The Influence of Sodium Dodesyl Sulfate Surfactant On the Physical Properties of ZnO by Wet Chemical Synthesis

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Abstract

ZnO nanoparticles have drawn a widespread attention recently due to their novel properties which contribute to various applications especially in gas sensing and optoelectronic devices. This paper presents a surfactant-assisted complex wet chemical method for the controlled preparation of Zinc Oxide (ZnO) nanoparticles using zinc acetate as starting material. Here, the spherical ZnO nanoparticles with average size of less than 50 nm were successfully synthesized and their optical properties were measured. In order to maximize its efficiency, surface modification with surfactants is vital as ZnO nanoparticles easily agglomerate. The effects of the surfactant on the average particle size and morphology of the ZnO nanoparticles were investigated using scanning electron microscopy. Well dispersed ZnO nanoparticles with a uniform size distribution were obtained using Sodium dodesyl Sulfate as a surfactant. The addition of surfactants controlled the particle size and reduces the formation of agglomerates and at the same time helped to produce more homogenous and uniformly dispersed particles.

Keywords: zinc oxide, nanoparticles, surfactants, wet chemical process.

INTRODUCTION

Nanotechnology, another wide concern in modern research and development activities performs much functional operations at quantum level for the prepared powder samples. In particular, ZnO (zinc oxide) is one of the most valuable materials in the study of crystal control because of its electronic and optical properties which are strongly influenced by the various morphologies, crystal sizes, dimentions and aspect ratios(1).Additionally,ZnO,as one of the popular n-type semiconductor metal oxides (SMOS),exhibits a wide band gap(3.37eV) and a high mechanical stability at room temp with a high exciton binding energy of 60 meV.(2).The synthesis procedure has a welcoming feature on the controlled growth of ZnO nanostructures (3,4).As most commonly, the methods involved in nanoparticle synthesis, nanoparticles microwave irradiation gains much importance due to production cost, higher yield rate and enhanced performance (5).On the other hand, the synthesis of nano-crystalline ZnO through wet chemical processes generally needs surfactants to reduce the long reaction time and also to enhance the poor crystallinity of ZnO obtained at low temperature. The effect of different surfactants on the ZnO nucleation has been discussed by many researchers (6-14). ZnO is a polar crystal and some surfactants or polymers interact with specific ZnO facets by chemical adsorption on a polar plane or physical adsorption on a certain plane. So, the surfactant has a speciality to adjust the growth velocity on different ZnO facets. In this paper, we report an easy approach to synthesize single crystalline ZnO with various morphologies using sodium dodesyl sulfate as surfactant. By adding the amount of SDS (sodium dodesyl sulfate) we can modify the size and shape of ZnO nanoparticles (15). Here two samples with different concentrations such as 0.1molar and 0.3molar concentrations were reported.

EXPERIMENTAL PROCEDURE

The synthesis strategy for ZnO nanostructure fabrication starts with the sequence of reactions. The precursors used for this investigation are Zinc acetate and liquid ammonia. Initially Zinc acetate was dissolved in double distilled water to obtain 0.1molar concentration. In the same way SDS also dissolved in double distilled water to obtain 0.1 molar concentration and the same solution was added drop by drop to the zinc solution. The solution was stirred vigorously and the pH value of the solution was adjusted to 8 by adding liquid ammonia. This solution was placed in microwave oven and irradiated for 15 minutes. The obtained product was filtered and washed with double distilled water. Finally, the sample was dried and kept in furnace at 120°C for 5 hours. The structural properties of ZnO nanoparticles with SDS was investigated by Fourier Transform Infrared Spectroscopy (FTIR), Scanning electron microscopy (SEM) and the optical properties were studied using UV visible spectroscopy.

Results and discussion

SEM ANALYSIS

To prove the role of surfactant on controlling the size and morphology of ZnO, a detailed investigation by electron microscopy was performed. Figure 1 and Figure 2 shows the SEM images of the samples synthesized. From the SEM photographs, it was understood that the samples consist of small and big grains. The variation in the morphology seemingly correlate with the variation in the crystallinity of the particles. The figure shows the ZnO synthesized at different molar ratios of SDS; 0.1 and 0.3 respectively. When SDS was added, the surfactant may cap the ZnO grains to inhibit further lateral growth. Therefore, the increase of SDS concentration gives the clear structure of the ZnO grains.

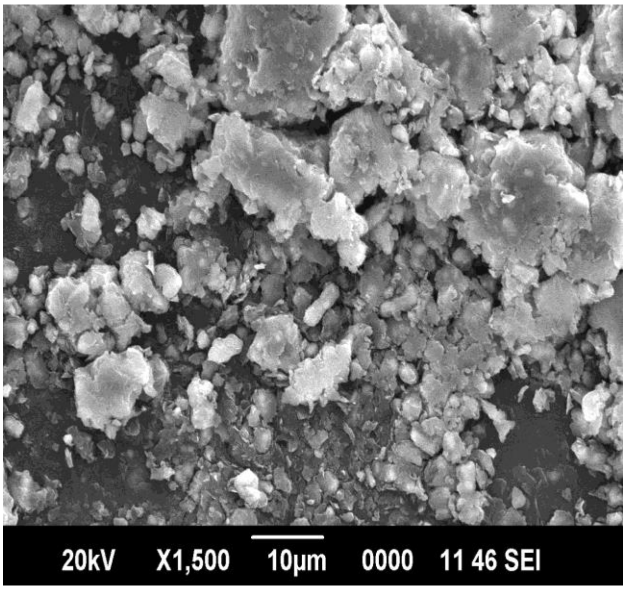

Fig 1.SDS with 0.1 molar concentration

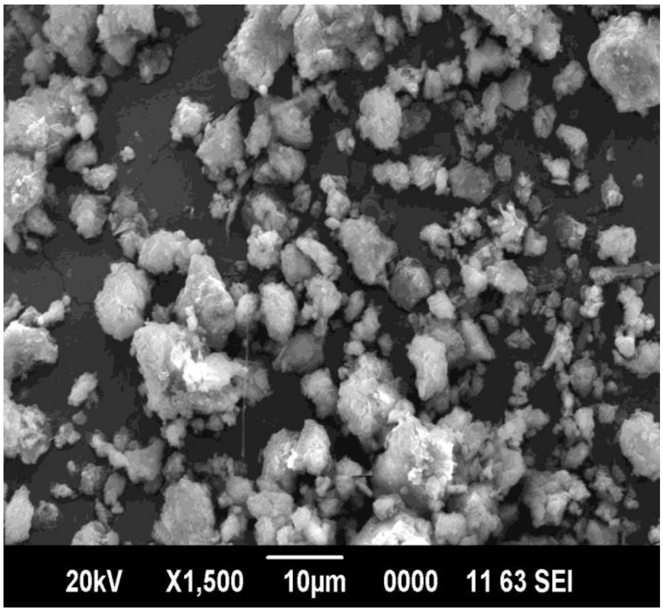

Fig 2.SDS with 0.3 molar concentration

EDAX ANALYSIS

EDAX analysis was carried out in order to investigate the elemental composition of the ZnO synthesized with surfactant. Fig 3 and Fig 4 shows the typical EDAX spectrum obtained. It can be evidenced only intense of Zn atoms peaks and single small peak which is associated with O. EDAX elemental analysis quantified the presence of Zn, O in the 1 to 1 atomic ratio, as expected for pure ZnO.

Table 1 : EDAX Results

S.NO	*Molar Concentration*	*ZnO wt %*	*O wt %*
1.	0.1M	61.8	13.42
2.	0.3M	51.44	18.61

The Table 1 shows the chemical composition of the synthesized ZnO nanostructure with a different molar concentrations of surfactant SDS.

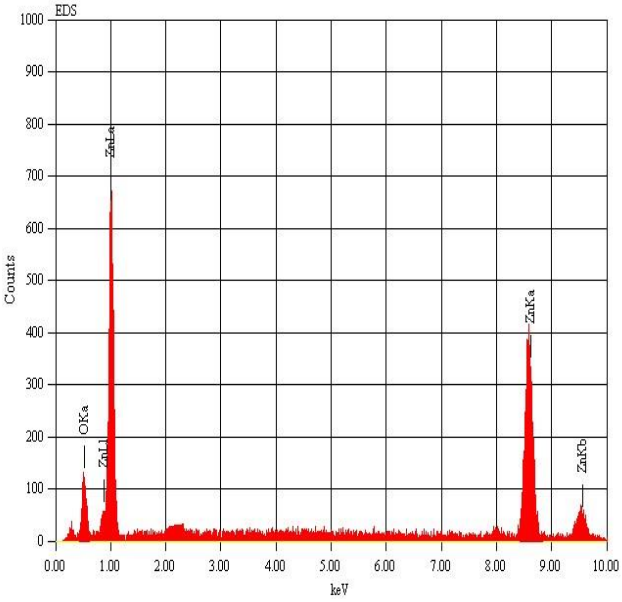

Fig 3.SDS with 0.1 molar concentration

FTIR ANALYSIS

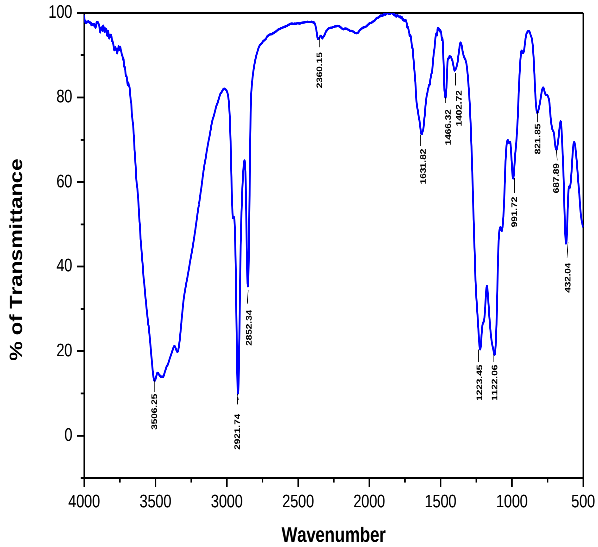

Fig 5.SDS with 0.1 molar concentration

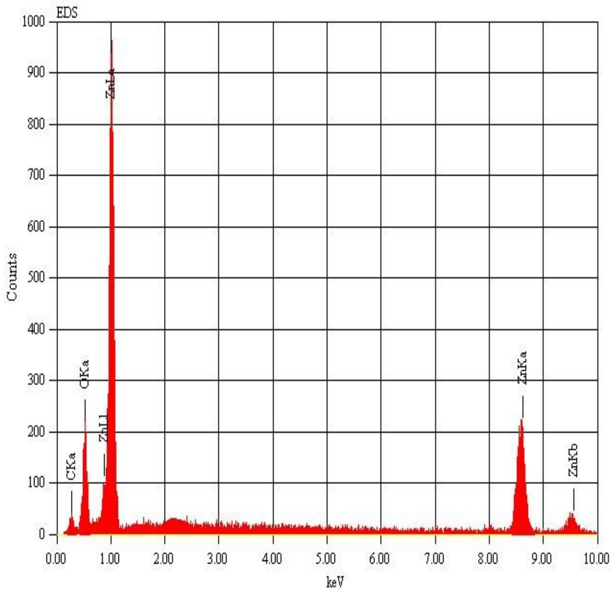

Fig 4.SDS with 0.3 molar concentration

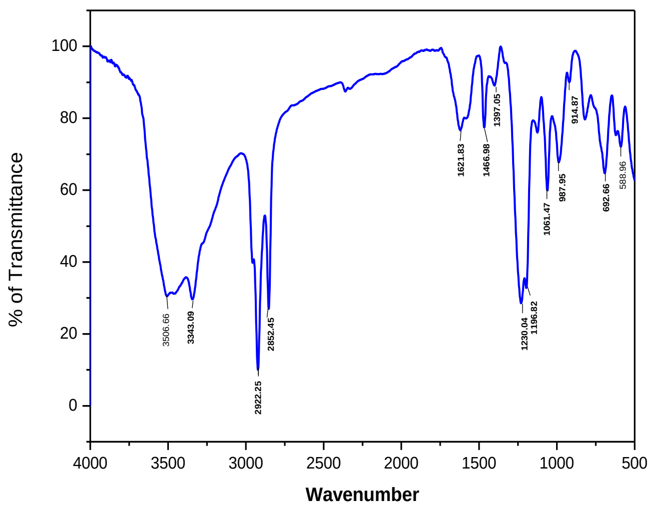

Fig 6.SDS with 0.3 molar concentration

To analyse the adsorption of surfactants on the surface of ZnO nanostructures, FTIR spectrum was recorded in the range of 4000-500 cm $^{-1}$ (Figure 5 &6). Samples prepared using SDS with two different molar concentrations 0.1M and 0.3M shows quite similar bands at 3506 cm^{-1} , 1621 cm^{-1} and 1402 cm^{-1} which corresponds to N-H stretching vibration and N-H bending respectively. The characteristic peak of ZnO absorption Can be clearly observed at 588.96 cm^{-1} and 432.04 cm^{-1} which clearly shows that by increasing the molar concentration of SDS, the peak shifted to lower wave numbers.

UV ANALYSIS

The UV-Visible spectrum is studied by Perkin-Elmer Lambda 35 spectrometer with nanoparticles of 0.1M concentration and 0.3M concentration in the range 200 to 800 nm.

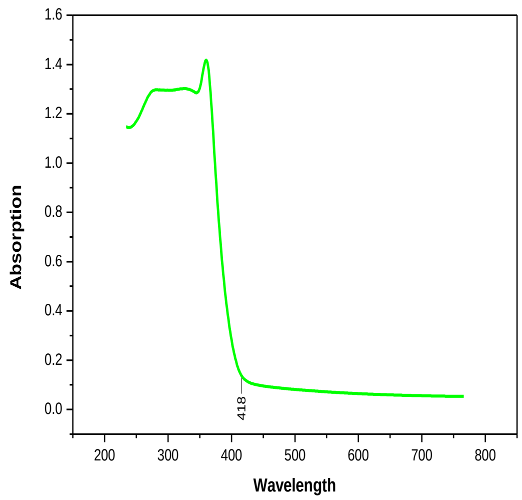

Fig 7.SDS with 0.1 molar concentration

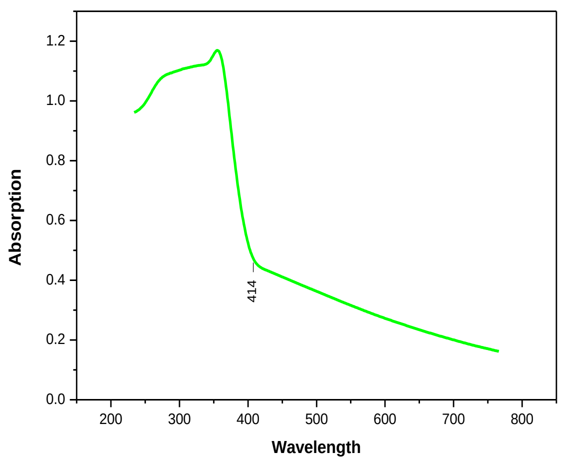

Fig 8.SDS with 0.3 molar concentration

Table 2: UV-VISIBLE RESULTS

S.NO	*Molar concentration*	*Absorption edge*	*Cut off wavelength (nm)*
1.	0.1M	1.417	418
2.	0.3M	1.168	414

The transmission range and transparency cut off wavelength are important for nanoparticles. The recorded transmittance spectrum is shown in Figure 7 & 8 for molar concentration 0.1M and 0.3M .The lower cut off wavelength are at 418nm for 0.1M and 414nm for 0.3M . The transmittance range is about 80% for 0.1M and 85% for 0.3M concentration respectively. The absorption edges are found to be 1.417 and 1.168 and hence for the fabrication of application oriented optical devices, the modification of optical parameter such as adsorption edge is extremely important.

CONCLUSION

ZnO nanoparticles were prepared by the microwave irradiation route by using SDS as surfactant. Morphological as well as optical properties were observed. These variations were dependent on the increase of the molar concentration of the surfactants. Moreover, by increasing the molar concentration of surfactant it seems that there is a shift in the characteristic peak of ZnO to lower wave numbers. The addition of surfactant to ZnO nanoparticles shows the better results in improving the crystallinity and structure of ZnO powders which in turn enhance its characteristic nature.

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