (6a-e) were synthesized via cyclisation, coupling and aldol condensation reactions. Final compounds were characterized by FTIR, ^{1}H and ^{13}C NMR spectroscopy. Synthesized compounds were screened against Mycobacterium tuberculosis H37Rv, MDR, and XDR strains. Compound 4f showed potential activity of 6.25 μg/mL against H37Rv, while compound 4c exhibited potential activity of 12.5 μg/mL. For the XDR strain, structure 4a, 4b demonstrated moderate efficiency of 12.5 μg/mL. All of the synthesized molecules were tested in comparison with a standard drug. Computational docking studies were performed for the active compound 4f against the enzyme M*tb* DNA Gyrase. The outcomes of the presented research will broadly help to the researchers working on developing antituberculosis drugs.

1. Introduction

Tuberculosis is an air-born contagious disease caused by mycobacterium tuberculosis (Mtb) [1,2]. In 2012, World Health Organization (WHO) reported 8.6 million infections, and among them, 1.3 million people died because of infectious diseases, and in 2016, 490,000 new cases of multidrug resistance were widely estimated [3]. There is a growing resistance to existing drugs resulting from deadly diseases that become more deadly and difficult to treat. MDR and extensive drug resistance (XDR) Mtb are diseases caused by bacteria that don't respond to first-line antitubercular drugs [4]. Existing treatment consists of various drugs that need to be taken for more than a year, resulting in numerous side effects and a substantial economic burden. In developing countries, pollution is the primary reason as Mtb can increase through the air. In recent years the death rate was declined, but it is still a significant cause of death after AIDS [5]. The drugs used for the treatment are streptomycin, Isoniazid, Ethambutol, Rifampicin, Ethionamide, Cycloserine, and Kanamycin. Most of these drugs have been discovered and used for the last 70 years [1]. Hence, there is an alarming concern about the drug-resistant strains of Mtb [6-9]. A constant research is underway for understanding the reasons behind the evolution and existence of resistant strains of Mtb [10]. Synthesis and high-throughput screenings of different derivatives with a broad spectrum of novel and known scaffolds were carried out to obtain lead derivatives as anti-TB [11-13]. The drug discovery and role of heterocyclic nuclei well known since the early 18th century [14]. The heterocyclic compounds are five or six-member rings bearing heteroatoms like nitrogen (N), oxygen (O), or sulfur (S). They play an essential role in all living cells' biochemical processes and find in natural and synthetic forms [15,16].

The fused heterocycles, such as oxazole and oxazoline, were commonly disturbed in nature and attracted considerable interest because of their various medicinal activities [17]. They were initially isolated from a marine source [18]. These hetero cores contains nitrogen and oxygen atoms in an aromatic five-membered ring that can bind with different receptors and enzymes in the biological system through non -covalent interactions [19]. Several advantages of the oxazole ring in medicinal chemistry are that it has weak interactions with H-bond, ion–dipole, π-π stacking, and a weak hydrophobic character. These nuclei found their applications in medicinal and agrochemical chemistry [20]. The natural and synthetic 1,3-oxazole nuclei exerts diverse range of biological activities like anti-mycobacterial [21], anti-tubercular [22-24], anti-bacterial [25], glycomimetic inhibitors [26], antiviral [27],

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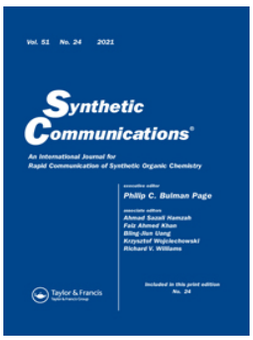

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A systematic appraisal on catalytic synthesis of 1,3-oxazole derivatives: A mechanistic review on metal dependent synthesis

Suraj R. Shinde, Pankaj Girase, Sanjeev Dhawan, Shaukatali N. Inamdar, Vishal Kumar, Chandrakant Pawar, Mahesh B. Palkar, Mahadev Shinde & Rajshekhar Karpoormath

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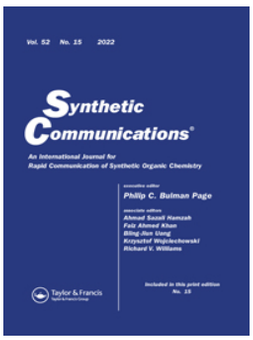

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Recent advances and approaches in the metal-free synthesis of 1,3-oxazole derivatives

Suraj Shinde, Shaukatali Inamdar, Mahadev Shinde, Narvadeshwar Kushwaha, Vincent Obakachi, Pankaj Girase, Babita Kushwaha, Sanjeev Dhawan, Vishal Kumar & Rajshekhar Karpoormath

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Physicochemical characterization, drug release, and biocompatibility evaluation of carboxymethyl cellulose-based hydrogels reinforced with sepiolite nanoclay

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ABSTRACT

Polymer–clay nanocomposite hydrogel films (PCNCHFs) were prepared from caboxymethyl cellulose, polyvinylpyrrolidone, agar and nanosepiolite clay (0, 0.3, 0.5, 0.7, 0.9 and 1.5% reinforcement) by treating thermally in a simple, rapid, and inexpensive route. The PCNCHFs and its 5-fluorouracil (FU)-loaded composites (PCNCHFs@FU) were tested for FU release and characterized by FTIR, XRD, FE-SEM, EDX, DSC, and TGA analyses to investigate their structural, morphological, and thermal properties. The nanosepiolite-loaded polymer composites (PCNCHF1 to PCNCHF5) exhibited higher tensile strength than the pristine polymer hydrogel (PCNCHF0); consequently, the thermal properties (glass- and melting-transition) were improved. The PCNCHFs@FU demonstrated prolonged FU release at pH 7.4 for 32 h. The biocompatibility of PCNCHFs was tested against human skin fibroblast (CCDK) cells. The viability of cells exposed to all PCNCHFs was >95% after 72 h of culture. The live/dead assay show the proliferation of fibroblast cells, confirming the biocompatibility of the hydrogels. The pH-sensitive PCNCHFs@FU release could be suitable for drug release in cancer therapy, and the developed PCNCHFs may also be useful for tissue engineering, food packaging, and other biological applications.

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1. Introduction

Biopolymer-based composite hydrogels are in great demand for various applications, including those encompassing the pharmaceutical, environmental, and biomedical fields, due to their economic, environment-friendly, biodegradable, and biocompatible nature [1–3]. In brief, three-dimensional hydrophilic polymeric networks with high water affinity usually do the construction of polymer-based hydrogels. Instead of dissolving into solution, their physically and/or chemically cross-linked structures allow them to hold water [4–6]. Hydrogels can be constituted with different macromolecules with various functional groups, such as -OH, $-SO_3H$, -COOH, -CONH-, and $-CONH_2$, in their polymeric backbone (either embedded in or grafted to). Because of their hydrophilic functional domains, the resulting hydrogels can absorb and retain large amount of water and other biological fluids/cells. Therefore, these swollen three-dimensional viscoelastic polymer network structures can resemble natural tissue and is of great importance in biomedical field [7–9]. Carboxymethyl cellulose (CMC) based hydrogel systems were developed by different methods, such as physical blending, chemical grafting, and ionic gelation etc. However, the polyelectrolyte behavior of CMC is due to the presence of carboxylate moiety, which is a pH sensitive group with in-situ gelation ability, resulting in bio-adhesive behavior. Hence, the electrically controlled CMC based systems are very useful in delivering various pharmaceuticals such as 5-fluorouracil (FU) for colon drug release, wound dressing, and tissue engineering, because of its biocompatibility [10–16].

Recently, the European Food Safety Authority reported that, CMC is a safe food additive for all animals; moreover, it was also shown to be harmless to the environment because of its biodegradation propensity [17]. The unique viscosity characteristics, hydrophilic nature, adhesive behavior, film forming ability, and biocompatibility, the CMC-based hydrogels have wide range of industrial applications [18–21], in addition to biomedical [22–24] and environmental applications [25–27]. The pristine polymer hydrogels show lower mechanical stability without chemical crosslinking agents. Therefore, it is necessary to use ecofriendly materials as alternative for reinforcement strategy. To

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Novel and efficient hybrid supercapacitor of chemically synthesized quaternary 3D nanoflower-like $NiCuCo_2S_4$ electrode

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ABSTRACT

In this work, we employed a simple and cost-effective chemical route to obtain a highly stable and efficient quaternary mesoporous 3D nanoflower-like $NiCuCo_2S_4$ nanocomposite for supercapacitor applications. The $NiCuCo_2S_4$ composite exhibited a mixture of $NiCo_2S_4$ and $CuCo_2S_4$ phases, confirming the formation a quaternary $NiCuCo_2S_4$ thin film. A surface morphological analysis revealed the unique nanoflower-like nanostructure of the annealed composite. The electrochemical analysis of the $NiCuCo_2S_4$ electrode demonstrated a high specific capacity (Cs) of 414 mAh g^{-1} at a lower scan rate of 10 mV s^{-1} and a superior cycling stability up to 3000 cycles. A solid-state hybrid supercapacitor (SHS) was also constructed by the $NiCuCo_2S_4$ and AC powder as positive and negative electrodes, respectively. The $NiCuCo_2S_4$//AC hybrid cell produced a high Cs, energy density, and power density of 159 F g^{-1}, 35.19 Wh kg^{-1}, and 0.66 kW kg^{-1}, respectively at a current density of 10 mA with good cycling stability. The results demonstrated that the fabrication process is effective for the development of a novel quaternary transition metal sulfide (TMS) electrode.

1. Introduction

The expansion of a high-energy storage system has fascinated significant consideration due to the rising demand for efficient renewable energy sources. The capable energy storage systems such as supercapacitors (Sc) offer a high power density, energy density, cycling stability, lower resistance, and greater safety compared to batteries [1,2]. Electrochemical supercapacitors store energy either through ion adsorption (electrochemical double-layer capacitors, EDLCs) or fast, reversible, multi-electron surface redox reactions (pseudocapacitors). Highly reversible redox reactions are responsible for the high specific capacitance of pseudocapacitor devices [3–5]. Physicochemical properties of the selected materials strongly affect the performance of supercapacitor devices. For instance, the electrochemical performance can degrade during the cycling due to change in the morphology of selected materials. Therefore, it is important to improve the morphological stability of supercapacitive electrode materials to maximize their cycle life [6]. Materials with hierarchical pores and tabular or layered structures are well-known to increase the charge transport, ion diffusion, power density, and the cycling stability [1,7]. In addition to structural design, the electrode composition also have a crucial role in the performance of electroactive materials [8]. The electrochemical performance can be tuned by optimizing the ratio of metal ions.

Several nanomaterials with desirable properties fabricated from carbonaceous materials and metal oxides have been employed in supercapacitor applications. In particular, metal chalcogenides exhibit excellent physiochemical properties that are suitable for supercapacitor applications. Ni, Co, and Cu-based materials have attracted significant attention in various fields, the oxides and sulfides of these metals have been proven to be useful for electrochemical energy storage applications [9]. These metals are an important strategic resources which are mostly suitable in electrochemical energy storage systems, catalysis, and other fields due to their unusual structural, optical, and electronic properties [10]. Ni, Co, and Cu-based battery materials in aqueous and alkaline electrolytes have been reported to facilitate fast Faradaic reactions on or near their surface, thus offering both high energy storage and power

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Green synthesis of novel $CuCo_2O_4$ nanocomposite for stable hybrid supercapacitors by deep eutectic solvents

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ABSTRACT

Currently, many transition metal oxides (TMOs) have been demonstrated as attractive nanomaterials for application in supercapacitors for energy storage/conversion systems. Among TMOs, $CuCo_2O_4$ has presented excellent electrochemical properties, including higher electrical behavior. Also, they are readily accessible in earth, ecofriendly and cost effective compared to other nanocompunds. In this research, we have for the first time synthesized $CuCo_2O_4$ (CCO) nanomaterials using a deep eutectic solvents (DES) method for supercapacitor (SC) applications. We systematically studied the effect of annealing temperature of CCO on its structural, morphological, and electrical properties. The CCO was annealed at different temperature of 150, 200, 250, and 300 °C for 3 h. CCO annealed at 250 °C exhibited the superior performance compared to other as-synthesized and annealed samples. The optimized CCO electrode shows outstanding supercapacitive properties with specific capacity 421 mAh g^{-1} at 10 mV s^{-1}, excellent GCD capability, and super cycling stability. This indicates that the DES-prepared CCO shows better electrochemical performance due to highly porous nanostructure providing more active sites for easy transformation of the ions.

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1. Introduction

Supercapacitors (SCs) are the core component in the development of sustainable energy storage systems with high power density, high energy density, fast charge–discharge, long life, cycling stability, and low cost [1–4]. SCs can be classified into two categories based on the charge storage mechanism: electrical double layer capacitors (EDLCs), which consist of electrostatic charge accumulation at the electrode/electrolyte interfaces, and pseudocapacitors, which comprise reversible Faradic reactions. Pseudocapacitors deliver much higher specific capacitance and energy density than the EDLC [5–7] Metal oxides of copper, nickel, cobalt, and manganese have gained increasing attention in SCs research because of their electrochemical properties [8,9]. Copper oxide and cobalt oxide has many potential applications in various scientific technologies. Among numerous metal oxides, binary transition metal oxides (TMOs) of copper and cobalt showed excellent electrochemical properties, such as specific capacitance, conductivity, cycling performance, and structural stability [10].

The earth abundant spinel type cobalt oxide and its derived compounds offer a promising alternative cheap material for electrochemical energy storage application because of its high theoretical capacitance ~ 3600 F g^{-1}, electrochemical reversibility, and stability. However, the electrochemical performance was slightly lower than expected due to the internal low conductivity, morphology, surface area, chemical composition, and crystallinity [11,12]. Recently, many efforts have been devoted to overcoming these obstacles by designing mixed-metal oxides, controlling morphology, size, and structural properties. Previous reports found that the introduction of Cu in the host cobalt oxide could be beneficial towards improving conductivity and electrochemical properties. Therefore, copper cobalt-based oxides have been highlighted because of their natural abundance, excellent stability, and low cost. Furthermore, amalgamation of metal oxides is a promising way to boost electrical conductivity, electro-chemical properties, and structural stability.

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Probing the electrochemical properties of $NiMn_2O_4$ nanoparticles as prominent electrode materials for supercapacitor applications

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ABSTRACT

$NiMn_2O_4$ (NMO) powders have been prepared by facile sol–gel route, and the effect of annealing temperature and the concentration of KOH electrolyte on its electrochemical performance has been investigated. The electrochemical performance of the NMO electrodes is tested via a three electrode arrangement in KOH electrolyte. The NMO electrode (NMO1) prepared from the powder synthesized at a temperature of 500 °C with an approximate crystallite size of 10 nm exhibits maximum specific capacitance of 571 Fg^{-1} at a scan rate of 5 mVs^{-1} in 1 M KOH electrolyte. The specific capacitance of the NMO1 electrode is found to be improved from 571 Fg^{-1} in 1 M KOH to 762 Fg^{-1} in 6 M KOH electrolyte. The improvement in the specific capacitance of the NMO1 working electrode in 6 M KOH electrolyte can be attributed to good electrochemical utilization and an effective charge storage mechanism.

1. Introduction

Supercapacitors (SCs) have attracted much attention because of the fast rechargeability, higher power density over the batteries, and more energy storage ability as compared to conventional capacitors. The SCs have enormous energy storage capacity besides possessing the combined property of both conventional capacitor and battery [1]. Based on the charge-storage mechanism, electrochemical SCs can be classified into three categories: viz, pseudocapacitors, electrical double-layer capacitors (EDLCs), and hybrid capacitors. The conducting polymers and various metal oxides are utilized as the active electrode materials in pseudocapacitors, whereas in EDLCs carbon-based materials such as activated carbon, graphene, and carbon nanotubes are used as active electrodes. One more type of SCs is a mixture of both pseudocapacitors and EDLCs, known as a hybrid capacitor. To construct these types of SCs, the active electrode materials are made by combining either two or three distinct elements which give very large specific capacitance and enhanced energy density than pseudocapacitors or EDLCs [2]. However, all the above-mentioned SCs still suffer from some significant disadvantages such as poor cyclic life span of conductive polymers, the low capacitance of carbon-based materials and high cost of typical transition metal oxides like RuO_2 [3]. RuO_2 has been extensively investigated as a promising material due to its high specific capacitance and excellent cycling stability, but rareness and the high cost of ruthenium element are putting significant barriers to its commercialization [4]. To overcome these significant disadvantages, it is necessary to explore other alternative materials for the fabrication of supercapacitors.

Mixed transition metal oxides (MTMOs) are preferred to fabricate electrode materials for supercapacitor application over the single transition metal oxide component due to its enhanced chemical stability and electrochemical properties [5]. Out of the different MTMOs, considerable attention has been centered towards the synthesis of cubic spinel $NiMn_2O_4$ (NMO) as it offers high conductivity, outstanding electrochemical capacitance, high redox-active sites, and exceptional chemical

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Hierarchical nanosheets of ternary CoNiFe layered double hydroxide for supercapacitors and oxygen evolution reaction

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ABSTRACT

The preparation of stable and efficient thin films with excellent energy storage and conversion capabilities has attracted great attention in the field of supercapacitors and electrocatalysis. Herein, hierarchical nanosheets-based ternary CoNiFe layered double hydroxide (LDH) thin films are prepared via an inexpensive and facile electrodeposition method. The structural, morphological, and electrochemical properties of films are systematically studied and compared with their binary counterparts. As prepared CoNiFe LDH shows a maximum specific capacity of 360 C g^{-1} at the current density of 0.4 A g^{-1} with a capacity retention of 51% even at the higher current density of 10 A g^{-1}. Moreover, it shows excellent cyclic stability of 84% after 2000 cycles. As an electrocatalyst, CoNiFe LDH demonstrates an excellent performance in OER, affording an overpotential of 196 mV at the current density of 10 mA cm^{-2} with a Tafel slope value of 49 mV dec^{-1}. Also, it depicts excellent catalytic stability with stable operation for over 10 h. Thus, ternary CoNiFe LDH thin film can be used as a promising electrode material for both electrochemical energy storage and catalysis.

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1. Introduction

The continuously increasing energy consumption and concerns over environmental pollution require significant global efforts on efficient generation, storage, and transmission of energy [1]. The electrochemical energy storage and electrocatalysis have been considered to be the most effective technologies to remove the aforementioned stumbling block [2]. Among electrochemical energy storage devices, such as batteries and supercapacitors (SCs), SCs have attracted great importance owing to their high specific capacitance, long cycle life, and high power density [3]. The SC bridges the gap between conventional capacitors and rechargeable batteries by combining advantages of both. However, SCs are characterized by their poor energy density. Therefore, a variety of different materials has been investigated to improve the energy density of SCs [4]. SCs are categorized into electric double layer capacitors (EDLCs) and pseudocapacitors. Compared with EDLCs, pseudocapacitors demonstrate superior capacitive performance owing to the involvement of fast redox reactions and tremendous scales of electrostatic charge diffusion and accumulation [5]. Electrode materials such as transition metal oxides, hydroxides, sulfides, carbides, nitrides, conducting polymers, etc. neither exhibit pure pseudocapacitive nor faradaic behavior. These materials can be classified as battery-like electrodes which have attracted great attention in recent years [6].

On the other hand, the electrochemical water splitting using high-performance electrocatalysts is imperative to produce oxygen and hydrogen for fuel cell and metal-air battery technologies [7]. During water splitting, the hydrogen evolution reaction (HER) is a straightforward process that readily happens at low overpotential. However, the oxygen evolution reaction (OER) ($4OH^- \rightarrow O_2 + 2H_2O + 4e^-$) is an arduous process owing to the sluggish four-electron transfer steps [2]. Previously, transition metal oxides such as RuO_2 and IrO_2 have been reported as high-performance electrocatalysts for OER [8]. However, it is important to explore highly competent and inexpensive OER catalysts based on earth-abundant elements.

Recently, transition metal-based layered double hydroxides (LDHs) have attracted great attention in the field of SCs, electrocatalysts, and electrochemical sensors because of their highly reversible redox kinetics, cost-effectiveness and excellent structural and compositional tunability [9–11]. The general formula for LDHs is

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Review

Review on biomass feedstocks, pyrolysis mechanism and physicochemical properties of biochar: State-of-the-art framework to speed up vision of circular bioeconomy

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ABSTRACT

The biochar is a solid carbon-rich, porous material produced by the thermochemical conversion of a diverse range of biomass feedstocks under an inert atmosphere (i.e., in the absence of oxygen). We can produce the biochar at all likely scales, ranging from the industrial to the domestic level and even at individual farms, thus, the biochar industry is leading as a most appropriate at different socioeconomic settings. The possibility of sustainable biochar production practices and multi-functionality features make it a promising candidate to fulfill an increasing demand in the fields of soil amendment, agricultural sustainability, environmental protection, cutting-edge materials, and to achieve circular bioeconomy and mitigation of climate change. An available fraction of waste biomass (agroforestry waste, biomass crops, agricultural residues, mill residues, and animal manure, and many more) can be used efficiently in pyrolysis and converted into desired biochar materials, besides this alternative energy products, such as syngas, bio-oil, electricity generation, and process heat. This report emphasizes the fate of biomass composition, pyrolysis mechanisms, and applications of modern analytical and characterization techniques that are being adopted, applied, and standardized to improve understandings of molecular, structural, and surface properties characteristics of biochar. To achieve precisely designed biochar, there is a need to understand the latest advances in biochar materialization mechanisms and structure-application relationships to speed up their agronomic applications and to achieve a zero-waste dream. This report also summarizes a wide range of literature published on feedstocks, pyrolysis, and biochar and suggests several practical recommendations appropriate to implement and bring together specific details on the thermochemical conversion of biomass, desired biochar properties, organic and inorganic phases, and the significance to the agronomic applications.

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Electrochemical synthesis of binder-free interconnected nanosheets of Mn-doped Co_3O_4 on Ni foam for high-performance electrochemical energy storage application

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ABSTRACT

In this study, various nanostructures of Mn-doped Co_3O_4 were synthesized on Ni foam using binder-free electrochemical technology for electrochemical energy storage applications. Using the cyclic voltammetry method with different scan rates, diverse nanostructures, i.e., irregularly oriented nanooctahedra, interconnected standing nanosheets, and nanopetals of Mn-doped Co_3O_4, were obtained. The standing interconnected nanosheets on the Ni foam exhibited remarkable supercapacitive performance due to the void space between the sheets and mesoporous structure, which provided additional active sites for faradic transitions. The nanosheets exhibited excellent electrochemical performance with a maximum specific capacitance of 1005F g^{-1} and a cyclic stability of 88% during 5000 charge–discharge cycles. Moreover, an asymmetric supercapacitor was assembled comprising activated carbon on Ni foam and interconnected nanosheets of Mn-doped Co_3O_4 on Ni foam as negative and positive electrodes, respectively. This assembled device exhibited an improved potential of 1.6 V, a maximum specific energy of 20.6 Wh kg^{-1}, and a maximum specific power of 16 kW kg^{-1} with 80.6% capacity retention after 2000 charge–discharge cycles, which is superior for SC devices.

1. Introduction

Effective electric energy storage and retrieval are important aspects for the development of sustainable and renewable energy devices. Most of the research on this topic has focused on the use of nontoxic, abundantly available materials for low production cost and enhanced operational safety [1]. In particular, Li-ion battery technology stands out for its ability to deliver high specific energy in various electrical appliances, including medical devices and communication implements [2,3]. However, for the development of next-generation hybrid devices, supercapacitors (SCs) with high specific power that can provide large amounts of electrical energy in short periods are required. Basic electrochemical reactions occurring at the electrodes of SCs play a vital role in SC operation. In this context, SCs can be divided into two types: electrical double-layer capacitors (EDLC) with nonfaradic charge storage and pseudocapacitors with faradic charge storage. In general, SCs based on carbon nanomaterials such as carbon nanotubes, graphene oxides, and activated carbon (AC) are EDLCs, which exhibit high electrical conductivity and large surface areas. In contrast, transition metal oxides (TMOs), including MnO_2, Mn_2O_3, RuO_2, Co_3O_4, Fe_2O_3, and TiO_2, which undergo reversible faradic reactions, are used as pseudocapacitive materials [1,4]. These TMOs can deliver much higher energy density than carbon-based materials [1,2]. In particular, thin-film nanostructures of Co_3O_4 are considered to be good pseudocapacitive materials offering broad redox peaks over wider potential ranges compared with the sharp redox peaks of battery electrode materials [5,6].

Unfortunately, the low conductivity of TMO materials is a limitation for SC applications, and extensive research efforts have been devoted to enhance their performance. Studies have shown that TMOs having more than one cation exhibit better performance than oxides with single cations [7-9] and that the properties of core TMOs can be altered by

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A review on electrodeposited layered double hydroxides for energy and environmental applications

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ABSTRACT

The great demand for efficient and low-cost materials for energy and environmental applications has been inspiring researchers to develop novel and advanced materials. Recently, layered double hydroxides (LDHs) are found to be admirable materials for various applications owing to their tunable elemental composition and diverse nanostructures. The preparation of binder-free LDHs thin-film electrodes has attracted great attention in the field of supercapacitors, electrocatalysts and sensors. The electrodeposition method exhibits the capability of fabricating binder-free, uniform and well-oriented thin films with tunable elemental composition. In the present review, we provide a detailed electrodeposition mechanism behind the formation of LDHs with nucleation and growth processes. Also, we summarize the literature on electrodeposited LDHs based electrode materials for energy and environmental applications. In energy storage applications, a loading amount of active materials on the substrate is crucial to improve the areal and volumetric capacities. Therefore, the utilization of low-cost and scalable scaffold materials such as carbon nanofibers, graphene foam, etc. is highly recommended.

1. Introduction

Layered double hydroxides (LDHs), often called hydrotalcite-like systems or anionic clays have attracted great attention owing to their tunable chemical and metal-anion compositions. The general formula for LDHs can be written as $[M^{II}_{1-x}M^{III}_{x}(OH)_2]^{x+}[A^{n-}_{x/n}\cdot yH_2O]^{x-}$ (where M^{II} and M^{III} represent the divalent and trivalent metal cations, A^{n-} represents n-valent anions). Depending upon the nature of cations and M^{II}/M^{III} molar ratios, LDHs can be prepared with a wide range of layered structures [1]. The tunability of the molar ratio of metal cations and the nature of interlaying compensating anions lead to the formation of different nanoarchitectures with versatile physical and chemical properties, extending their applicability in diverse fields [2]. LDHs have been reported for different energy and environmental applications such as electrochemical energy storage, electrocatalyst, sensors, etc. These applications demand well-oriented, uniform and high conducting thin films [3,4]. Previously, LDHs have been prepared by different chemical methods such as co-precipitation [5], hydrothermal [6], sol-gel [7] and urea hydrolysis [8], either in thin film or powder form. These chemical methods are time-consuming and complex. Also, the powdered materials need to be combined with binders and conducting additives to be applied for many energy and environment-related applications, imposing additional inactive mass to the electrode [9]. In order to overcome these disadvantages, a binder-free LDHs can be prepared using electrodeposition method. The electrodeposition is rapid, facile, and scalable method which deposits well oriented and high quality thin film materials on the conducting support with enhanced conductivity and electrochemically active sites [10]. Recently, variety of different LDHs thin films have been prepared using electrodeposition method. Fig. 1 shows the number of publications and number of citations received by the research papers published in the field of electrodeposited LDHs, indicating the influence of the field.

Recently, some review articles have been published in the field of LDHs [1,11–13]. However, they mainly focus on general synthesis methods and their different applications. To the best of our knowledge, there is no review article published that emphasizes the detailed electrodeposition mechanism behind the formation of LDHs and review of electrodeposited LDHs for energy and environmental applications. It is important to understand the detailed electrodeposition mechanism in preparing LDHs for a variety of applications to fabricate efficient materials by overcoming present difficulties. Therefore, in this review, we have discussed the fundamentals of electrodeposition methods with

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polymers

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Article

α-Cellulose Fibers of Paper-Waste Origin Surface-Modified with Fe_3O_4 and Thiolated-Chitosan for Efficacious Immobilization of Laccase

Gajanan S. Ghodake [1], Surendra K. Shinde [1], Ganesh D. Saratale [2], Rijuta G. Saratale [3], Min Kim [4], Seung-Cheol Jee [4], Dae-Young Kim [1], Jung-Suk Sung [4] and Avinash A. Kadam [3,*]

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Abstract: The utilization of waste-paper-biomass for extraction of important α-cellulose biopolymer, and modification of extracted α-cellulose for application in enzyme immobilization can be extremely vital for green circular bio-economy. Thus, in this study, α-cellulose fibers were super-magnetized (Fe_3O_4), grafted with chitosan (CTNs), and thiol (-SH) modified for laccase immobilization. The developed material was characterized by high-resolution transmission electron microscopy (HR-TEM), HR-TEM energy dispersive X-ray spectroscopy (HR-TEM-EDS), X-ray diffraction (XRD), vibrating sample magnetometer (VSM), X-ray photoelectron spectroscopy (XPS), and Fourier transform infrared spectroscopy (FT-IR) analyses. Laccase immobilized on α-Cellulose-Fe_3O_4-CTNs (α-Cellulose-Fe_3O_4-CTNs-Laccase) gave significant activity recovery (99.16%) and laccase loading potential (169.36 mg/g). The α-Cellulose-Fe_3O_4-CTNs-Laccase displayed excellent stabilities for temperature, pH, and storage time. The α-Cellulose-Fe_3O_4-CTNs-Laccase applied in repeated cycles shown remarkable consistency of activity retention for 10 cycles. After the 10th cycle, α-Cellulose-Fe_3O_4-CTNs possessed 80.65% relative activity. Furthermore, α-Cellulose-Fe_3O_4-CTNs-Laccase shown excellent degradation of pharmaceutical contaminant sulfamethoxazole (SMX). The SMX degradation by α-Cellulose-Fe_3O_4-CTNs-Laccase was found optimum at incubation time (20 h), pH (3), temperatures (30 °C), and shaking conditions (200 rpm). Finally, α-Cellulose-Fe_3O_4-CTNs-Laccase gave repeated degradation of SMX. Thus, this study presents a novel, waste-derived, highly capable, and super-magnetic nanocomposite for enzyme immobilization applications.

Keywords: α-Cellulose; waste-paper-biomass; chitosan; laccase immobilization; super-magnetic

1. Introduction

Paper and cardboards related waste count near about 30% of the total urban solid waste produced worldwide [1]. Despite recycling rates is higher in most of the developed countries, solid paper waste [2], and food waste [3,4], remained as a significant concern to the landfill sites. At the same time, the growing population worldwide, and the emergence of linear bio economies in addition to the growing demand for end-use products causing over-exploitation of natural resources at a rapid pace [5,6]. On average about 55% of the slurry from the paper industry globally are made from the secondary fibers called

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Biological characteristics and biomarkers of novel SARS-CoV-2 facilitated rapid development and implementation of diagnostic tools and surveillance measures

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ABSTRACT

Existing coronavirus named as a severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) has speeded its spread across the globe immediately after emergence in China, Wuhan region, at the end of the year 2019. Different techniques, including genome sequencing, structural feature classification by electron microscopy, and chest imaging using computed tomography, are primarily used to diagnose and screen SARS-CoV-2 suspected individuals. Determination of the viral structure, surface proteins, and genome sequence has provided a design blueprint for the diagnostic investigations of novel SARS-CoV-2 virus and rapidly emerging diagnostic technologies, vaccine trials, and cell-entry-inhibiting drugs. Here, we describe recent understandings on the spike glycoprotein (S protein), receptor-binding domain (RBD), and angiotensin-converting enzyme 2 (ACE2) and their receptor complex. This report also aims to review recently established diagnostic technologies and developments in surveillance measures for SARS-CoV-2 as well as the characteristics and performance of emerging techniques. Smartphone apps for contact tracing can help nations to conduct surveillance measures before a vaccine and effective medicines become available. We also describe promising point-of-care (POC) diagnostic technologies that are under consideration by researchers for advancement beyond the proof-of-concept stage. Developing novel diagnostic techniques needs to be facilitated to establish automatic systems, without any personal involvement or arrangement to curb an existing SARS-CoV-2 epidemic crisis, and could also be appropriate for avoiding the emergence of a future epidemic crisis.

1. Introduction

A severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) was first appeared in the China Hubei Province, Wuhan at the end of December 2019. Considerable number of sick patients with severe and moderate symptoms including fever, shortness of breath, and coughing were rushed for admission to the nearby hospitals. These patients were underwent computed tomography (CT) scans and the results revealed opacities in their lungs (profuse, dense, and confluent types), which were differed from that of the CT scan images of the healthy human lungs (Ai et al., 2020; Zhou et al., 2020c). Ahead of the development, existing nucleic acid-based diagnostic kits, CT scans, and symptoms were collectively used in the initial diagnosis of SARS-CoV-2 infections. Later, well-established nucleic acid-based test kits were made available for most of the known viral panels and performed with a straight multiplex approach using a well-known technique called real-time polymerase chain reaction (RT-PCR), but, the results were found to be negative, indicated that the contagion of the infection was novel and thus, the origin of virus was unknown (Park et al., 2020; Zhang et al., 2020d). In the first week of January 2020, bronchoalveolar lavage (BAL) fluid samples of different patients were examined and mysterious virus with great similarity to the viral genome of the betacoronavirus-B family

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Using chemical bath deposition to create nanosheet-like CuO electrodes for supercapacitor applications

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ABSTRACT

We report the effect of ionic liquids on chemically synthesized hierarchical-like copper oxide (CuO) thin films for supercapacitor applications. Concisely, the CuO thin films were deposited via chemical bath deposition (CBD) using 2-dimethylimidazolium chloride [HPDMIM(C1)], 1-(2′,3′-dihydroxypropyl)-3-methylimidazolium chloride [DHPMIM(C1)], and *N*-(3-methyl-2-oxopropyl)pyridine chloride [MOCPP(C1)] ionic liquid solvents. The effects of the ionic liquid solvents on the morphological evolution of the as-prepared films were analyzed, and electrochemical properties were investigated. The highest specific capacitance was achieved for the electrode with a nanosheet-like structure produced by functionalization with the HPDMIM(C1) ionic liquid. The maximum specific capacitance achieved for the HPDMIM(C1):CuO hybrid electrode was 464 F g^{-1} at 5 mV s^{-1} in a 1 M Na_2SO_4 electrolyte. Thus, our findings, in addition to the stability of the HPDMIM(C1):CuO, indicate that it is a candidate for energy-storage applications.

1. Introduction

Increasing worldwide energy demand has played a catalytic role in the advancement of several energy storage technologies [1]. Two of the most important factors in energy storage research is renewability and sustainability [1–4]. Many researchers are currently focusing on addressing problems regarding energy storage technologies such as batteries and supercapacitors [4–9]. The main motivation in the case of supercapacitors is to improve their performance because these devices can supply very high power compared with batteries and other electronic devices [1–6]. Supercapacitors are distributed into three core types: electrochemical-double-layer capacitors, pseudocapacitors, and hybrid capacitors [1,5–9]. All three supercapacitor types have high charge–discharge rates, high power densities, long lifecycles, and safe operating processes [2,2,3,4].

Copper oxides are useful in various applications involving heterogeneous catalysis [5–9], gas sensing [10], photoelectrochemical cells [11], and supercapacitors [12]. They have been extensively investigated as an electrochemical material for supercapacitors because of their high abundance in the earth's crust, low cost, low toxicity, and good charge transport properties, all of which are beneficial in supercapacitor applications. The copper oxide are two common phases likes copper (II) oxide (CuO) and copper (I) oxide (Cu_2O) [13–15]. Different CuO nanostructures have been prepared and applied in supercapacitors, including flower [16,17] and nanoflakes [18], willow-leaves [19], micro-roses and micro-wool [20], nanosheets [21,22], nanospheres [23], nanoplatelets [24], nanowires [25], nanoribbons and nanoflowers [26], dandelion-like CuO microspheres [27], and nanorods [28].

Several methods have been used to prepare CuO and Cu_2O electrodes for supercapacitors [29–35]. Ghasemi et al. [36] reported using electrodeposited Cu_2O–$Cu(OH)_2$ nanoparticles as a supercapacitor electrode material. They attained a specific capacitance 425 F g^{-1} in 0.5 M Na_2SO_4 electrolyte. Li et al. [37] synthesized CuO thin films and its different nanostructures using thermal method. He reported a

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Flower-like $NiCo_2O_4/NiCo_2S_4$ electrodes on Ni mesh for higher supercapacitor applications

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ABSTRACT

In this research, we have effectively synthesized a novel $NiCo_2O_4/NiCo_2S_4$ powder by co-precipitation and thin films prepared using a screen-printing method on Ni mesh for supercapacitor applications. Herein, we report the effect of unique hierarchical nanostructures and the systematic effect of Ni and Co on the structural, morphological and electrical properties of the $NiCo_2O_4/NiCo_2S_4$ electrodes. The optimized $NiCo_2O_4/NiCo_2S_4$ electrode shows outstanding performance with a specific capacitance of 1966 $F\,g^{-1}$ at 5 $mV\,s^{-1}$. The cycling stability reports indicate the $NiCo_2O_4/NiCo_2S_4$ electrodes have an outstanding cyclic stability with 91% capacity retention. From the supercapacitor performance results, we confirmed that the $NiCo_2O_4/NiCo_2S_4$ electrode is useful for the fabrication of symmetric supercapacitors. These results reveal that the $NiCo_2O_4/NiCo_2S_4$ electrodes is a capable electrode material for supercapacitor applications in the future.

1. Introduction

In recent years, with the growth of the world economy, society has demanded electrical energy storage devices with high power and energy densities for use with alternative energy sources [1]. In recent years, many electrical energy storage devices are available in the market. Out of these, supercapacitors receive great consideration due to their low-cost, high power and energy densities [1,2], excellent stability [3], and fast charge-discharge compared to lithium-ion batteries and traditional capacitors [4]. Anodic and cathodic materials play an important role in the storage of electrical energy in supercapacitors [1–5]. However, the main problem in commercial device fabrication is lower power and energy density in supercapacitors [5]. Specific capacitance and cycling performance of supercapacitors can be enhanced by changing working materials. This is an important factor, which is beneficial for commercial applications of supercapacitors [6]. The main key is developing new strategies to improve energy storage with higher specific capacitance and long cyclic stability [7].

Currently, binary and ternary transition metal oxides are used for higher theoretical and experimental specific capacitance, which are very useful for portable electronic device fabrication [8]. However, transition metal oxides have comparatively lower electrical conductivity and low cyclic stability [9]. To avoid these problems, we apply a new strategy to design new nanostructure composite materials that have higher electrical conductivity and device performance [10,11]. Binary and ternary metal sulfides, like NiS, CoS and $NiCo_2S_4$, demonstrate better performance in various fields, such as oxygen evolution reactions [12], supercapacitors [13], water splitting [14], photocatalytic hydrogen evolution [15], and dye-sensitized solar cells [16], etc., than other oxides and hydroxides, for example NiO, CoO, $Co(OH)_2$, $Ni(OH)_2$, $MnCo_2O_4/CoCo_2O_4$, Mn:Co_3O_4, and $ZnCo_2O_4$ thin films [17–19]. Out of these ternary transition metal sulfides, $NiCo_2S_4$ and $NiCo_2O_4$ electrodes are better for supercapacitor application, because they provide higher electrical conductivity, high surface area, have excellent capacitive properties, and are environmentally stable [20–22].

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Short communication

Effect of deposition parameters on spray pyrolysis synthesized CuO nanoparticle thin films for higher supercapacitor performance

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ABSTRACT

In this study, copper oxide (CuO) thin films were synthesized at different deposition temperatures on fluorine doped tin oxide coated glass (FTO) substrates by spray pyrolysis for supercapacitor applications. The physical and electrochemical properties of the as-synthesized CuO samples were characterized via different analytical techniques such as X-ray diffraction (XRD), X-ray photoelectron spectroscopy, scanning electron (SEM) microscopy, surface wettability tests, and electrochemical measurements. The results showed that the deposition temperature affected their structural, morphological, and supercapacitor properties. The higher specific capacitance and extensive charge/discharge capability of the nanoparticle-like CuO thin films demonstrated their suitability as outstanding candidates in electrochemical applications. The evaluated specific capacitance further confirmed the effect of the deposition temperature on the supercapacitor performance of the CuO electrodes; its values for the thin films synthesized at 300, 350, and 400 °C were 363, 691, and 487 F g^{-1}, respectively, at a scan rate of 5 mV s^{-1} in a 2 M Na_2SO_4 aqueous electrolyte. Hence, this study demonstrates that the surface morphology and electrochemical supercapacitive properties of materials are dependent on the deposition temperature of CuO thin films.

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1. Introduction

The world is currently demanding for new energy storage/conversion devices that are lightweight, eco-friendly, and inexpensive. Various types of such devices including capacitors [1], batteries [2], fuel cells [3,4], solar cells [5], and supercapacitors are available commercially [6–8]; among them, supercapacitors are better than capacitors and batteries because of properties such as their high energy and power densities [7-10], fast charging/discharging, and long-term cycling stability [11,12]. These properties are useful in various applications, including in portable media players, digital electronics and cameras, medical devices, railways, street lights, and power banks [9–13]. Supercapacitors can be classified as EDLCs and pseudocapacitors based on their charge storage mechanism [7, 10–15]. This mechanism is related to non-faradaic capacitance resulting from the ion transformation in the Helmholtz double layer between the electrode and electrolyte in the former [11,13–19] and to faradaic reactions involving electrostatic charge storage in the latter [20,21].

Researchers have been investigating various metal oxide materials such as ruthenium oxide, iron oxide, manganese dioxide, nickel oxide, and copper oxide as well as conducting polymers for use in supercapacitors [8–13,20,21]. Among them, ruthenium oxide has exhibited high specific capacitive, high power density, and good stability, but its commercial distribution is hindered by its higher cost and environmental impact compared to those of other binary metal oxides. Dubal et al. [22] synthesized CuO via chemical bath deposition (CBD), reporting three different nanostructures that affected the supercapacitor performance; they attained a higher specific capacitance of 346 F g^{-1} with microwoolen-like CuO nanosheets at a scan rate of 5 mV s^{-1}. Sagu et al. [23] deposited CuO thin films as photoactive materials on FTO-coated glass substrates using electrodeposition, and measured a highest photocurrent density of 2.1 mA cm^{-2} in a 1 M NaOH electrolyte. Shu et al. [24] fabricated CuO thin films on a Cu foam by electrochemical anodization; they observed single-phase copper oxide with good electrochemical properties and a specific capacitance of around 600 mF cm^{-2} in a 2 M KOH aqueous electrolyte at a current density of 1 mA cm^{-2} and excellent cycling stability with around 94% retention

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Variation in chemical bath pH and the corresponding precursor concentration for optimizing the optical, structural and morphological properties of ZnO thin films

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Abstract
In the present study, ZnO thin films were deposited by chemical bath deposition carried out by selective correlation of varying (i) pH values at fixed concentration and (ii) concentration of the precursors at fixed pH. The selective correlations were done by using the characterization tools like X-ray diffraction, scanning electron microscopy, transmittance, refractive index, dielectric constant, Fourier-transform infrared spectroscopy and IV measurements. Transmittance was found to increase from 57 to 87% on varying the pH from basic side (10.8) to acidic side (pH 6.8) with a blue shift in band gap. The nature and morphology of the deposited films were found to be dependent on pH as well as concentration. Acidic pH 5.0 was found to be most suitable for deposition of highly transparent film with low absorption coefficient, refractive index and dielectric constant. On the other hand, nearly complete coverage of the substrate and high purity was observed in the ZnO thin films which was deposited by taking equal 100 mM concentration of $Zn(NO_3)$ and HMTA precursors at a fixed pH 5.0 as desired, sheet resistance was also found to increase on the acidic pH side which is useful in case of buffer layer solar cell application. These studies lay a foundation stone for understanding the optical and morphological parameters by selectively correlating the pH and concentration variation at the same time.

1 Introduction

Zinc oxide (ZnO) is a wide bandgap semiconducting material with unique chemical, optical and electrical properties. It has attracted considerable attention due to its various applications such as gas sensor [1], solar cell materials [2], antimicrobial materials [3, 4], optoelectronics devices [5, 6] and several other important applications [7]. These films are widely used as conductive and optical cover layers of large area solar cells [8, 9]. Different methodologies have been reported by several groups for deposition of ZnO nanostructures [10, 11]. Wet chemical techniques [12], physical vapor deposition [13], metal organic chemical vapor deposition (MOCVD) [14], pulsed laser deposition [15], molecular beam epitaxy (MBE) [16], sputtering [17], electrospinning [18] etc. are few common techniques. Most of these techniques are performed at high temperature and require expensive instrumentation. Wet chemical methods are comparatively simple, less expensive and reliable method.

Chemical bath deposition (CBD) is a low temperature wet chemical technique being widely used for the deposition of ZnO thin film buffer layers [19, 20]. It is a simple technique,

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Mechanistic study of colorimetric and absorbance sensor developed for trivalent yttrium (Y^{3+}) using chlortetracycline-functionalized silver nanoparticles

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ABSTRACT

The presence of hazardous, radioactive, and rare earth metal such as yttrium (Y^{3+}) in water poses a serious health concern to the public health, thus, exploring novel Y^{3+}-binding molecules and colorimetric indicators are desired. Chlortetracycline (CTC)-functionalized silver nanoparticles (AgNPs–CTC) were synthesized, purified by centrifugation and then characterized by UV–vis spectroscopy, XPS, XRD, and HR-TEM. Functionalization of AgNPs with CTC molecules enabled the rapid and sensitive detection of trivalent yttrium ion (Y^{3+}). A decrease in the intensity of the original surface plasmon resonance peak at 420 nm was observed within the fraction of a min, with the simultaneous appearance of a new peak at a longer wavelength (540 nm); thus, a novel colorimetric and ratiometric absorbance probe was achieved. The free-O-containing moieties of CTC on the AgNPs surface coordinate with Y^{3+}. Thus, CTC molecules led to the bridging of the AgNPs and subsequent aggregation. A good linear relationship (R^2 = 0.933) in the range of 18 to 243 nM for Y^{3+} was observed, and the limit of detection (LOD) for ratiometric results was approximately 57.7 nM. The AgNPs–CTC sensor exhibited better colorimetric performance in terms of excellent sensitivity, LOD, and rapid formation of the AgNPs-CTC complex towards Y^{3+}. The Y^{3+} spiked water samples from different sources and fetal bovine serum suggest that the developed method is practically useful and essentially portable for on-site monitoring. The AgNPs–CTC sensor can be also applied as a common colorimetric indicator for the detection of trace levels of Y^{3+} and lanthanides.

1. Introduction

Facile detection of metal ions is of interest with high sensitivity, basically in aqueous media, is an important research area. Over the past several decades, research into the applications and biological significance of yttrium-compound based biomedical products has increased dramatically [1,2]. It is one of the important radioisotopes frequently released from radioactive waste into the environment [3]. Yttrium (Y^{3+}) are quite hazardous and non-biodegradable; thus, they must be detected and safely removed from polluted streams. Similarly, increased use of lanthanides in catalysis, fertilizer, and medical diagnosis, it has raised serious concerns over their potential in pollution and deserves new methods detection of trace levels [4]. Traditional methods such as inductively coupled plasma atomic emission spectrometry [5], and inductively coupled plasma mass spectrometry (ICP-MS) [6] have typically been used to detect Y^{3+}. Also, some fluorescence sensors for Y^{3+} have also been reported, that shown molecular recognition capability for the Y^{3+} metal ions [7,8]. In addition, only a limited number of Y^{3+} samples have thus far been examined [9]. As such, the developments of more effective, rapid, and selective colorimetric or spectrophotometric methods with the capability to detect Y^{3+} ions with nanomolar-level sensitivity are needed. To the best of our knowledge, the present work is the first report on the sensitive colorimetric detection and determination of Y^{3+} using chlortetracycline (CTC)-functionalized silver nanoparticles (AgNPs–CTC) with a dependable and rapid absorbance response.

Organic compounds with electron-donor functionality are important in analytical chemistry, where they participate in environmental, biological, medicinal, and organometallic coordination reactions for binding with metal ions [10]. Members of the tetracycline class of

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Research Article

Capacitive property studies of inexpensive SILAR synthesized polyaniline thin films for supercapacitor application

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Abstract
The polyaniline (PANI) is an eco-friendly conductive polymer which has been considered for diverse applications. The partially oxidized phase of the PANI is useful for the charge storage application. Here, a unique nanograin/nanofiber structured PANI was grown on inexpensive stainless steel (SS) current collector by the simple oxidative polymerization process and its charge storage properties were systematically investigated. For that, the inexpensive successive ionic layer adsorption reaction method was used to grow a uniform nanostructured PANI on the SS conductor. This evolution of the nanostructure was studied with the Field emission scanning electron microscope. Furthermore, the as-prepared PANI was confirmed by the X-ray diffraction and the Fourier-transform infrared spectroscopy. In the half cell electrochemical testing, the prepared PANI exhibited a maximum specific capacitance of 710 F g^{-1} with a specific discharge capacity of 119 mAh^{-1} at 0.2 mA cm^{-2} in 1 M H_2SO_4 for the supercapacitor application. Also, by using the power-law relation it was observed that, in a charging and a discharging current, initially a contribution of the diffusive faradaic reactions is more as compared with the surface capacitive non-faradaic reactions.

Keywords Polyaniline (PANI) · Supercapacitor · SILAR · Stainless steel · Power-law · Charge storage

1 Introduction

Evolution in the electrical systems for a wide spectrum of application in recent years have been increased the demand for electrical energy consumption [1, 2]. The sophisticated energy storage units with desired energy-power output for targeted electrical systems has been the main goal in front of the research community. In the global market, batteries, supercapacitors (SCs), hybrid energy storage systems have been providing the desired requirements of electrical systems. Among several energy storage systems, the Li-ion batteries are still dominating in the market for different applications, from the medical devices to the hybrid vehicles as the main central electrical energy storage and supplying system (EES) unit [3–5]. However, SCs with low initial capital costs, low operation-maintenance costs, with easy and efficient operation, high power density have been considered as the best option for main backup EES unit [6–8].

The materials generally used in the SC's stores electrical energy either in the form of columbic (electric double layer) and faradaic (redox reaction) charge transfer process or the combination of both, which influences its power-energy output [9, 10]. The SCs having more electric double layer transitions can deliver more electric power density due to the fast charge transfer rate of adsorbed ions on the electrode surface. Whereas, the SCs having more redox transitions can deliver low power density due to poor charge transfer rate [11, 12]. More surface adsorption reaction in the charge transfer process increases the

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Nanorods to hexagonal nanosheets of CuO-doped manganese oxide nanostructures for higher electrochemical supercapacitor performance

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ABSTRACT

In this work, the extraordinary properties of CuO addition on the morphology and supercapacitive performance of Mn_2O_3 electrodes were demonstrated. Concisely, CuO/Mn_2O_3 thin films were prepared by an easy and inexpensive successive ionic layer adsorption and reaction (SILAR) method. The prepared thin films were characterized by various sophisticated physiochemical systems. The results demonstrated formation of Mn_2O_3 thin films with noteworthy morphological alteration upon introduction of CuO. Furthermore, a significant effect of CuO introduction was observed on the electrocatalytic properties of the nanostructured Mn_2O_3 electrodes. At 3% CuO doping, the Mn_2O_3 electrodes displayed the maximum specific capacitance owing to formation of nanoplate-like structures. The enhanced specific capacitance attained for 3% CuO doping in the Mn_2O_3 electrode was 500 F/g at 5 mV/s in a 3 M KOH electrolyte. All results confirmed the plausible potential of the CuO/Mn_2O_3 electrode for supercapacitor applications.

1. Introduction

In recent years, supercapacitors have emerged as good candidates for different energy storage applications owing their excellent power density, extensive cycle life, high rate capability, high reversibility, and extremely fast charging/discharging [1]. The increasing energy demands and the consequent environmental impact have encouraged a search for alternative clean and sustainable energy storage technologies with high efficiency and excellent performance [2]. Accordingly, considerable attempts have been made to find a suitable electrode materials with decent capacitive features analogous to those of NiO, CoOx, CuO, MnO_2, Fe_3O_4, etc. [3–7]. Among the different transition metal oxides, manganese oxide has attracted attention because of its low cost, environmental friendliness, high energy density, universal abundance, high theoretical capacity (1370 F/g), and excellent electrochemical properties for applications in supercapacitors and use as an electrocatalyst in basic reagents for the oxygen reduction reaction (ORR) [2,8–10].

Different strategies have been proposed to boost the electrochemical properties of manganese oxides. The electrochemical features of a substance are mainly determined by their electronic structure. Extra energy states can be introduced to metal oxides by doping other materials to alter their electronic characteristics [8]. The most prominent method to enhance the specific capacity of metal oxide is the addition of metal ions to develop desired mixed metal compounds [11]. The doping of heteroatoms can strengthen the pseudocapacitive and electrochemical properties of manganese oxides [8]. Among different metal dopants, the copper cation is considered as a superior dopant because of its electrical conductivity, environmentally benign nature, and low cost [2,12]. P-type materials such as CuO and manganese oxides with a tiny band gap (E_g = 1.2 eV) are considered dynamic materials in batteries and supercapacitors [2]. Copper-based manganese oxides material has been used as catalyst for the oxidation of CO [13], hydrogenation reaction [14], oxidative decomposition of ethyl acetate [15], and oxidation of 5-hydroxymethylfurfural [16], Fe, and Mn doped CuSe [17].

Recently, Li et al. prepared various transition metal (Fe, Co, Ni, and V) ion-doped MnO_2 on carbon for the ORR and supercapacitor applications. They prepared manganese oxides nanosheets by a redox reaction between the macroporous carbon and a $KMnO_4$ solution. They found that the electrochemical performance can be improved by doping

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nanomaterials

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Communication

Facile Synthesis of Triphenylamine Based Hyperbranched Polymer for Organic Field Effect Transistors

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Abstract: In this study, we reported the synthesis and characterization of a novel hyperbranched polymer (HBPs) *tris*[(4-phenyl)amino-*alt*-4,8-bis(5-(2-ethylhexyl)thiophen-2-yl)benzo[1,2-b;4,5-b′]dithiophene] (PTPABDT) composed of benzo[1,2-b:4,5-b′]dithiophene (BDT) and triphenyleamine (TPA) constituent subunits by $A_3 + B_2$ type Stille's reaction. An estimated optical band gap of 1.69 eV with HOMO and LUMO levels of −5.29 eV and −3.60 eV, respectively, as well as a high thermal stability up to 398 °C were characterized for the synthesized polymer. PTPABDT fabricated as an encapsulated top gate/bottom contact (TGBC), organic field effect transistors (OFET) exhibited a p-type behavior with maximum field-effect mobility (μmax) and an on/off ratio of 1.22×10^{-3} cm^2 V^{-1} s^{-1} and 7.47×10^2, respectively.

Keywords: benzo[1,2-b:4,5-b′]dithiophene; triphenylamine; Stille reaction; OFET

1. Introduction

Solution processable π-conjugated semiconductors, a subset of organic materials, has progressively attracted much attention from both academic and industrial applications as the best candidate for lightweight, transparent, flexible electronic devices with less production cost for high throughput processing [1–4]. These materials have been fabricated as active organic layers in organic field-effect transistors (OFETs), organic photovoltaic (OPV) cells, and organic light emitting diodes (OLEDs) [5,6]. OFETs remain as the fundamental building block for flexible electronics [7,8]. Significant progress has enhanced device performance remarkably and currently considered as viable alternative to amorphous silicon-based transistors [9–12]. In spite of that, further fabrication methods and reliable device models are required for expansion of its application in sophisticated electronics [7,13]. This realization

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Silver nanoparticle probe for colorimetric detection of aminoglycoside antibiotics: picomolar-level sensitivity toward streptomycin in water, serum, and milk samples

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Abstract

BACKGROUND: The low cost of aminoglycoside (AMG) antibiotics facilitates their excessive use in animal husbandry and the agriculture sector. This scenario has led to the occurrence of residues in the food chain. After several years of AMG use in antibacterial therapy, resistance to streptomycin has begun to appear. Most of the detection methods developed for AMG antibiotics lacks specificity. A broad target specific nanoprobe would be ideal for detecting the entire class of AMGs. A rapid and sensitive method for the detection of AMGs is urgently needed.

RESULTS: Gallic acid-coated silver nanoparticles (AgNPs) were demonstrated as a nanoprobe for the colorimetric detection of AMGs (yellow to orange / red). A linear dynamic range of 50–650 pmol L^{-1} was achieved readily by ratiometric spectrophotometry (A_{560}/A_{400}) with a limit of detection (LOD) as low as 36 pmol L^{-1}. The amine-groups of the AMGs function as molecular linkers, so that electrostatic coupling interactions between neighboring particles drive the formation of AgNP aggregates. The assay can also be applied for the determination of streptomycin residues in serum and milk samples.

CONCLUSION: This study revealed the potential of an AgNP probe for the rapid and cost-effective detection of low-molecular-weight target analytes, such as the AMGs. A ligand-induced aggregation of AgNPs coated with gallic acid was reported to be a rapid and sensitive assay for AMGs. Analysis of streptomycin was demonstrated with excellent picomolar-level sensitivity. Thus, the validated method can find practical applications in the ultrasensitive detection of AMGs in complex and diagnostic settings.
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Keywords: AgNP probe; ratiometric assay; picomolar sensitivity; antibiotics residues; food safety

INTRODUCTION

Aminoglycoside (AMG) antibiotics are RNA-binding drugs with a common core structure called the streptamine ring. They bind to the ribosomal subunit, thereby hindering mRNA translation and finally leading to nonsense mutation and rapid cell death. Aminoglycoside antibiotics are known for their broad-spectrum antibacterial action against a range of gram-negative aerobic bacteria.[1] However, the substantial variation between the administered AMG antibiotic dose and variations in the resultant levels in the blood is of great concern.[2] The negative impact of antibiotic residues in food and water has also received worldwide attention due to their abuse in animal husbandry and agricultural practices.[3,4] This global scenario has emerged as a pressing concern owing to the evolving multi-drug resistance observed for bacteria.[5] There is thus an urgent need to develop novel assays with high selectivity and sensitivity for the detection of AMG antibiotics in water and food samples.

Streptomycin is a broad-spectrum AMG antibiotic that was discovered in 1943 from a soil actinomycete, *Streptomyces griseus*.[6] It is effective for gram-negative bacterial treatment and is used not only in controlling human diseases but also in modern agriculture

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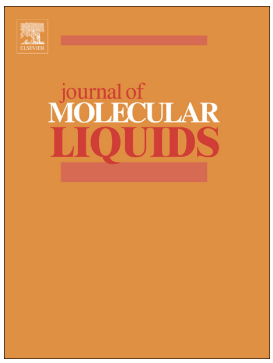

High-performance symmetric supercapacitor; nanoflower-like NiCo2O4//NiCo2O4 thin films synthesized by simple and highly stable chemical method

S.K. Shinde, H.M. Yadav, Sivalingam Ramesh, C. Bathula, Nagesh Maile, G.S. Ghodake, Haridas Dhaygude, D.-Y. Kim

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nanomaterials

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Article

Extracellular Synthesis and Characterization of Silver Nanoparticles—Antibacterial Activity against Multidrug-Resistant Bacterial Strains

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Abstract: Herein, we report the use of a cell-free extract for the extracellular synthesis of silver nanoparticles (AgNPs) and their potential to address the growing threat of multidrug-resistant (MDR) pathogenic bacteria. The reproducibility of AgNP synthesis was good and AgNP formation kinetics were monitored as a function of various reaction factors via ultraviolet-visible absorption spectroscopy. This green method was dependent on the alkaline pH of the reaction mixture. With the addition of dilute sodium hydroxide, well-dispersed AgNPs could be produced in large quantities via the classical nucleation and growth route. The new biosynthetic route enabled the production of AgNPs within a narrow size range of 4 to 17 nm. The AgNPs were characterized using various techniques and their antibacterial activity against MDR pathogenic bacteria was evaluated. Field-emission scanning electron microscopic imaging revealed prominent morphological changes in *Staphylococcus aureus* cells due to mechanical damage, which led to cell death. *Escherichia coli* cells showed signs of contraction and intracellular fluid discharge as a consequence of disrupted cell membrane function. This new biologically-assisted extracellular strategy is potentially useful for the decontamination of surfaces and is expected to contribute to the development of new products containing AgNPs.

Keywords: extracellular nanosynthesis; green chemistry; silver nanoparticles; intracellular fluid discharge; pathogenic bacteria

1. Introduction

The frequent and widespread use of antibiotics in the last few decades has led to the development of antibiotic-resistant bacteria. In recent years, *Escherichia coli* (*E. coli*) and *Staphylococcus aureus* (*S. aureus*) have been identified as the sources for most common infections. Multidrug-resistant (MDR) pathogens are known to cause scalded skin syndrome, meningitis, endocarditis, osteomyelitis, food poisoning, urinary tract infections, pneumonia and diarrhea worldwide [1–3]. Resistance in pathogenic microorganisms poses a severe threat to global public health because conventional antibiotics will no longer be effective [4,5]. Thus, there is an urgent need for the development of novel antibiotics, antimicrobial agents and nanomaterials that exhibit strong antimicrobial activity without the induction of resistance in bacterial strains.

Oxide nanomaterials, including copper, zinc, cerium and iron, appear promising as antibacterial agents. However, oxide nanomaterials are limited by their poor dispersibility and

Journal Pre-proof

Gallic acid-functionalized silver nanoparticles as colorimetric and spectrophotometric probe for detection of Al^{3+} in aqueous medium

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Full Length Article

Assembling ZnO and Fe_3O_4 nanostructures on halloysite nanotubes for anti-bacterial assessments

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Biofilms

ABSTRACT

This study reports anti-bacterial assessments of 'halloysite nanotubes (HNTs) surface-tuned with Fe_3O_4 and ZnO nanostructures (M-HNTs-ZnO)' against the non-drug resistant pathogenic *E. coli* and *S. aureus*, drug-resistant methicillin-resistant *S. aureus* (MRSA) and their respective biofilms. Naturally occurring clay mineral the halloysite nanotubes (HNTs) are emerging materials in nano-bio-medicines. Fabricating HNTs' tunable surface with anti-bacterial nanomaterials can be a significant application in combating the deadly bacterial infections. SEM, TEM, FT-IR, XPS and VSM analysis corroborated a successful synthesis of M-HNTs-ZnO. The acquired results established the significant anti-bacterial potential of M-HNTs-ZnO against the *E. coli*, *S. aureus* and MRSA, respectively. The stepwise modifications made on HNTs enhanced anti-bacterial performance. Detailed SEM image analysis established possible anti-bacterial mechanisms. M-HNTs-ZnO found effective against the successfully established biofilms of *S. aureus*. The M-HNTs-ZnO applied in repeated anti-bacterial performance against *E. coli*, *S. aureus* and MRSA, marked its importance for water-treatments. In conclusion, M-HNTs-ZnO showed significant anti-bacterial properties that can be used in the treatment of infectious diseases. Also, its repeated anti-bacterial capabilities might be applied in water disinfection protocols.

1. Introduction

The use of antibiotics dominated as a treatment for the pathogenic micro-organisms in the last century [1]. The dramatic increase in antibiotic resistance of pathogenic bacteria constitutes one of the major threats to human health [1,2]. To combat these problems, several antimicrobial nanomaterials have been studied in recent years for the replacement of antibiotics. Despite this, the robust nano-material with natural-availability, higher-efficiency, and multi-functional properties are necessary to be investigated. However, the highly-applicable and multi-dimensional materials which have the anti-bacterial effect to methicillin-resistant *Staphylococcus aureus* (MRSA) and their biofilms can counter the rising drug-resistance in micro-organisms.

Halloysite nanotubes (HNTs) are the biocompatible materials, known for exceptional drug carrier potential [3-6]. HNTs are naturally occurring clay mineral having a significant potential of the surface modification for diverse applications [3]. Structurally, HNTs $[Al_2Si_2O_5(OH)_4{\cdot}2H_2O]$ are made up of aluminosilicate layers with the composition of aluminum, silicon, hydrogen, and oxygen [7]. HNTs structure shows hollow-tubular nature with an inner-lumen diameter of 5–20 nm and the length of the tube is in the range of 0.5–10 μm [8]. Chemistry of HNTs includes a tubular morphology with the Al—OH sheet forming the inside and the Si–O sheet the outside [9,10]. The HNTs' outer surface mainly covered by Si—O—Si groups and have some Si—OH groups present on the edges [11]. HNTs nano-tubular framework provides there utilization in diverse applications including; environmental, catalytic, and nano-medicinal [12]. Due to their outstanding properties, HNTs are widely used in many emerging applications. So, the impact of the HNTs on human health and the environment needs to test. The biocompatibility of HNT is one of the

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Short Communication

Microwave assisted synthesis of imidazolyl fluorescent dyes as antimicrobial agents

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Antimicrobial agents

ABSTRACT

In this article, we report, the synthesis and characterization of series of novel fluorescent imidazolyl dyes **(5a-d)** *via* highly efficient and cost-effective microwave assisted protocol as a potential candidate to overcome the problem of microbial resistance. By utilizing the green microwave protocol the reactions are completed in a short span of time without using the harsh conditions. The incorporation of imidazole nucleus is an important strategy in drug discovery. While designing desired fluorescent imidazole dyes **5a-d**, with a suitable auxiliary donor such as aromatic rings and $-OCH_3$ group on one end of the imidazolyl moiety and electron acceptors such as $-NO_2$ and $-COOH$ on other end of the compounds was achieved to get a promising fluorescent dyes for antimicrobial. The optoelectronic properties and antimicrobial studies of the synthesized materials indicated their exploration as a promising candidate as antimicrobial agents.

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Original Article

Fabrication of nanostructured SnO_2@Co_3O_4/nitrogen doped graphene oxide composite for symmetric and asymmetric storage devices

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ABSTRACT

The fabrication, and characterization of SnO_2@Co_3O_4/NGO composite with a nanogranular-like morphology was synthesized by a thermal reduction process in presence of ammonia and urea as catalyst. The structure and morphology of the composite were investigated by sophisticated techniques. Cyclic voltammetry was performed to determine the electrochemical performance of the composite electrode for supercapacitor applications. The composite symmetrical electrode was displayed a specific capacitance of ~375 F g^{-1} at 0.5 A/g in a 2 M KOH aqueous electrolyte with a capacity retention of ~93% after 10,000 cycles. The SnO_2@Co_3O_4/NGO composite asymmetric electrode exhibited a specific capacitance of~256 F/g at 1 A/g and excellent cyclic retention. The improved electrochemical properties of the composite depends on the nanogranular-like morphology, large surface properties, and excellent conductive networks. Therefore, the ternary oxide@NGO composite electrode is promising architecture for energy storage applications.

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Designing of nanoflakes anchored nanotubes-like $MnCo_2S_4$/halloysite composites for advanced battery like supercapacitor application

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$MnCo_2S_4$/HNTs composite
Coprecipitation
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ABSTRACT

In this study, we report a facile chemical synthesis of a novel $MnCo_2S_4$/halloysite (HNTs) nanoflakes decorated on nanotubes which coated on Ni foam via a screen-printing technique. The $MnCo_2S_4$ thin films were prepared using a coprecipitation method which demonstrate battery kind of behavior. The $MnCo_2S_4$/HNTs-based electrode shows a specific capacity of 359 mAh g^{-1} at 5 mV s^{-1} with excellent cycling stability. Furthermore, the symmetric system exhibits an outstanding energy density and power density of 6.98 Wh kg^{-1} and 1976.0 W kg^{-1}, respectively. The results obtained with the $MnCo_2S_4$/HNTs composite in a symmetric system indicate that this composite material can potentially be used as an alternative electrode material for electrochemical energy storage.

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1. Introduction

In recent years, world pollution has rapidly increased, necessitating the development of alternative energy sources and storage schemes. Although the existing energy sources and storage techniques are convenient, they face various limitations such as low abundance and poor renewability [1–5]. Examples of non-renewable energy sources include fuels such as oil, coal, natural gas, and wood [5–7]. Overcoming such problems involves the progress of novel energy storage systems that alleviate environmental pollution, are based on a renewable energy source, and are green and cost effective. To this end, solar cells, supercapacitors, batteries, and capacitors are now commercially available [8–10]. Solar cells, batteries and supercapacitors are the most capable electrical energy storage systems. In supercapacitors, battery type materials are particularly promising because they show outstanding characteristics such as high energy and power densities and good long-term cycling stability; they also do not generate environmental pollution and are inexpensive to fabricate [11–15].

Currently, many researchers are developing various binary and ternary metal oxide/hydroxide/chalcogenide nanostructures [16–20] for use in supercapacitors [21], batteries [22], dye-sensitized solar cells [23], sensors [24], water-splitting [25], hydrogen/oxygen evolution [26,27], and various electronic devices. Among these transition-metal chalcogenides, we have chosen

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Synergistics of Cr(III) doping in TiO_2/MWCNTs nanocomposites: Their enhanced physicochemical properties in relation to photovoltaic studies

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ABSTRACT

In the present investigation, optoelectronic modifications of the TiO_2 host lattice through insertion of Cr(III) (0.5–3.0 mol.%) as a dopant and thereafter its composites with MWCNTs prepared using single step *in-situ sol-gel* route and its photovoltaic performance of the hybrids was investigated using Ru(II) based sensitizer. The physicochemical properties (viz. structural, opto-electrical, morphological and charge transfer behavior) of the ternary Cr@TiO_2/MWCNTs NCs are compared with the TiO_2/MWCNTs NC through various spectroscopic (XRD, Raman, UV–Visible DRS, XPS, FT-IR, PL, TRPL and EIS measurements) and microscopic (HR-TEM with SAED) analysis. TRPL and EIS studies reveals that, average life time of the electrons in the excited state increases and interfacial charge transfer resistance decreases after the insertion of Cr(III) ion into the TiO_2 host lattice. After the detailed physicochemical investigations, binder free NCs were deposited on the F:SnO_2 (FTO) by doctor-blade technique using DMF and CH_3CN solvents and then anchored with N719 dye. Finally, sensitized photoelectrode sandwiched with Pt-counter electrode for making the sandwich dye sensitized solar cells (DSSCs) and photovoltaic performance of the assembled devices was measured under AM 1.5 solar simulator for *I-V* and *IPCE* measurements. The $Cr_{.0.010}$@$Ti_{0.990}C$ NCs based DSSCs shows highest photovoltaic conversion efficiency up to η = 7.69% which is 20% (η = 6.18%) higher to that of undoped TiO_2/MWCNTs based DSSCs.

1. Introduction

Recently, semiconducting ternary nanocomposites (NCs) have pivotal role in the leading potential fields of the sustainable survive viz. energy conversion and storage (Chen et al., 2015; Rakhi et al., 2012; Santra and Kamat, 2013), environmental remediation (Deng et al., 2017), catalysis (Miao et al., 2017), sensing (Malik et al., 2018), biomedical (Regulacio et al., 2018), and electronics (Hu et al., 2018) due to their well coverage of the optical region of electromagnetic spectrum (Liu et al., 2013), tuning electronic properties (Mao et al., 2011), and separation of charge carriers (Mondal et al., 2018) etc. Among these potential applications, energy harvesting has a priority choice due the present need of the sustainable energy and available conventional energy sources are insufficient to consume the modern society and also injurious to environment (Yun et al., 2018). Hence, from last two decades investigators intent on the efficient conversion of highly abounded sunlight into electrical energy through low cost, stable dye sensitized solar cells (DSSCs) compared to conventional Si-based solar cells and recently used perovskite based solar cell devices (Mathew et al., 2014). From the discovery of DSSCs (O'regan and Grätzel, 1991), investigators demonstrated, the semiconducting TiO_2 acts as an efficient photocatalyst compared to others such as SnO_2 (Snaith and Ducati, 2010), ZnO (Sakai et al., 2013), Nb_2O_5 (Ou et al., 2012), and $SrTiO_3$ (Tang and Yin, 2015) etc. utilized for the DSSCs. Because of its tunable morphology (Bai et al., 2014), opto-electronic properties (Lee et al., 2012) higher chemical stability (Lee et al., 2012) and higher dye loading capability compared to others (Bai et al., 2014). Also its HOMO-LUMO levels are well matchable to the excited dye (De Angelis et al., 2011), and hence recently reported the highest photovoltaic conversion efficiency up to 14.5% for TiO_2 based DSSCs (Kakiage et al., 2015). With these advantages, it has some constrains viz., it active only in the UV region due to its wider energy band gap (Dette et al., 2014), and

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nanomaterials

MDPI

Article

Chlortetracycline-Functionalized Silver Nanoparticles as a Colorimetric Probe for Aminoglycosides: Ultrasensitive Determination of Kanamycin and Streptomycin

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Abstract: Aminoglycosides (AMGs) have been extensively used to treat infectious diseases caused by Gram-negative bacteria in livestock and humans. A selective and sensitive colorimetric probe for the determination of streptomycin and kanamycin was proposed based on chlortetracycline-coated silver nanoparticles (AgNPs–CTC) as the sensing element. Almost all of the tested aminoglycoside antibiotics can rapidly induce the aggregation of AgNPs, along with a color change from yellow to orange/red. The selective detection of aminoglycoside antibiotics, including tobramycin, streptomycin, amikacin, gentamicin, neomycin, and kanamycin, with other types of antibiotics, can be achieved by ultraviolet (UV) spectroscopy. This developed colorimetric assay has ability to detect various AMGs using in-depth surface plasmon resonance (SPR) studies. With this determination of streptomycin and kanamycin was achieved at the picomolar level (pM) by using a UV–visible spectrophotometer. Under aqueous conditions, the linear range of the colorimetric sensor for streptomycin and kanamycin was 1000–1,1000 and 120–480 pM, respectively. The corresponding limit of detection was 2000 pM and 120 pM, respectively. Thus, the validated dual colorimetric and ratiometric method can find various analytical applications for the ultrasensitive and rapid detection of AMG antibiotics in water samples.

Keywords: chlorotetracycline antibiotics; silver nanoparticles; ultrasensitive detection; aminoglycoside antibiotics; water samples; picomolar level sensitivity

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Research article

Photocatalytic activity of $CuO/Cu(OH)_2$ nanostructures in the degradation of Reactive Green 19A and textile effluent, phytotoxicity studies and their biogenic properties (antibacterial and anticancer)

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ABSTRACT

In this study, $CuO/Cu(OH)_2$ (denoted as CuONs) nanostructures were synthesized relying to a cheap and rapid chemical co-precipitation method using copper sulfate and liquid ammonia as precursors. Results obtained from X-ray diffraction, and field emission scanning electron microscopy analysis revealed the crystalline nature of synthesized CuONs. Fourier transform infrared spectroscopy and energy dispersive spectroscopy studies showed interactions between copper and oxygen atoms. Synthesized CuONs showed the size in the range of 20–30 nm using high resolution transmission electron microscopy analysis. The photocatalytic degradation performance of Reactive Green 19A (RG19A) dye using CuONs was evaluated. The results showed that CuONs exhibited 98% degradation efficiency after 12 h and also complete mineralization in form of reducing chemical oxygen demand (COD) (84%) and total organic carbon (TOC) (80%). The nanocatalyst was recovered from the dye containing solution and its catalytic activity can be reused up to four times efficiently. CuONs was also able to decolorize actual textile effluent (80% in terms of the American Dye Manufacturers' Institute (ADMI) value) with significant reductions in COD (72%) and TOC (69%). Phytotoxicity studies revealed that the degradation products of RG19A and textile effluent were scarcely toxic in nature, thereby increasing the applicability of CuONs for the treatment of textile wastewater. Additionally, the CuONs showed a maximum antibacterial effect against human pathogens which also displayed synergistic antibacterial potential related to commercial antibiotics. Moreover, CuONs displayed strong antioxidant activity in terms of ABTS (2,2′-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (IC_{50}: 51 μg/mL) and DPPH (1,1-diphenyl-2-picrylhydrazyl) (IC_{50}: 60 μg/mL) radical scavenging. The CuONs exhibited dose dependent response against tumor rat C6 cell line (IC_{50}: 60 μg/mL) and may serve as anticancer agents.

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1. Introduction

Extensive research in the area of nanotechnology has grown to a higher extent attention and plays a ground-breaking role in modifying the molecular and atomic stages of materials. Materials reduced at nanometric scale display significantly different and exclusive characteristics and are extensively applied with variations in scientific fields (Saratale et al., 2017, 2018). Nanoscale metal oxide materials are considered as vital constituents in micro/nanoscale devices due to its certain specific size and size oriented physico-chemical characteristics. Cupric oxide (CuO) has become a widely accepted metal oxide because of a large surface area,

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Effect of Mn doping on the chemical synthesis of interconnected nanoflakes-like CoS thin films for high performance supercapacitor applications

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ABSTRACT

Herein, supercapacitor developed using Mn-doped CoS thin films (1–5% Mn) were prepared using the successive ionic layer adsorption and reaction (SILAR) method. The effect of the Mn-doped CoS thin films on the structural, morphological, and supercapacitor properties were studied using X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), field emission scanning electron microscopy (FE-SEM), transmission electron microscopy (TEM), and electrochemical evaluation. Doping up to 3% Mn lead to improvements in peak intensity. Also, the morphological results indicated that doping of Mn affected the CoS nanostructures. The 3% Mn-doped CoS electrodes had an interconnected nanoflakes-like nanostructure, with a high porosity compared to the other electrodes. XPS data strongly supported the XRD results. The Mn-doped CoS electrodes showed a higher capacitance (621 F g^{-1}) than the other electrodes, and electrochemical impedance spectroscopy indicated that the 3% Mn-doped CoS electrode was highly conductive. The characteristics of the 3% Mn-doped CoS electrode proved its applicability in supercapacitors.

1. Introduction

Recent years have experienced a substantial movement toward more, clean, environmental pollutant-free, low-cost, and sustainable energy sources. Several sustainable energy sources are available, like solar cells [1], batteries [2], fuel cells [3], oil, supercapacitors [4], and natural gas. Of these energy sources, solar cells, batteries, and supercapacitors are most favorable applicants for the energy conversion and storage [5–9], and all represent main energy sources for practical applications at the industry level in the portable electronic device industry [5,10–13]. Among these devices, supercapacitors are more beneficial, due to a high power density, long time charging-discharging [6–9], and long-term cyclic stability relative to conventional batteries [14–19]. Supercapacitors usually classified into different types: electrochemical double layer capacitors and pseudocapacitors [20].

Many researchers are currently working on the development of new nanostructures, such as hierarchical, hybrid, and hetero-structured nanomaterials, for improving the specific energy, power, and cycling stability [5,21]. Previously, different binary and ternary phases of cobalt sulfide/oxides, including several binary compounds, were investigated [22–26]. Recently, supercapacitors of ternary metal sulfides revealed as an exciting electrode material, due to its high redox reaction and high conductivity of $NiCo_2S_4$ electrodes [27].

Among the binary and ternary metal sulfide/semiconductors, binary CoS electrodes are the most capable electrode nanomaterials for supercapacitor application because of their high redox reaction, multiple and changeable valence states, as well as higher electrical conductivity. Hu et al. [3] successfully synthesized a hierarchical hollow nanostructure-like CoS electrode for electrochemical application, assembled from nanocubes, nanosheets (NSs), and nanoparticles (NPs) that resulted in double-shelled CoS-NP/CoS-NS constructs with exceptional capacitance (980 F g^{-1}) at current densities of 1 A g^{-1}. Faber et al. [24] prepared CoS_2 thin films by a thermal method on a glass substrate for solar cell applications and demonstrated that CoS_2 displayed high electrocatalytic activity in the electrolyte. Liu et al. [25] established a facile hydrothermal method to prepare a porous nanocoral-like Co_3S_4 thin film directly on a Ni foam. Both, the crystal growth mechanism and the development of the coral-like Co_3S_4 on Ni foam, were explained. Subsequent electrochemical testing revealed the Co_3S_4 electrode for supercapacitor has a large specific capacitance in KOH electrolyte. Xie et al. [28] used a hydrothermal approach to prepare carbon-coated CoS_2 as a thermal battery electrode, which presented higher cell

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Accepted Manuscript

Exceptional electromagnetic interference shielding and microwave absorption properties of room temperature synthesized polythiophene thin films with double negative characteristics (DNG) in the Ku-band region

Gopal Kulkarni, Priyanka Kandesar, Ninad Velhal, Varsha Phadtare, Aviraj Jatratkar, S.K. Shinde, Dae-Young Kim, Vijaya Puri

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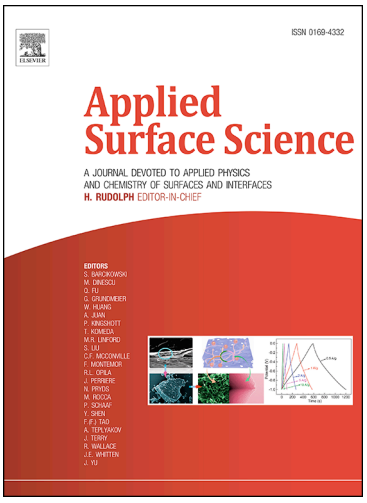

Full Length Article

Chemical synthesis of flexible nanoflakes-like $NiCo_2S_4$ electrodes for high-performance supercapacitor application

S.K. Shinde, M.B. Jalak, G.S. Ghodake, N.C. Maile, V.S. Kumbhar, D.S. Lee, V.J. Fulari, D.-Y. Kim

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Adsorptive remediation of cobalt oxide nanoparticles by magnetized α-cellulose fibers from waste paper biomass

Avinash Kadam, Rijuta Ganesh Saratale, Surendra Shinde, Jiwook Yang, Kyojung Hwang, Bhupendra Mistry, Ganesh Dattatraya Saratale, Saifullah Lone, Dae-Youg Kim, Jung-Suk Sung, Gajanan Ghodake

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Article

Green-Synthesis of Anisotropic Peptone-Silver Nanoparticles and Its Potential Application as Anti-Bacterial Agent

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Abstract: This study demonstrates a green-route-based synthesis of high-concentration suspensions of anisotropic silver nanoparticles (AgNPs) by peptone (Pep), a soluble protein hydrolysate and an abundantly used nutrient source in microbial-media. The transformation of Ag ions from solution into a high-concentration suspension of anisotropic Pep-AgNPs, at an extremely low concentration of peptone (0.02%), indicates that the present green-route synthesis method follows "low volume high concentration nano-synthesis", and, hence, enhances the economic significance of the process. Process optimization with different concentrations of AgNPs (1–5 mM), NaOH solution (5–40 mM), and peptone (0.004%–0.12%) gave the optimized Pep-AgNPs synthesis at 3 mM of $AgNO_3$, 20 mM of NaOH, and 0.02% of the peptone concentrations. The green-route synthesized Pep-AgNPs were structurally characterized by the TEM, XPS, FT-IR, and XRD analyses. The Pep-AgNPs against the clinically relevant bacteria *Escherichia coli* and *Staphylococcus aureus* gave significant anti-bacterial properties, with a MIC (minimum inhibitory concentration) of 100 ppm. The colony counting and morphological observation of the bacterial cell under SEM corroborated an anti-bacterial potential of the Pep-AgNPs. Therefore, Pep-AgNPs are green-route synthesized, anisotropic, and have a significant anti-bacterial potential that can be used in many relevant applications.

Keywords: Peptone; Microbial nutrient; Anti-bacterial silver nanoparticle; *Escherichia coli*; *Staphylococcus aureus*

1. Introduction

As the development of nanotechnology progresses, the silver nanoparticles (AgNPs) have become one of the most demanding nanoparticles, owing to their increasing number of applications in different sectors [1–9]. The shape, surface chemistry, and size of the AgNPs gives them typical physical, optical, chemical, and electronic properties. Therefore, the specific design of AgNPs has

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Effect of different electrolytes and deposition time on the supercapacitor properties of nanoflake-like $Co(OH)_2$ electrodes

N.C. Maile, S.K. Shinde, R.R. Koli, A.V. Fulari, D.Y. Kim, V.J. Fulari

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Electromagnetic shielding, magnetic and microwave absorbing properties of Polypyrrole/$Ba_{0.6}Sr_{0.4}Fe_{12}O_{19}$ composite synthesized via in-situ polymerization technique

Ninad Velhal, N.D. Patil, Gopal Kulkarni, S.K. Shinde, N.J. Valekar, H.C. Barshilia, Vijaya Puri

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Effect of different electrolytes and deposition time on the supercapacitor properties of nanoflake-like $Co(OH)_2$ electrodes

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ABSTRACT

The effect of ultrasonic treatment and deposition time on nanoflake-like $Co(OH)_2$ thin films were prepared using the potentiostatic mode of electrodeposition method on stainless steel substrates by a nitrate reduction reaction. After ultrasonic treatment, we used stainless steel substrates for deposition of the nanoflakes like $Co(OH)_2$ thin films. The effect of deposition times and electrolytes on different physico-chemical properties of $Co(OH)_2$ was investigated in detail, such as X-ray diffraction (XRD), field emission scanning electron microscopy (FE-SEM), energy dispersive X-ray spectroscopy (EDS), and electrochemical testing. After ultrasonic treatment $Co(OH)_2$ thin films had devolvement of the uniform and interconnected formation of nanoflakes nanostructures. Supercapacitor performance of the $Co(OH)_2$ electrodes suggest that, specific capacitance are depends on the surface morphology, and $Co(OH)_2$ electrodes after ultrasonic treatment exhibited higher performance than without ultrasonication. The maximum specific capacitance of the 30 min. deposited $Co(OH)_2$ nanoflakes exceeded 276 Fg^{-1} in 0.5M KOH electrolyte at 5 mVs^{-1} scan rate.

1. Introduction

Supercapacitors are promising energy-storage devices because of their high-power density and their capability to quickly charge and discharge, which are characteristics desirable for devices used in hybrid vehicles, backup energy systems, and portable electronics [1,2]. Supercapacitors store energy in the form of a double layer or in the form of redox reactions involving a change in the oxidation state during the charging and discharging process [3]. For both mechanisms, functional electrode materials are crucial for the conversion and storage of energy, and they are an essential component of supercapacitors. Among different methods of fabricating functional electrode materials, electrochemical deposition is a simple, binder-free, low-cost method compared with evaporation, sputtering, chemical vapor deposition (CVD), etc.

Homogeneous surface morphologies are of the interesting the formation of different functional coatings for the electrochemical testing. Morphology could be observed, controlled, and studied in electrodeposition by optimizing parameters such as deposition time. Previous studies have investigated the effect of deposition time on surface morphology for metal oxides such as MnO_2 [4], TiO_2 [5], Cu_2O [6,7], Fe_2O_3 [8], and WO_3 [9], hydroxides (Ni–Co)$(OH)_2$ [10], conducting polymers such as polypyrrole [11] and carbon nanotubes [12], etc. These studies have identified the crucial deposition time-dependent properties of these materials. For supercapacitors, transition metal oxides and hydroxides are considered to be the most promising electrode materials. The high-cost RuO is not commercially available even though it has a high specific capacitance [13]. On the other hand, Co$(OH)_2$ is considered to be a promising electrode material due to its layered structure with large interlayer spacing [14]. The electrodeposition method of $Co(OH)_2$ on nickel foam has been demonstrated by Kong et. al. [15]; they found that $Co(OH)_2$ was too thin to form stable and effective structures with a short deposition time, whereas the pores were covered by nanostructured flakes with a longer deposition time, resulting in a significant decrease in the specific capacitance value. Cost-effective stainless steel has been used for the deposition of $Co(OH)_2$ thin films. The cathodic potentiostatic electrodeposition of Co$(OH)_2$ on a stainless steel substrate was reported by Gupta et. al. [16]; they found that the specific capacitance value was not affected by mass loading from 0.1 to 0.8 mg/cm^2. There have been no reports on the specific capacitance values for higher mass loading and higher deposition time. The significance of deposition time in electrodeposition method and the effect of the different electrolytes on the specific

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