Research Progress in Mechanical and Manufacturing Engineering Vol. 2 No. 2 (2021) 390-398

RPMME

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rpmme
e-ISSN : 2773-4765

Zinc Oxide Nanoparticle Synthesize by Green Approach

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DOI: https://doi.org/10.30880/rpmme.2021.02.02.044
Received 20 July 2021; Accepted 25 Nov.2021; Available online 25 Dec. 2021

Abstract: Zinc oxide has been widely investigated by many researchers due to their potential opto-electric devices. This review was implemented to prepare ZnO nanoparticles using green synthesis method and to investigate the characteristic of ZnO nanoparticles with different reaction temperature and reaction time. There are several methods to prepare the ZnO nanoparticles. For this review, ZnO nanoparticles are synthesize by using different type of leaf extract. Characterization process of ZnO nanoparticles was described by using a XRD, UV-vis and photocatalytic activity to study the effect of nanoparticles of ZnO, characteristic morphological with different reaction temperature and time.

Keywords: Zinc Oxide (Zno), Plant Extract, X-Ray Diffraction (XRD), UV-Vis, Photocatalytic Activity.

1. Introduction

Zinc oxide is an inorganic chemical compound commonly used in daily life. A very rapid growth of nanotechnology, visible in recent years has led to the development of zinc oxide nanomaterials with new properties. ZnO nanostructures have been the focus of substantial study due to their multifunctional capabilities in a variety of applications. The nanostructured ZnO has considered as a leading contender for use in sensors, energy harvesting, and a variety of electrical devices. In the biomedical and antiviral fields, several pronounced applications are currently being studied. This environmental friendly synthesis of metal and metal oxide nanoparticles utilizing biological supports has been actively investigated in order to replace commonly used chemical and physical processes in production [1].

Zinc oxide nanoparticles can be obtained through chemical, physical or biological processing. Chemical techniques include precipitation, microemulsion, chemical reduction, sol-gel and hydrothermal techniques, which when high pressure or temperature conditions are needed in the process, can lead to high energy consumption. Zinc oxide is one of the most significant semiconductor n-type materials in the UV region with a 3.37 eV band gap at room temperature and 60 meV excitation binding energy, making this nanoparticle an effective UV absorber. ZnO nanostructures offer a

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significant benefit when introduced to a catalytic reaction phase due to larger surface area and strong catalytic activity. Considering zinc oxide has variable chemical and physical properties depending on the morphological of nanostructures, it is critical to examine not only different techniques of synthesis, as well as the chemical and physical properties of synthesised zinc oxide in terms of its morphological [2].

The use of plants to synthesise novel nanoparticles and offers an alternative to chemical and physical synthesis that is cost-effective and environmentally friendly. Plant extract is selected as a material to get a nanoparticle of ZnO. Green synthesis process is usually used water as a solvent for plant extraction. By using aqueous extract from different plant extract, it can be less chemical used for environment safety. The objective of this research is to review the zinc oxide synthesis from aqueous extract plant and to evaluate secondary data of zinc oxide photocatalytic dye degradation potentials.

2. Materials and Method

2.1 Materials

In this study, there are several materials that was used to prepare ZnO solution as shown in Table 1. The zinc acetate dehydrates (Zn AC), distilled water (H_2O), the plant extract was used to produce the solutions of ZnO.

Table 1: List of raw material used to synthesis ZnO

Material	Molecular formula	Weight Molecule (g/mol)	Density (g/mL)
Zinc acetate dehydrate (ZnAC)	$Zn\ (CH_3COO)_2\ 2H_2O$	219.50	1.84
Distilled water	H_2O	18.02	1.000
Plant	NA	NA	-

2.1.1 Preparation of Aqueous Plant Extract

Before doing experiments such as the above topic related to the use of every plant need to do some preparation and washed with running water for several times and then with distilled water. Then the plant allowed to dry in the shade at room temperature until all moisture was lost. The dried plant was grinding by using a blender as a grinder for several times and then it is produced powder. The resulting powder yield two type of powder which is coarse and smooth powder. In this study, smooth powder is recommended to use for making a solution of plant extract. The plant powder was stored at room temperature and safety place for the further use.

For preparation of plant, 10 g powder of plant was boiled in double distilled water which 100 mL for 15 min and then transferred to beaker 500 ml and the content was placed on a magnetic stirrer. After finish 1h extracting, the mixture on the magnetic heater was removed, cooled, and finally filtered by using filter paper Whatman No.1 and stored in refrigerator at 4 °C for further use. Plant extract was stored in an airtight container at room temperature for next following cycles of synthesis preparation. The preparation of synthesis ZnO nanoparticles were explained in the next subtitle below based on the continuity of the plant extract produced.

Figure 1 : Example of plant powder

Figure 2 : Example of plant extract

2.2 Experimental Methodology

In this experimental methodology, the entire procedure for the processing of ZnO nanoparticles was carried out as stated. The method will include the use of raw materials, the equipment and apparatus used, the preparation of plant extract, the preparation of ZnO sol-gel nanoparticles, the synthesis of ZnO nanoparticles and the characterization of ZnO nanoparticles.

2.2.1 Synthesis of ZnO Nanoparticles

ZnO nanoparticles were synthesized in this study using zinc acetate dehydrate Zn $(CH_3COO)_2 2H_2O$ as previously mentioned. A 0.01 M solution of zinc acetate was taken, and plant extract was added. The zinc acetate was combined with the plant extract and stirred for 2 hours on a magnetic hot plate. The precipitate of ZnO was centrifuged for 15 minutes at 15000 rpm before drying and filtered using Whatman No. 1 filter paper and then dried using an oven to obtain the actual sample of ZnO nanoparticles. By varying different parameters included in this synthesis, the synthesis conditions of ZnO nanoparticles were optimized for the current reaction. The precipitate was initially dried at a reaction temperature of 60,70,80 and 90 °C. For this synthesis, the same temperature was used for the 30 m, 60 m, 90 m, 120 m drying time of the obtained precipitate.

Figure 3 : ZnO synthesis from plant extract

2.2.2 Characterization of Zinc Oxide

The obtained ZnO nanoparticles were characterized using various techniques to determine their size, shape, and functionalization. XRD analysis is used to identify the crystalline phases present in a material and thus reveal chemical composition information to determine the crystal structure. The specimen's needs should be used to establish the various parameters, such as scan step size, collecting time, range, X-ray tube voltage and current. The photocatalytic activity of ZnO nanoparticles in green synthesis was characterised and assessed by measuring the degradation of MB (test pollutant) UV radiation. With the assistance of photo-emitted charge pairs under visible light, photocatalysis requires oxidation and reduction reactions. For characterize the presence of plant extract through the bonding formation, UV-Vis were performed to produce Zno nanoparticle.

3. Results and Discussion

3.1 XRD analysis of ZnO NPs

The XRD device was performed as a characterization tool for sample to identify the crystalline size and structural properties of the ZnO nanoparticles by using plant extract [3]. Figure 4.1 shows the result of XRD pattern of biosynthesis ZnO nanoparticles by using a variety of plant extraction. Based on the result XRD pattern the analysis was performed almost at range $2\theta = 20^{o}$- 80^{o} and it was commonly a maximum range for ZnO nanoparticles.

ZnO nanoparticle samples were formed using *Calotropis procera* showed almost the same particle size of about 24nm based on XRD analysis [4]. This might be conceivable because of the stability as prepared of the samples. Based on the reported by Jamdagni a similar observation of ZnO nanoparticles were synthesized and was performed by using *Nyctanthes flower* extract. In their study, XRD were revealed a crystallite size about 16.58nm which falls within the size range 12-32nm. In this case, crystal agglomeration has occurred on the ZnO nanoparticles [5]. On the other findings by Ekennia,ZnO nanoparticle were synthesized by using *Alchornea Laxiflora* and found that particle size were calculate at 46mm [6].

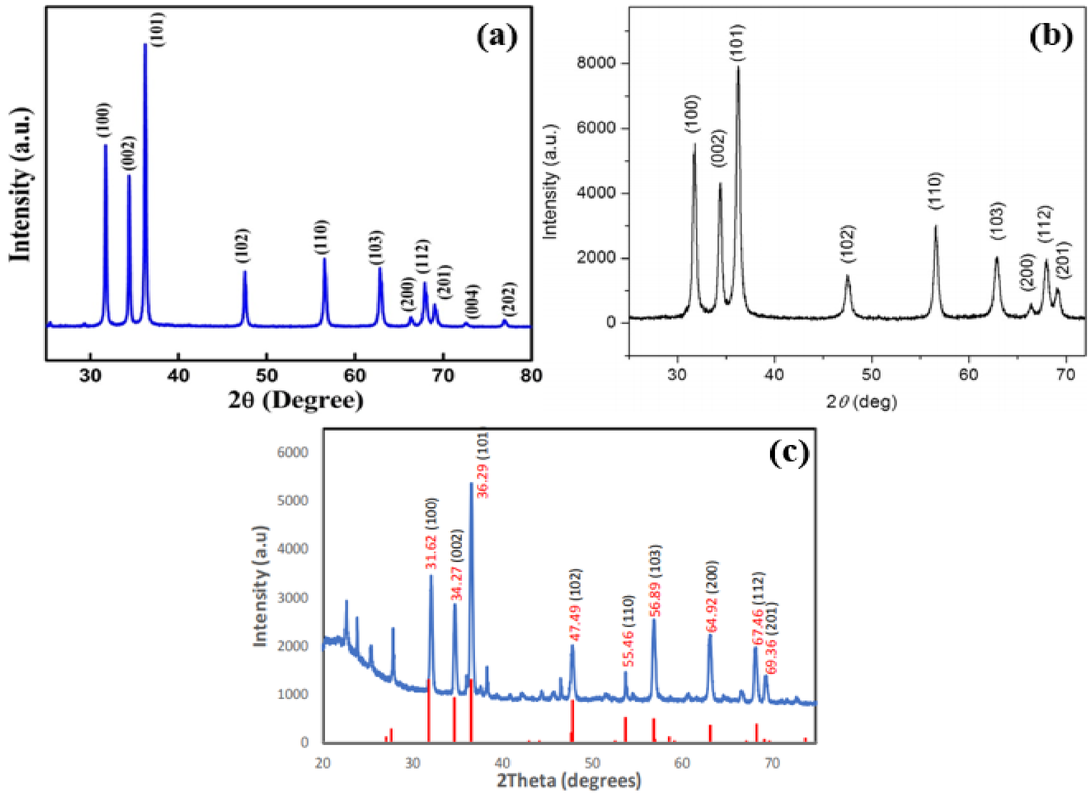

Figure 4 : (a). XRD pattern of synthesis ZnO NPs [4]. (b). XRD spectrum of ZnO NPs ([5]. (c) XRD diffractogram of ZnO NPs [6]

From all the XRD spectrum results of the sample ZnO nanoparticles, the samples were displayed the number of strong peaks diffraction corresponding to 100, 002, 101, 102, 111, 110, 103, 112 and 201 reflection lines of spherical and hexagonal wurtzite structure of ZnO nanoparticles. According to Suresh the peak number presence of 100, 002, and 101 on the XRD pattern result indicates the formation of high purity of the ZnO nanoparticles diffraction peaks from impurities were not detected, it showed that the samples are pure ZnO nanoparticles [7]. By comparing all the XRD patterns, all the samples indicated that all peaks correspond to the characteristic peaks of the hexagonal and spherical wurtzite structure of ZnO.

Plant extraction is often use as one of the alternatives to synthesis ZnO nanoparticles by using the biosynthesis method. Part of the plant such as leaf, fruit, stem, seed, and root are often been used for synthesis ZnO nanoparticles because of their character which is phytochemical features that their produce [2]. According to Sutradhar and Saha, natural extract or plant extract one of the most preferred sources for nanoparticle synthesis because it affected largescale production, production of stable, size of nanoparticles, and varied in shape of nanoparticles [8]. The main objective used plant extraction is as a reductant zinc salt which is zinc acetate, zinc chloride and zinc nitrate without using base group or perilous chemical and next, it allowed complexation of zinc ions with phytochemical contained in plant extract, and ZnO nanoparticles finally were produced [9].

3.2 Result of Ultraviolet-visible spectrometer (UV-vis)

UV-visible (UV-Vis) absorption spectroscopy is a significant optical characterization method that can be used to determine the band gap energy and absorbance of the sample nanoparticles under investigation [9]. The creation of ZnO nanoparticles is supported by a literature review based on UV-vis studies of green produced ZnO nanoparticles. Figure 5 represented on the nanoparticles of ZnO by using plant extract.

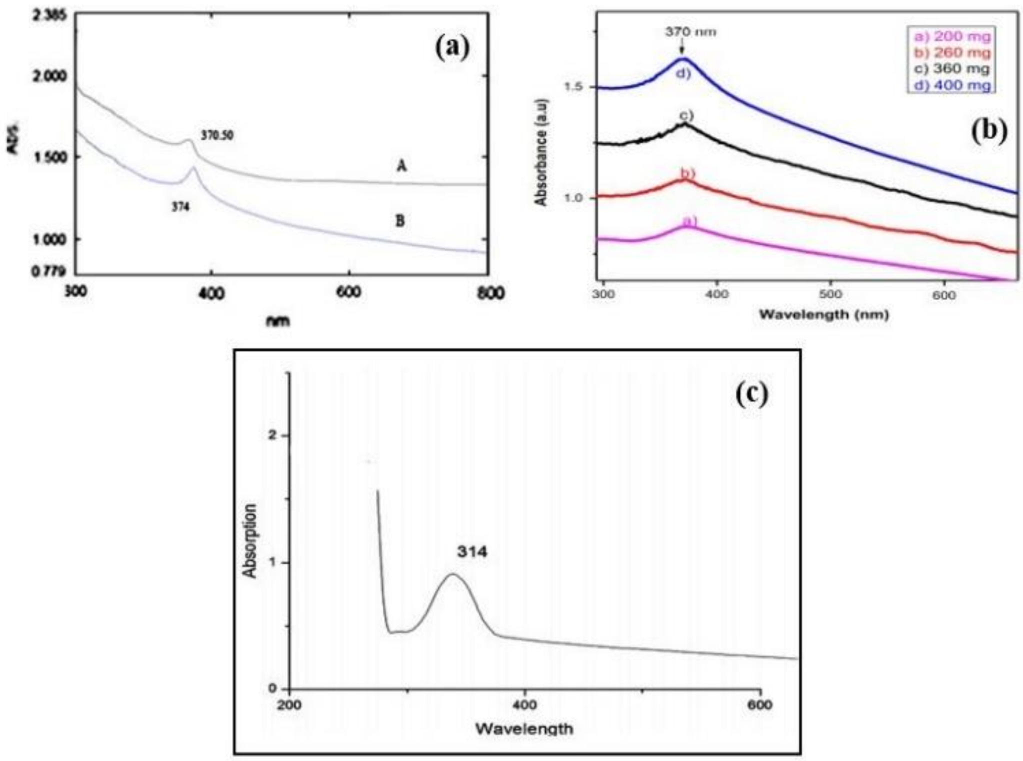

Figure 5 : (a) UV-Vis spectra of ZnO nanoparticles [10]. (b). UV-vis absorption spectra of ZnO nanoparticles [7]. (c). Uv-vis spectroscopy of synthesized ZnO nanoparticle [8]

Based on described by Rajiv, the synthesis of ZnO nanoparticles by using *Parthenium hysterophorus* extraction had small particles with high band gap energies when contrasted with the chemical for synthesize [10]. According to Suresh, the sum of *Cassia fistula* extract was diverse from 200, 260, 360, and 400 mg. The UV-Vis spectra showed the result from these samples absorption bands at 371.54, 371.50, 371.37, and 370 nm, respectively [7]. For Sutradhar and Saha findings mentioned that UV-vis spectrum of ZnO revealed an absorption peak at 345nm, which corresponded to the expected value for ZnO nanoparticles from tea leaf extract. Based on that, the absorption peaks are observed to shifts toward the lower wavelengths with an increasing the concentration extraction, leads to a steady increase in their optical band gap energy [8].

From the explanations above, it is clear that biosynthesized ZnO nanoparticles may have smaller particle size distribution than chemically synthesized ZnO nanoparticles and eco-friendly alternative to the chemical method in terms of almost zero contamination in the environment [11]. Regarding the observed above, that has many factors that were responsible for increasing the concentration of plant extract, the formation of smaller particles led to smaller particles while higher pH supported optimal absorbance rather than lower pH. Based on optimize considering all these factors, the ZnO nanoparticles of the desired size may be obtained.

3.3 Photocatalytic activity

Researchers have created a variety of biodegradable methods that are simple, efficient, cost-effective, non-toxic, and eco-friendly for treating wastewater and waste products that contain non-biodegradable colours that accumulate in ground water and the environment. In this regard, green synthesised ZnO NPs have high photocatalytic activity. [12].

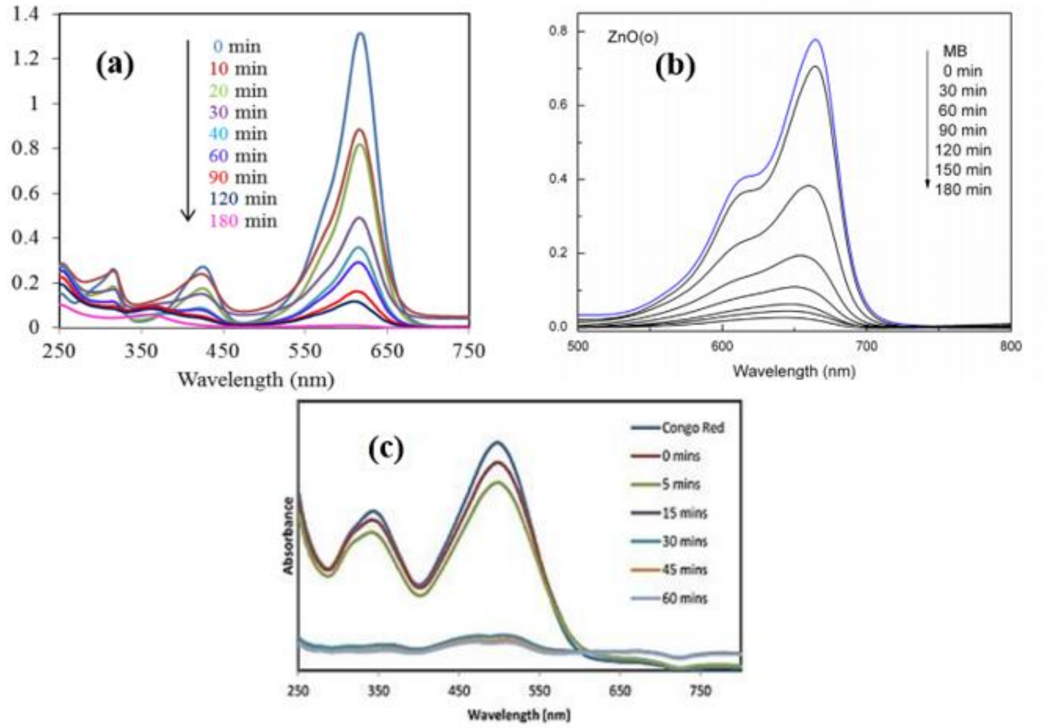

Figure 6: (a) Time dependent UV-Vis absorption spectra of photocatalytic degradation [13]. (b). Time dependent UV–vis spectral changes of MB (methylene blue) in the presence of ZnO [14]. (c) Absorption spectra at different time intervals [6]

Based on describe by Aminuzzaman, it displays the absorption spectra of *mangostana fruit* pericarp following photocatalytic degradation with ZnO at various solar irradiation durations ranging from 0 to 180 minutes. The findings show that MB dye has a strong absorption peak at 615 nm, which decreases slowly as the irradiation period increases [13]. According to Stan show *Petroselinum crispum*, the intensity of the peak position at 663 nm drop as the irradiation period increases, showing that the concentration of MB in the solution decreases significantly. After 30 minutes of equilibrium in the dark, it was noticed the amount of dye molecules maintained in the solution with ZnO [14]. In the study reported by Ekennia shows the destruction of Congo Red (CR) using ZnO NPs extracted from *Alchornea laxiflora* leaf extract. The peak has the greatest intensity at 508 nm and gradually fades as the irradiation time increases and the CR solution turns colourless. The dye was nearly completely degraded within 60 minutes, with an 87% degradation rate [6].

The maximum absorption peak in the examined sample of ZnO NPs ranges from 360 nm to 615 nm. During the first 30 minutes, the sample displays great photolytic activity by degrading dye by more than 50%. After 60 minutes, the dye degradation percentage exceeds 80%, and after 60 minutes and more, the dye turns colourless.

4. Conclusion

The review is on ZnO NPs that are synthesis using plant extract. The ZnO NPs are characterize using XRD, and photocatalytic activity is evaluate using UV-Vis Spectrophotometer. Zinc oxide is a multifunctional material with a wide range of essential uses, including UV absorbance, excellent photostability, and biodegradability. ZnO can also be produced in a variety of particle forms, which affects its utilization in advanced techniques and potential applications across a wide range of technical fields. As can be shown from the study of recent literature shown here, the requirement to produce the content of zinc oxide in particular materials while limiting the degree of agglomeration has led to the formation of various methods of displaying the ZnO surface. Numerous reports in the literature indicate that displaying processes can be carried out using FESEM, TEM, FTIR and EDX depending on how the systems obtained are to be used. In mixed with other materials, crystalline oxide powders provide the potential for better chemical, mechanical, optical, or electrical properties.

According to this review of the literature, zinc oxide can be classified as a multifunctional material. This is due to characteristics such as excellent chemical stability, a wide set of radiation absorption, and high photostability. It is fair to assume that interest in zinc oxide will continue to expand, resulting in the development of new applications for it.

Acknowledgement

The authors wish to thank to the Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia that has supported on the accomplishment of research activity.

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