



## Preparation of bunker C fuel oil mediated ZnO nanoparticles for supercapacitor applications

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### Abstract

In the present work demonstrates a sol-gel approach for the preparation of nanosized ZnO for use in supercapacitor applications. For that zinc acetate dihydrate and sodium hydroxide have been utilized in the presence of solvent medium bunker C fuel oil. The preparation of ZnO NPs was analyzed for their structural, morphological and electrochemical properties. The results of X-ray diffraction imply that the prepared particles are having hexagonal wurtzite structure with average crystallite size of the ZnO NPs are 19 nm. SEM micrograph of ZnO NPs was observed by spherical like morphology. The cyclic voltammetry of ZnO NPs provides the peaks of oxidation and reduction revealing its supercapacitor nature. Furthermore, at a scan rate of 10 mV/s, ZnO exhibited a capacitance of 396 F/g for supercapacitor application.

**Keywords:** bunker C fuel oil; ZnO; nanoparticles; Sol-gel; supercapacitor

### 1. Introduction

Metal oxides in the nano dimension have consumed ample space in the field of science and technology owing to their wide spread applications. Among the metal oxides, novel properties like binding energy, high refractive index, thermal conductivity and electrochemical nature of ZnO suggesting its usage in supercapacitor applications [1]. There are several methods like sol-gel, thermal decomposition; chemical vapor decomposition and alloy evaporation-deposition have been reported so far to prepare ZnO nanoparticles [2-13]. Compared with other methods, the sol-gel approach is suitable for the preparation of ZnO nanoparticles because it is carried out at low temperature. Fernanda *et al.*, have reported the electrochemical properties of microwave assisted hydrothermal synthesized ZnO. Kuwang *et al.*, have studied the electrochemical properties of ZnO prepared by the precipitation method. As per the available literature researches have prepared the ZnO NPs using different solvents like ethanol, water, ethanolic acid, ionic liquid and NH<sub>4</sub> OH and show different morphologies and crystallite size [16-19]. In the present work, we have attempted to prepare ZnO nanoparticles by a sol-gel approach for use in supercapacitor applications. For that zinc acetate dihydrate and sodium hydroxide have been utilized in the presence of solvent medium bunker C fuel oil. Further, the synthesized particles were analyzed for their structural, morphological and electrochemical properties of ZnO nanoparticles.

### 2. Materials and Method

#### 2.1 Materials

ZnO nanoparticles were synthesized using zinc acetate dihydrate (C<sub>4</sub>H<sub>6</sub>O<sub>4</sub>Zn 2H<sub>2</sub>O), sodium hydroxide (NaOH pellets), glycolic acid, bunker C fuel Oil, ethanol and ultra pure DI-water. All reagents were used without any further purification.

#### 2.2 Preparation Method

During the sol-gel synthesis of ZnO, were taken as 0.98 g of zinc acetate dihydrate and 0.5 g sodium hydroxide in 50 ml of deionized water added to 25 ml glycolic acid in 100 ml of bunker C fuel oil and magnetically stirred for 30 min at a temperature of 90 °C. Next, to initiate the ionization of the zinc acetate 25 ml of ethanol was added drop by drop. The entire solution was stirred for 10 h to convert the solution into a gel. The resulting gel was washed several times with water and then dried at 150 °C for 2h. The dried product was then annealed at 750 °C for 8 h to get gray colored ZnO powder.

#### 2.3 Characterization Techniques

The X-ray diffraction (XRD) patterns of the powdered samples were recorded using X'PERT PRO diffractometer operating at 40kV and 30 mA with Cu-K $\alpha$  radiation ( $\lambda = 1.5406 \text{ \AA}$ ) over the range 10° to 80° (2 $\theta$ ) at room temperature. The FT-IR spectrum was recorded using Perkin Elmer - Spectrum with a resolution of 4 cm<sup>-1</sup>. Measurements were performed with pressed pellets which were made using KBr powder as diluents. SEM image was recorded using JSM-6610LV scanning electron microscope. Electrochemical measurements were carried out using CHI 660 cyclic voltammetry in 0.2 M tetra butyl ammonium per chlorate aqueous electrolyte using a three electrode system. Of the three electrodes, ZnO, Ag/AgCl and a platinum wire were served as working, reference, and counter electrodes, respectively.

### 3. Result and discussion

#### 3.1 Structural Analysis

The X-ray diffraction pattern of the ZnO nano powder were recorded in the diffraction angle ranging between 10° and 80° and the obtained pattern is shown in Fig.1. As shown in the figure, all the diffraction peaks are sharp and intense are

exactly matched with the hexagonal wurtzite ZnO (JCPDS card no 36-1451). The sharpness of the peaks specifies that the prepared particles are highly crystalline in nature. The average crystalline size of the particles was calculated from Scherrer equation  $D = K\lambda / \beta \cos\theta$ , where D is the mean size of crystallites (nm), K is crystallite shape factor a good approximation is 0.9,  $\lambda$  is the X-ray wavelength,  $\beta$  is the full width at half maximum (FWHM) in radians of the X-ray diffraction peak and  $\theta$  is the Bragg's angle. In the present study suggest that the crystallite size of the ZnO NPs is observed 19 nm.

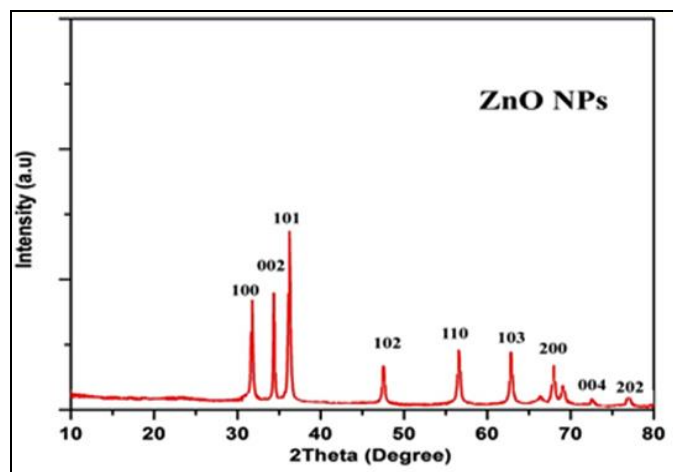


Fig 1: XRD spectrum of ZnO NPs

### 3.2 Functional group analysis

ZnO NPs was analyzed using FT-IR spectroscopy within range 4000-400  $\text{cm}^{-1}$  and obtained spectrum is shown in Fig.2. The characteristic peaks are observed at 3432, 2929 and 2852  $\text{cm}^{-1}$  indicates the presence of -OH vibrations. The absorption bands at 2343 and 1635  $\text{cm}^{-1}$  are showing the presence of  $\alpha$ , and  $\beta$  unsaturated compounds. The peaks appearing around 1444 and 1138  $\text{cm}^{-1}$  are ascribed to aromatic and aliphatic vibrations [20, 21].

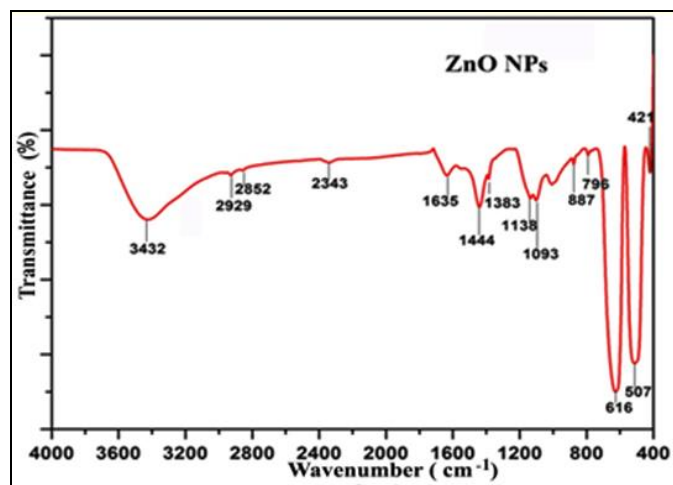


Fig 2: FT-IR spectrum of ZnO NPs

The presence of peak at 1383  $\text{cm}^{-1}$  represents O-H bending vibration, whereas, the peak at 1093  $\text{cm}^{-1}$  indicates bending

vibration of C-O. The vibrational frequencies of ZnO are presented at 887 and 796  $\text{cm}^{-1}$ . The strong bands appearing at around 616, 507 and 421  $\text{cm}^{-1}$  represent Zn-O stretching vibrations.

### 3.3 Scanning Electron Microscope (SEM)

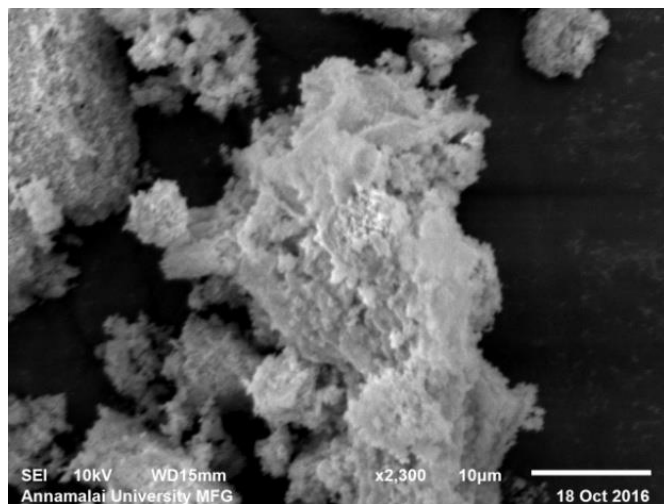


Fig 3: SEM image of ZnO NPs

Fig.3 represents scanning electron micrograph of Bunker C fuel oil mediated ZnO NPs. The SEM micrograph clearly shows that most of the particles display more or less of spherical morphology with a little agglomeration. The better dispersing ability of Bunker C fuel oil is the potential reason for little agglomeration [22, 23]. Agglomeration impact was very familiar in natural solvents as results of organic solvent have higher dispersing ability. The decrease particle size is originating in one amongst a sort solvent medium [24, 25].

### 3.4 Electrochemical property

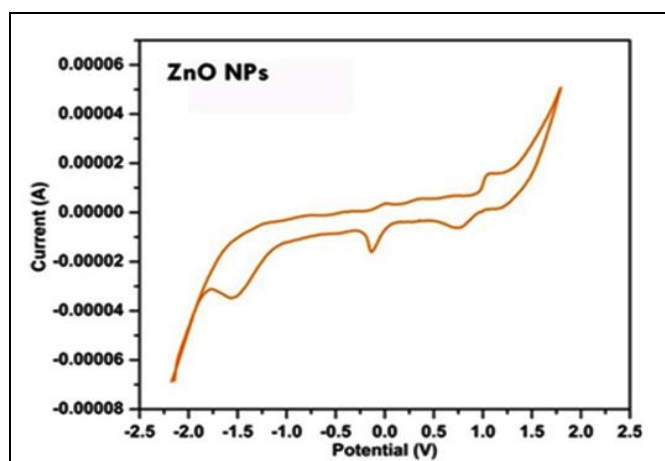


Fig 4: Cyclic voltammetry of ZnO NPs

Cyclic voltammetry (CV) can give adequate information regarding the suitability of the electrode material for supercapacitor applications. Fig.4 depicts that cyclic voltammetry curve of ZnO NPs. From the figure, shows that the CV curve of the ZnO NPs recorded at a scan rate of 10

mV/s in the potential range of - 0.25 to +0.25 V using 0.2 M tetra butyl ammonium per chlorate aqueous electrolyte. As shown in the figure.4, shape of curve from rectangle might be due to the pseudocapacitive properties of the synthesized nanoparticles. ZnO shows a pair of redox peaks, indicating the pseudocapacitance of the prepared electrode. The value of capacitance was calculated from the usual formula and is 396 F/g. The present study suggests that the scan rate 10 mVs<sup>-1</sup> with specific capacitance value of 396 Fg<sup>-1</sup> is suitable for supercapacitor application.

#### 4. Conclusion

A sol-gel approach was used to fabricate ZnO electrode for use in supercapacitor applications. XRD result confirmed the hexagonal wurtzite crystal structure of ZnO. The crystallite size was observed by ZnO NPs were 19 nm. The presence of functional groups and the chemical bonding with Zn are confirmed by FT-IR spectrum. The SEM micrograph clearly shows the presence of spherical particles with a little agglomeration implying that the selection of solvent is a key factor for obtaining high quality of nano-sized ZnO via the sol-gel route. Furthermore, the analyzed electrochemical properties suggest that the ZnO electrode is the most suitable for supercapacitor applications due to its capacitance of 396 F/g which is suitable for supercapacitor application

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