

Direct Electrochemical Detection of Hemoglobin using Screen-Printed Electrode Modified with Methylene Blue/Graphene Nanocomposite

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A screen-printed electrode (SPE) modified by self-assembly methylene blue/graphene (MB/Gr) nanocomposite for direct electrochemical hemoglobin (Hb) sensor. The MB/Gr using a simple functionalization through π - π stacking interaction between MB and Gr. Moreover, SPE is the new choice for the application of electrochemical sensor due to its convenience and disposable. Hence, in this work an electrochemical sensor for Hb based on MB/Gr was developed. Cyclic voltammetry and amperometry techniques were used to measure catalytic response to Hb and demonstrated excellent performance of electrocatalytic activity. The linear range response from 10 nM to 1 μ M with a corresponding sensitivity of 1598 mA M⁻¹ and detection limit of 1.40 nM (S/N=3).

Keywords Hemoglobin; Methylene blue; Graphene; Screen-printed electrode; Electrochemical sensor

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Facile and Sensitive Assay for Carbofuran Detection using Coupling Reaction-Based Metal Nanoparticles

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Gold nanoparticles (AuNPs) were widely used as substrates to increase Raman signal and improve the detection limit *via* surface-enhanced spectroscopy technique. Because of their localized surface plasmon resonance (LSPR), AuNPs can enhance the Raman signal of target molecule nearby the surface. In this work, surface-enhanced resonance Raman scattering (SERRS) by nanostructure engineering and surface functionalization of AuNPs is able to be a selective and sensitive detection method for trace analysis of organic contaminants in food, especially Carbofuran. Carbofuran is one of the most toxic carbamate insecticides (see a chemical structure in Figure 1(A)). For SERRS measurements, a starch-reduced gold nanoparticle colloid with an extinction maximum (λ_{\max}) at 548 nm was synthesized. The ionic surfactant-mediated Langmuir-Blodgett method was used to fabricate the gold nanoparticle film from a colloid of starch-reduced gold nanoparticles. The surface of AuNPs was functionalized by 4-aminothiophenol. Then, 4-aminothiophenol was modified to form diazonium ion (Pauly's reagent), which binds selectively with phenolic compounds. After that, Carbofuran was hydrolyzed in alkaline solution to form carbofuran phenol, which can react directly with diazonium ion (see Figure 1(B)). Diazonium ion on AuNPs film and carbofuran phenol react together to generate Raman dye with an absorbance around 480 nm, which gives resonance Raman scattering (RRS) with 532 nm excitation laser. The combination between RRS and surface-enhanced spectroscopy due to a large electronic field on AuNP surface provides a strong SERRS signal. Therefore, the trace analysis of carbofuran can be achieved.

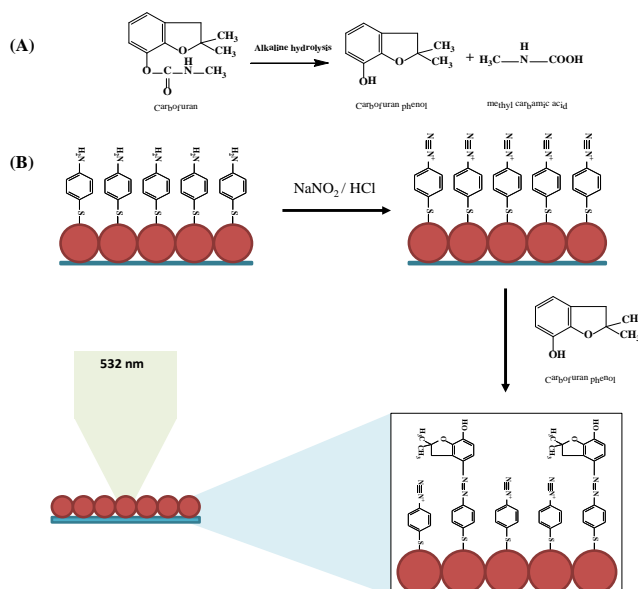


Figure 1. (A) Hydrolysis reaction of carbofuran, (B) the formation of diazonium ion (Pauly's reagent) on a surface of AuNPs and the reaction of carbofuran phenol with diazonium ion.

Keywords Gold nanoparticles; Surface-enhanced resonance Raman scattering; Carbofuran; Diazonium ion

Fabrication of Redox-Mediator Silica Particles as Electrochemical Label for Simultaneous Detection

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A redox mediator is an electroactive species that can be used as a label for biomolecule detection. Different electrochemical redox species provide oxidation peaks at different potentials, and thus can be used to construct labels which enable simultaneous detection within a single voltammetric sweep. In our work, well-dispersed redox-loaded silica microspheres were prepared by coating preformed monodispersed silica particles (diameter = 450 nm), with a silica layer containing either methylene blue (MB), acridine orange (AO), ferrocenium tetrafluoroborate (Fe), and *tris* (2,2'-bipyridyl) dichlororuthenium (II) hexahydrate (Ru(bpy)₃²⁺). The diameter of the silica particles increased to 575-598 nm upon loading, depending on the mediator. We expect these the cationic mediators were through electrostatic attraction with the negative charge of the silanolate groups in the amorphous silica layer. Differential pulse voltammetry revealed distinct oxidation peaks at -0.32 V (MB), -0.03 V (Fe), 0.71 V (AO), and 0.96 V (Ru(bpy)₃²⁺), respectively for the redox-modified particles. We describe how these particles can be applied to simultaneous detection.

Keywords Silica particle; Redox-mediators; Electrochemical label; Simultaneous DNA detection

Electrode Materials Prepared by Nano-Coating of Pore Walls of Mesoporous Silica with Nitrogen-doped Carbon

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Mesoporous materials with ordered porous structure and doped with nitrogen are obtained by coating mesoporous silica SBA-15 with a thin layer of carbon. The coating is carried out by means of chemical vapor deposition using acetonitrile as carbon source. This method gives rise to a homogeneous coating of the silica surface with a nitrogen-doped carbon. Unlike in the preparation of conventional ordered mesoporous carbons obtained using the hard template method, the silica is not removed. The final material shows therefore almost the same pore structure as the pristine mesoporous silica although the pore size is reduced. The carbon layer endows the composite material (silica/carbon) with electrical conductivity, which makes them good candidates for porous electrodes. Hence, the effect of the nitrogen surface chemistry on two different electrochemical applications is studied by using the nitrogen-doped carbon-coated mesoporous silica. For the sake of comparison, a carbon-coated SBA-15 without N-doping is also prepared using acetylene as carbon source in the chemical vapor deposition. An enhancement of the electrochemical performance due to the presence of the nitrogen was observed. Thus, the capacitance retention in aqueous electrolyte (1M H₂SO₄) is improved. Moreover, the onset potential of the oxygen reduction reaction is shifted to higher potentials and the current intensity is increased in neutral medium (phosphate buffer solution pH 6.86).

Keywords Mesoporous silica; Carbon coating; Nitrogen doping; Electrochemical performance.

Bacterial DNA Extraction by Magnetic Nanoparticles

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Bacterial DNA detection in stool sample is important for diagnosis, control and prevention of the infectious diarrhea. To enhance efficiency of the detection, magnetic nanoparticles (MNPs) have been applied for DNA separation. In this study, enterotoxigenic *Escherichia coli* (ETEC) was used as a target bacteria. The carbodiimide method was used to immobilize amino modified forward primers on surface of carboxylated MNPs (primer-MNPs). After heated ETEC sample for cell lysis, the primer-MNPs were added to isolate ETEC DNA from other contaminants in sample. The ETEC DNA bound MNPs was magnetically collected and detected by conventional polymerase chain reaction (PCR). The gel electrophoresis results demonstrated that ETEC DNA could be separated using the primer-MNPs. This DNA extraction technique using MNPs could be applied to detect target DNA in other complicated samples such as stool, blood, water and soil to improve sensitivity and specificity of the detection.

Keywords Magnetic nanoparticles; Enterotoxigenic *Escherichia coli*; Bacterial DNA detection

Lead Ion Detection using DNAzyme

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DNAzyme is a functional DNA sequence which displays catalytic activity depending on a specific metal ion. DNAzyme composes of an enzyme-stranded DNA (Enz) and a substrate-stranded DNA (Sub) that contains a cleavage site. The Sub strand is cleaved in the presence of specific metal ion. Herein, a lead ion specific DNAzyme is used with a well-known agglutination platform to construct an on-site lead ion biosensor. Oligonucleotide probes complementary to each end of DNAzyme are attached to latex particles (probe-latex) and used as DNAzyme linker. These probe-latexes once hybridize to DNAzyme enable latex-DNAzyme-latex network formation that leads to latex particles agglutination. This latex-DNAzyme agglutination can be observed by naked eye and can be re-dispersed in the presence of lead ion. Polyacrylamide gel electrophoresis (PAGE) result confirms the formation of DNAzyme and the effect of lead ion concentrations on DNAzyme formation. From the PAGE analysis, band intensities of the cleaved Sub product increase with lead ion concentrations. Latex-DNAzyme network formation conditions have successfully been optimized. Next, selectivity, sensitivity and detection limit of the latex-DNAzyme agglutination system will be focused.

Keywords DNAzyme; Lead ion detection; Latex agglutination

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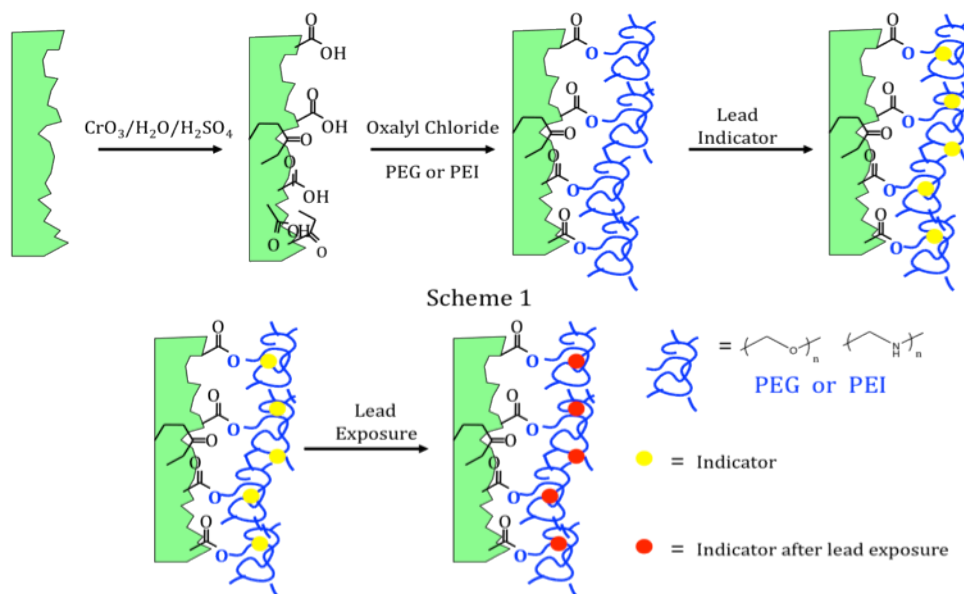
Surface Modification of High Density Polyethylene Film with the Attachment of Polyethyleneglycol and Polyethyleneimine, as a Tool to Detect Lead Contaminants

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Lead (Pb) contamination is a major problem in both developed and developing countries. The contaminations are often found in products such as children toys, paints, and food products. As a result, there is an urgent need for an economical heavy metal indicator. In order to address this issue, the simple series of organic reactions to modify a surface of polyethylene can be used. The strip of high-density polyethylene (HDPE) was obtained from used water and milk bottles. A solution of chromium trioxide and sulfuric acid was then used to oxidize the surface of HDPE into multiple carboxylic acid groups. The polyethylene glycol and polyethyleneimine were attached covalently to the surface of HDPE by the esterification and amidation processes using oxalyl chloride. The newly made HDPE with hydrophilic surface was non-covalently embedded with various types of ligands that can change their colors based on the coordination with lead.



Keywords HDPE; Surface modification; Lead

Effect of Background Light on Output Signal of the Colorimetric Optical pH Sensor Using a Dual-color System

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Carboxyfluorescein (CF) indicator emits green fluorescent light ($\lambda_{\text{emit}} = 515$ nm) when it is excited with the blue light ($\lambda_{\text{ex}} = 490$ nm) at $\text{pH} > 3$ and its fluorescent intensity changes (increasingly) with the pH between 3-14. This allows CF to be used as a sensing material for the intensity-based optical pH sensor. In this work, the new colorimetric-based optical pH sensor was developed using the coupled signals from the CF's green fluorescence and the background red light of suitable intensity, resulting in a mixed output color. The dual-color optical sensor system consists the CF film (dipped in a pH solution), a blue LED (an excitation light source, 465 nm) and a red LED (an external, background light, 660 nm). The CF film was prepared via a sol-gel process and it contained CF indicator dispersed in a porous silica matrix on glass slide. The blue LED was placed on the top of cuvette and the red placed across the detector. UV-Vis spectrometer used to record the spectra. The results found that after adding the green background red light, the output intensity change from green to yellow, orange and red, depending on the relative intensities of the green fluorescent and red background light. As the solution pH changed from 3 to 14, the output color changed from green to yellow, orange and red, when a suitable, fixed intensity of the background red light was used. The resulting color was clearly visible. The pH change between 3 and 14 can be followed both qualitatively (by the color chart) and quantitative (by the ΔE values of the CIE Lab color system).

Keywords Colorimetric; Optical pH sensor; Carboxyfluorescein; Dual-color system

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Fluorescence Landscapes of Natural Teeth and Restorative Resin Composites

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Dentists nowadays use modern dental materials to create restorations that match visual properties of teeth while simultaneously ensure the required level of stability. Over the past years, resin composites have evolved as esthetic restorative material, incorporating various optical properties of natural teeth like translucency, opalescence, different levels of opacity, etc. Fluorescence in a natural tooth occurs primarily in the dentin because of the higher amount of organic material present.¹ Ambient, non-visible, near-ultraviolet (UV) light is absorbed and then fluoresced back as visible light primarily in the blue end of the spectrum. Since the restorative materials do not present the fluorescence in its basic components, the restorations appear darker compared to natural dentition. In this report we aimed to present comprehensive analysis of teeth and composite resin fluorescence by measuring fluorescence landscapes (so called excitation-emission matrices, EEM). In this way the complete fluorescence fingerprints of the materials are captured and, then, parallel factor analysis (PARAFAC) was used to identify and describe observed differences. The use of rare earth phosphor materials as additives in resins which are able to produce missing fluorescence is discussed.

Keywords Teeth fluorescence; Dental resins; Phosphors; Excitation-emission matrices

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Electrodeposition of Zn-Mn Alloy on Low Carbon Steel for Anodic Protection

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The zinc-manganese alloy (Zn-Mn alloy) coating possesses the highest corrosion resistance compared with zinc and other zinc-based alloy coatings. In chloride environment, its corrosion resistance is comparable to that of cadmium coating. The corrosion resistance of Zn-Mn alloys increases with manganese content. The aim of this study is, therefore, to improve coating efficiency by increasing manganese content in the Zn-Mn coating. The electrodeposition of Zn-Mn alloy on low carbon steel substrates was performed in a basic citrate bath. The effects of current density, bath temperature and bath agitation on the coating efficiency (%CE), manganese content, surface morphology and corrosion resistance of Zn-Mn alloy coating were investigated. The results show that the current density lowers coating efficiency but increases manganese content. Bath temperature increases coating efficiency but slightly reduces manganese content. For agitation, pump agitation, ultrasonic agitation and co-agitation of pump and ultrasonic were applied. The results showed that the highest coating efficiency and manganese content were obtained when ultrasonic agitation was applied. The Zn-Mn alloy coatings for all coating conditions show nodule morphology. The potentiodynamic test indicated that all coating possess passivation protection. The higher Mn-content of the coating, the higher is corrosion protection.

Keyword Zinc-manganese alloy coating; Corrosion resistance; Manganese content; Ultrasonic agitation

Development and Characterization of Electrospun Fibers for Tissue Engineering Scaffolds

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Electrospinning process is an easy and economical method that produces polymer fibers (micro to nanometer in diameter) with a large surface area, high porosity and enhances specific mechanical performance. In this study, we report the development and fabrication of poly(vinyl alcohol) (PVA) (a water soluble and biodegradation polymer) and silk protein sericin (SS) (from *Bombyx Mori* silkworm cocoons). PVA/SS fibers were fabricated and the operational parameters were varied, such as the concentration of electrospun solutions and processing parameters (applied voltage, flow rate, size of the tip and distance between the collector and the tip of the syringe). The morphology and functional groups of the fibers were also investigated by using scanning electron microscope and Fourier transform infrared spectroscopy, respectively. Surface wettability was detected by water contact angle method at room temperature. The optimum conditions for fabrication were a PVA concentration of 10-15 wt%, a flow rate of 0.02 ml/min, a diameter of tip 0.7 mm and a distance from tip to collector of 20 cm, these conditions yielded fibrous structures with interconnected pores. The average fiber diameters of the PVA fibers depended on the applied voltage, with higher voltage (B, 30 kV, 104 nm) producing smaller size of fibers than that of low voltage (A, 25 kV, 214 nm) (Figure 1). In addition, using higher concentration of SS (D) caused the fibers to have more and larger beads than the lower concentration of SS (C). Not only PVA but also other biodegradable polymers such as poly (lactic acid) were of interest to produce electrospun fibers using this fabrication method. These electrospun fibers could potentially be considered for use as scaffolds in tissue engineering for biomedical applications.

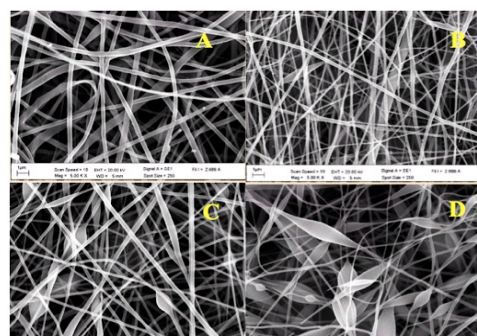


Figure 1. SEM images of electrospun fibres: A. 10 wt% PVA (25-29kV), B. 10 wt% PVA (30kV), C. 15 wt% PVA/5 wt% SS, and D. 15 wt% PVA /10 wt% SS, at magnification of 5000x

Keywords Electrospinning; Poly(vinyl alcohol); Protein sericins; Poly(lactic acid)

Preparation and Characterization of 3D-Poly (Vinyl Alcohol)/Silk Sericin Scaffolds for Skin Tissue Regeneration

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Poly (vinyl alcohol) (PVA)/silk sericin (from *Bombyx Mori* silkworm cocoons) scaffolds were successfully fabricated by a lyophilization technique to promote porous three-dimensional (3D) structures. The effect of the different concentrations of the cross-linking agent (dimethylolurea (DMU)) on the morphology and chemical structure functionality were studied using scanning electron microscope (SEM) and fourier transform infrared spectroscopy (FT-IR), respectively. The materials equilibrium water content, tensile strength, and *in vitro* degradation using weight loss analysis were also investigated as well as cell culture to assess the biocompatibility. The results showed that better uniformity and porosity were found when higher concentrations of DMU were utilized in the scaffolds. The percentage of weight loss of PVA/silk sericin scaffolds is higher than that of neat PVA, and highest when using 60 %w/w of DMU. The peak position in absorption bands of amide groups of secondary protein; amide I (1700-1600 cm⁻¹), amide II (1580-1520 cm⁻¹), amide III (1340-1220 cm⁻¹), IV (570-520 cm⁻¹) and V (3550-3200 cm⁻¹) were shifted due to the appearance of hydrogen bonding interactions between sericin, PVA or DMU resulting in a change in conformational structure of the protein molecules. The work confirmed that varying the concentration of DMU had a significant effect onto the physical properties, as well as the morphology and degradation performance of the scaffolds. These 3D-PVA/silk sericin scaffolds show good promise to be able to be used for tissue engineering and skin tissue regeneration.

Keywords Silk; Poly (vinyl alcohol); Sericin; Dimethylolurea; Scaffold

Light-Triggered PEG-PCL Copolymer Micelles for Anti-cancer Drug Controlled Release

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Stimuli-responsive micelles and nanoparticles have gained increased interest in the past decade as a promising controlled release system. Light-responsive micelles are one of the most interesting topics because of their precise and explicit triggered release process. In this study, novel light-responsive copolymer micelles have been developed. The design is based on a well-known amphiphilic block copolymer, a poly(ethylene glycol)-poly(ϵ -caprolactone) or PEG-PCL, modified with photo-dimerizable coumarin derivatives via click chemistry. Attached coumarin moieties allow PEG-PCL copolymer micelles to undergo photo-dimerization under specific wavelength radiation (>310 nm). This process is reversible and can be decrosslinked when irradiated with another wavelength of light (<260 nm). Crosslinking provides stability to the micelles and prevents premature drug release. While decrosslinking triggers drug release by destabilizing the polymeric micelles. In this work, an effect of various coumarin contents modified onto PEG-PCL block copolymer has been investigated. In addition, a light exposure time for crosslinking /decrosslinking copolymer micelles will be optimised by UV-Visible spectroscopy to determine drug loaded capacity. Finally, the effect of photo-crosslinking degree on drug releasing profile will be investigated using hydrophobic anti-cancer drug with High-performance liquid chromatography (HPLC) technique.

Keywords Light-responsive micelles; PEG-PCL block copolymer; Coumarin dimerization; Reversible photo-crosslinking; Click chemistry

Surface and Water Binding Properties of Novel Biphasic N-vinylformamide Copolymer Hydrogels

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N-vinylformamide (NVF) is an isomer of acrylamide (AAm), but possesses some favorable properties over AAm such as; a lower toxicity, is more hydrophilic, more reactive and is liquid at room temperature so has easier usage. The term biphasic means that the gels possess two phases and in this case a hydrophilic and hydrophobic phase. This enables a large variety of active agents to be incorporated into hydrogels that possess this structure for use in many applications. The hydrogels were synthesized by using N-vinylformamide (NVF) with other hydrophilic monomers such as 2-hydroxyethyl methacrylate (HEMA), 2-carboxyethyl acrylate (CEA) and also with lipophilic monomers like N-vinylpyrrolidone (NVP) and 4-acryloylmorpholine (AMO). The gels were synthesized by photopolymerization; the monomer mixture was poured into a mould and placed under UVA lamp for 8 minutes to form sheet hydrogels. The simple physical properties of NVF biphasic hydrogels were assessed such as the Equilibrium Water Content (%EWC) and swelling ratio (%SR) for example the 100% NVF hydrogel had an EWC of 93.3%. NVF with the other hydrophilic monomers showed a slight decrease in %EWC (53.1-94.1%) but an improve in mechanical strength. When lipophilic co-monomers were used the %EWC ranged from 60.9-78.2%. Differential scanning calorimetry (DSC) was used to measure the amounts of bound and free water present in the hydrogels, this is an important property if active agents are to be incorporated into the hydrogel. The surface properties of the hydrogels are key to success in a lot of applications and these were measured via contact angle using the sessile drop method. All of these measurements and techniques relate to how the water behaves in and at the surface of the hydrogels, and by using biphasic hydrogels we have greater control over this, which enables these gels to be tailored for their desired application.

Keywords Biphasic hydrogel; N-vinylformamide; Water binding; Surface properties

The Development of Sulfonate-based Nonporous and Porous Hydrogels for Wound Dressing Applications

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In this work we developed sulfonate containing sheet hydrogels that contained both conventional and porous structures. 2-acrylamido-2-methyl-1-propanesulphonic acid (AMPS) was used as the main monomer, which possesses the sulfonate group (SO₃⁻). The sulfonate group has a greater number of water molecules associated with in compared to other common hydrophilic groups (hydroxyl or carboxyl). Both hydrogel types were prepared by redox initiation using ammonium persulphate (APS) and N, N, N, N-tetramethyl ethylenediamine (TEMED) and crosslinked with Di(ethylene glycol) diacrylate. The porous hydrogels have some extra ingredients to give the porous structure such as a foaming agent and stabilizer. The foaming agent was sodium bicarbonate, which was decomposed via an acid (methacrylic acid (MAA)) and the foam was stabilized by a surfactant (Pluronic F127). The effect of varying the amounts of; acid, surfactant, water, and foaming agent along with initiator concentration were studied. The relationship between polymerisation (gelation time) and foam time / height plays a critical role in the final structure of the porous hydrogels. The average gelation time for the both types of hydrogel was ~0.5-1 min and foam time was on average 1 min. The benefits of a porous structure are that it enables the gels to uptake fluid at an increased rate. This is important because the application of these hydrogels is for wound dressings with moderate to heavy exudating wounds, in which current hydrogel wound dressings cannot be used. The swelling ratio of the porous and conventional gels were compared. The porous gels swell much faster, reaching a 300% increase in size and weight in 5 mins; whereas, the conventional hydrogels require 30 mins to reach the same value. Finally, the mechanical properties of the gels were measured via rheology (dynamic mechanical testing), as the gels must maintain adequate cohesive and adhesive strength even with the porous structure.

Keywords Hydrogels; Porous hydrogels; Wound dressings; Sulfonate containing; Swelling

Incorporation of Tamarind Extract into a Novel Cosmetic Hydrogels system

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This project was interested in producing a product to be used as a rejuvenating facial patch in the form of a sheet hydrogel, which is a cross-linked network of a one or more hydrophilic polymer(s) that is swelled by but insoluble in water. Hydrogels possess an abundance amount of water, which allows them to mix together with water-soluble extracts and active agents. The focus was on a specific extract from of tamarind, which has a variety of natural fruit acids (Tartaric Acid, Citric Acid, Malic Acid). To incorporate the tamarind extract together with the hydrogel the active agents were extracted from the fruit tamarind and then dissolved in water, this water was then mixed with the other hydrogel components. The monomer used in the synthesis was 2-acrylamido-2-methyl-1-propanesulfonic acid and initiators were the redox pair of Oxone and L-ascorbic acid. A stable hydrogel was formed which possessed 15% of the tamarind fruit extract. Hydrogels wettability with the tamarind extract was assessed and tested by measuring their equilibrium water content (EWC), swelling ratio and contact angle measurements. The gels were also tested for short periods on unbreached skin. The results showed that these hydrogels are very hydrophilic (EWC >95%) and did not cause any reactions on unbreached skin, thus, show potential to be used for cosmetic treatments. This approach has the advantage in reducing beauty treatment costs by using locally produced active agents within a novel sheet hydrogel system.

Keywords Hydrogel; Tamarind; Cosmetic patch

Synthesis and Characterization of ZnFe₂O₄/TiO₂ Nanocomposites for Photodegradation of Methylene Blue

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The zinc ferrite/titanium dioxide (ZnFe₂O₄/TiO₂) nanocomposites with various mole ratios of ZnFe₂O₄ to TiO₂: 0.2:0.8, 0.4:0.6, 0.5:0.5, 0.6:0.4, and 0.8:0.2. were prepared by coupling of the modified sol-gel and hydrothermal methods. All of nanocomposites were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), energy dispersive X-ray spectroscopy (EDS), photoluminescence (PL) spectroscopy, Brunauer Emmett and Teller (BET)-specific surface area and vibrating sample magnetometry (VSM) techniques. The XRD results indicated the TiO₂ presented in mixed phase structures of anatase and rutile, while ZnFe₂O₄ presented cubic spinel structure. The SEM and TEM images showed that ZnFe₂O₄/TiO₂ nanocomposites were spherical particles with average particle size of 50 nm. The specific surface area of nanocomposite was found in the range of 142–180 m²/g. The saturated magnetization of pure ZnFe₂O₄ and 0.2ZnFe₂O₄/0.8TiO₂ samples were found to be 2.704 and 2.582 emu g⁻¹, respectively. The photocatalytic activity was studied by photodegradation of methylene blue under solar light irradiation. Results clearly showed that nanocomposite in the mole ratio of 0.2CoFe₂O₄/0.8TiO₂ exhibited higher photocatalytic activity than other photocatalyst. The lowest PL intensity of 0.2ZnFe₂O₄/0.8TiO₂ indicated that the recombination of photogenerated charge carriers was inhibited in the composite.

Keywords Methylene blue; Nanocomposite; Photocatalytic activity; Photodegradation; TiO₂; ZnFe₂O₄

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Effect of Silver and Zirconium Dopants on TiO₂ Photocatalytic Reactivity under Visible Light

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In this study, the visible light responsive nanocomposite powders were prepared by a convenient and inexpensive method. Ag and Zr doped TiO₂ powders were prepared by a sol-gel process. Zr concentration was varied in the range of 5, 10 and 15 % mol, while Ag ratio was fixed at 5 % mol. After calcination at 500°C for 5 h, the synthesized nanocomposite powders were characterized by X-ray diffraction (XRD), UV-Vis spectrophotometry and field emission scanning electron microscopy (FE-SEM). The photocatalytic activity of the samples was evaluated by photocatalytic decolorization of methylene blue (MB) dye under UV and visible light irradiation. Results indicated that the crystallinity of TiO₂ doped with Ag and Zr was 100% anatase phase and its wavelength absorption in visible light was significantly improved. The 5 % mol of Ag and 10 % mol of Zr co-doping provided the highest reactivity of MB dye degradation (98.07%), higher than that of bare TiO₂ as 8.6 times. The band gap energy (E_g) of the nanocomposite was reduced from 3.1 to 2.8 eV. The co-doping of Ag and Zr on TiO₂ is a recommended method to improve photocatalytic reactivity under visible light.

Keywords Photocatalytic reactivity; Visible light; Silver; Zirconium; Titanium dioxide

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Tungstophosphoric Acid–Titania Nanofibers for Photocatalytic Degradation of Methylene Blue

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TiO₂ nanofibers incorporated with tungstophosphoric acid (TPA) with different TPA contents (0, 1.0, 5.0 and 10%w/w) have been fabricated by the electrospinning technique. Titanium isopropoxide was used as precursor and alcoholic solution of polyvinylpyrrolidone was used as fibrous template. The photocatalysts were characterized by scanning electron microscopy (SEM), X-ray diffraction (XRD), UV–Vis diffuse reflectance spectroscopy and infrared spectroscopy (IR). The effect of calcination temperature for the photocatalysts (450, 500, 550, 600, 700 and 800 °C) was studied. The photo-catalysts were also evaluated in the degradation of methylene blue under fluorescent lamp irradiation. The results indicate that when the calcination temperature of the photocatalyst is increased to 550°C, its photocatalytic activity also increases. However, the photocatalytic activity decreases with increasing temperature from 600 °C to 800 °C. In addition, the enhanced photocatalytic activity of the photocatalysts compared to pure TiO₂ nanofibers is achieved with suitable TPA contents.

Keywords Photocatalyst; TiO₂; Tungstophosphoric acid; Electrospinning; Nanofibers

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Designable of the Continuous Flow Photoreactor for Removal of Volatile Organic Compound using Titanium Dioxide Thin Film

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Volatile organic compounds (VOCs) belong to the group of main air pollutants. A combination of benzene, toluene, ethyl benzene and xylene or BTEX has been well known as major VOCs contaminants found in oil refineries and petrochemical plants. High toxicity of BTEX leads to health concern such as cancer and nervous system damage. This work aims to report employing photocatalytic oxidation processes as an energy efficient and effective technology to control VOC level. A continuous flow photoreactor system containing TiO₂ catalysts derived from various titanium precursor was employed for removal of 70 ppm benzene gas, the most difficult-to-oxidize compound in BTEX. Titanium tetra-isopropoxide (TTIP) and tetrabutyl titanate (TBOT), titanium precursors, were used to obtain hydrothermally synthesized TiO₂ powdered catalysts. The properties and photocatalytic activities of synthesized catalysts were compared with those of commercial TiO₂ (Degussa P25). It was found that both synthesized catalysts effectively remove benzene with superior efficiency to P25 (commercial available TiO₂) under UV light irradiation for 30 minutes. However, later on, their efficiencies dropped possibly due to large amount of adsorbed intermediate products on the catalyst surface inhibiting further reactions to occur at active sites. By contrast, P25 effectively remove benzene through a 2 hours UV light irradiation. Moreover, the removal efficiencies further increased by increasing relative humidity (RH) in the photoreactor. The high benzene removal efficiencies will be discussed in terms of the catalysts' energy band gap and surface properties, including effects of humidity in the system.

Keywords TiO₂; Photocatalyst; BTEX

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A Study of Titanium Dioxide Thin Films Prepared by Homemade Spray Pyrolysis Apparatus

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The spray pyrolysis is one of the most widely used technique for thin film deposition because it is a low cost, simplified system due to film deposition without using any vacuum system. Un-doped titanium dioxide thin films were prepared by the homemade spray pyrolysis apparatus. The sprayed solution contained titanium (IV) isopropoxide (TTIP, $C_{12}H_{28}O_4Ti$) and acetylacetonate (AcAc, $CH_3COCH_2COCH_3$) with the molar ratio of 1:2 and diluted in ethanol at the concentration of 6 vol. %. The air pressure of air blast atomizer was set at 0.1 MPa and the solution flow rate was 12 ml/min. The substrate temperature was set at 300 °C and the total deposition time was 50 minutes. The atomizer was turned on for 1 sec. and then turned off for 11 sec. of each spraying cycle to reduce the effect of substrate cooling temperature. After that the crystal structure, optical properties and morphology were characterized by x-ray diffraction (XRD), spectrophotometer and scanning electron microscope (SEM), respectively. It was found that the prepared films exhibited polycrystalline structure, anatase phase with the preferred orientation of (101) and (200) planes. The film's thickness was about 240 nm and the average grain size was 20 nm. The transmittance was approximately 75% in visible wavelength range and the energy gap was 3.48 eV.

Keywords Titanium dioxide; Spray pyrolysis; Self-cleaning

Effects of Surfactant and Process Temperature on the Characteristics of Hydrothermally Synthesized Magnesium Aluminate Spinel

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Magnesium Aluminate Spinel (MgAl_2O_4) has been studied extensively as a high performance material widely used in many fields, e.g., electrical, refractory, transparent material and structural applications. In this study, hydrothermal synthesis of MgAl_2O_4 powder was attempted in order to produce pure, nanosized and well dispersed powder which is qualified for the further fabrication to transparent material. 4.5 wt.% of surfactant (Cityl trimethylammonium bromide, CTAB) was added into a mixed solution of magnesium and aluminium nitrates. Hydrothermal syntheses were performed at 120, 140, 160 and 180 °C. The phase and morphology of as-synthesized powder and the calcined powder at elevated temperatures were characterized by X-ray diffraction (XRD) and Scanning Electron Microscope (SEM), respectively. The results showed that, none of MgAl_2O_4 phase was found in the as- synthesized powder and the degree of crystallinity of MgAl_2O_4 increased with the calcination temperature. Single-phase well-crystalline MgAl_2O_4 powder could be obtained after heat treatment at 1100°C for 1 hour and the particle size of the calcined powders tended to increase with the hydrothermal temperature.

Keywords Hydrothermal; Magnesium aluminate spinel; Morphology

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Chain Organization and Photophysical Properties of Regioregular Poly(3-Alkylthiophene)s in Solvent/Non-Solvent Systems: Effects of Alkyl Side Chain Length and Temperature

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Poly(3-alkylthiophene) (P3AT) is one type of conjugated polymers that has a potential for advanced technologies such as plastic solar cell. It has been known that the variation of chain organization of P3AT results in the difference of its electrical and photophysical properties. In this study, we investigate the molecular parameter and environments that affect the chain organization of P3AT in mixed solvent/non-solvent systems. The effect of alkyl side chain length is studied by using a series of P3ATs constituting butyl (BT), hexyl (HT), octyl (OT), decyl (DT) and dodecyl (DDT) side chains. The P3ATs are dissolved in a good solvent, toluene. The solubility of the P3ATs is varied by the addition of poor solvents, ethanol, butanol, octanol and octane, at various ratios. The addition of octanol causes the formation of aggregates in all systems, indicated by the growth of red shift peaks in their absorption spectra. However, the variation of photoluminescence (PL) spectra depends significantly on the length of alkyl side chain. The addition of octanol into P3BT and P3HT solutions causes the red-shift peak in absorption spectra but their PL spectra hardly change compared to that of the isolated chain in good solvent. This indicates that the aggregates are the non-emissive species. In the systems of P3OT, P3DT and P3DDT, on the other hand, the PL spectra red shift significantly, corresponding to the formation of emissive aggregates. In addition, PL pattern of the emissive aggregates varies with the alkyl chain length of the P3ATs. The increase of alcohol polarity also promotes the formation of emissive species in these systems. The temperature-dependent experiments also detect the change of chain organization and dissociation in each P3AT system. Our results have shown that the differences of molecular structure and environments significantly affect chain organization and photophysical properties of P3AT, important for their development for advanced technologies.

Keywords Conjugated polymer; Aggregation; Photophysics; Side chain effect

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Effect of Surface Modification of Silane Coupling Agent on Mechanical Properties of Short Natural Fiber Reinforced Poly (ϵ -caprolactone) Composites

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The natural fiber/poly (ϵ -caprolactone) (PCL) composites were prepared with two types of fibers (pineapple leaf fiber, PALF and banana fiber, BF) as reinforcement and PCL matrix by melt mixing in two rolls mill. The surface of short fibers was treated with NaOH solution and three different silane coupling agents, γ -(Aminopropyl) trimethoxy silane (APS), γ -Methacrylate propyltrimethoxy silane (A 174), 3-Glycidyloxypropyl trimethoxy silane (GPS), respectively. The scanning electron microscopy (SEM) was used to observe the surface of fibers, the surface of untreated fiber was found to be considerably covered with impurities. Comparatively, the fibers treated with NaOH displayed a neat which demonstrated dislodging of impurities on surface. After treated with silane, the surface was found the thin film on fibers. The Fourier transform infrared (FT-IR) was employed to analyze the chemical structure of fibers before and after modification. The results indicated different mechanisms for the modification of fibers. The NaOH partly dissolved the lignin and amorphous fibers, which resulting the fibers into the smaller size. The effect of surface modification on mechanical properties was evaluated by tensile test, the NaOH and silane treatment decreased the tensile strength at break and elongation at break. It was conclude that the enhancement of mechanical properties after coupling agent modification ineffective to improve adhesion between fibers and PCL due to the preparation step of composite.

Keywords PCL; Natural fiber; Mechanical properties.

Silane Treated Pineapple Leaf Fiber Reinforced Polylactic Acid Composites : DMA Analysis, WAXS and SAXS Study

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In this work, dynamic thermal mechanical properties, crystal orientation and structural organization of pineapple leaf fiber (PALF)/poly (lactic acid) (PLA) composites were studied. PALF were treated with silane coupling agents i.e. γ -(aminopropyl) trimethoxy silane (APS), γ -methacrylate propyl trimethoxy (A174) and bis[3-(triethoxysilyl)propyl] tetrasulfide (Si69). The results showed that storage modulus and tan delta were affected by the content of PALF and silane coupling agent. Since the interfacial compatibility between PALF and PLA was poor, the dynamic thermal mechanical properties of composites were improved when 0.5% Si69 treated fiber was added and amount of PALF was 20%. Whereas APS and A174 treated fiber did not show much improvement in storage modulus. Increasing fiber contents show low damping property. This is related to high percentage of crystallinity of composite from Si69 treated fiber. In addition WAXS study of composite from Si69 treated fiber reveals sharp crystalline peaks of PLA while the others silane treatments show amorphous characteristic of PLA. WAXS and SAXS results reveal that the chemical treatment does not affect to the crystal orientation and structural organization when samples were crystallized under non isothermal condition. PALF/PLA composites show broad peaks which are similar to PLA crystallized from non isothermal. This is indicating an amorphous structure of PLA at the scattering angle $2\theta \approx 16^\circ$. At high content of Si69 treated fiber show a strong peak of the reflection of equatorial section of WAXS pattern which is similar to the PLA crystallized from isothermal crystallization condition.

Keywords Pineapple leaf fiber (PALF) composite/Polylactic acid (PLA); Silane treatment; Dynamic thermal mechanical properties

Effect of Alkaline Electrolytes on the Charge Storage Capacity and Morphology of Porous Layered Double Cobalt Hydroxide-Coated Graphene Supercapacitor Electrodes

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Although alpha-cobalt hydroxide ($\alpha\text{-Co(OH)}_2$) with a layered double hydroxide (LDH) structure has been widely used as the supercapacitor electrode, the effect of alkaline electrolyte on the charge storage performance of the $\alpha\text{-Co(OH)}_2$ has not yet been investigated. In this work, $\alpha\text{-Co(OH)}_2$ was electrodeposited on reduced graphene oxide-coated carbon fiber paper (rGO/CFP) using a chronoamperometry at -0.5 V vs. Ag/AgCl. The effect of alkaline aqueous electrolytes to the performance of the $\alpha\text{-Co(OH)}_2$ /rGO/CFP electrodes was then investigated by means of scanning and transmission electron microscopies, X-ray photoelectron and absorption spectroscopies, and electrochemical techniques. It was found that the concentrated alkaline electrolytes (i.e., 3-6 M [OH⁻]) can strip off and/or deform the porous structure of the $\alpha\text{-Co(OH)}_2$ deposited on rGO/CFP leading to poor charge storage capacity. 1 M [OH⁻] was found to be a suitable electrolyte concentration providing high specific capacitance (1096 F g⁻¹ at 1.8 A g⁻¹) without the deformation of the porous $\alpha\text{-Co(OH)}_2$ structure after testing. Morphological and electrochemical analyses of the $\alpha\text{-Co(OH)}_2$ /rGO/CFP electrodes suggest that the effect of the alkaline electrolyte concentration plays a major role to the charge storage performance of $\alpha\text{-Co(OH)}_2$ -based supercapacitors.

Keywords Supercapacitor; Cobalt hydroxide; Graphene

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Biodegradable Poly (lactic acid)-Epoxidized Palm Oil Blend/Graphene Nanocomposite for Electronic Packaging Application

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The generation of electrostatic charges is undesirable event and a major problem during the production of electronic components. However there are intrinsically conducting fillers, such as graphene, that have conductivity levels between those of semiconductors and metals for conductivity enhancement in insulating polymer. This research project focused on preparation of biodegradable polylactic acid (PLA)-epoxidized palm oil (EPO) blend nanocomposites with static dissipative property of Graphene. Graphene nanoparticles prepared by electrolytic exfoliation method were investigated as conducting filler for PLA-EPO blend. The PLA-EPO blend/graphene nanocomposites were successfully prepared by melt blending method with EPO content specified at 3 phr (part per hundred of PLA neat) and the amount of graphene was varied from 0.2 to 1.0 phr. The PLA-EPO blend reinforced with Graphene resulted in the increase of up to 420 % of the elongation at break of the nanocomposites. When comparing with neat PLA, the tensile strength and modulus of composite were slightly decreased. Barrier properties of the PLA-EPO blend/Graphene nanocomposites were greatly improved to less than 50%. The optimal conductivity for electrostatic discharge protection was increased from 10^{-9} S/cm to 10^{-6} S/cm by the addition of a small amount of graphene (<0.6phr). The low oxygen percolation threshold and superior electrical conductivity were attributed to the high aspect ratio, large specific surface area and uniform dispersion of the graphene nanosheets in the polymer matrix. These results corresponded with the morphology and structural characterization of the nanocomposites as analyzed from transmission electron microscope, X-ray diffraction and scanning electron microscope. Therefore, these PLA-EPO blend/Graphene nanocomposites are considered to be appropriate for use in electronic packaging applications.

Keywords Static dissipative property; Graphene; Biodegradable polymer; Electronic packaging applications

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Effect of H₂ Flow Rate on Optical Properties, Crystal Structure and Absorption Peaks of OH Group in NiO_xH_y Thin Film Prepared by DC Reactive Magnetron Sputtering

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Nickel oxide (NiO) is the most common low-cost and high-efficiency anodic electrochromic material that is used for the smart windows application. The NiO_xH_y thin films of various thicknesses were studied in this research. All samples were deposited on unheated glass slide substrates by DC reactive magnetron sputtering from metallic Ni target in Ar/O₂ and Ar/O₂/H₂ atmospheres at power of 25 watts under the operating pressure in order of 10⁻³ mbar. The crystal structure, optical properties and absorption peak of OH group were characterized by x-ray diffraction (XRD), spectrophotometer and FTIR, respectively. It was found that the prepared films exhibited polycrystalline structure and the preferred orientation was (111) and (200) planes. The transmittance of films increased due to increasing of H₂ flow rate. The FTIR results of infrared spectra (4100-1100 cm⁻¹) showed that the absorption peaks are associated with free 'OH' and OH stretching vibrations.

Keywords NiO_xH_y; Smart windows; DC reactive magnetron sputtering

Rapid Chemical Reactions Induced by Electrical Discharge Mechanical Milling

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Advanced materials manufacturing methods require clean non-pollution process, high speed and precise process, mechano-chemically integrated process, and highly reliable final products. Many functional materials are traditionally synthesized by slow reaction processes that are energy and time consuming. In the present world there is strong demand on development of modern materials and materials processing methods that could offer rapid reaction rates, energy efficiency and be environmentally safe. Electric discharge assisted mechanical milling (EDAMM) [1] is a new and exciting materials processing technique which combines the attributes of conventional mechanical milling with all effects generated by electric discharges. It is demonstrated that EDAMM induces rapid chemical reactions resulting in rapid synthesis of a range of functional materials in a matter of minutes, rather than days. This presentation provides an overview of recent development of Electric Discharge Assisted Mechanical Milling and its application in rapid materials processing and synthesis of functional materials and their applications.

Keywords Plasma assisted reactions; Electric discharge assisted mechanical milling; High dielectric constant; Electric discharge assisted mechanical milling; Hardmetals; High dielectric constant ceramic

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XANES Studies on the Oxidation States of Copper and Iron in Silicate Glass Matrix

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The base composition of the glass sample containing mixed transition metal ions is composed of SiO₂ (from rice husk ash), Na₂CO₃, K₂CO₃, ZnO, H₃BO₃, CaO, Al₂O₃ or Al, CuO and Fe₂O₃. The colors of the glass obtained were varied from greenish blue to brisk-red depending on the glass composition. The expansion coefficients of the copper doped glass are in the range of 12.80×10^{-6} – 13.83×10^{-6} (°C⁻¹) which is common for the silicate glass. The finger prints of the bond vibrations were studied using IR spectroscopy. While the oxidation states and the coordination information of the copper and iron ion in the glass matrix were investigated using X-ray absorption spectroscopy. From the data, copper ions exist in the glass matrix in the form of Cu²⁺ and Cu⁺¹ both in the presence and absence of aluminum. In the presence of aluminum, the amount of Cu⁺ in the mixed-metal ion doped glass was increased when the molar ratio of iron to copper was increased. While in the absence of aluminum, iron exists in the glass matrix in the form of Fe³⁺. In the presence of aluminum, only Fe²⁺ was found.

Keywords Copper in glass; Iron in glass; XANES spectrum