4th International Conference on Advanced Materials Science and Technology (ICAMST-2016)

IOP Conference Series: Materials Science and Engineering
Volume 202

Malang, Indonesia
27 - 28 September 2016

Editors:

Markus Diantoro

ISBN: 978-1-5108-4176-5
ISSN: 1757-8981

EDITORIAL BOARDS

Table of contents

Volume 202

2017

Previous issue Next issue

The 4th International Conference on Advanced Materials Science and Technology 27–28 September 2016, Universitas Negeri Malang, Indonesia

View all abstracts

Accepted papers received: 12 May 2017
Published online: 31 May 2017

Preface

Papers

R Rahmawati, A Melati, A Taufiq, Sunaryono, M Diantoro, B Yuliarto, S Suyatman, N Nugraha and D Kurniadi

+ View abstract View article PDF

OPEN ACCESS 012014

The Scale Formation of Barite ($BaSO_4$) from Laminar Flowing Water in The Presence of Tartaric Acid and Ba^{2+} Concentration Variation of Solution

F Fatra, G Ivanto, N S Dera, S Muryanto and A P Bayuseno

+ View abstract View article PDF

OPEN ACCESS 012015

Citric Acid Addition to Controlling Crystallization of Barium Sulphate ($BaSO_4$) in Pipes through Ba^{2+} Concentration Variation in the Solution

G Ivanto, F Fatra, N S Dera, S Muryanto and A P Bayuseno

+ View abstract View article PDF

OPEN ACCESS 012016

Phase Transformation of Limonite Nickel Ores with Na_2SO_4 Addition in Selective Reduction Process

W Mayangsari and A B Prasetyo

+ View abstract View article PDF

OPEN ACCESS 012017

The Use of Heterogeneous Catalysts of Chitosan Sulfonate Bead on the Esterification Reaction of Oleic Acid and Methanol

H N Chamidy and Riniati

+ View abstract View article PDF

OPEN ACCESS 012018

$CaSO_4$ Scale Inhibition by a Trace Amount of Zinc Ion in Piping System

W Mangestiyono and Sutrisno

+ View abstract View article PDF

OPEN ACCESS 012019

Low-Temperature Carbothermic Reduction of Indonesia Nickel Lateritic Ore with Sub-Bituminous Coal

I Setiawan, S Harjanto and R Subagja

+ View abstract View article PDF

M Oktivina, D T Nurrohman, A N Q Z Rinto, E Suharyadi and K Abraha

+ View abstract View article PDF

OPEN ACCESS 012033

Effects of Sintering Holding Time on the Structural, Electrical and Magnetic Properties of $Zn_{0.95}Ni_{0.05}O$

M Ginting, D Aryanto, C Kurniawan, A Y Sari, A Subhan, T Sudiro, P Sebayang, E R Tarigan, M N Nasruddin and K Sebayang

+ View abstract View article PDF

OPEN ACCESS 012034

Synthesis and Characterization of Ti-6Al-6Mo Prepared by Arc Melting Process

G Senopati, I N G Putrayasa and A C Sutowo

+ View abstract View article PDF

OPEN ACCESS 012035

Corrosion Behavior of Magnesium Based Foam Structure in Hank's Solution

P L Franciska, A Erryani, D Annur and I Kartika

+ View abstract View article PDF

OPEN ACCESS 012036

The Effect of Substrate Temperature on Surface Modification of Polystyrene by using Nitrogen Plasma

A F Novi, D J D H Santjojo and Masruroh

+ View abstract View article PDF

OPEN ACCESS 012037

Optimizing Heat Treatment Process of Fe-13Cr-3Mo-3Ni Martensitic Stainless of Steel

M S Anwar, S Prifiharni and E Mabruri

+ View abstract View article PDF

OPEN ACCESS 012038

Fe-doped ZnO Supported with Montmorillonite: Synthesis, Characterization, and Photocatalytic Activity

M I Pratiwi, N Afifah and R Saleh

+ View abstract View article PDF

OPEN ACCESS 012039

Study of Sigma Phase in Duplex SAF 2507

D M Fellicia, Sutarsis, B A Kurniawan, D Wulanari, A Purniawan and A T Wibisono

+ View abstract View article PDF

OPEN ACCESS 012040

Study of Raman Spectra of Aluminum Powder-Substituted Barium Hexaferrite (BaM) $BaFe_{12-x}Al_xO_{19}$ as a Result of Solid State Reaction Process

S Mustofa, R Rizaldy and W A Adi

+ View abstract View article PDF

OPEN ACCESS 012041

Analysis of Distribution of Polyvinyl Alcohol Hydrogel Nanocrystalline by using SAXS Synchrotron

Sunaryono, A Taufiq, N Mufti, N Hidayat, S Rugmai, S Soontaranon, E G R Putra and Darminto

+ View abstract View article PDF

OPEN ACCESS 012042

Crystal Structure, Optical, and Electrical Properties of SnSe and SnS Semiconductor Thin Films Prepared by Vacuum Evaporation Techniques for Solar Cell Applications

Ariswan, H Sutrisno and R Prasetyawati

+ View abstract View article PDF

OPEN ACCESS 012043

Synthesis of Polyvinylpyrrolidone (PVP)-Green Tea Extract Composite Nanostructures using Electrohydrodynamic Spraying Technique

Kamaruddin, D Edikresnha, I Sriyanti, M M Munir and Khairurrijal

+ View abstract View article PDF

OPEN ACCESS 012044

Photodegradation of Rhodamine B by using $ZnFe_2O_4$ Nanoparticles Synthesized through Precipitation Method

Karnaji and I Nurhasanah

+ View abstract View article PDF

OPEN ACCESS 012045

Effect of Synthesis Parameter on Crystal Structures and Magnetic Properties of Magnesium Nickel Ferrite ($Mg_{0.5}Ni_{0.5}Fe_2O_4$) Nanoparticles

R Maulia, R A Putra and E Suharyadi

+ View abstract View article PDF

OPEN ACCESS 012046

Study on The Influence of Crystal Structure and Grain Size on Dielectric Properties of Manganese Ferrite ($MnFe_2O_4$) Nanoparticles

Kurnia, Heriansyah and E Suharyadi

+ View abstract View article PDF

OPEN ACCESS 012047

Study of Structural and Magnetic Properties of Silica and Polyethylene Glycol (PEG-4000)-Encapsulated Magnesium Nickel Ferrite ($Mg_{0.5}Ni_{0.5}Fe_2O_4$) Nanoparticles

F Deswardani, R Maulia and E Suharyadi

+ View abstract View article PDF

OPEN ACCESS 012048

Effect of Synthesis Temperature and NaOH Concentration on Microstructural and Magnetic Properties of $Mn_{0.5}Zn_{0.5}Fe_2O_4$ Nanoparticles

N Siregar, I P T Indrayana, E Suharyadi, T Kato and S Iwata

+ View abstract View article PDF

OPEN ACCESS 012049

Effect of Cu-Dopant on the Structural, Magnetic and Electrical Properties of ZnO

D Aryanto, C Kurniawan, A Subhan, T Sudiro, P Sebayang, M Ginting, S M K Siregar and M N Nasruddin

+ View abstract View article PDF

OPEN ACCESS 012050

Effect of Growth Time on the Characteristics of ZnO Nanorods

R Idiawati, N Mufti, A Taufiq, H Wisodo, I K R Laila, A Fuad and Sunaryono

+ View abstract View article PDF

OPEN ACCESS 012051

Synthesis and Characterization of Magnetic Elastomer based PEG-Coated Fe_3O_4 from Natural Iron Sand

C Kurniawan, A S Eko, Y S Ayu, P T A Sihite, M Ginting, P Simamora and P Sebayang

+ View abstract View article PDF

OPEN ACCESS

Sonocatalytic Degradation of Methylene Blue with $LaMnO_3$ Supported by Different Surface Area of Graphene

N Afifah and R Saleh

+ View abstract View article PDF

OPEN ACCESS 012066

Nanoneedles of Lanthanum Oxide (La_2O_3): A Novel Functional Material for Microwave Absorber Material

W A Adi, S Wardiyati and S H Dewi

+ View abstract View article PDF

OPEN ACCESS 012067

Effect of Thermal Processes on the Electrical and Optical Properties of Fe_2TiO_5 Ceramics

R Fajarin, Widyastuti, M A Baqiya and I Y S Putri

+ View abstract View article PDF

OPEN ACCESS 012068

Mechanosynthesis of A Ferritic ODS (Oxide Dispersion Strengthened) Steel Containing 14% Chromium and Its Characterization

A K Rivai, A Dimyati and W A Adi

+ View abstract View article PDF

OPEN ACCESS 012069

Methyl Ester Production via Heterogeneous Acid-Catalyzed Simultaneous Transesterification and Esterification Reactions

S Indrayanah, Erwin, I N Marsih, Suprapto and I K Murwani

+ View abstract View article PDF

OPEN ACCESS 012070

Synthesis of Zinc Oxide Nanoparticles using Anthocyanin as a Capping Agent

N L W Septiani, B Yuliarto, M Iqbal and Nugraha

+ View abstract View article PDF

OPEN ACCESS 012071

Microstructure Transformation of Mg-1.6Gd during Hot Rolled at High Deformation Ratio

O Susanti, M A Mochtar and S Harjanto

+ View abstract View article PDF

OPEN ACCESS 012072

The Effect of Molar Ratio on Crystal Structure and Morphology of $Nd_{1+X}FeO_3$ (X=0.1, 0.2, and 0.3) Oxide Alloy Material Synthesized by Solid State Reaction Method

V Zharvan, Y N I Kamaruddin, S Samnur and E H Sujiono

+ View abstract View article PDF

OPEN ACCESS 012073

Modification of Pseudobrookite $Fe_{2-X}Mn_xTiO_5$ with Solid State Reaction Method using a Mechanical Milling

Y Sarwanto and W A Adi

+ View abstract View article PDF

OPEN ACCESS 012074

Effect of Precursor Concentration Ratio on The Crystal Structure, Morphology, and Band Gap of ZnO Nanorods

A Fuad, A A Fibriyanti, Subakti, N Mufti and A Taufiq

+ View abstract View article PDF

OPEN ACCESS 012075

Physical and Magnetic Properties of $La_{0.5}Ca_{0.5}Mn_{0.9}Cu_{0.1}O_3$ at Temperature in the Range of 10-100 K

Y E Gunanto, W A Adi, E Steven, B Kurniawan, T Ono and H Tanaka

+ View abstract View article PDF

OPEN ACCESS 012076

Effect of Heat Treatment on The Crystal Structur, Electrical Conductivity and Surface of $Ba_{1.5}Sr_{0.5}Fe_2O_5$ Composite

P Purwanto, WA Adi and Yunasfi

+ View abstract View article PDF

OPEN ACCESS 012077

Monitoring Microalgae Population Growth by using Fe_3O_4 Nanoparticles-based Surface Plasmon Resonance (SPR) Biosensor

D T Nurrohman, M Oktivina, E Suharyadi, E A Suyono and K Abraha

+ View abstract View article PDF

OPEN ACCESS 012078

The Addition of Graphene and Magnetite Materials in TiO_2/CuO Catalyst for Enhancing Photosonocatalytic Performance and Reusability

A Taufik, A Muzaki and R Saleh

✚ View abstract View article PDF

OPEN ACCESS 012079

Synthesis and Characterization of Acrylic-Based Photopolymer as a Candidate for Denture Base Material

S T Wicaksono, Rasyida and H Ardhyananta

✚ View abstract View article PDF

OPEN ACCESS 012080

Composite Based Chitosan/Zinc-Doped HA as a Candidate Material for Bone Substitute Applications

S T Wicaksono, A Rasyida, A Purnomo, N N Pradita, H Ardhyananta and M I P Hidayat

✚ View abstract View article PDF

OPEN ACCESS 012081

Investigation on the Mechanical Properties of A356 Alloy Reinforced AlTiB/SiC_p Composite by Semi-Solid Stir Casting Method

E I Bhiftime and N F D S Gueterres

✚ View abstract View article PDF

OPEN ACCESS 012082

Poly (1,8 Octanediol-co-Citrate) Hydroxyapatite Composite as Antibacterial Biodegradable Bone Screw

P Widiyanti, I Sholikhah, A Isfandiary, NAF Hasbiyani, M B Lazuardi and R D Laksana

✚ View abstract View article PDF

OPEN ACCESS 012083

The Effects of the Addition of Silica Mol Fraction (x = 1.5; 2; 2.5) as a Solid Electrolyte on Ion Conductivity of NASICON ($Na_{1-x}Zr_2Si_xP_{3-x}O_{12}$) Using Solid-State Method

V M Pratiwi, H Purwaningsih, Widyastuti, R Fajarin and H Setyawan

✚ View abstract View article PDF

OPEN ACCESS 012084

Effects of Austenitizing and Forging on Mechanical Properties of MIL A-12560/AISI

4340 Steel

S Herbirowo, B Adjiantoro and T B Romijarso

+ View abstract View article PDF

OPEN ACCESS 012085

Influence of Austenitizing Heat Treatment on the Properties of the Tempered Type 410-1Mo Stainless Steel

E Mabruri, Z A Syahlan, Sahlan, S Prifiharni, M S Anwar, S A Chandra, T B Romijarso and B Adjiantoro

+ View abstract View article PDF

OPEN ACCESS 012086

Fluorescence Sensing of Nitrite Ions on Polyvinylpyrrolidone/Zinc Oxide Composites Prepared by Impregnation Method

L Yuliati, S Z M So'ad, N S Alim and H O Lintang

+ View abstract View article PDF

OPEN ACCESS 012087

Blending of Low-Density Polyethylene and Poly-Lactic Acid with Maleic Anhydride as A Compatibilizer for Better Environmentally Food-Packaging Material

A H Setiawan and F Aulia

+ View abstract View article PDF

OPEN ACCESS 012088

Mechanical and Thermal Properties of Unsaturated Polyester/Vinyl Ester Blends Cured at Room Temperature

H Ardhyananta, F D Puspadewa, S T Wicaksono, Widyastuti, A T Wibisono, B A Kurniawan, H Ismail and A V Salsac

+ View abstract View article PDF

OPEN ACCESS 012089

Characteristics of Al-Si-Mg Reinforced SiC Composites Produced by Stir Casting Route

A Zulfia, T Zhakiah, D Dhaneswara and Sutopo

+ View abstract View article PDF

OPEN ACCESS 012090

The Structure, Magnetic and Absorption Properties of Zn-Ti Substituted Barium-Strontium Hexaferrite Prepared by Mechanochemical Process

D S Winataputra, T L Ujiyanti and W A Adi

+ View abstract View article PDF

OPEN ACCESS 012091

Influence of External Magnetic Field on Potential Differences of Long Josephson Junction

A Hidayat, Y P Hardianto, E Latifah, H Wisodo and A Taufiq

+ View abstract View article PDF

OPEN ACCESS 012092

The Effect of Temperature in Induction Surface Hardening on the Distortion of Gear

N F D S Guterres, Rusnaldy and A Widodo

+ View abstract View article PDF

OPEN ACCESS 012093

Effect of Temperature on the Conduction Properties of Oligo-phenyl-phenylene (OPP) Molecule

S Setianto, H S Aswad and Y M Jajat

+ View abstract View article PDF

OPEN ACCESS 012094

Risk Analysis of Central Java Gas Transmission Pipeline by Risk-Based Inspection Method

Mediansyah, G D Haryadi, R Ismail and S J Kim

+ View abstract View article PDF

OPEN ACCESS 012095

Finite Element Study of the Effect of UHMWPE Liner Thickness on the Contact Area and Stress Distribution in a Bipolar Hip Joint

J Jamari, E Saputra, I B Anwar, R Ismail and E V D Heide

+ View abstract View article PDF

OPEN ACCESS 012096

Influence of Glass Fiber Nonlinearity and Dispersion on Light propagation in Double Core Optical Fiber

A Hidayat, A Listanti, E Latifah, H Wisodo, Nugroho A P and A Taufiq

+ View abstract View article PDF

JOURNAL LINKS

Journal home

Information for organizers

Information for authors

Search for published proceedings

Contact us

Reprint services from Curran Associates

IOP Conference Series: Materials Science and Engineering

Country	United Kingdom
Subject Area and Category	Engineering Engineering (miscellaneous) Materials Science Materials Science (miscellaneous)
Publisher	
Publication type	Conferences and Proceedings
ISSN	17578981
Coverage	2009-ongoing

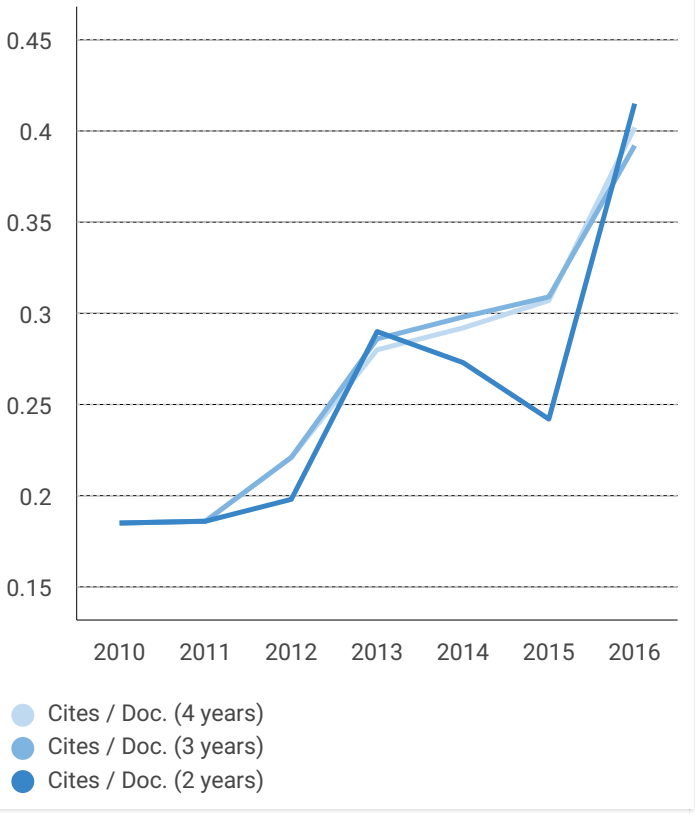
13

H Index

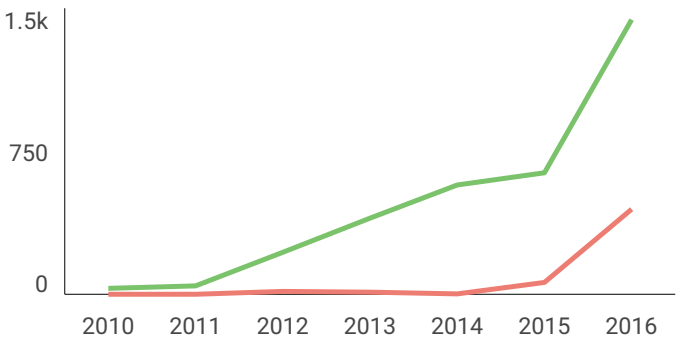
SJR

Year	SJR
2010	0.151
2011	0.155
2012	0.161
2013	0.183
2014	0.186
2015	0.172
2016	0.187

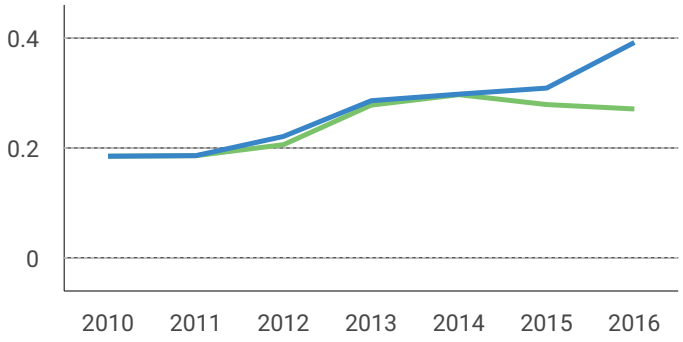
Citations per document



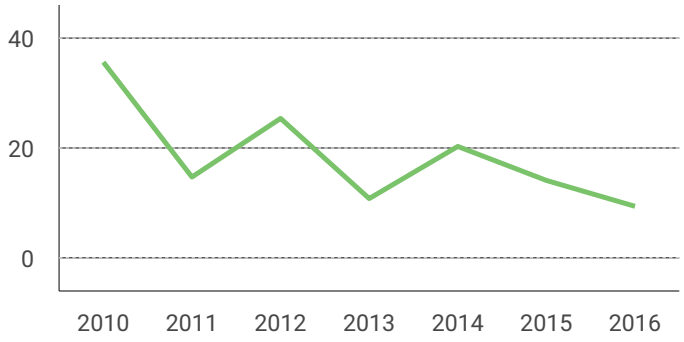
Total Cites Self-Cites



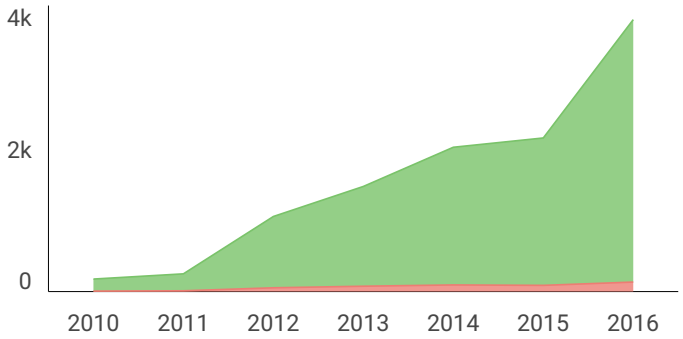
External Cites per Doc Cites per Doc



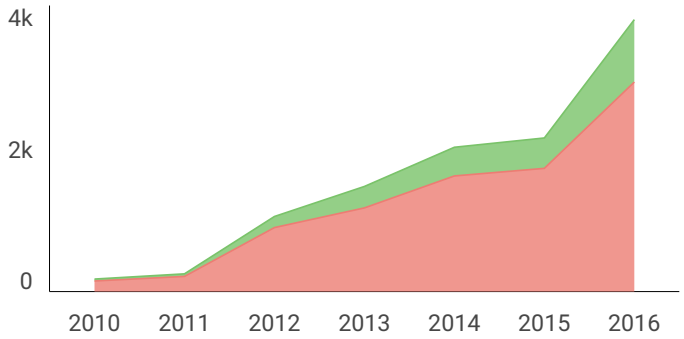
% International Collaboration

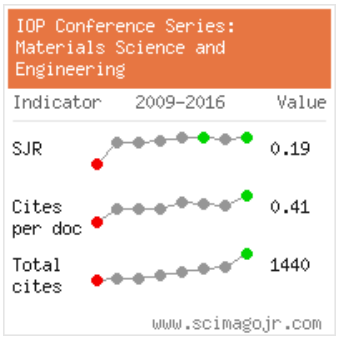


Citable documents Non-citable documents



Cited documents Uncited documents





← Show this widget in your own website

Just copy the code below and paste within your html code:

<a href="http://www.scimagojr.

Developed by:

Powered by:

Follow us on Twitter

IOP Conf. Series: Materials Science and Engineering **202** (2017) 012086 doi:10.1088/1757-899X/202/1/012086

Fluorescence Sensing of Nitrite Ions on Polyvinylpyrrolidone/Zinc Oxide Composites Prepared by Impregnation Method

L Yuliati[1,2], S Z M So'ad[3], N S Alim[3] and H O Lintang[1,2]

[1] Ma Chung Research Center for Photosynthetic Pigments, Universitas Ma Chung, Malang 65151, East Java, Indonesia
[2] Centre for Sustainable Nanomaterials, Ibnu Sina Institute for Scientific and Industrial Research, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia
[3] Department of Chemistry, Faculty of Science, Universiti Teknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia

Email: leny.yuliati@machung.ac.id

Abstract. A series of polyvinylpyrrolidone/zinc oxide (PVP/ZnO) composites with different loading amounts of PVP was prepared by an impregnation method. Successful formation of the composites was analyzed by the Fourier transform infrared (FTIR), diffuse reflectance ultraviolet-visible (DR UV-Vis) and fluorescence spectroscopies. Prepared composites were then further tested as fluorescence sensors by conducting quenching studies in the presence of nitrite ions (NO_2^-). Among the prepared composites, the ZnO with 1% PVP exhibited the highest sensing performance for the NO_2^-detection (K_{sv} = 0.07 μM^{-1}). The efficiency of the composite was *ca.* 1.7 and 1.4 times higher than the bare ZnO and the best composite prepared by the physical mixing method, respectively. These results suggested that impregnation method is a suitable method to prepare the PVP/ZnO composites as fluorescence sensor for the NO_2^-detection.

Keywords: polyvinylpyrrolidone/zinc oxide, composite, impregnation, fluorescence sensor, nitrite ion

1. Introduction

Nitrite (NO_2^-) is commonly used as a preservative and fertilizing agent for food as well as an inorganic fertilizer. Since NO_2^- has ahigh level of solubility in water, these ions also have high mobility, which has led to constant threats whenever agriculture processes are involved [1]. The emergence of NO_2^-as one of the hazardous contaminants has become a grave concern since NO_2^-can react with secondary or tertiary amines to form nitrosamines, which are carcinogenic compounds [2-4]. Ingestion of NO_2^-might cause endogenous nitrosation that is probably carcinogenic to human [5] and associated with colorectal and stomach cancers [6]. Furthermore, $NO_2^-$is also known to result in respiratory deficiencies as NO_2^- would react with hemoglobin forming methemoglobin, which disturbs the transport of oxygen [7, 8]. Therefore, it is a must to develop tools or methods that are simple, non-toxic, selective and sensitive to detect the presence of NO_2^-.

For nitrite/nitrate determination, one of the most generally reported methods is spectroscopy method owing to its great limit of detection and easy protocols [1]. Particularly, fluorescence sensors have attracted many attentions since they are simple, their signal can be amplified, they can be fabricated easily into devices, and they can be combined with various outputs [9]. One of the best candidates for a simple, inexpensive, and non-toxic solid material in the detection of NO_2^- is a semiconductor-based sensor. Particularly, zinc oxide (ZnO) has been widely used as a sensor for thedetection of various gasses, pollutants, and biomolecules [10-13].

As semiconductor gas sensor, ZnO has been extensively investigated for the detection of gas leaks and environmental monitoring of gaseous pollutants. For instance, ZnO showed excellent sensitivity to detect some flammable gasses as well as corrosive vapors with fast response-recovery characteristic, great selectivity, and stability [10]. ZnO was also reported serving as a sensor for sensing liquefied petroleum gas (LPG) and ethanol [11]. It was observed that ZnO also has good sensitivity at low temperature and it also showed better response and shorter recovery time. The application of ZnO as a sensor for methanal and xylene has also been investigated [12]. In addition, ZnO was also pointed out to improve signal in DNA sensor arrays [13].

In order to enhance the performance of ZnO as a sensor, ZnO can be modified with polymers [14-17]. It is recognized that grafting polymers onto the surface of ZnO was an effective way to improve its dispersion in a polymer matrix and the composites showed improved properties [14]. One of the potential polymers is polyvinylpyrrolidone (PVP), which has been reported to be a potential fluorescence sensor for the detection of nitrate (NO_3^-) [18]. Recently, the addition of PVP to ZnO by a physical mixing method has been reported to be able to increase the sensing efficiency of ZnO towards the NO_2^-detection [15]. In this study, we newly reported a higher enhancement of the fluorescence sensing capability for NO_2^- detection when the PVP/ZnO composites were prepared by an impregnation method.

2. Experimental Method

2.1. Materials

The materials used were zinc acetate dehydrate 99.5% ($Zn(CH_3COO)_2.2H_2O$, QRëc), sodium hydroxide pellet 99 % (NaOH, QRëc), cetyltrimethylammonium bromide ($C_{19}H_{42}BrN$, CTAB, Fischer Scientific), polyvinylpyrrolidone 45% in H_2O ($(C_6H_9NO)_n$, PVP, Sigma-Aldrich), sodium nitrite 99.5% ($NaNO_2$, Merck), and distilled water.

2.2. Methods

2.2.1. Preparation of ZnO. Zinc acetate dihydrate, $Zn(CH_3COO)_2.2H_2O$ was used as a precursor to synthesize the ZnO. The $Zn(CH_3COO)_2.2H_2O$ (4.5 g) was dissolved in distilled water (100 ml) as solution A. For the preparation of solution B, NaOH (6.4 g) was dissolved in distilled water and followed by the addition of CTAB (7.28 g) into the mixture and stirred for 1 hour to obtain a homogeneous solution. After 1 hour, solution A was added into solution B and heated at 70 ^oC for 1 hour. The remaining solid was subsequently filtered and washed with distilled water. The solid powder was dried at room temperature and then calcined at 500 ^oC at a rate of 1.0 $^oC\ min^{-1}$ and further tempered for another 1 h at the same temperature.

2.2.2. Preparation of PVP/ZnO composites. Various PVP/ZnO composites were prepared by an impregnation method, in which the concentration ratios were varied to 0.1, 1 and 3 % (v/w). The sampleswere labeled as PVP(x)/ZnO, with x that shows the ratio of PVP to the ZnO. For a typical synthesis of PVP (1)/ZnO composite, the ZnO (1 g) was dispersed in distilled water (30 mL). The PVP (0.2020 mL) from 5 % PVP solution was then added dropwise to the mixture containing ZnO and distilled water, followed by stirring and drying at 80 °C on a hot plate.

2.2.3. Characterizations. As for characterizations of the prepared ZnO and PVP/ZnO composites, FTIR spectroscopy (Thermo Scientific, Nicolet iS50) was applied to investigate the functional groups in the prepared ZnO and PVP/ZnO composites. For the measurement, potassium bromide (KBr) pellet technique was used. The FTIR spectra were measured in the range of 400 to 4000 cm^{-1} with 32 scan number. Nitrogen gas was purged into the system before analysis to exclude moisture for better background correction. DR UV-Vis spectroscopy (UV-2600 with an integrating sphere, Shimadzu) was used to measure the absorption spectra of the samples. The absorption spectra were recorded in the wavelengths range from 250 to 500 nm. Scan speed was at the rate of 300 nm min^{-1} and the slit width was set at 1 nm. As a reference, barium sulfate ($BaSO_4$) was used in the measurement. The fluorescence spectra were recorded on the fluorescence spectrophotometer (FP-8500, JASCO) at room temperature. The emission spectra were measured when the excitation wavelength was 365 nm.

2.3. Sensor tests

Sensor tests for the detection of NO_2^- were carried out based on the quenching study, by monitoring the decreases in the emission intensity of the sensor when various concentrations of the NO_2^-were added into the sensor. Typically, the sensor sample (0.3 g) was transferred into a fluorescence sample holder and placed at the fluorescence instrument. Initial readings for excitation and emission peaks were firstly recorded in the absence of the NO_2^-. As for the quenching test, the selected concentration of NO_2^- (2−10 μM) with a volume of 10 μL was added slowly on top of the sample. The emission spectra were then recorded at an excitation wavelength of 365 nm for ZnO and all the PVP/ZnO composites. The efficiency for the detection of the NO_2^- was further determined by Stern-Volmer plot on each of the prepared sample.

3. Results and Discussion

3.1. Functional groups

The functional groups of PVP, ZnO, and PVP/ZnO composites were examined by using the FTIR spectroscopy. FTIR spectroscopy gives qualitative information on the type of functional groups that present in the samples. As shown in Figure 1(a), PVP gave OH stretching vibration from a water molecule at around 3447 cm^{-1} due to the hydrophilic nature of the PVP, while the peaks observed around 2800-3000 cm^{-1} were assigned to C-H stretching. The characteristic peaks of PVP could be seen at 1655 and 1461 cm^{-1}, which were corresponding to C=O and C−N stretching, respectively. The presence of C−N stretching was also shown at around 1370 cm^{-1} and the peaks below 700 cm^{-1} gave the evidence of C−C chains and N−C=O bending [19].

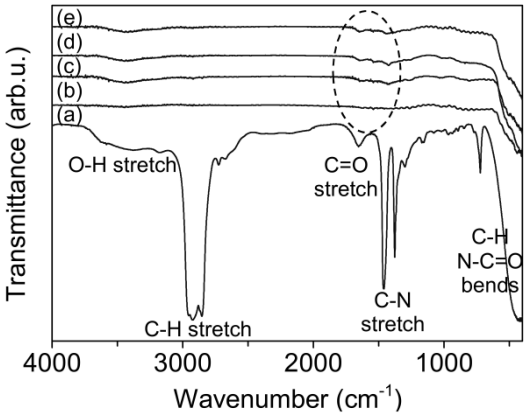


Figure 1. FTIR spectra of(a) PVP, (b) ZnO, (c) PVP(0.1)/ZnO, (d) PVP(1)/ZnO and (e) PVP(3)/ZnO samples

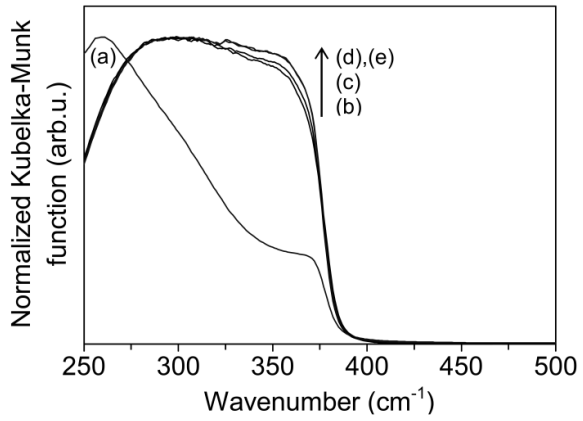


Figure 2. DR UV-Vis spectra of(a) PVP, (b) ZnO, (c) PVP(0.1)/ZnO, (d) PVP(1)/ZnO, and (e) PVP(3)/ZnO samples

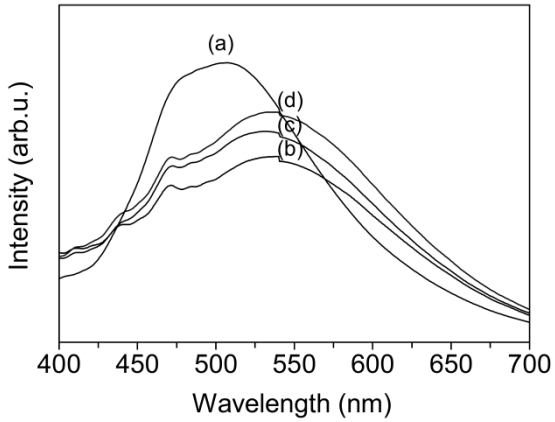


Figure 3. Emission spectra of(a) ZnO, (b) PVP(0.1)/ZnO, (c) PVP(1)/ZnO, and (d) in PVP(3)/ZnO samples

Displayed in figure 1(b) is the FTIR spectrum of ZnO. The ZnO showed a sharp peak at around 420 cm^{-1} that could be assignedas the stretching mode of Zn−O [20, 21]. Figures 1(c)−(e) show the FTIR spectra for the PVP/ZnO composites. All the composite samples gave the presence of Zn−O stretching as well as two peaks appeared at 1647 and 1434 cm^{-1} that could be related to C=O and C−N stretching, respectively. Both of the latter peaks came from the PVP. It has been suggested that the peak shift can be related to the hydrogen bond formation [19, 20]. Therefore, the shifting observed on the PVP/ZnO samples might be the outcome of the hydrogen bonding interaction between the surface hydroxyl of ZnO and the functional group in the PVP. Another responsibility that can be proposed was the existence of a strong coulombic interaction between the ZnO and the polymeric matrix [22]. When the amount of PVP in the PVP/ZnO composite increased, the intensity of C=O stretching and C−N stretching also increased owing to the increment amount of PVP contained in the PVP/ZnO composites. The FTIR spectra suggested the successful preparation of the PVP/ZnO composites.

3.2. Optical properties

The optical properties of the PVP, ZnO, and PVP/ZnO composites were investigated using the DR UV-Vis spectroscopy and are displayed in Figure 2. As shown in Figure 2(a), PVP exhibited intense narrow bands centered at 265 and 370 nm, which might be due to the presence of C=O and N−C groups, respectively [19]. On the other hand, Figure 2(b) shows a strong absorption peak of ZnO in the UV region, which was centered at 330 nm due to the electron charge transfer in the Zn−O linkage [23, 24]. The DR UV-Vis spectra of the PVP/ZnO composites are shown in Figures 2 (c)−(e). All the composite samples showed similar absorption peak to each other, where the main absorption peak of ZnO was clearly observed and the loading amount of PVP also slightly increased the absorption band of PVP. It can be observed that the addition of PVP did not give considerable influence to the band structure of the ZnO.

3.3. Fluorescence properties

Fluorescence spectroscopy is a powerful non-destructive technique to explore the fluorescence properties of thematerials. Figure 3 shows the emission spectra of the prepared ZnO and PVP/ZnO composites. Shown in Figure 3(a) is the emission spectrum for ZnO when the excitation wavelength at365 nm was used. ZnO gave one broad emission peak at 517 nm, which has been recognized as the green emission of ZnO, reflecting the presence of oxygen defect on the surface and deep level of the ZnO [22]. As can be seen from Figure 3(b)−(d), all PVP/ZnO composites have a lower emission intensity as compared to the ZnO. In addition to the reduced fluorescence intensity, the addition of PVP also shifted the emission peak to a longer wavelength. The decrease in fluorescence intensity and

the strong peak shifting indicated that there were interactions existed between the PVP and the ZnO. The most possible interactions between PVP and ZnO would occur via hydrogen bonding and/or coulombic interaction.

3.4. Sensing performance

The sensing performance of the ZnO and the PVP/ZnO composites towards the $NO_2^-$was evaluated via quenching tests by monitoring the decreases in the emission intensity after the additions of various concentrations of the NO_2^-(0−10 μM) to the ZnO and the PVP/ZnO composites. All samples showed similar results, where the emission intensity was reduced gradually with the increase in the concentration of the NO_2^-. As arepresentative, the changes of the emission spectra in the absence and presence of $NO_2^-$for the PVP(1)-ZnO composite are illustrated in Figure 4(a).

The relative emission intensity can bestrongly related to the concentration of NO_2that investigated by a Stern-Volmer plott. In the plot, the relative emission intensity is expressed as a function of the NO_2^-concentrations, following the Stern-Volmer plot as shown in Equation (1).

$$I_o/I = K_{SV}[Q] + 1 \quad (1)$$

Where I_o and I show the fluorescence intensity without and with NO_2^-, respectively, Qshows the concentrations of NO_2^-, and K_{SV} is the Stern-Volmer quenching constant. The calculated K_{SV} indicated the efficiency of the sensor. Higher K_{SV} value suggested a larger efficiency of the sensor. All the ZnO and PVP/ZnO composites gave almost linear curves, suggesting that the ZnO and the PVP/ZnO composites can be potential fluorescence sensors in the detection of the NO_2^-. As representative of the samples, Figure 4(b) illustrates the linear Stern-Volmer plots of the ZnO and the PVP(1)/ZnO composite in the presence of NO_2^-.

K_{SV}values of the ZnO and the PVP/ZnO composites are given in Figure 5. The K_{SV} value of the ZnO was determined to be 0.04 μM^{-1}. It was evident that the addition of PVP from 0.1 to 1% improved the ZnOsensing performance, where the K_{SV} value increased from 0.04 to 0.05 and 0.07 μM^{-1}, respectively. Unfortunately, the sensing performance decreased to 0.026 μM^{-1} when the loading amount of PVP was too high (3%). It was shown that the addition of PVP reduced the ZnO intensity, thus, when the loading of PVP was too high, the reduced emission intensity would decrease the sensitivity of the sensor. This study showed that the PVP(1)/ZnO was the best sample showing the highest efficiency towards the detection of NO_2^-.

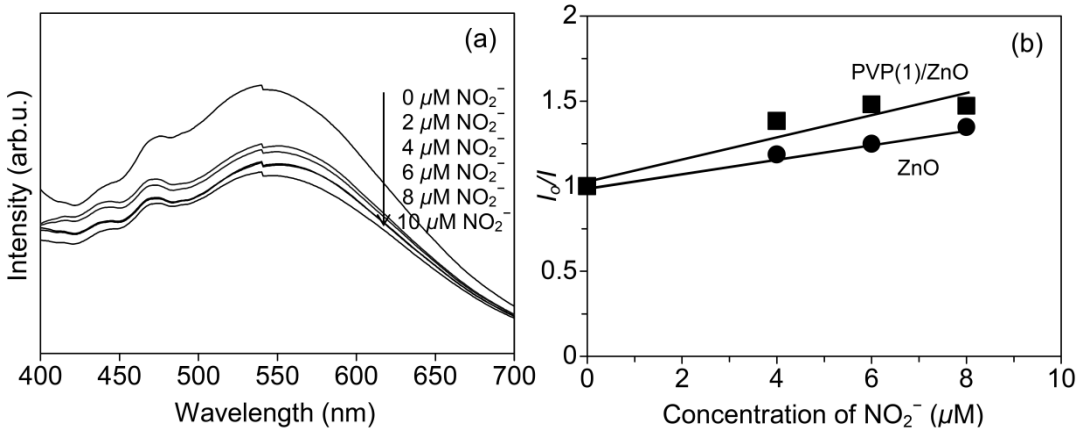


Figure 4. (a)Emission spectra of PVP(1)/ZnO in the absence and presence of different concentrations of $NO_2^-$and (b) Stern-Volmer plots of PVP(1)/ZnO and ZnO samples

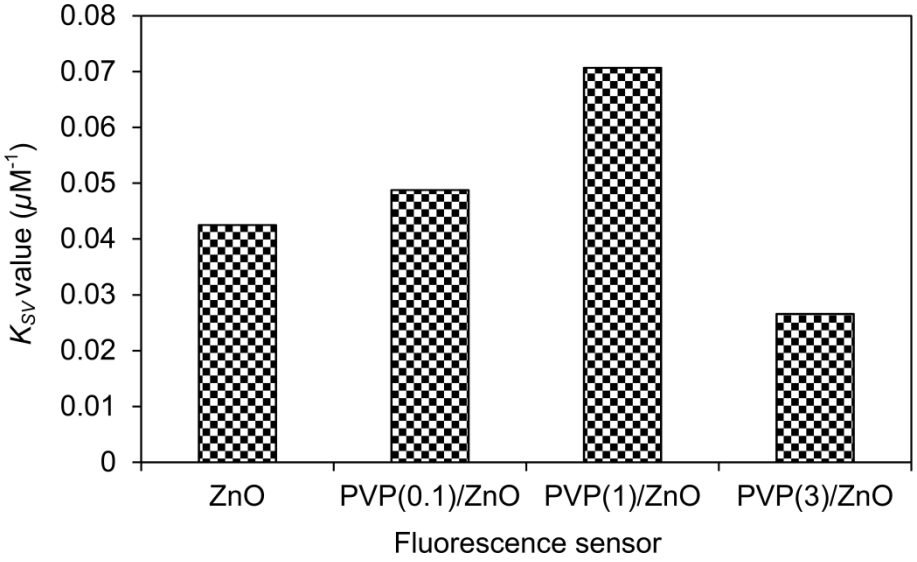


Figure 5. Comparison of K_{SV} values of ZnO and PVP-ZnO composites

It was reported that the best PVP/ZnO composite prepared by physical mixing, the PVP(0.1)/ZnO, gave K_{SV} value of 0.05 μM^{-1} [15]. Comparison to the best PVP/ZnO composite prepared by physical mixing showed that the best PVP/ZnO composite developed by the impregnation method gave a higher K_{SV} value of 0.07 μM^{-1}. It was proposed that better interaction between the PVP and the ZnO prepared by the impregnation method would be the crucial factor to get a higher efficiency. Since the impregnation method employed a sonication step, the PVP would be dispersed better on the ZnO than that prepared by physical mixing. This study demonstrated that the impregnation method was better than the physical mixing to prepare the PVP/ZnO composites as fluorescence sensor of the NO_2^-.

4. Conclusion

The PVP/ZnO composites were successfully prepared by an impregnation method as evidenced by FTIR, DR UV-Vis, and fluorescence spectroscopies. The prepared ZnO and composites gave good linear Stern-Volmer plots with various concentrations of NO_2^-, suggesting the potential capability of these samples as fluorescence sensors for the NO_2^-detection. The best composite, which was PVP(1)-ZnO, gave K_{SV} value of 0.07 μM^{-1}, which was 1.7 times higher than that of the ZnO.

5. References

[1] Moorcroft M J, Davis J and Compton R G 2001 *Talanta* **54** 785
[2] Lijinsky W and Epstein S S 1970 *Nature* **225** 21
[3] Cassens R G 1997 *Food Technol.* **51** 53
[4] Tricker A R and Preussmann R 1991 *Mutat. Res.***259** 277
[5] Grosse Y, Baan R, Straif K, Secretan B, El Ghissassi F, Cogliano V and WHO International Agency for Research on Cancer Monograph Working Group 2006*Lancet Oncol*. **7** 628
[6] Bouvard V, Loomis D, Guyton K Z, Grosse Y, El Ghissassi F, Benbrahim-Tallaa L, Guha N, Mattock H, Straif K, and International Agency for Research on Cancer Monograph Working Group 2015*Lancet Oncol.* **16** 1599
[7] Fan A M and Steinberg V E 1996 *Regul. Toxicol. Pharmacol.* **23** 35
[8] Niţuc E, Năstase V, Mihăilescu G and Chioveanu D 2010 Rev. Med. Chir. Soc. Med. Nat. Iasi. **114** 580
[9] Kim H N, Guo Z, Zhu W, Yoon J and Tian H 2011 *Chem. Soc. Rev.* **40** 79
[10] Ma S, Li R, Lv C, Xu W and Gou X 2011 *J. Hazard. Mater.* **192** 730
[11] Baruwati B, Kumar D K and Manorama S V 2006 *Sensor Actuator B-Chem*. **119** 676

[12] Cao Y, Hu P, Pan W, Huang Y, and Jia D 2008*Sensor Actuat. B-Chem.* **134** 462
[13] Kumar N, Dorfman A and Hahm J I 2006 *Nanotechnology* **17** 2875
[14] Tshabalala M A, Dejene B F and Swart H C 2012 *Physica B* **407** 1668
[15] Tang I H, Mohd So'ad S Z, Lintang H O and Yuliati L 2015 *Malay. J. Fund. Appl. Sci.* **11** 139
[16] Tang H, Yan M, Ma X, Zhang H, Wang M and Yang D. 2006 *Sensor Actuat B-Chem*. **113** 324
[17] He J H, Ho C H and Chen C Y 2008 *Nanotechnology* **20** 1
[18] Tang I H, Sundari R, Lintang H O and Yuliati L 2016 *Malay. J. Anal. Sci.* **20** 288
[19] BashaMA F 2010 *Polym. J.* **42** 728
[20] Liufu S, Xiao H and Li Y 2004 *Powder Technol.* **145** 20
[21] Lepot N, Van Bael M K, Van den Rul H, D'Haen J, Peeters R, Franco D and Mullens J 2007 *Mater. Lett.* **61** 2624
[22] Feng W, Tao H, Liu Y and Liu Y 2006 *J. Mater. Sci. Technol.* **22** 230
[23] Hussin F, Lintang H O and Yuliati L 2015*Malay. J. Fund. Appl. Sci.***11** 134
[24] Hussin F, Lintang H O and Yuliati L 2016*Malay. J. Anal. Sci.* **20** 102

Acknowledgements
The work was financially supported by the Ministry of Higher Education (MOHE, Malaysia) and the Universiti Teknologi Malaysia (UTM, Malaysia) through a Tier-1 Research University Grant (cost center code: Q.J130000.2509.06H66).