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Synthesis, Characterization and Application of undoped and doped ZnO- photocatalyst

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Abstract:

Undoped and doped ZnO photocatalyst anywhere characterized by Fourier transform infra red (FTIR), Diffuse reflectance spectra (DRS), Scanning electron microscope (SEM), Brunauer-Emmett-Teller (BET) and X-ray diffraction (XRD). From these studies we investigate the optical absorption (λ_{max}), functional group, surface morphology, particle size and elementary composition of undoped and doped ZnO. The dopants used where five atomic percentage of Mn^{2+}, Fe^{2+}, Co^{2+} and Ni^{2+}.

Keywords: *photocatalyst ZnO metal doped, FTIR, DRS, BET, SEM and XRD.*

1. Introduction

Extensive band-gap oxide semiconductors, when doped with transition metal ions (Mn, Fe, Co and Ni) include attracted much attention for their promising versatile applications. ZnO is an n-type semiconductor through wide direct bandgap energy (3.37 eV) and a larger binding energy (60 meV). Due to its exclusive characteristics similar to low cost, non toxicity, abundance in nature, suitability to doping, this material has got wide applications in electronic and optoelectronic devices such as ultraviolet light-emitters, piezoelectric transducers and solar cells [J. Bao *et al* 2006, H. C. Cheng *et al* 2007, P. P. Sahay *et al* 2008, J. Xu *et al* 2005]. In this paper, we present our investigation to understand the pure ZnO and metal doped ZnO photocatalyst prepared through a hydrothermal method. The synthesis and metal doped to understand the photocatalyst different characterization.

2. Experimental methods

2.1 Photocatalyst preparation

Zinc oxide, were purchased from sigma Aldrich and was of analytical reagent 95 grade and used without further purification. Deionised water was used in all experimental preparations. The samples were prepared by hydrothermal method [K.B. Dhanalakshmi *et al* 2008]. High temperature sintering method is adapted for the preparation of the photocatalyst. In the container of doping, a usual procedure was followed: An aqueous slurry of the semiconductors powder include designed amount of transition metal salt be stirred magnetically (REMI-magnetic stirrer-2MLH) used for 2 hours to distribute the metal ions uniformly upon the semiconductor powder. This slurry was then evaporated within an air oven at 100-200^{o}C. The dried samples were ground to fine powder, loated in a silica boat with introduced into a muffle furnace for sintering. Sintering was carried out at 450^{o}C for all the samples. Stepwise increases of temperature increased the effectiveness of doping [K. Mori *et al* 1985, K.M. Prabu *et al* 2004]. Sintering of samples is carried out within an inert atmosphere, after cooling to room temperature, the sintered samples be ground to fine powder.

2.2 Instrumentation

Fourier transform infrared spectra (FT-IR) were recorded in a Bruker 3000. UV-vis diffuse reflectance spectra (DRS) were determined by recorded on Varian Cary 5000 model UV spectrometer. Scanning electron microscopy (SEM) measurements were performed on 'ZEISS'. The face area of the photocatalyst powders be calculated using a BET apparatus. X-ray diffraction patterns be record using computer controlled XRD unit (X-ray

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generator: PW 1130: perpendicular diffractometer: PW 1050; Diffractometer control PW 1710; Philips, Holland).

3. Results and discussion

3.1 Characterization studies

3.2 Fourier Transform-Infrared (FT-IR)

FTIR spectra of pure and metal doped ZnO photocatalyst are shown in the **Fig. (1)**. The broad peak within higher energy into the region at 3400 - 3600 cm^{-1} is due to OH stretching or it may be due to the M-OH-M. The peak in the range 1400 - 1757 cm^{-1} is outstanding to OH bending of adsorbed moisture in the sample and all additional peaks are attributed to the characteristic of the material. The major absorption band is due to Zn-O stretching of ZnO in the range of 600 - 400 cm^{-1}. FTIR spectra of pure sample of the present investigation are similar to that of Cr doped ZnO samples and are in good agreement with the reported values [S. Kurian *et al* 2004, B. S. Rema *et al* 2007, S. Maensiri *et al* 2006, S. Suwanboon, 2008, B. N. Dole *et al* 2011]. (ZnO and Fe-ZnO), the peaks in the range of 400-700 cm^{-1} were attributed to ZnO stretching modes [R. Saleh *et al* 2013]. Also an additional peak is obtained in the range from 800 – 1500 cm^{-1}, which could be accredited to the inclusion of Fe^{3+} ions into the lattice position of the ZnO nano-structures [T. Pandiyarajan *et al* 2012].

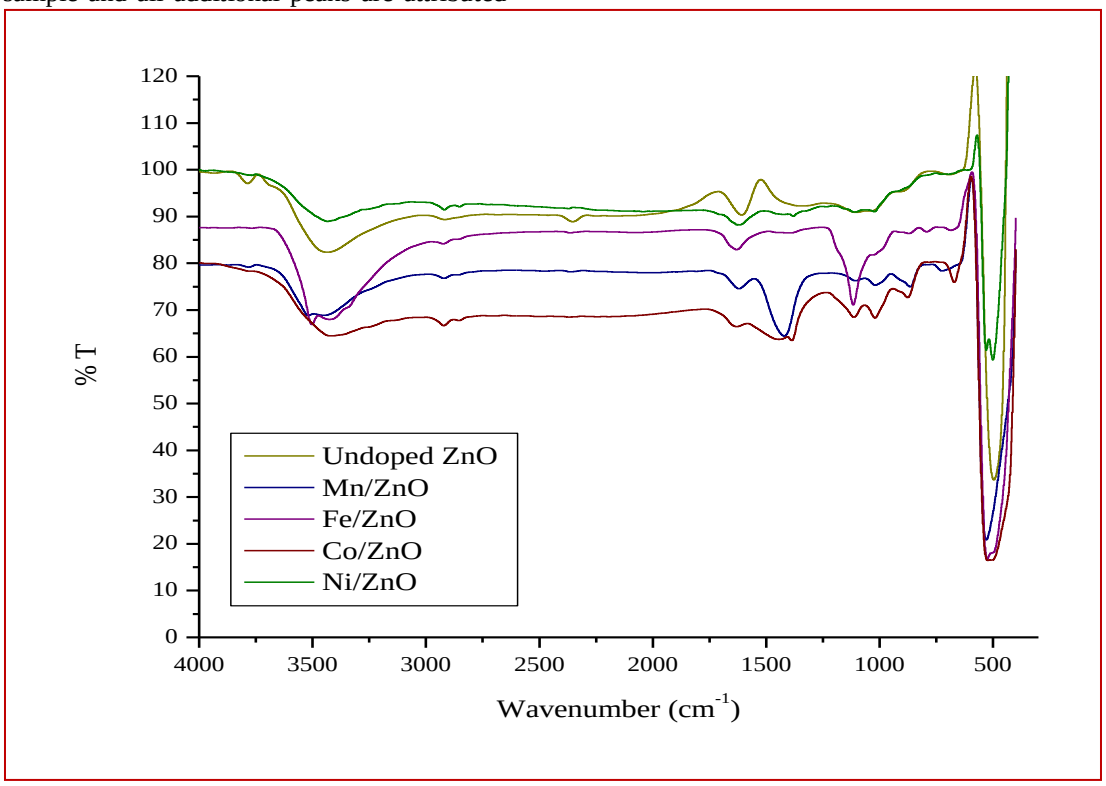

Fig. 1 IR Spectra of undoped and metal ions ZnO

3.2 Diffuse Reflectance Spectra (DRS)

The UV-Visible diffused reflectance spectra (DRS) of the undoped and Mn, Fe, Co, Ni- doped ZnO samples are shown in **fig. (2),** the band gap (E_g) of ZnO nanoparticles be calculated by using $E_g = hc/\lambda$, where h = plank's constant, c = velocity of light and λ = wavelength. The most absorption for every one of samples is observed in 380 nm from which the approximate band gap of 3.2 eV is calculated.

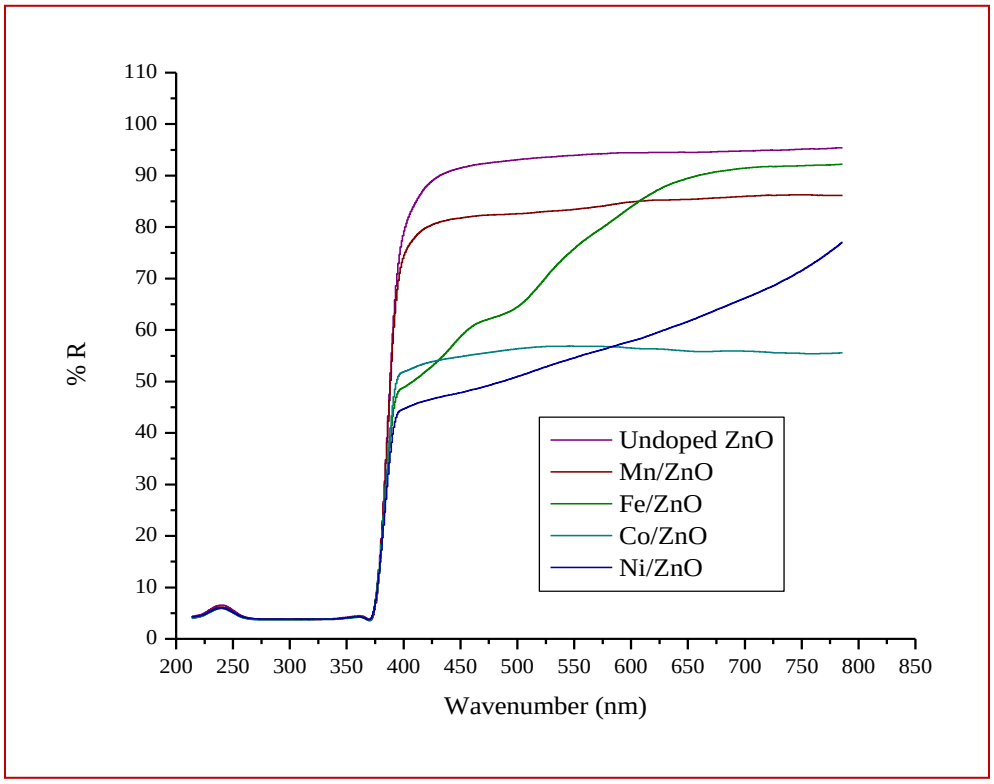

Fig.2 Diffuse absorption spectra of undoped and metal ions doped ZnO

3.3 Scanning Electron Microscope (SEM)

The SEM is used to study the surface morphology of as-synthesized samples. The SEM micrographs of as-synthesized samples of pure ZnO and metal doped ZnO are shown in f**ig. (3).** As synthesized samples of undoped particle size on the surface of small. The doped samples particle size is very large is observed.

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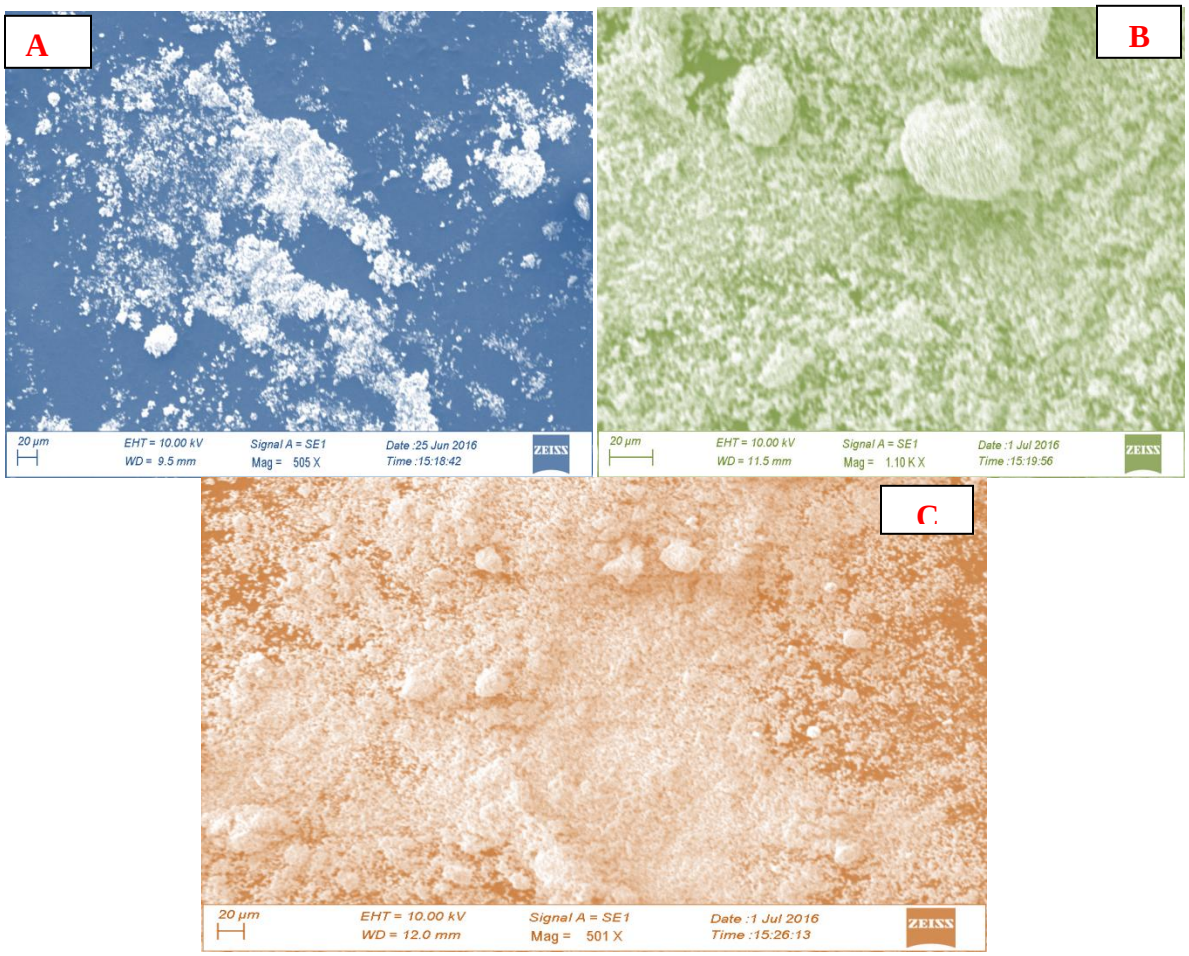

Fig.3 Scanning Electron Micrographs of (a). Undoped ZnO (505 X) (b). Five atomic percentage Fe doped ZnO (1.10 KX) (c). Five atomic percentage Co doped ZnO (501 X)

3.4 Surface area measurements (BET)

The surface area of undoped ZnO is found to ~ 4.6 m^2/g. It is usually experimental that the surface areas of the doped samples slightly enlarged from those of the undoped samples. However, the difference in the surface areas of every sample is almost negligible. Hence, the differences in the photocatalytic efficiencies of these undoped and doped samples cannot be due to the little differences in the surface area although due to the other factors such as dopant nature, dopant concentration, *etc*.

3.5 X-ray diffraction (XRD)

X-ray diffraction measurements have been taken in the range, $2\theta = 20^0 - 80^0$ for the undoped and doped (Mn/ZnO, Fe/ZnO, Co/ZnO and Ni/ZnO) photocatalysts. The 2θ values at which major peaks appear have been originate to be almost the equal for both undoped and doped samples excluding the intensities of the peaks. It is out of the ordinary to the crystallinity has been enlarged as evidenced from the more intense peaks observed in the doped samples. This examination is also support by XRD spectrum **fig. (4)** Wherever additional intense and sharp peaks are observed for the doped samples.

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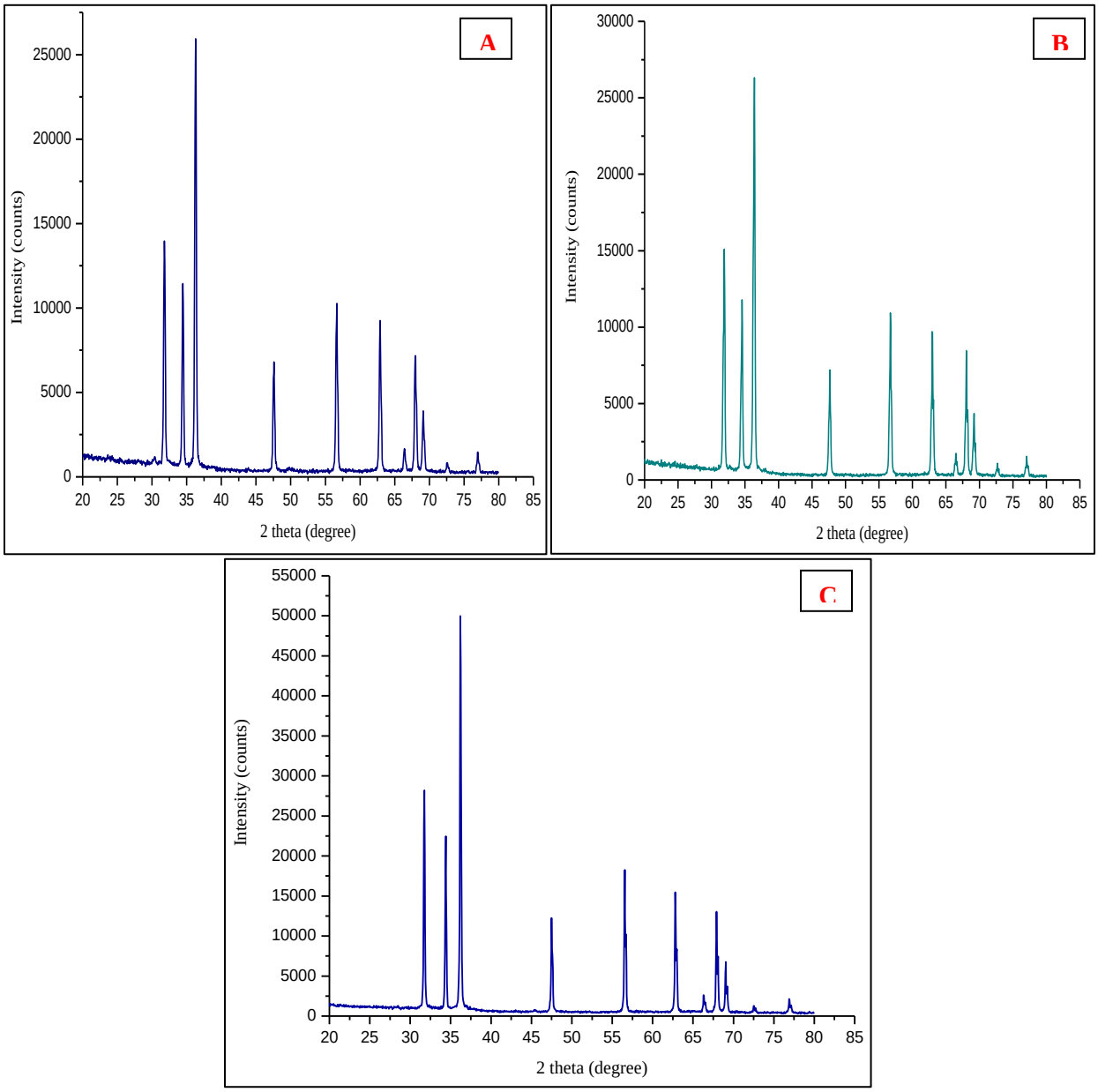

Fig.4 X-diffractogram of (a) Undoped ZnO (b) Five atomic percentage Fe doped ZnO (c) Five atomic percentage Co doped ZnO

4. Conclusion

This present study showed a very simplest technique for metal doping five atomic percentage Mn^{2+}, Fe^{3+},Co^{2+} and Ni^{2+} the chemical groups of the samples have been identified by FTIR spectra. The discontinue wavelengths be identified by UV-Visible (DRS) analysis and the band gap energies of the undoped and doped crop are lies connecting 3.2 eV. The SEM image of particle size long-established that doped and undoped morphology of the goods. This surveillance is also support by the XRD spectrum everywhere more intense and sharp peaks are observed for the doped samples

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