

EMPOWERING SCIENCE AND MATHEMATICS FOR GLOBAL
COMPETITIVENESS

Empowering Science and Mathematics for Global Competitiveness

VOLUME 1

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PROCEEDINGS OF THE SCIENCE AND MATHEMATICS INTERNATIONAL CONFERENCE
(SMIC 2018), JAKARTA, INDONESIA, 2–4 NOVEMBER 2018

Empowering Science and Mathematics for Global Competitiveness

Edited by

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Typeset by V Publishing Solutions Pvt Ltd., Chennai, India

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Published by: CRC Press/Balkema
Schipholweg 107C, 2316 XC Leiden, The Netherlands
e-mail: Pub.NL@taylorandfrancis.com
www.crcpress.com – www.taylorandfrancis.com

ISBN: 978-1-138-61666-0 (Hbk + USB card)

ISBN: 978-0-429-46190-3 (eBook)

DOI: <https://doi.org/10.1201/9780429461903>

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Preface

We are delighted to publish the SMIC Conference Proceedings 2018 as an important outcome of the Science and Mathematics International Conference (SMIC) 2018. The conference was organized by the Faculty of Mathematics and Natural Sciences, Universitas Negeri Jakarta (UNJ), and took place in the Lumire Hotel and Convention Centre, Jakarta, 2–4 November 2018. The theme of the conference was *Empowering Research and Education in Science and Mathematics for Global Competitiveness*.

We received 214 registrations and accepted 119 proposals from researchers in 12 countries and many parts of Indonesia. Conference participants came from Australia, USA, Japan, Philippines, Nepal, Vietnam, Egypt, Malaysia, Thailand, China, Ghana and Nigeria. The main speakers were drawn from Indonesia, Australia, Germany, Egypt, Singapore, Philippines, and Malaysia. We received papers on a range of topics in the closely related fields of mathematics, science, mathematics education and science education. The conference generated new ideas for the further development of theory and applications of research that will enhance the quality of science and mathematics research, teaching and learning.

The conference commenced with 3 one-day workshops facilitated by: Dr. Elisabeth Taylor (Values and Character Teaching, Edith Cowan University, Australia), Dr. Rachel Sheffield (STEM, Curtin University, Australia), and Dr. Rekha Koul (Learning Environment Research, Curtin University, Australia). Plenary sessions were presented by outstanding keynote speakers: Prof. Intan Ahmad, Ph.D (UNJ, ITB, Ministry of Research, Technology, and Higher Education, Indonesia), Prof. Berinderjeet Kaur, Ph.D (NIE Singapore), Prof. Dr. Russell Tytler (Deakin University, Australia), Prof. Dr Akrajas Ali Umar (National University of Malaysia), Prof. Dr. Carlene Arceo (The University of Philippines), Prof. Dr. Peter Charles Taylor (Murdoch University, Australia), Dr. Mohamed Helmy Khafagy (Fayoum University, Egypt), and Prof. Dr. Hans-Dieter Barke (Muenster University, Germany). We were also proud to have presentations by specially invited speakers: Prof. Dr. Asep Kuswandi (UNPAD, Indonesia), Prof. Dr. Liliyasi (UPI, Indonesia), Prof. Herawati Susilo, Ph.D (UM, Indonesia), Isnaeni, Ph.D (LIPI, Indonesia), Sri Fatmawati, Ph.D (ITS, Indonesia), and Setia Pramana, Ph.D (STIS, Indonesia).

We conducted blind reviews of 82 papers through the EasyChair platform (<https://easychair.org>). The review process involved 59 reviewers from 11 countries: Australia, USA, Philippines, Thailand, Malaysia, China, Ghana, Egypt, Nepal, Pakistan, and Indonesia. 72 papers were accepted for publication in the proceedings. The authors recognise that globalisation processes link education to technological and economic development, and that education systems face the challenging task of preparing students to live productively and ethically in a complex and competitive world that confronts them with local, national and global issues.

The papers selected for this proceeding contribute to our understanding of important new developments in (i) science and mathematics, especially nanotechnology, materials, environmental science, statistics and computer science; and (ii) science and mathematics education, in particular environmental sustainability, STEM and STEAM pedagogies, technology education, and green chemistry. Importantly, papers by leading educators provide innovative strategies for transforming mathematics and science education policies and practices, helping to empower teachers to develop students' 21st century skills. We are excited that the papers chosen for this proceeding will enable STEM practitioners, STE(A)M educators and citizens to meet the challenges of global competitiveness and sustainability for the 21st century.



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Acknowledgements

These conference proceedings could be published only because of the support and cooperation of various parties. On this occasion, I would like to give my dedicated appreciation to the Deputy Dean of the Mathematics and Science Faculty, the Dean, and all Vice Deans who trusted us to organize this conference and for their willing support. I thank wholeheartedly our Rector, all Vice Rectors, and the Head of the Mathematics and Science Department of the Universitas Negeri Jakarta for their wonderful support. I take this opportunity to also thank the committee members for their hard work, commitment and dedication in organizing this conference. Great thanks go to the Publication Team for their hard work. I would also like to acknowledge our conference organizers and reviewers.

Profuse thanks to all the presenters, participants, student volunteers and all others who directly or indirectly contributed to enabling the publication of the SMIC 2018 conference proceedings. There are many parties that we cannot mention one by one who supported the conference. Hopefully, this publication will benefit not only the conference participants but also all the representing countries, as well as the broader development of science and technology education.



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Green synthesis and characterization of Zinc Oxide (ZnO) nanoparticles using *Uncaria gambir* leaf extract

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ABSTRACT: The aim of this work is to investigate the capabilities of *Uncaria Gambir* Leaf Extract (UGLE) in the synthesis of ZnO Nanoparticles (NPs) via a green approach. We made two types of nanoparticles. The first nanoparticles were prepared by dissolving $\text{Zn}(\text{Ac})_2 \cdot 2\text{H}_2\text{O}$ in UGLE and the second nanoparticles were prepared by dissolving $\text{Zn}(\text{Ac})_2 \cdot 2\text{H}_2\text{O}$ in isopropanol. The ZnO NPs were characterized by Differential Thermal Analysis and Thermogravimetric Analysis (DTA-TGA), Fourier Transform Infra Red (FTIR) spectroscopy, X-Ray Diffractometer (XRD) and Scanning Electron Microscopy (SEM). The synthesized NPs have a wurtzite hexagonal structure, with the average particle size, as calculated from XRD analysis, being 65 nm and 35 nm, for ZnO NPs without UGLE and with UGLE, respectively. Scanning Electron Microscopy (SEM) analysis revealed a ZnO rod without UGLE and a spherical shape with UGLE.

1 INTRODUCTION

The field of nanotechnology is one of the most studied in modern materials science. Today, the green synthesis of metal oxide nanoparticles is an interesting issue in the fields of nano-scale and nanotechnology. The use of plant extracts in nanoparticle synthesis is one of the most environmentally friendly alternative methods (Yuvakkumar et al., 2015). Utilizing plant extracts in synthesizing nanoparticles has produced highly stable nanoparticles (Gunalan et al., 2013) in various shapes and particle sizes (Rafaie et al., 2014).

In recent years, ZnO has been extensively studied due to its unique optical and electronic properties (Iwan et al., 2018). It has wide applications in the field of optoelectronic devices (Al-Ghamdi et al., 2014), photocatalysts (Toubane et al., 2016), antimicrobials (Jayaseelan et al., 2012), antioxidants (Nagajyothi et al., 2014) and so forth. Previous green synthesis of ZnO nanoparticles (NPs) has been reported, such as *Cassia fistula* (Suresh et al., 2015), *Pasiflora caerulea* (Santhoshkumar et al., 2017) and *Lycopersicon esculentum* (Sutradhar & Saha, 2016).

Gambir is a specific plant from West Sumatra, Indonesia and nearly 90% of its production is from this area (Fauza, 2014). Gambir leaf extract contains flavonoids which are a group of secondary metabolites produced by plants belonging to a large group of polyphenols. Following previous studies, it is known that the polyphenol content of gambier extract can reduce Ag (I) to Ag (0) (Arief et al., 2015).

In this study, ZnO nanoparticles were synthesized using *Uncaria gambir* leaf extract through the sol-gel method. The synthesized ZnO NPs were characterized using Differential Thermal Analysis and Thermogravimetric Analysis (DTA-TGA), Fourier Transform Infra Red (FTIR) spectroscopy, X-Ray Diffractometer (XRD) and Scanning Electron Microscopy (SEM).

2 METHOD

Uncaria gambir Robx. leaves were collected from the Agricultural Garden of Universitas Andalas, Padang, West Sumatera, Indonesia. Zinc acetate dihydrate ($\text{Zn}(\text{CH}_3\text{CO}_2)_2 \cdot 2\text{H}_2\text{O}$) and isopropanol ($(\text{CH}_3)_2\text{CHOH}$) were purchased from Merck, Germany. The gambir leaves were subjected to washing several times with fresh water to remove any dust particles. They were cut into pieces and dried in the shade for seven days. The dried leaves were crushed using a grinder. *Uncaria gambir* leaf extract (UGLE) was prepared through the maceration of gambir leaves in an ethanol solvent (1:6) for four days followed by filtration and evaporation to get the concentrated extract. The color of the extract was dark brown. Subsequently, 10 g of concentrated UGLE was dissolved in 100 ml of isopropanol.

Nanoparticles of ZnO were synthesized through the sol-gel method. One gram of zinc acetate dihydrate was dissolved in 10 ml of UGLE. For comparison, 1 g of zinc acetate dihydrate was dissolved in 10 ml of isopropanol. These mixtures were stirred for 2.5 h at 65°C and then were dried at 100°C to yield ZnO powder. Finally, the powder was treated in an air heated furnace at 500°C for 1 h. The thermal behavior of the powder was examined with a Shimadzu DTG-60 simultaneous DTA-TG. Fourier transform infrared spectra were recorded in the 400–4000 cm^{-1} region using a Perkin Elmer Frontier FT-IR Spectrometer. The structure and the crystallinity of the powder were analyzed through an X-ray diffractometer using an X'pert pro, PANalytical. The morphology and size distribution were examined with a Scanning Electron Microscope (Hitachi SU 3500).

3 RESULTS AND DISCUSSION

3.1 DTA-TGA analysis

Figure 1 presents typical differential thermal analysis and thermogravimetric analysis (DTA-TGA) curves of the ZnO precursor sol with UGLE, analyzed at temperatures ranging from 25 to 575°C. The weight loss at about 100°C indicates the evaporation of H_2O and 2-propanol, endothermically caused by the dehydration of zinc acetate dihydrate (Kim et al., 2017). The weight loss in the range of 100–450 °C indicates the evaporation of acetic acid, while in the range of 460–530 °C it represents the change from zinc acetate to zinc oxide

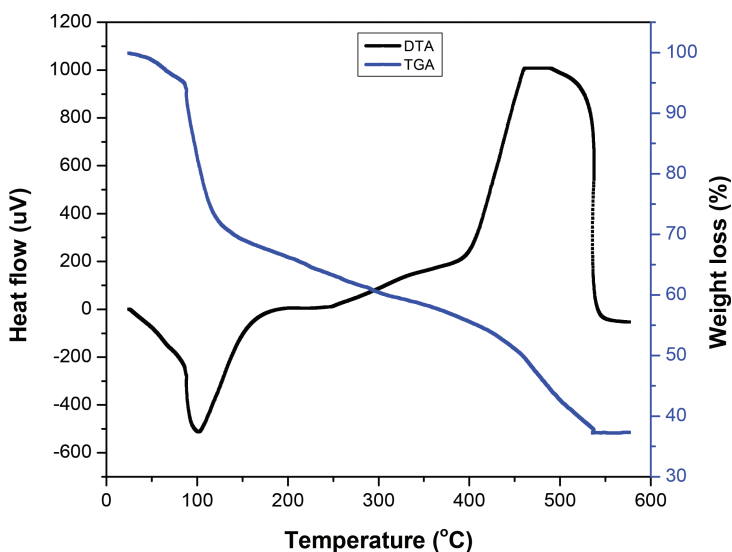


Figure 1. DTA-TGA curves of ZnO precursor sol with UGLE.

(Ramesh et al., 2015). The results show that a calcination temperature of 500°C would be suitable for synthesizing ZnO nanoparticles.

3.2 FTIR analysis

FTIR spectrum of UGLE and ZnO powder synthesized without and with UGLE shown in Figure 2. ZnO powder samples synthesized without UGLE showed absorption bands at 2329, 2046, 880 and 528 cm^{-1} (Figure 2(a)). UGLE shows absorption bands at 3333, 2968, 1618, 1377, 1303, 947, 812 and 608 cm^{-1} (Figure 2(b)). The ZnO powder synthesized using UGLE showed absorption bands at 2307, 2071, 1572, 1238 and 562 cm^{-1} (Figure 2(c)). These absorption bands were observed in the region of between 500–3500 cm^{-1} and consist of 3333 cm^{-1} (amine), 2968 cm^{-1} and 1377 cm^{-1} (alkanes), 1618 cm^{-1} (alkenes), 1303 cm^{-1} (nitro compound), and 1121 cm^{-1} (alcohol, ether, carboxylic acid, ester); the band is slightly wider in the wavelength range 550 to 637 cm^{-1} (CH, C = C, NH). ZnO stretches were found in the wavelength range of 400 to 600 cm^{-1} (Sangeetha et al., 2011). In this study, ZnO stretch without UGLE occurred at the wavelength of 528 cm^{-1} , and stretched ZnO with UGLE occurred at the wavelength of 562 cm^{-1} . In general, metal oxides are characterized by intrinsic absorption bands below 1000 cm^{-1} arising from interatomic vibrations (Matinise et al., 2017).

3.3 XRD analysis

X-ray diffraction was used to further confirm the crystallinity of ZnO nanoparticles. The XRD patterns of ZnO powder synthesized without and with UGLE are shown in Figure 3. The XRD peaks were identified as (100), (002), (101), (102), (110), (103), (200), (112), (201),

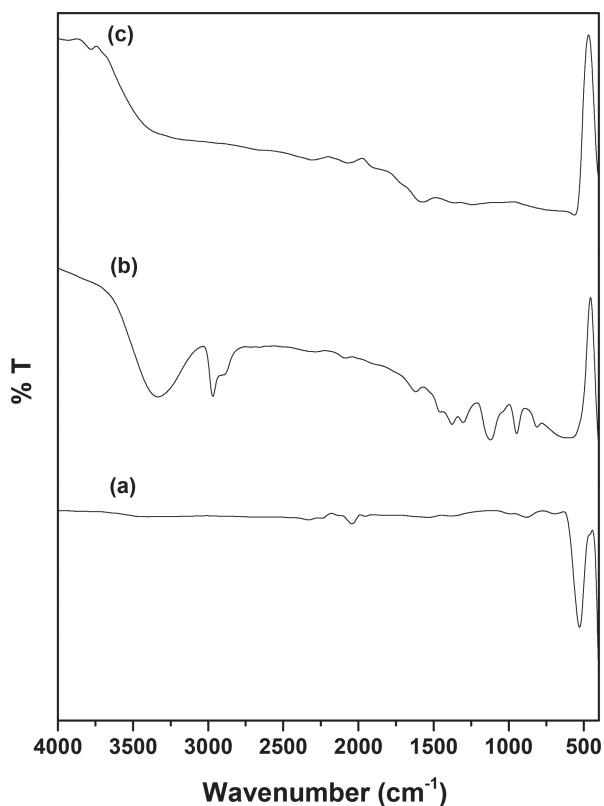


Figure 2. FTIR spectra of (a) ZnO NPs without UGLE, (b) UGLE and (c) ZnO NPs with UGLE.

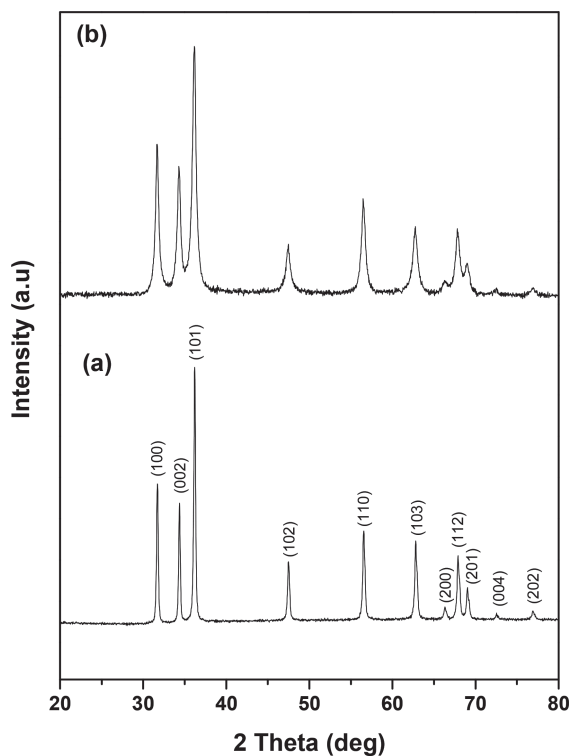


Figure 3. XRD pattern of ZnO NPs (a) without UGLE and (b) with UGLE.

(004) and (202) in both powder samples. This shows that the formed nanoparticles are polycrystalline with hexagonal wurtzite structures. The diffraction peaks correspond with ZnO 01-076-0704 ICSD (inorganic crystal structure database) data. The narrow and strong diffraction peaks in both types of ZnO NPs show that the resulting products have a good crystallinity. The decrease in the intensity and widening of the FWHM (full width at half maximum) of ZnO NPs with UGLE (Figure 3(b)) indicates changes in particle size.

The size of ZnO NPs synthesized without and with UGLE were found to be 65 and 35 nm, respectively, which have been calculated using the Scherrer equation (Foo et al., 2014):

$$D = \frac{\kappa\lambda}{\text{FWHM}\cos\theta} \quad (1)$$

where κ is the Scherrer constant that depends on the shape of crystallite (0.9); λ is the wavelength of the X-ray used, which is 1.54 Å; FWHM is the width of the line at half the maximum intensity; and θ is the Bragg angle. The average size of ZnO NPs with UGLE is smaller than the size of ZnO NPs without UGLE. This indicates that *Uncaria gambir* leaf extract is responsible for the reduction of the particle size.

3.4 SEM analysis

The morphology of nanostructures was investigated using scanning electron microscopy (SEM). Figure 4(a) shows an image of ZnO NPs synthesized without UGLE. Most of the nanoparticles are rod-shaped and are clearly observable, with a diameter of approximately 60–120 nm. Meanwhile, Figure 4(b) shows that ZnO NPs synthesized using UGLE have a spherical shape and a particle size in the range of 50–80 nm. It can be concluded from these results that *Uncaria gambir* leaf extract does affect the shape and the particle size of ZnO nanoparticles.

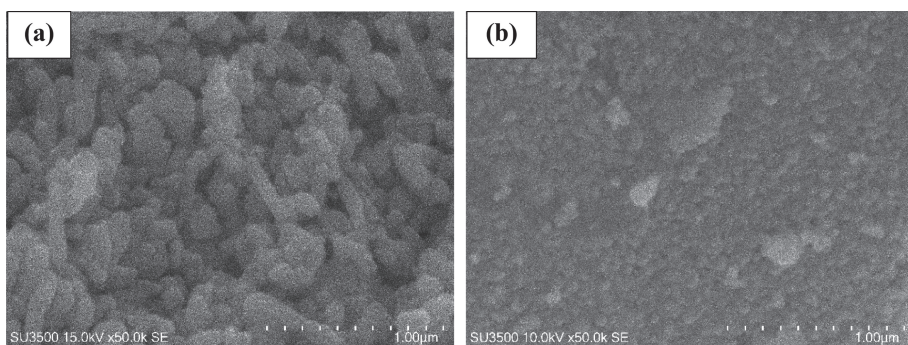


Figure 4. SEM images of ZnO NPs (a) without UGLE and (b) with UGLE.

4 CONCLUSION

The green synthesis of ZnO nanoparticles using *Uncaria gambir* leaf extract has been successfully carried out. The XRD pattern shows the high crystallinity of ZnO NPs with a hexagonal wurtzite structure. The particle size of ZnO NPs with UGLE (35 nm) is smaller than that of ZnO NPs without UGLE (65 nm). SEM analysis confirmed the spherical shape of ZnO NPs with UGLE and the rod shape of ZnO NPs without UGLE. The particle size of the spherical shaped NPs is in the range of 50–80 nm and the diameter of the rod-shaped NPs is approximately 60–120 nm. This shows that *Uncaria gambir* leaf extract affects the shape and the size of ZnO nanoparticles.

ACKNOWLEDGEMENT

This research has been supported by Beasiswa Unggulan Dosen Indonesia Dalam Negeri (BUDI-DN) through the Ministry of Research, Technology and Higher Education of the Republic of Indonesia (KEMRISTEKDIKTI), together with the Indonesia Endowment Fund for Education (LPDP).

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