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Structural, Optical, Functional and morphological activities of Pure and Copper Doped Magnesium Oxide Nanoparticles

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Abstract: Magnesium oxide an inorganic material used in water purification, optoelectronics, and microelectronics. The pure and copper doped Magnesium oxide nanoparticles have been synthesized by sol-gel method. The obtained sample can be calcinated as 300 ˚C for one and half hour. The characteristics of pure and copper doped Magnesium oxide nanoparticles have been analyzed with SEM, XRD and FTIR. On doping with Copper with Magnesium oxide, the grain sizes are looks like a spherical shape in an agglomerated form. With FTIR, the functional groups have been identified. The X-ray diffraction pattern reveals that the average particles are increases with increasing Copper doped content.

Keywords: Sol gel method, MgO, SEM, FTIR, X-ray diffraction, Copper

1. Introduction

The recent scientific research in the field of Nanotechnology focuses in the development of supercapacitors [1, 2]. Materials production and materials fabrication are the main process in nanoscience and engineering. Nanoparticles are the main part of nanotechnology which had wide range of applications in various fields of technology. Metal nanoparticles can have wide range of applications like magnetic data storage, magnetic resonance imaging and as electrode for supercapacitors [3]. Further, it has been used as an oxide barrier in spin tunneling devices as well as substrate in super conducting and ferroelectric film. The MgO nanoparticles have high catalytic activity [4-6], on doping with Copper it will enhance the catalytic property and used in superconductors. Because of good control over composition and particle size, and a substantial reduction in the formation temperature, sol gel fabrication methods have received more focus of research.

2 Experimental Details

2.1 Preparation Method

Magnesium oxide nanoparticles can be used in heavy fuel oil, paint, gas separation, bactericides, and insulator in industrial cables, crucibles, and refractory materials. The Magnesium oxide and Copper doped Magnesium oxides nanoparticles were synthesized by sol gel method because of better homogeneity and purity. Sol-gel technique is one of the most popular solutions processing for nanoparticles (mostly oxides) production. The sol-gel method is a versatile process used in making various colloidal dispersions of inorganic and organic hybrid materials, particularly oxides and oxide based hybrid [4, 5].

2.2 Preparation of MgO and Cu doped MgO nanoparticles

1.0M of Magnesium choloride with 100ml distilled water was taken in a beaker that was stirred for 30 minutes.1.0M of NaOH pellets with 100ml distilled water taken in an another beaker it is stirred for 30 minutes to attain NaOH solution. Finally the mixture of NaOH solution was added drop wise to the above prepared $MgCl_2$ solution and stirred for 30 minutes. The gel was obtained and it was filtered and washed for several times by distilled water. It was then dried at 100°C in hot air oven for 14hrs.Finally the dried samples are grained by using morter and pestle. Then the powered was calcined at 300°C for 1 1/2 hours. Finally the pure MgO nanoparticles were collected in an air tight container. Cu doped MgO nanoparticles were prepared by the same procedure for two molar concentrations (3% and 5%).

3. Results and Discussion

The characterization of pure Maganesium oxide and Copper doped Maganesium oxide nanoparticles were analyzed.

3.1 XRD analysis

X-Ray Diffraction pattern for pure and Cu doped MgO nanoparticles obtained are shown in the figures 1.1 (a) and (b). The average crystallite size was calculated using Debye-Scherer formula and the values are listed in the table1.

$$D = k\lambda/\beta\cos\theta$$

The narrow peaks in the XRD pattern indicates the crystalline nature of nanoparticles, so the peaks corresponding to 2 θ values of 32.0^0,37.12^0,45.89^0 and 66.92^0 which may corresponding to miller indices (111),(200),(211) and (222) respectively that represent cubic structure. This result were good comparable to the standard data of JCPDS card no: 76-1363. The peaks were slightly narrowed with an increase in the Cu concentration; this indicates a possible change in grain size. Due to shift in angle of diffraction, the crystalline size also gets slightly varied.

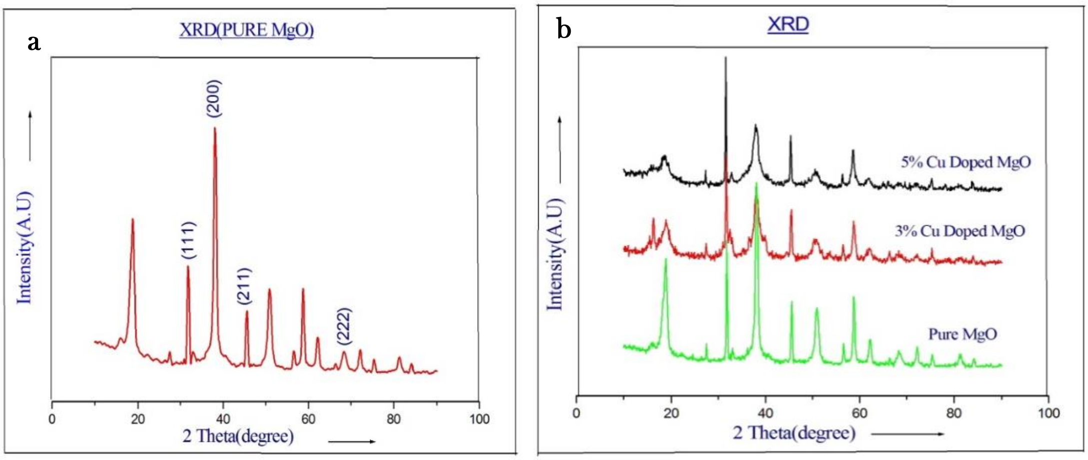

Figure 1(a) XRD pattern for pure MgO, **(b),** Comparative XRD pattern for pure and Cu doped MgO

Table1. XRD result of pure and Cu doped MgO nanoparticles

Samples	2 θ (degree)	D-spacing(Å)	h k l	Average crystallite size(nm)
Pure MgO	32.00	2.713	(1 1 1)	17.30
	37.12	2.440	(2 0 0)	
	45.89	1.990	(2 1 1)	
	66.92	1.408	(2 2 2)	
3% Cu doped MgO	32.76	2.731	(1 1 1)	24.88
	37.89	2.372	(2 0 0)	
	45.33	1.999	(2 1 1)	
	65.98	1.415	(2 2 2)	
5% Cu doped MgO	32.40	2.761	(1 1 1)	37.07
	37.70	2.384	(2 0 0)	
	45.44	1.994	(2 1 1)	
	65.73	1.419	(2 2 2)	

3.2 Morphology by SEM analysis

The microscopic images of Cu doped MgO are shown in figure 2(a), (b) and (c).The observed agglomeration of compound increases with changes in the concentration of the samples x-3% and 5%. The morphology and size distribution of nanoparticles are irregular form. The particles are spherical like structure The figures also revealed that, upon Cu composition increase, grain size also increased. The particle size of the pure MgO was found to be 65 nm, whereas on addition of Cu there is an increase in the particle size ranging from 75-100nm.

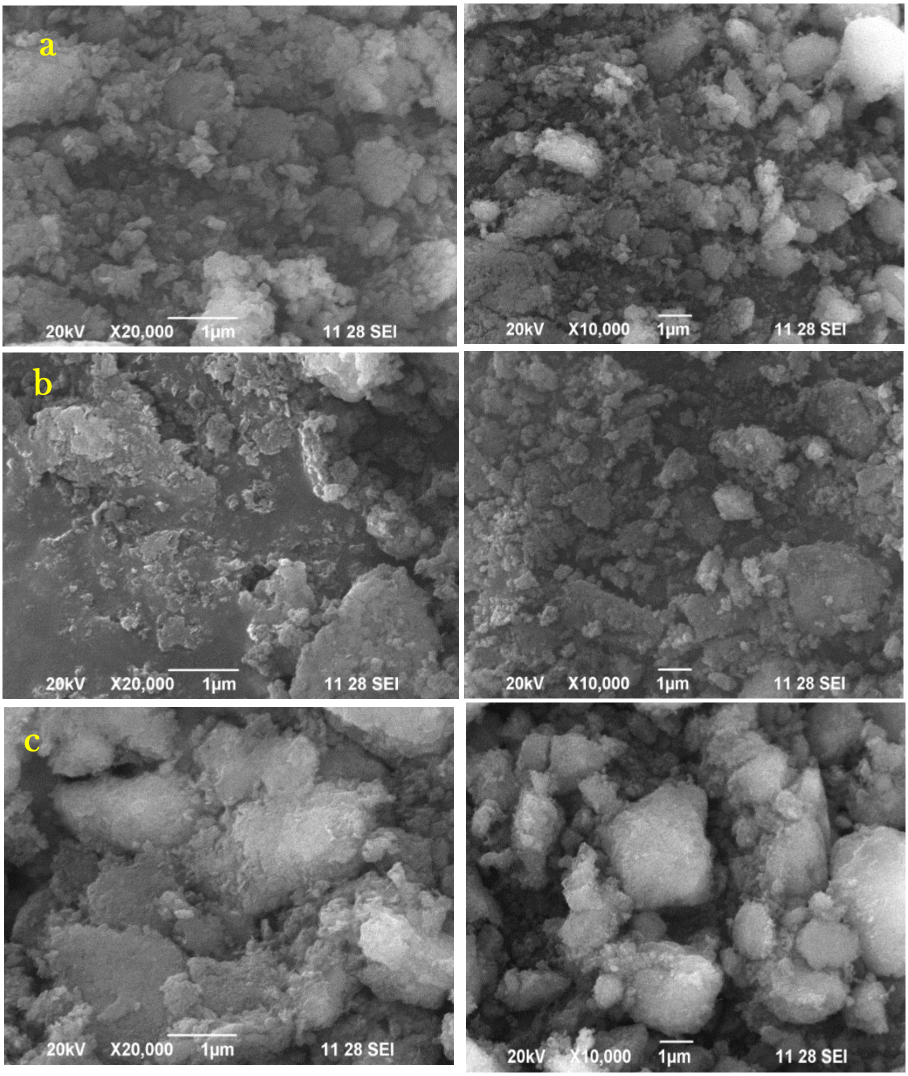

Figure 2(a),(b),(c). SEM image for pure MgO and Cu doped MgO

3.3 Assignments by FTIR

FTIR spectra of pure and Cu doped MgO are recorded in the range of 400-4000 cm^{-1} and is shown in the fig 3 (a) and 3 (b). The spectrum displays broad absorbance peak around 1446cm^{-1} corresponding to Mg-O stretching vibration. The band at 447cm^{-1} corresponding to S-S stretching. The band at 572 cm^{-1} corresponding to C-H stretching. The band at 1635 cm^{-1} corresponding to C=O stretching. The band at 3411cm^{-1} corresponding to the stretching vibration in hydroxyl group(O-H). The peak at 3699 cm^{-1} corresponding to the $Mg(OH)_2$ [7].

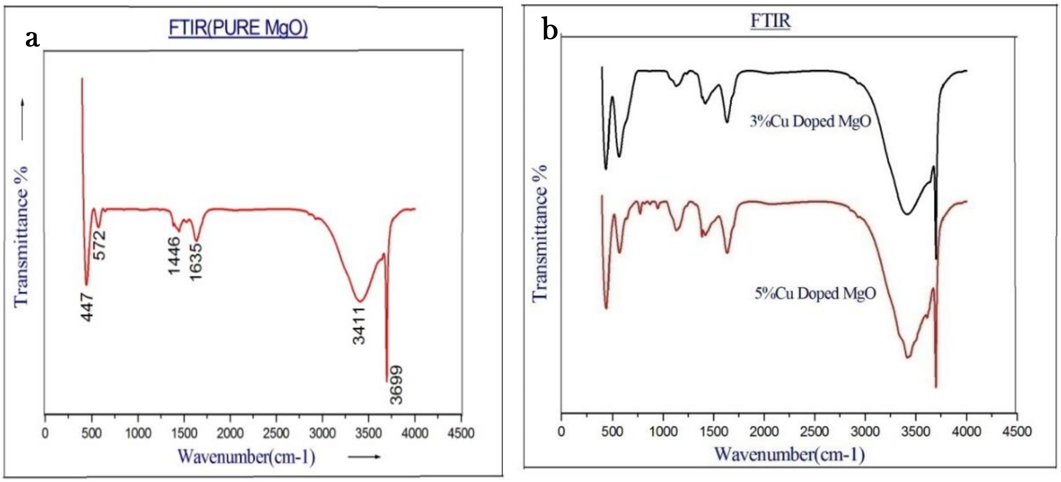

Figure 3. a) FTIR spectrum of Pure MgO, b) FTIR spectrum of Cu doped MgO(3% and 5%)

4. Conclusion

The pure and Cu doped MgO were synthesized by sol gel method. X-Ray Diffraction studies revealed the cubic structure of Mgo and Cu doped MgO .The grain sizes of the samples were found in the range of nanometers. The average crystallite size increases with Cu concentration. SEM image particles are looks like a spherical shape in an agglomerated form. FTIR spectrum identifies the functional groups of the samples. The spectrum displays broad absorbance peak around 1446 cm^{-1} is attributed to the MgO stretching vibration. With these results, these particles are good agreement in a photocatalystic test and superconductor products.

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Conflict of interest: The Authors have no conflicts of interest to declare that they are relevant to the content of this article.