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Structural and Optical Properties of Alcohol, Alcohol-Aqueous and Aqueous Mediums Mediated Zinc Oxide/Copper Oxide (Zno/Cuo) Nanocomposites Synthesized Via Co-Precipitation Process

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Abstract: ***By using different solvents the zinc oxide/copper oxide (ZnO/CuO) nanocomposites were synthesized via co-precipitation process. A Physico-chemical property of zinc oxide/copper oxide nanocomposites was identified by powder X-ray diffraction (XRD) and Photoluminescence (PL) techniques. The obtained results were demonstrated that the alcoholic mediated zinc oxide/copper oxide nanocomposites are exhibit smaller crystalline size and enhanced optical properties than that of aqueous mediated nanocomposites materials. From the results, it was confirmed that the synthesized samples would be promising metal oxide composites materials for opto-electronic device applications.***

Keywords: Different solvents, ZnO/CuO, Nanocomposites, Optical Properties.

I. INTRODUCTION

The nanomaterials have unique properties than that of bulk counterpart, due to its size in nano-scale region, which are using worldwide in various commercial applications. Among the functional materials, metal oxide nanoparticles show versatile interesting properties which could be useful in various commercial applications such as gas sensing, medicine, catalysis and etc. [1-5]. Generally, binary (two materials) and ternary (triple materials) metal oxide materials that are metal oxide nanocomposites exhibit excellent properties than that of independent metal oxide nanoparticles [6]. ZnO is n-type semiconductor material with huge range of applications such as gas sensors, solar cells, photocatalysts etc with band gap energy 3.37 eV [7]. Copper oxide (CuO) has a wide range of application with a narrow band gap 1.4 eV. Among the different nanocomposites materials, the metal oxide based nanocomposites are very effective in field of optoelectronics and various applications due their excellent physico-chemical properties [8, 9]. Here in our work we have synthesized ZnO/CuO nanocomposites through co-precipitation process and investigated their properties as a function of different solvents medium. Finally, their properties were comparatively discussed.

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II. EXPERIMENTAL DETAILS

1.1 Synthesis of Zinc oxide/Copper oxide nanocomposites

The chemicals were commercial with analytical reagents purity and used as received without purification. In a typical preparation of zinc oxide/copper oxide nanocomposites, the parent precursors that are zinc and copper contents (zinc acetate and copper acetate) were added into 100 ml of alcohol (ethanol) under stirring and made transparent solution. While stirring appropriated amount of sodium hydroxide were added to form precipitation, which was stirred for one hour. To remove the impurities available in the precipitates, the collected precipitates were involved in the process of filtrations and washes with water and absolute alcohol (ethanol) then dried the final precipitates at 60ºC for 12 hrs. Then, ash colored ZnO/CuO nanocomposites was obtained, when dried sample was calcined at 400ºC for 1h. The above mentioned procedures were followed for the preparation of ZnO/CuO in mixed solvents alcohol-aqueous (ethanol-water) and aqueous (water) as solvents. The formation of ZnO/CuO nanocomposites is given in the equation below:

$$\begin{matrix} Zn(CH_3COO)_2{\cdot}2H_2O \\ + \\ Cu(CH_3COO)_2{\cdot}H_2O \\ + \\ 2NaOH \end{matrix} \xrightarrow{120^{\circ}C} Zn(OH)_2/Cu(OH)_2 + 2NaCH_3COO + 3H_2O \quad \text{----- (1)}$$

$$Zn(OH)_2/Cu(OH)_2 \xrightarrow{400^{\circ}C} ZnO/CuO + 2H_2O \quad \text{----- (2)}$$

2.2 Characterization of synthesized nanocomposites

Physico-chemical properties of the prepared nanocomposites should be analysis by involving through different characterizations. Powder X-ray diffraction (XRD) and photoluminescence (PL) emission characterization were done for the different solvents mediated samples.

The XPERT PRO X-ray diffractometer and FLUOROMAX-4 were used to collect the data for the synthesized samples.

III. RESULT AND DISCUSSION

Synthesized nanocomposites crystal size and structure were determined using XRD pattern. Figure 1 shows the XRD patterns of synthesized nanocomposites. All the XRD peaks could be identified for both the hexagonal (ZnO) and monoclinic (CuO) phase with good in crystalline nature. One set of diffraction peaks (2 theta) located at 32.26°, 34.39°, 36.26°, 47.57°, 56.67°, 62.79° and 67.89° were related to 100, 002, 101, 102, 110, 103 and 112 planes respectively for hexagonal wurtzite structure of zinc oxide crystal planes (JCPDS card number 36- 1451). Another set of diffraction peaks (2θ) located at 33.54°, 35.49°, 38.72°, 48.76°, 61.52° and 66.27° were corresponding to (110), (-111), (111), (-202), (-113) and (022) planes respectively for monoclinic structure of CuO crystal planes (JCPDS card number 05-0661) [11].

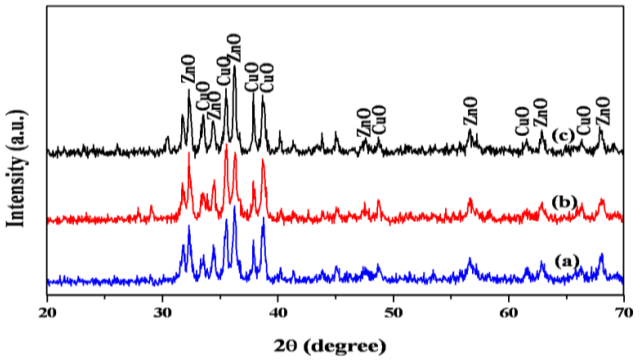

Fig. 1 XRD patterns of ZnO/CuO nanocomposites prepared in (a) ethanol, (b) ethanol-aqueous and (c) pure aqueous mediums.

Moreover, the pattern confirmed that synthesized samples have double phases with ZnO and CuO, not a single phase. There are no any other diffraction peaks due to impurities such as zinc acetate, zinc hydroxide, cupper acetate and copper hydroxide which confirmed that the synthesized samples are highly in purity and the precursors were completely converted into ZnO/CuO nanocomposites. Interestingly, the diffraction peaks intensities were decreased with alcoholic solvents adopted samples that pure aqueous solvents mediated ZnO/CuO. The decreasing peaks intensities with increasing broadening indicates that the decreasing in particles size of the synthesized samples. By using Debye Scherrer's formula crystallite size of synthesized zinc oxide/copper oxide nanocomposites were calculated, which are given below [10].

$$D = \frac{0.9\lambda}{\beta \cos \theta}$$

where,

D = Average crystallite size,

λ = Wavelength of X-rays,

β = Full Width at Half Maximum (FWHM) in radian

θ = Bragg's angle

Average crystallites sizes of ZnO/CuO samples synthesized in alcohol, alcoho-aqueous and aqueous are found to be 18, 22.65 and 29.8 nm, respectively. Due to the good disperse and capping ability of alcohol (ethanol), sample (a) shows most ultra fine.

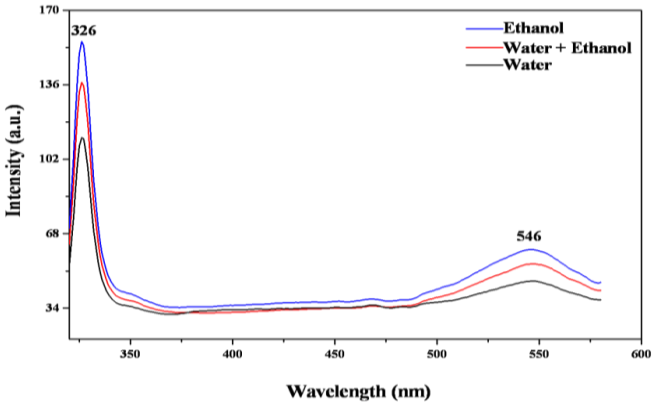

Fig. 2 Photoluminescence emission spectra of ZnO/CuO nanocomposites.

To understand the physical properties and potential applications of the synthesized nanocomposites, an optical investigation is the very useful technique. Figure 2 shows PL emission spectra of alcohol, alcohol-aqueous and aqueous medium mediated ZnO/CuO nanocomposites. Generally, two type defects were occurred in the synthesized metal oxide nanoparticles / metal oxide nanocomposites, which are intrinsic and surface defects. The photoluminescence emission spectra exhibit strong UV emission and broad visible (green) emission at 326 and 546 nm, respectively. The strong UV and broad visible emissions are attributed that the prepared zinc oxide/copper oxide nanocomposites are in highly crystalline in nature and surface related defects of the samples such as oxygen vacancies [12]. Notably, changes are visible in photoluminescence emission spectra, which is alcoholic medium mediated samples show higher intensity than that pure aqueous medium mediated sample which might be due to smaller crystalline size and more surface defects such as oxygen vacancy of the sample. Hence, the optically strong samples are promising materials for optoelectronic devices [13].

IV. CONCLUSION

Sizes with 18, 22.65 and 29.8 nm, zinc oxide/copper oxide nanocomposites were successfully synthesized via co-precipitation process by using three different solvents medium such as pure alcohol (ethanol), mixed of alcohol-aqueous (ethanol-aqueous) and pure aqueous. Photoluminescence emission exhibit the strong UV emission and broad visible (green) emission, which indicating that the synthesized nanocomposites are highly in crystalline in nature with good crystal quality. Moreover, due to large number of oxygen vacancies this ZnO/CuO is promising candidate for optoelectronic devices.

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