International Journal of Scientific Research in Science and Technology
Print ISSN: 2395-6011 | Online ISSN: 2395-602X (www.ijsrst.com)
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Synthesis and Spectroscopic Characterization of Silicon Carbide (SiC) nanoparticles

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ABSTRACT

Silicon carbide (SiC) nanoparticles have been synthesized via sol-gel method. The size, morphologies and bonding states of synthesized SiC nanoparticles were investigated by X-ray diffraction (XRD), scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FTIR). The results show that the synthesized SiC nanoparticles are high-quality crystals with high aspect ratios. The thermodynamics analysis of SiC nanoparticles in organic base fluids were studied with purpose of applications in various fields. X-ray diffraction (XRD) results indicated the major phases of SiC. Scanning electron microscopy (SEM) images shows that SiC particles mainly composed of crystalline nanoparticles. FTIR provides valuable and practical information about the chemical bond states of the materials. FTIR spectra of the SiC nanoparticles have revealed strong absorption bands with a very small variation [1-5].

Keywords : SiC nanoparticles; Sol-gel technique; XRD; SEM.

I. INTRODUCTION

In nanoparticle synthesis it is very important to control not only the particle size but also the particle shape and morphology as well. In the present investigation, the synthesis of SiC Nanoparticles via solgel method is discussed, which is an easy, simple, cost effective and convenient route for preparing nanoparticles. Silicon carbide is a well-known ceramic type nanoparticle which shows diverse scope due to its exclusive properties like high strength, hardness, chemical, thermal stability, high melting point, oxidation resistance, etc. Therefore, they used in high temperature electronic devices, abrasion and cutting applications [6,8].

II. Synthesis of SiC nanoparticles:

During the synthesis of SiC nanoparticles, the mixture of SiO2:Mg in the molar ratio 1:2 were heated in the furnace at 650°C for 6 hours. For an acid etching of the obtained product for 5 hour a mixture of HF 10% wt and HNO3 4 M were used. Then the mixture is formed washed with distilled water and dried at room temperature. The final product is SiC in powder form [9-11].

III. Spectroscopic Characterization of SiC Nanoparticles:

X-Ray Diffraction (XRD) was obtained with a diffractometer 'PAN analytical,' Model: Xpert PRO, equipped with Cu $K\alpha_1$ radiation. Scanning Electron Microscopy (SEM) research was made using a field

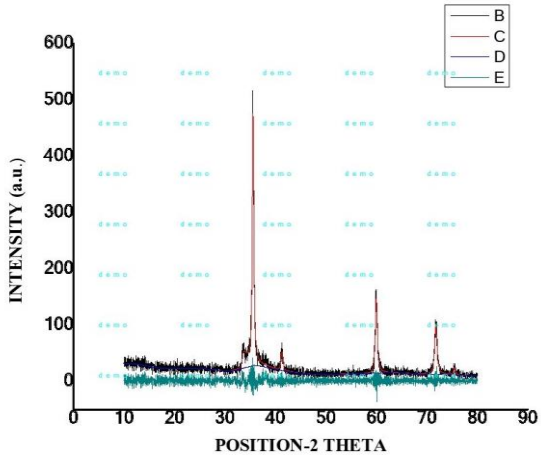
emission JSM-7401F Scanning Electron Microscope. Infrared spectrum of absorption or emission of nanoparticles was obtained by Fourier Transform Infrared (FTIR) spectrophotometer Nicolet.

a X-Ray Diffraction (XRD)

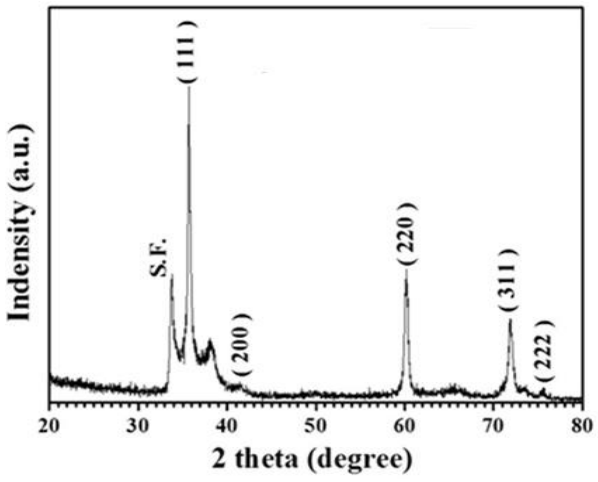
Many techniques are used to identify the various properties of nanomaterials. Some of the most important techniques are: XRD is a non-destructive versatile technique used to analyze the structure of crystalline materials and to identify the crystalline phases present in a material. It provides detail information about the chemical composition and crystallographic structure of natural and manufactured materials. In a crystalline solid, the constituent particles are arranged in regular periodic manner. An interaction of a particular crystalline solid with X-ray helps in investigation of its actual structure. Crystal is found to act as diffraction grating for X-ray and this indicates that the constituent particles in the crystal are arranged in planes at close distance in repeating patterns. The 2θ a value corresponding to peak in the X- ray diffraction is an important tool to understand the properties of characterizes materials. In nanomaterials number of atoms is very small. Nanoparticles cannot be considered as an infinite arrangement of atoms. In case of amorphous nanoparticles broad diffraction peaks are expected to occur similar to amorphous bulk solid materials. However, in case of nanoparticles atoms do not have ordered lattices, some changes in diffraction are to be expected as compared to single crystal. Nanoparticles do not have grain boundaries. It has been found that diffraction peaks in nanocrystalline particles are broadened compared to a single or polycrystalline solid of same materials. From XRD pattern, Debye Scherrer gives an equation to determine nanoparticles size as,

$$D = \frac{0.9\lambda}{\beta Cos\theta} \quad \text{---------- (1)}$$

In above equation β is the broadening caused by nanoparticles size, θ is the Bragg's angle and λ is the wavelength of X-ray beam. Figure 1 shows the XRD pattern of Silicon carbide (SiC) nanoparticles reporting some silicon and carbon phases centered at 2θ = 35⁰. The XRD measurement carried out by using "PAN analytical" X-ray diffractometer keeping the parameter constant at start position [°2Th.]: 10.0154 End Position [°2Th.]: 89.9834, Step Size [°2Th.]: 0.0170, Scan Step Time [s]: 5.7150, Scan Type: Continuous, Measurement Temperature [°C]: 25.00 Anode Material: Cu, K-Alpha1 [Å]: 1.54060. It is seen that the materials are well crystalline in nature and well agreed with standard JCPDS file number 029-1129 file. The estimate size of SiC nanoparticles using Debye Scherrer formula is found about 30 nm.



(a) XRD pattern of Silicon carbide



(b) XRD pattern of silicon carbide nanoparticles JCPDS file No 029-1129

Figure 1. X- ray diffraction pattern of Silicon carbide (SiC) nanoparticles

b Fourier Transform Infrared Spectroscopy (FTIR)

An infrared spectrum of absorption or emission of nanoparticles is obtained by FTIR technique. This technique collects simultaneously high spectral resolution data over a wide spectral range. FTIR analysis indicated the vibrations of Silicon-oxygen (Si–O) groups. FTIR spectroscopy shows the degradation phases and absorption in different regions which indicates structural relationship between them. From figure 3 it is seen that the inorganic groups is gradually decomposed at 1078.95 cm^{-1} and 804.72 cm^{-1}. Also the Si-OH absorption peak observed at 2887.74 cm^{-1} due to the symmetrical stretching vibrations of the N–O group, which might have come from the nitrate of the starting material. The spectrum shows a peak at1078.95 cm^{-1}, which is due to the Si-C vibrations in the spinel block alumina structure.

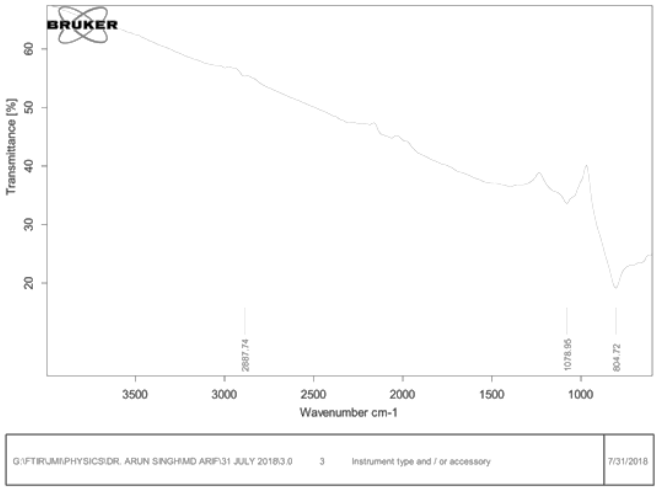


Figure 2. FTIR of Silicon carbide (SiC) nanoparticle

c Scanning Electron Microscopy (SEM):

The electrons in the samples interact with atoms and generate various signals that contain information about surface topography and composition of the sample. The images of a sample are produced by SEM technique by scanning the surface with a focused beam of electrons. SEM study is carried out to observe the overall surface morphology and crystallite sizes of the prepared nanomaterials. This material has been synthesis by sol-gel method. From the SEM images are observed under 10 μm resolutions which shows the foam like surface morphology as shown in figure 4. In the depicted images of SiC nanomaterials, it can be clearly seen that the micrograph crystallite sizes may vary from a 10 μm to few microns range if we magnify further. The crystallites look like having a sharp surface edge as well as crystalline grains and the particles foam-like morphology can be formed from highly agglomerated crystallites. Also, it is confirmed that the crystallite sizes are nearly equal for all sample.

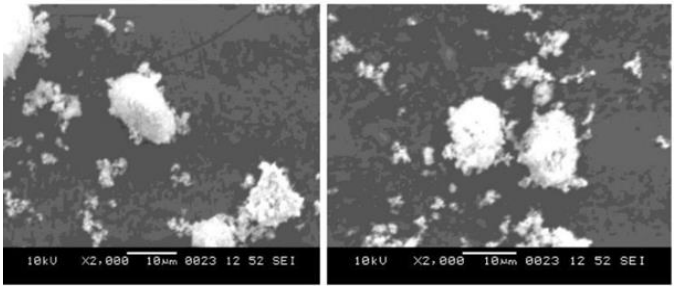


Figure 4. SEM images of SiC nanoparticles

IV.CONCLUSION

1. Nanoparticles of SiC were synthesized via sol technique.
2. The estimate size of SiC nanoparticles using Debye Scherrer formula is found about 30 nm.
3. Characterization of SiC nanoparticles via XRD and SEM showed that nanocrystalline SiC is formed.
4. FTIR spectra of the SiC nanoparticles have revealed strong absorption bands with a very small variation.

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