# Characterization of Oil Palm Leaves and Effect of pH Variation on Sol-Gel Synthesis of ZnO Using Oil Palm Leaves

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*Abstract*— **ZnO is one of the most used nanoparticles globally these days. ZnO can be classified in the group of inorganic metal oxides that comprises a wide range of nanostructures. This research is focusing on the application of ZnO as the material for manufacturing food packaging. Production or synthesis of nanoparticles can be achieved by different methods. Some of the routes such are associated with environmental pollution. These problems lead to finding an alternative that can ensure a cleaner and safer route for synthesizing ZnO. Thus, using plant extract as reducing agents for synthesizing the nanoparticles provide more safe and convenient making it becoming the most preferred methods as they are clean and cost effective. Oil palm leaves was selected as the material for biosynthesis of ZnO nanoparticles because of its availability in this country as it generated as the by-product of palm oil. Thus, as for the aim of this study, characterization of the oil palm leaves must be done to study the zinc and other minerals contents of the oil palm leaves using ICP-OES and FTIR analysis. Green Sol-gel method is chosen as the method for synthesizing ZnO and to study the effect of pH variation to the properties of ZnO by using XRD and FTIR analysis. The FTIR analysis for the both leaves extract liquid and powder shows peak at 3316.09 and 3296.12 cm-1, respectively. This alcohol O-H stretching group indicates that the leaves extract has the similar hydroxyl bond with alcohol that makes it suitable for alcohol substituent for ZnO synthesis. The ICP-OES data confirms the presence of Zinc component in the leaves that indicates the compatibility of oil palm leaves for synthesizing of ZnO. The ZnO was synthesis at different pH. From FTIR analysis of the ZnO, it can be confirmed there was presence of ZnO in the precipitate as shown in the peak of the range 800-900 cm-1 for all variation of ZnO. It also confirms that indeed the pH of the solution does affect the properties of the synthesized ZnO. The XRD analysis shows that average size increasing from 15.19 to 20.51 nm as the pH of the solution increases from 7 to 12. The composition analysis of XRD exhibits that only at pH 12 the ZnO produce is in pure form.**

***Keywords— nanoparticles, synthesis, ZnO, pH, palm***

## I. INTRODUCTION

Nanotechnology especially nanoparticles plays a major part in science fields including chemistry, physics, biology and material sciences. These nanoparticles have spread its application throughout the globe and give certain amount of impact to various industries involving in manufacturing. Production or synthesis of nanoparticles can be achieved by different methods; chemical, physical, irradiation and biological (Bhumi and Savithramma, 2014).

ZnO nanoparticles have high level of antibacterial activity against high temperature and pressure resistant organisms such as spore (Nicole et al., 2008). This ability of ZnO makes it applications in designing microbial resistant material for preserving food, wood products cosmetics, wound dressing and disinfecting agents (Parthasarathy, et al, 2016).

ZnO nanoparticles commonly used as a transparent UV absorbers in polyolefins for manufacturing of food packaging (Drew, et al, 2016). The main purposes for the uses of nanoparticles in food packaging includes providing antimicrobial and barrier properties to prevent food spoilage, increasing the layer of mechanical properties such as emulsification, foaming and water binding capacity (Beltran, et al, 2014). It also works to enhancing the chemical-physical properties including thermal stability and crystallinity of the polymers used in food packaging for example polyolefins.

The development of new chemical or physical methods for synthesizing ZnO nanoparticles has resulted in environmental contaminations, since the chemical procedures involved in the synthesis of nanomaterials generate a large amount of hazardous byproducts. Some of the routes such as hydrothermal, sol-gel synthesis, micro emulsion methods and precipitation method are associated with environmental pollution and contamination (Ochieng, et al, 2015). In the light of recent research, many green synthesis method of producing nanoparticles that provides a clean, safe, eco-friendly and environmentally nontoxic is commonly applied (Bhumi and Savithramma, 2014).

This problem leads the manufacturers and researcher to find an alternative to produce greener and cleaner methods for synthesizing nanoparticles. In the past decades, there were many methods for green synthesis of nanoparticles that does not give negative impacts to the environment. Using plant extract as reducing agents for synthesizing the nanoparticles provide more safe and convenient making it becoming the most preferred methods as they are clean, cost effective, considerable rapid and often single step procedures (Ochieng et al, 2015). Furthermore, nanoparticles prepared using plant extract as the reducing as well as the capping agents have been found to be nontoxic and can be employed in medicine. Green synthesis routes provide nanoparticles of better defined sizes and morphology as compared to other physicochemical methods of producing nanoparticles (Raveendrand et al, 2003).

Malaysia is one of the largest producers of palm oil in the world. Oil palm tree originated from the tropical forest located in West Africa (Zawawi, et al, 2015). The first oil palm tree only planted in Malaysia around 1871. Being the main producer of the palm oil, the palm oil industry generated a large amount of waste including the leaves of the oil palm tree. Because of these reasons, oil palm leaves was selected as the material for biosynthesis of ZnO nanoparticles because of its availability in this country as it generated as the by-product of palm oil. In 2009, a total of 83 million tons of oil palm frond was produced (Roslan et al, 2014) and left in the plantation for nutrient recycling.

This research is focusing on the green synthesis of ZnO nanoparticles to reduce the negative impact from synthesizing ZnO nanoparticles by using oil palm leaves extract as the reducing agents. The parameter that is focused and set in this study is the pH and temperature of solution and reaction. How the pH can affect the physiochemical properties of the synthesized ZnO nanoparticles.

Thus, as for the aim of this study, characterization of the oil palm leaves must be done to study the zinc and other minerals contents of the oil palm leaves using Inductive Coupled Plasma (ICP) and Fourier Transform infrared spectroscopy (FTIR) analysis. Biological or green Sol-gel method is chosen as the method for synthesizing ZnO nanoparticles and to study the effect of pH variation to the properties of ZnO by using X-Ray Diffraction (XRD) and FTIR analysis.

## II. METHODOLOGY

### *A. Materials*

Oil Palm Leaves sample is used as the main material in this study. The leaves sample was obtain from an oil palm plantation in Felda Pasoh 3, Negeri Sembilan. For FTIR analysis, the chemical used was Methanol (ME) as solvent. For ICP analysis, the reagent used for microwave digestion is nitric acid.

### *B. Preparation of Samples*

The shade dried leaves of the oil palm leaves sample were powdered in mechanical grinder. For liquid sample, 20 grams of leaf powder of the samples was weighed. 150 ml of methanol solvent was added and kept for 3 days. The extract was filtered using filter paper and the supernatant was collected. The residue was again extracted two times (with 3 days of interval for each extraction) and supernatants were collected. The supernatants were pooled and evaporated at room temperature, until the volume was reduced to 150 ml. Extracts of the leaf powder and liquid samples with methanol were prepared and stored in air tight bottles for further analysis.

### *C. Characterization of Oil Palm Leaves*

#### *FTIR Analysis*

Dried powder of the extracts of the samples materials were used for FTIR analysis. The powdered sample of oil palm leaves sample was loaded in FTIR spectroscope, with a scan range from 400 to 4000 cm-1 with a resolution of 4 cm-1. The analysis was repeated using the liquid form of oil palm leaves sample that have been prepared

#### *Acid Digestion*

5 grams of Oil Palm Leaves powder sample was weighed out and put in a crucible. Then, the leave powder must undergo ashing procedure. The powder was put into a furnace at 200 °C overnight. After the process completion, the sample was weighed and put in a conical flask. 10 mL of sulphuric acid was added into the flask and stirred. The solution was then filtered using filter paper. Let the solution evaporated until half of the amount evaporated. Then, the solution was diluted with distilled water and stored for further analysis.

#### *ICP Analysis*

The ICP-OES is started up. To ensure sufficient stability of the plasma, it should be started up at least half an hour before the measuring operation. The wavelength is set to be 213.856 nm (Ruden et al, 2012). Calibration is carried out on a daily basis using the appropriate program options of the apparatus.

The coefficient of correlation r should be > 0.995. Should r < 0.995 and the calibration still be used, the reason must be explicitly stated. After calibration, the samples are analyzed under the same conditions as the standards. The prepared samples are diluted in order to be analyzed within the working range of the method.

### *D. Synthesis of ZnO using Sol-Gel method*

The oil palm leaves samples were cut into small pieces to make it easier to be grinded. The leaves samples then were dried in oven overnight to remove all the moisture content in the leave samples. After that, the dried samples were grinded in a mechanical grinder to obtain small and homogeneous particles. The grinded samples were stored in a container for further experiment.

20 grams of the leaves sample was weighed and boiled with distilled water for 4 hours. Then, the extract was filtered using filter paper with the aids of filter pump. The liquid extract then was pour into centrifuge tube for centrifuge process. This process was to remove any unwanted substance and impurities in the liquid extract.

2 grams of Zinc Acetate Dihydrate was weighed. The Zinc Acetate was used as the precursor for the reactions to occurs. The weighed Zinc Acetate Dihydrade then was mixed with 400 mL of distilled water in 500 mL beaker. The solution was stirred using magnetic stirrer on a hot plate for 10 minutes. The 20 mL of prepared sample of leaves extract was added drop wise using a dropper. The initial pH and temperature of the solution was recorded.

2 Molar of Sodium Hydroxide solutions were prepared. By using a dropper, the NaOH solution was added into the beaker until the pH of the solution reached 12. The solution was stirred for about 4 hours. A precipitate occurred and leave for rest. After that, the solution was filtered and the precipitate was collected. Then, the precipitate was put on aluminium foil and dried in oven overnight.

The precipitate was weighed and recorded. Then the precipitate was grinded in mortar and pestle to obtain fine powder form. The sample was stored for further analysis.

The experiment was repeated using different pH of solution of 11, 10, 9 and 7. All data was recorded for further analysis.

### *E. Characterization of ZnO Nanoparticles*

The synthesized ZnO nanoparticles from the oil palm leaves extract is obtained and undergoes characterization process to determine its characteristics. Two analyses using two equipments will be conducted in this research. The first characterization is by using the same equipment which is Fourier Transform infrared spectroscopy (FTIR) analysis. It is used to determine the functional group of the particle after it has been synthesized and ZnO particle is formed. The next analysis is the X-Ray Diffraction analysis. The purpose of this analysis is to determine the phase presence in the molecule of ZnO and to examine the average size of the nanostructure that has been formed earlier.

#### *FTIR Analysis*

The ZnO nanoparticle that has been recovered is washed with ethanol and distilled water to remove any residual substance and surfactant molecules. After that, the nanoparticles is dried and proceeed to the analysis.

The same procedure used for characterization of the leaves extract is used in this analysis. The powdered sample of each plant specimen was loaded in FTIR spectroscope), with a scan range from 400 to 4000 cm-1 with a resolution of 4 cm-1.

#### *X-Ray Difraction (XRD) Analysis*

Basically, to conduct an X-Ray diffraction test to the particle of ZnO, the basic requirements is the sample of ZnO that have been synthesized, the X-ray source and a detector to pick up the rays that have been diffracted.

## III. RESULTS AND DISCUSSION

### *A. Introduction*

In order to achieve the objectives of this study, a few experimental analyses had been done. The experimental analysis of this study was divided into two main parts. The first part is to study the characteristic and analysis of chemical compound and the functional group of the oil palm leaves sample. FTIR and ICP analysis is done for this part of study.

The second part of this study is by using the same sources of oil palm leaves, ZnO nanoparticles have been synthesized and the characteristic of the nanoparticles was studied. The main discussion in this research is to study the effect of pH and temperature to the physical and chemical properties of the synthesized ZnO nanoparticles. The synthesized ZnO will be studied based on the functional group by FTIR analysis and XRD analysis for the phase identification of the crystalline material that is formed and providing on information on the cell unit dimensions. Based on these properties, the results will be compared to identify the effects of different pH and temperature to the synthesized ZnO.

## *B. FTIR Analysis of Oil Palm Leaves*

Fourier Transform Infrared Spectrophotometer (FTIR) can be categorized as the most reliable tool to identify the types of functional group or the types of chemical bond in a compound. The wavelength of light absorbed is characteristic of the chemical bond as can be seen in the annotated spectrum. By interpreting the infrared absorption spectrum, the chemical bonds in a molecule can be determined.

After the sample preparation of the oil palm leaves which have been obtained was done for the analysis, the sample was undergoes the FTIR analysis. The first sample for FTIR analysis was prepared in liquid form. A few steps of preparation were done in order to obtain the liquid extract of the oil palm oils as shown in the procedure of preparation.

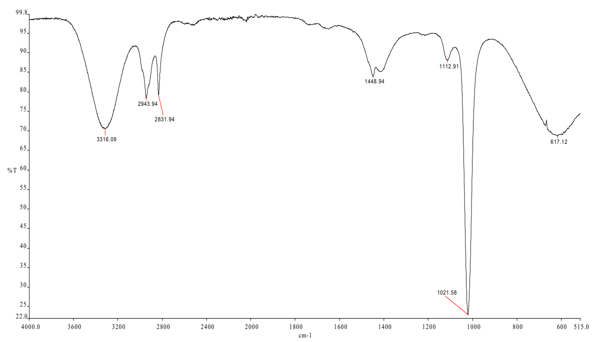


Fig. 1: FTIR Spectra for Oil Palm Leaves Extract (liquid form).

As can be seen in figure 1, the FTIR spectra for the liquid samples of oil palm leaf extract was shown and can be observed for the analysis. The FTIR spectroscopy determines the types of functional group that is available in the sample.

There are a few major peaks that can be seen from the spectra that were in the diagnostic region. The diagnostic region is the region where the peaks located at region above 1500 cm-1. This type of bonds usually has strong absorption from the stretching vibration. The peaks in the diagnostic region which is 3316.09 cm-1 that is in the range of 3200 – 3600 region corresponded to O-H (alcohol) stretching vibrations. It can be said that the sample contains the trace and belongs to the group of cellulose and water absorbing material (Nordin et. al, 2016). The second major peak is at 2943.94 cm-1 which in the range of 2850 – 2970 cm-1 region that belongs to C-H stretching vibration. There is no peak at all at the range 1500 – 2000 and 2000 – 2500 cm-1 indicating that there is no trace of triple bond and double bond, respectively.


Fig. 2: FTIR Spectra for Oil Palm Leaves Extract (Powder form).

The figure 4.2.2 shows the FTIR spectra of oil palm leaves extract that was prepared in powder form. There were no major differences can be observed when comparing with the oil palm leaves extract in the liquid form since the both of the samples were obtained from the same source and not subjected to any treatments or modification. The only difference can be seen is at the intensity and the level of absorption of the bond. As can be observed, the first major peak at 3296.12 cm-1 which is located at the range 3200 – 3600 cm-1 belongs to the O-H (alcohol) stretching vibration. Similar to the sample in liquid form, it can be said that the sample contain the traces of cellulose and water absorbing materials. The second major peak that is shown in the spectra is at 2917.31 cm-1 is in the range 2850 – 2970 cm-1 which corresponded to the C-H stretching vibration. Lack of peaks at the range 1500 – 2000 and 2000 – 2500 cm-1 on both samples indicated that there is no C=O stretching of hemicelluloses and lignin. Also there is no trace of C=C aromatic skeletal vibration of lignin contained in the oil palm leaves extracts. Both of these components only present in the frond parts of the oil palm tree as has been studied by Nordin et al, (2016). Both samples show really strong absorption of O-H stretching vibration that corresponded to the hydroxyl bond that is similar with alcohol. This makes the oil palm leaves extract can be used as the substitutes of alcohol, methanol for example as the solvent for the synthesizing of ZnO nanoparticles that is way cleaner and safer for the environment.

Table 1: List of peak FTIR spectra of Oil Palm Leaves Extract

| **Oil Palm Leaves Extract** | **Peak Values (cm-1)** | **Functional Groups** |
|---|---|---|
| Liquid | 3316.09 | O-H Stretching Group |
| | 2943.94 | C-H Stretching group |
| | 1021.58 | |
| | 617.12 | |
| Powder | 3296.12 | O-H Stretching Group |
| | 2917.31 | C-H Stretching group |
| | 2849.69 | |
| | 1039.21 | |

## *C. ICP-OES Analysis of Oil Palm Leaves*

The Inductive Coupled Plasma – OES requires specific sample of preparation of the oil palm leaves extract in order to make it possible for the equipment to analyze the content of zinc in the oil palm leaves samples. The sample preparation procedures were included the ashing procedure where the sample of oil palm leaves that have been dried and grinded was put in furnace overnight. This step was needed for acid digestion process.

## *D. Synthesis of ZnO Nanoparticles*

After the characterization for the oil palm leaves was completed, the sample then was used for the synthesizing of ZnO nanoparticles. The parameter that was set in this experiment was the pH and temperature of the solutions. Different pH were set during this experiments which are 7, 9, 10, 11 and 12. The temperatures of the solutions were recorded and after the precipitate produces were filtered and dried, the ZnO precipitate were weighed and recorded.

As can be seen in the table 2, the ZnO has been synthesized at different pH. As expected, at different pH, the recorded temperature will be affected and will give out different values. The weight of ZnO precipitate that has been dried was recorded and also gives out different values as the results of different pH of the solution. The weight of the ZnO precipitate was gradually increased as the pH of the solution increased. The initial pH of the solution that was recorded have slight different values but still in the similar range. The initial pH of the solution should have similar value because there is no addition of NaOH yet at the initial state of the solution.

Table 2: Synthesis of ZnO at different pH

| pH | Initial pH | Weight (g) |
|---|---|---|
| 7 | 5.65 | 0.47 |
| 9 | 5.97 | 0.59 |
| 10 | 5.96 | 0.58 |
| 11 | 5.62 | 0.77 |
| 12 | 5.24 | 0.81 |

## *E. FTIR Analysis of ZnO Nanoparticles*

In FTIR, the intensity-time output of the interferometer is subjected to a Fourier Transform to convert it to the family infra-red spectrum for example, the intensity frequency. The identification of the atomic arrangement and the concentrations of the chemical bonds present in the samples have been carried using Fourier Transform Infra-red Spectroscopy (FTIR), in which percentage transmission and wave number are the output.

Table 3: FTIR data for ZnO Nanoparticles at Different pH

| ZnO at different pH | Peak Values (cm-1) | Functional Groups |
|---|---|---|
| pH 7 | 3372.55 | O-H Stretching Group |
| | 2923.13 | C-H Stretching group |
| | 880.96 | Zn-O Bond |
| pH 9 | 3392.45 | O-H Stretching Group |
| | 2913.93 | C-H Stretching group |
| | 823.57 | Zn-O Bond |
| pH 10 | 3340.16 | O-H Stretching Group |
| | 2922.13 | C-H Stretching group |
| | 810.26 | Zn-O Bond |
| pH 11 | 3335.15 | O-H Stretching Group |
| | 2918.03 | C-H Stretching group |
| | 810.29 | Zn-O Bond |
| pH 12 | 3356.19 | O-H Stretching Group |
| | 2918.03 | C-H Stretching group |
| | 815.16 | Zn-O Bond |

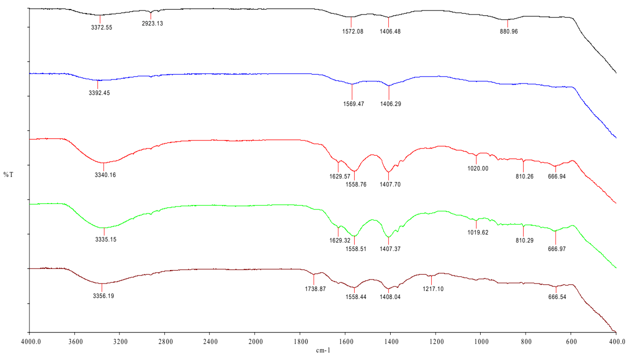

Fig. 3: FTIR Spectra for Oil Palm Leaves Extract (Powder form).

FTIR spectra in Figure 3 show the IR spectra of the ZnO samples at different pH. Basically, all the IR spectra of have a quite similar series of absorption peaks ranging from 1000 to 4000 cm–1, corresponding to the carboxylate and hydroxyl impurities in materials because of sourcing from the same component. To be more specific, a broad band ranging between 3200 and 3600 cm–1 is assigned to the O-H stretching mode of hydroxyl group and associated with the extracted polyphenols from the plant extract. Peaks between 2830 and 3000 cm–1 are due to C-H stretching vibration of alkane groups. The peaks observed at 1600 and 1400 cm–1 that are clearly visible on all the spectra at different pH are due to the asymmetrical and symmetrical stretching of the zinc carboxylate, respectively.

The increasing in pH of the solution will cause the size of the nanoparticles increases as discussed in the literature review. According to G. Xiong et al, (2006), as the size of the nanoparticles increases, the content of the carboxylate (COO-) and hydroxyl (-OH) groups in the samples decreased. The carboxylate probably comes from reactive carbon containing plasma species during synthesis and the hydroxyl results from the hygroscopic nature of ZnO. Together this suggests that these FTIR-identified impurities mainly exist near ZnO surfaces.

Another visible peak that is visible in every spectrum at different pH was at the range 800 to 900 cm-1. The peak at this range was attributed to characteristic absorption peak of Zn-O bond. Reported similar investigations have shown that metal oxides give absorption bands in the fingerprint regions below 1000 cm-1 arising from inter-atomic vibrations (Ochieng et. al, 2015).

Almost all the peaks share quite the same properties and does not have vast amount of different because the only difference that differentiate during the synthesis of this ZnO was only the pH of the solution. For example, at pH 7, the peaks at C-H stretching in the extract and nanoparticle spectra remained considerable intact while the OH peak almost vanished. This implies that phenolic compounds containing OH groups like flavanols and caffeic acid present in the oil palm leaves extract might have been responsible for the synthesis of ZnO nanoparticles. In addition, it was observed that the nitrile groups from proteins showing stretching band around 2921.13 cm-1, carbonyl groups at 1572.08 cm-1 was still present in the spectrum of the ZnO nanoparticles. These compounds might have been responsible for the capping of the ZnO nanoparticles by forming a layer covering the nanoparticles and thus preventing agglomeration and providing stability of the material.

## *F. XRD Analysis of ZnO*

X-Ray diffraction (XRD) technique is widely used in research and development and industry for material characterization and process control, as it can provide detailed information about lattice parameters of single crystals, phase, texture or even stress of polycrystalline materials. Analysis of XRD peak profiles indicated that full-width at half-maximum (FWHM) is sensitive to the variation in microstructure and stress–strain accumulation in the

Table 4: XRD Data of ZnO Nanoparticles at Different pH

| No. | pH | Crystal | Volume | FWHM | Height (cps) | D (nm) |
|---|---|---|---|---|---|---|
| 1 | 7 | Hexagonal | 47.720 | 0.6429 | 82.480 | 0.2819 |
| 2 | 9 | Hexagonal | 47.609 | 0.4228 | 103.71 | 0.2816 |
| 3 | 10 | Hexagonal | 48.067 | 0.4466 | 108.02 | 0.2833 |
| 4 | 11 | Hexagonal | 47.490 | 0.5407 | 110.73 | 0.2812 |
| 5 | 12 | Hexagonal | 47.807 | 0.5235 | 106.73 | 0.2819 |

Table 5: XRD Properties of ZnO Nanoparticles at Different pH

| No. | pH | Composition | 2Theta | Average Size (nm) |
|---|---|---|---|---|
| 1 | 7 | Zincite, Syn | 36.2285 | 15.19 |
| 2 | 9 | ZnO (0.99), Co (0.01) | 36.2568 | 16.46 |
| 3 | 10 | ZnO (0.99), Co (0.01) | 36.0803 | 18.08 |
| 4 | 11 | ZnO (0.99), Co (0.01) | 36.2907 | 20.48 |
| 5 | 12 | ZnO (1.00) | 36.1727 | 20.51 |

material. Many researchers have successfully attempted the use of FWHM in different manufacturing processes.

A handful of researchers have identified various material properties via the FWHM of XRD peaks. An increase in stacking faults and structural disorder widens the XRD peaks. Increases in hardness and density of point defects affect the crystallinity and grain boundary mobility, which in turns causes a linear increase in the FWHM of XRD peak. Presence of tensile stress in the material causes increase in the FWHM while relaxation of tensile stress decreases FWHM. This means that peak width (FWHM) due to crystallite size varies inversely with crystallite size as the crystallite size gets smaller, the peak gets broader. The crystallite size broadening is most pronounced at large angles 2 Theta.

According to the spectrogram of the crystal structure, the well defined peaks typical of all ZnO at different pH in the crystal structure of ZnO for are clearly noticed. This is in compliance with the reports of the norms of the joint committee on powder diffraction standard JCPDS card number 36-1451. The peaks are in well defined shape and form. This clearly indicates the crystallinity of the synthesized nano-particles. According to Jenkin et al 1996, the particle size affects the effect on broadening of the peaks in the XRD spectrogram.

As can be seen in the table 4, the average size of the ZnO that has been synthesized at different pH was varied. As the pH of the solution increased, the size of the ZnO also increased. When the concentration of OH- ions because the pH is low, ZnO nanoparticles do not grow in size due to the lack of Zn(OH)2 formation in the solution. Since the solution with pH less than 7 would not have sufficient OH- concentration, no formulation of nanoparticles has been observed. For pH greater than 7 formulations of nanoparticles is observed. When ZnO reacts with hydroxide ion (OH -), the dissolution of OH- occurred. The variation in FWHM of the dominating 2θ peak was occurred with increasing pH. It can be clearly seen that FWHM decreases on increasing pH. The decrease in FWHM with increase in pH implies the increase in crystallite size.

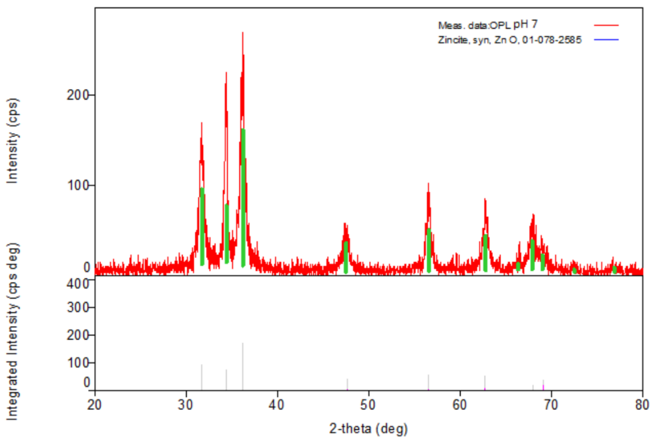


Fig. 4: XRD Graph for ZnO Nanoparticles at pH 7

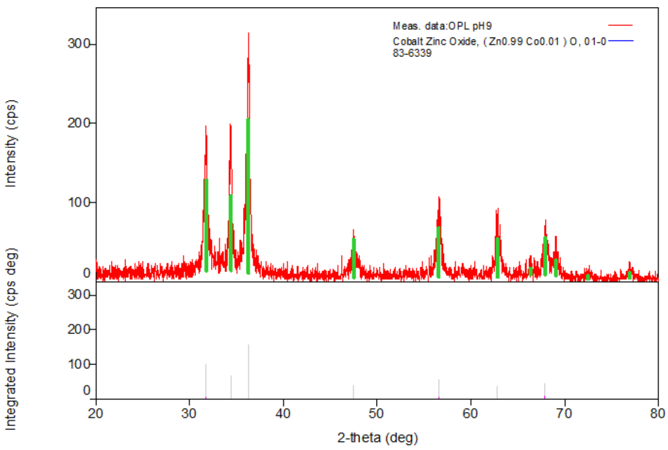


Fig. 5: XRD Graph for ZnO Nanoparticles at pH 9

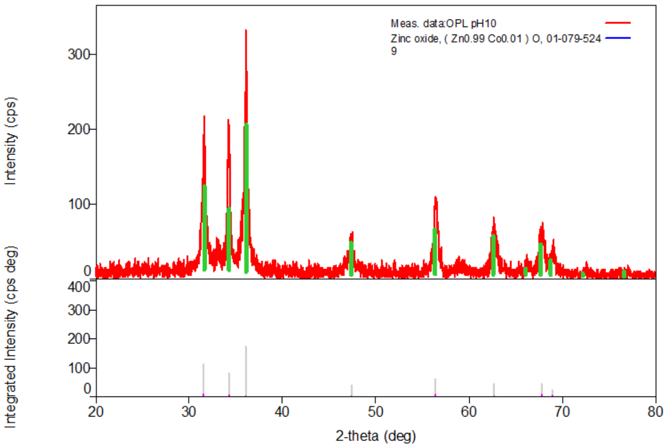

Fig. 6: XRD Graph for ZnO Nanoparticles at pH 10

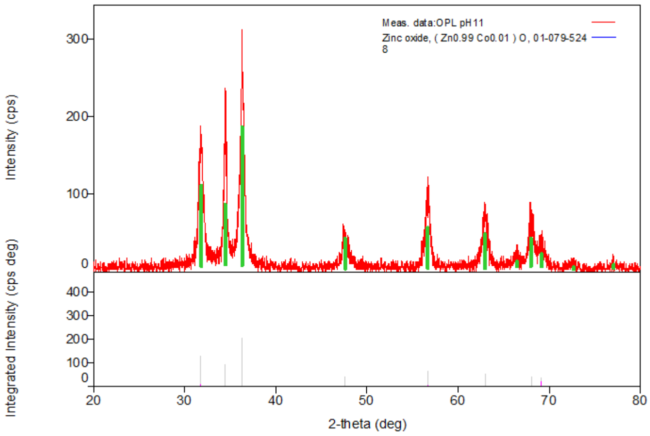

Fig. 7: XRD Graph for ZnO Nanoparticles at pH 11

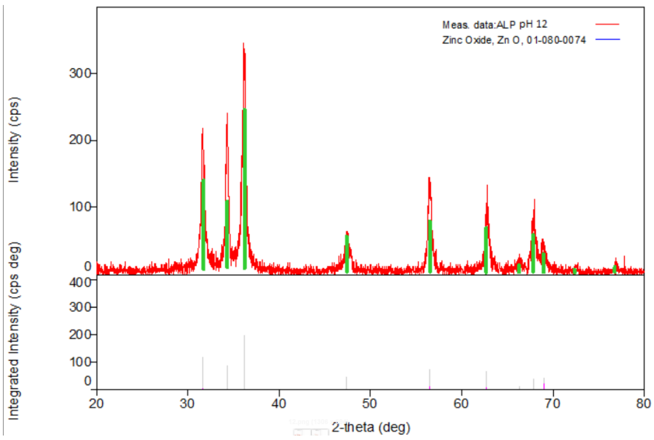

Fig. 8: XRD Graph for ZnO Nanoparticles at pH 12

XRD graph in Figure 4 to 6 shows the XRD graph peak analysis for the ZnO Nanoparticles at different pH. It gave us the information about the elements of the particles formed at pH 7, 8, 10 and 12. From the graph, it can be inferred that the purity of nano ZnO produced increased as pH increased. Only at pH 12 the 100% ZnO without any contamintants or mixture with other compounds were obtained. According to Ikono et. al, (2012), the growth of ZnO is normally enhanced in basic medium. The final growth of ZnO depends upon the competition between growth and etching of the solution. The size became significantly bigger at basic or alkaline condition maybe because high purity ZnO nanoparticles tend to bind each other and agglomerate.

In lower pH, although the particle was much smaller in size, the ZnO obtained was still in mixture with other compounds, such as CH3COONa and Zn(OH)2, therefore they tend to be separated, hence each has small size. Furthermore, at pH 7 there was almost no ZnO particles could be observed. It can be understood that at pH 7, the growth of ZnO was suppressed. It can be predicted that at pH lower than 7, there might be no ZnO produced by sol-gel method using protocol implemented in this research.

## IV. Conclusion

The FTIR and ICP-OES analysis that has been done to the sample of oil palm leaves shows that the oil palm leaves does possessed a variant properties of its kind and made a suitable reagent for the synthesis of ZnO nanoparticles. The FTIR analysis for the both leaves extract liquid and powder shows peak at 3316.09 and 3296.12 cm-1, respectively. This alcohol O-H stretching group indicates that the leaves extract has the similar hydroxyl bond with alcohol that makes it suitable for alcohol substituent for ZnO synthesis. The ICP-OES data confirms the presence of Zinc component in the leaves that indicates the compatibility of oil palm leaves for synthesizing of ZnO. Using oil palm leaves extract as the alternative for better and cleaner method of synthesizing of ZnO has been proved by many researches and studies. This approach of using plant extract, oil palm leaves as example as the substituent for chemical reagent clearly offer a much safer alternative for this application because of non-toxic properties and free from environmental contaminants. Furthermore, using oil palm leaves as the material for synthesizing was also cost effective as it is mainly considered as the source from agricultural waste.

The analysis from the results and discussion reveals a few deductions. From the FTIR analysis of the ZnO, it can be confirmed the presence of ZnO in the precipitate as shown in the peak of the range 800-900 cm-1 for all variation of ZnO. It also confirms that indeed the pH of the solution does affect the properties of the synthesized ZnO nanoparticles. Increasing in the pH of the solution resulting in the increasing of the average size of ZnO produced.

Besides, the results proved that by increasing the pH of the solution, the purity of ZnO will also increasing. The XRD analysis shows that average size increasing from 15.19 to 20.51 nm as the pH of the solution increases from 7 to 12. The composition analysis of XRD exhibits that only at pH 12 the ZnO produce is in pure form.

Environmental problem related to hazardous substance from the synthesis of nanoparticles created the urge for researchers and manufacturers to come out with better approach for creating safer and cleaner method for synthesizing ZnO. Thus, using plant extract as the material for synthesizing ZnO has been applied and developed over the years as it gives many advantages rather than conventional methods.

As summary, all the objectives of this study has been achieved and completed. The successful of synthesizing ZnO from oil palm leaves extract and to study the effects of pH variation towards the properties of the ZnO that have been produced can be further improvise. Even though all the data shows in the result fulfilled the hypothesis, the results were not very significant and show only small differences. Few adjustments can be made for example, such as using different equipments for better analysis and various types of data that can be discussed.

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