World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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FTIR study of ZnO powder prepared by self-combustion method at different temperature

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World Journal of Advanced Research and Reviews, 2021, 10(03), 277–280

Publication history: Received on 10 May 2021; revised on 15 June 2021; accepted on 17 June 2021

Article DOI: https://doi.org/10.30574/wjarr.2021.10.3.0237

Abstract

Nowadays nanomaterial is used widely because of their change in characteristics from bulk to nano. In this paper the preparation of ZnO nano powder by self-combustion high temperature method was discussed. The solution of Zinc Nitrate as a precursor and dextrose as a fuel was kept in furnace at 400,500 and 600 ^{0}C for 5-15 minute to complete the reaction. The ZnO thick films were prepared by screen printing and fired at 650 ^{0}C. The effect of different synthesis temperature on ZnO thick films were study by FTIR analysis. The applications of zinc oxide powders were discussed in these papers.

Keywords: Nano-powder; Zinc nitrate; FTIR; Self-combustion; Precipitation

1. Introduction

Semiconducting II-VI group zinc oxide (ZnO) has been attracting material for research because of different application of ZnO. The electrical, optical, photochemical, structural characteristics of ZnO has made it one of the most widely used materials amongst other metal oxides. ZnO is an interesting material for a variety of application ranging from cosmetics to laser and sensing operation. ZnO is an important electronic and photonic material because of its wide band gap of 3.37eV. Nowdays ZnO nano crystals have been used for gas sensor [1], solar cell application [2] and for some pollutant gas detection [3].

Of all the materials investigated, semiconductor metal oxides are promising for monitoring the harmful volatile organic compounds for example simple fabrication process, rapid response and recovery and low cost. Various different fabrications methods from lithographic to chemical have been developed today's world. In present work we have used the self-propagating high temperature gel combustion method. Gel combustion method gives a homogenous high purity and high quality nano powders due to the possibility of stoichiometric control. In gel combustion an oxidizing agent (usually a nitrate compound) and a fuel as a reducing agent are used. A suitable ratio of oxidant to fuel is required because it create a high heat induced from the reaction (exothermic reaction).

In gel combustion method, the raw materials are dissolved in water. The mixed solution is heated to change the sol to a high viscosity gel. Then increasing temperature causes the exothermic combustion process where fuel gets ignited by the oxidizer to yield oxide. In an exothermic combustion process the reducing and oxidizer changes the gel to a very fine and porous substance. The final product will be prepared by calcination.

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In this work, a gel combustion method was used to prepare ZnO nano powder using zinc nitrate and dextrose [3].

2. Experimental Procedure

The experiment was carried out using analytical grade zinc nitrate hexahydrate and dextrose as a raw material. The specified amounts of zinc nitrate hexahydrate (1.35M) and dextrose (0.79M) were dissolved in 25ml double distilled water. The solution was heated on hot plate up to 80 °C. As the solution dehydrates and changes to a high viscosity gel. The solution was placed in a preheated muffle furnace at different temperature [4]. For this study we choose the temperature 400, 500 and 600 ˚C. The solution boils, ignites with flame and total reaction was completed with 5 to 15 minutes. The powder was highly amorphous. The powder was calcinated at 650 °C. The FTIR pattern of this powder provides the information about its functional group.

3. Results and discussion

3.1. FTIR study of prepared ZnO powder

FTIR spectrum is the characteristic of a particular compound providing information about its functional group, molecular geometry and inter/intra molecular interactions. The infrared spectrophotometer provides a record of the infrared absorbency or transmittance of a sample as a function of wave number. The functional groups in the substance was indicated by the frequencies at which absorption occurs.

The FTIR is taken as [5] transmission/absorption mode spectra in the range of 4000 cm^{-1} to 400 cm^{-1} for 650°C sintered/fired pure ZnO powder and is the best characterization from sensor point of view. Generally it is carried at in air. The sample was taken after few days for recording the FTIR spectra after sintering at 650°C. Hence it has effect of atmospheric moisture.

Fourier Transform Infrared (FTIR) spectroscopy (Perkin Elmer 100 FTIR) was used to characterize the presence of oxide group in synthesized zinc oxide powder. Fig.1 shows the FTIR spectra of ZnO powder synthesizes at 400 °C. The spectra locating at 485 cm^{-1} attributes to Zn – O stretching vibration in the ZnO lattice this shows the ZnO bond. The bond at 1927 cm^{-1} is due to C = O stretching of dextrose. The absorption peaks at 3126 cm^{-1} due to OH stretching vibration of adsorbed water.

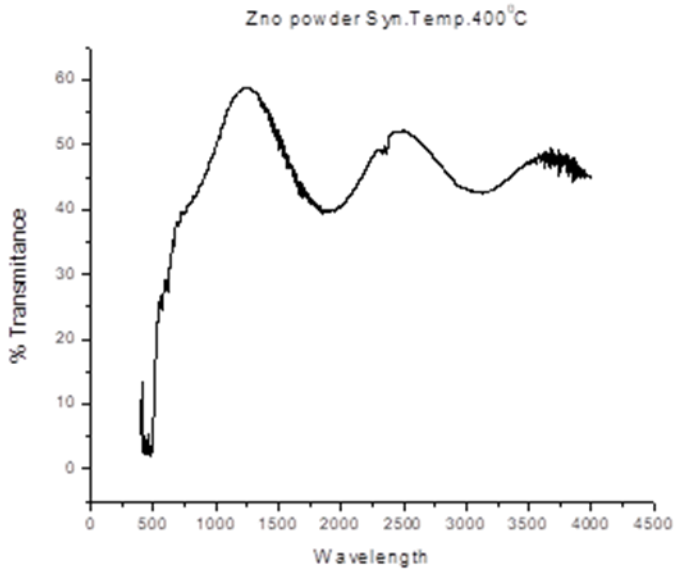

Figure 1 FTIR spectra of ZnO powder prepared at 400 °C

Figure 2 shows the FTIR spectra of ZnO powder synthesizes at 500 °C. The absorption peak situated at 471 cm^{-1} showing the bond formation of ZnO bond. The peak at 3352 cm^{-1} is due to OH stretching vibration of adsorbed water.

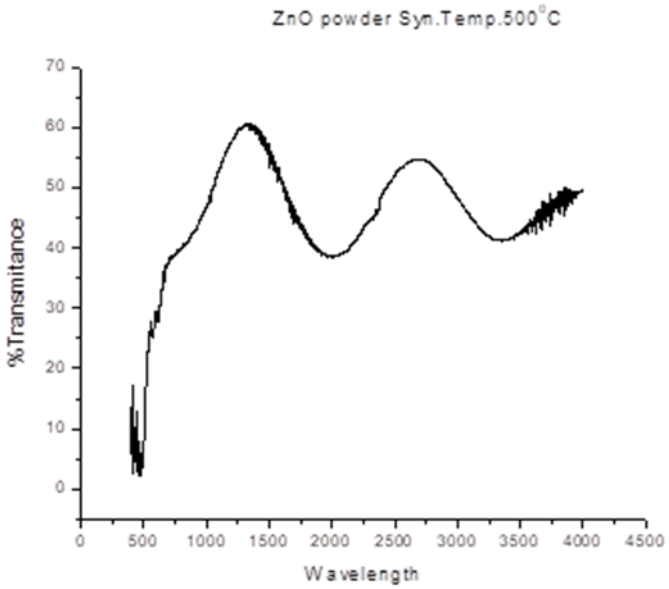

Figure 2 FTIR spectra of ZnO powder prepared at 500 ℃

Figure 3 shows the synthesis temperature of ZnO powder was 600 °C. The 468 cm^{-1} attributes to ZnO stretching vibration in the ZnO. The peak at 1027 cm^{-1} is due to symmetric stretching vibration bonds of N –O which indicates the presence of nitrate complex. The peak at 1573 cm^{-1} is due to vibration of $–CH_2$ group. The peak at 2871 cm^{-1} is due to C – H stretch.

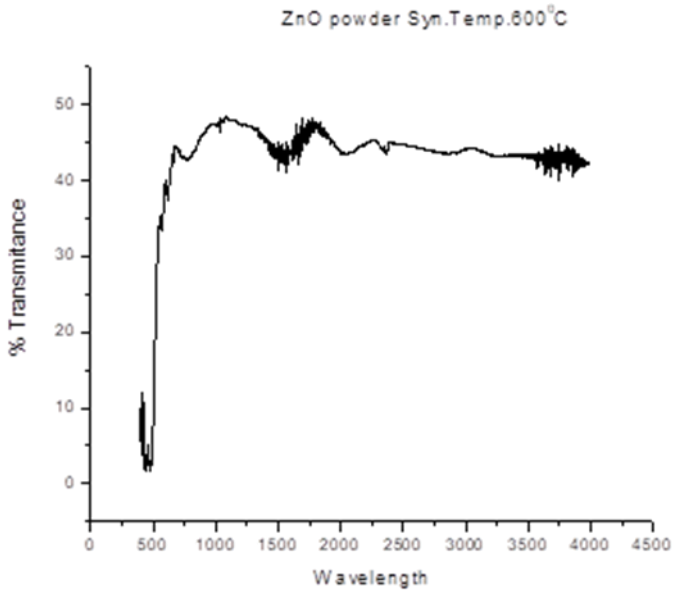

Figure 3 FTIR spectra of ZnO powder prepared at 600 ℃

As IR spectra showing characteristics band of ZnO in fingerprint region which can be used for confirmation of the shape of ZnO particles. Spherical particle of ZnO has absorption bands at 512 and 406 cm^{-1}. In present work we obtain band at 485 cm^{-1}, 471 cm^{-1} and 443.8 cm^{-1} are believed as spherical particle of ZnO.

4. Conclusion

The ZnO powder was prepared by gel combustion at different high temperatures. The dextrose was used as a fuel. The FTIR of the synthesized powder confirms the formation of ZnO in spherical shape. The availability of OH bond shows the presence of moisture in the powder.

Compliance with ethical standards

Acknowledgments

We are very much thankful to our institute MGV's M.S.G. College Malegaon for cooperation and promoting for research always. Also thankful to the coauthors for helping, guiding and promoting for research. For analysis they provide me the facility for analysis. Available in their respective labs.

Disclosure of conflict of interest

None.

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