ISSN: 2320 – 8791 (Impact Factor: 2.317)
www.ijreat.org

Optical and FTIR Studies of Silver-Poly (Methyl methacrylate) nanocomposites

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ABSTRACT

In the present work, Silver-poly (methylmethacrylate) (Ag-PMMA) nanocomposites have been synthesized via ex-situ chemical reduction method using sodium borohydride as reducing agent for metal salt. These samples were analyzed using UV-Visible absorption spectroscopy and Transmission electron microscopy (TEM) and Fourier transform infrared spectroscopy (FTIR). The appearance of SPR peak characteristic of Ag nanoparticles around 420 nm in optical spectra indicate towards the formation of silver nanoparticles. The size of the silver nanoparticles in PMMA has been found to be 5.4 nm using TEM image. Shifting of carbonyl group in PMMA to low wavenumber shows the binding of silver nanoparticles with polymer matrix.

Keywords: silver nanoparticles, nanocomposite, SPR, particle morophology.

Introduction: Metal-polymer nanocomposites have received considerable attention due to their interesting optical, electrical, thermal, dielectric and structural properties that cannot be achieved from their bulk counterparts. Silver nanoparticles exhibits unusual optical properties due to its Surface Plasmon Resonance (SPR). These nanocomposites have potential applications in optics [1], electronics [2], photonics [3] and biomedicine [4].

In present work, Ag-PMMA nanocomposite films were prepared by chemical reduction method with thickness in the range of 20-30 µm and were further characterized by UV-VIS spectroscopy, TEM and FTIR.

Experimental: For the preparation of silver nanoparticles, Silver nitrate ($AgNO_3$) was used as precursor and Sodium borohydride ($NaBH_4$) was used as reducing agent. These were procured from Rankem. Polyvinyl pyrrolidone (PVP) and Polymethylmethacrylate (PMMA) used as stabilizer and host-matrix respectively were purchased from Himedia. Double deionized water and chloroform were used as solvent. Chloroform was procured from Himedia. All the chemicals and reagents were of analytical grade and used without further purification.

Aqueous solution of $AgNO_3$ (1.0 mM) was added drop wise to aqueous solution of $NaBH_4$ (2.0 mM) under vigorous stirring. A pale yellow solution indicated the formation of silver nanoparticles. 15 ml of this aqueous solution was slowly added to the solution of PMMA in chloroform under high ultrasonication. 2 ml ethanol was added to the resulting solution for binding Ag nanoparticles with PMMA and 0.228 gm PVP was added to prevent agglomeration of Ag nanoparticles. The obtained solutions were poured in the petri dishes and dried at room temperature for two days. The resulting Ag(0.013wt%)-PMMA nanocomposite films were then peeled off for further characterization. Thin film of PMMA was also obtained in the same manner [5].

The optical properties of PMMA and Ag-PMMA nanocomposite films were analyzed using a Shimadzu Double Beam Double Monochromatic Spectrophotometer (UV-2550), equipped with an Integrating Sphere Assembly ISR-240A in the wavelength range of 190-900 nm with a resolution of 0.5 nm. The morphology of Ag nanoparticles embedded in PMMA has been studied using a TEM (Hitachi H-7500). FTIR spectra of pure PMMA and Ag-PMMA nanocomposite films were recorded using a Shimadzu 01369 spectrometer, in the 350-4000 cm^{-1} range.

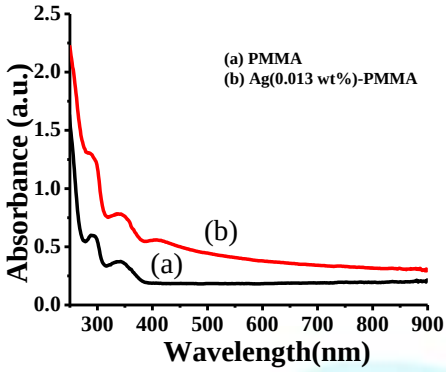

Fig.1: UV-VIS absorption spectra of (a) Pure PMMA (b) Ag (0.013 wt%)-PMMA nanocomposite film.

Results and discussions

Fig.1. shows the UV-VIS absorption spectra of pure PMMA and Ag-PMMA nanocomposites films in wavelength range 190nm to 900nm. A broad absorption band was observed at about 420 nm [6] in Ag-PMMA nanocomposite films characteristic to the plasmon band of silver nanoparticles. The shape of the band was slightly unsymmetrical, with a tail at higher wavelengths, probably due to larger aggregates of nanoparticles, that agrees with the electron micrograph.

Fig. 2. shows typical TEM micrograph and the corresponding particle size distribution. It is clearly observable that the silver nanoparticles are not much agglomerated, well bounded with PMMA. The average diameter for spherical silver nanoparticles was found to be 5.4 nm.

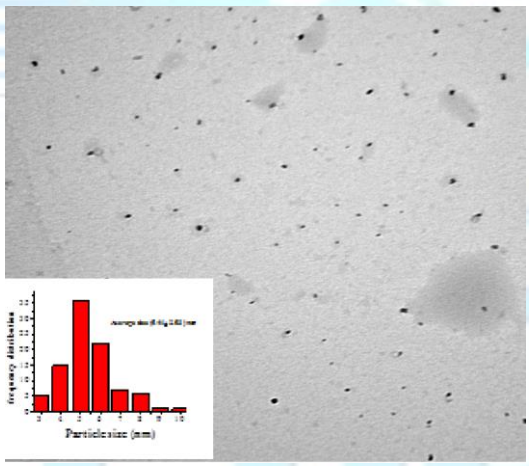

Fig. 2: TEM micrograph of Ag (0.013 wt%)-PMMA and corresponding particle size distribution

Fig. 3. depicts the FTIR spectra (500-3500) cm^{-1} for pure PMMA and Ag (0.013 wt%)-PMMA nanocomposite film. For pure PMMA film, a very distinctive transmission band was observed at 1750 cm^{-1} due to the stretching of C=O of the ester side group which shift to 1742 cm^{-1} in Ag (0.013wt%)-PMMA nanocomposite film, indicating that the silver particles are bounded to the C=O functional groups present in PMMA which may be taken as a good evidence for some structural modification. Especially peak for O-H stretching was at about 3431 cm^{-1} in pure PMMA, while the broad absorption bands at 3422 cm^{-1} was observed in Ag (0.013 wt%)-PMMA nanocomposite film. The shifting of the peak is due to formation of co-ordination bond between the silver atom and the electron rich groups (oxygen) present in PMMA [7-8].

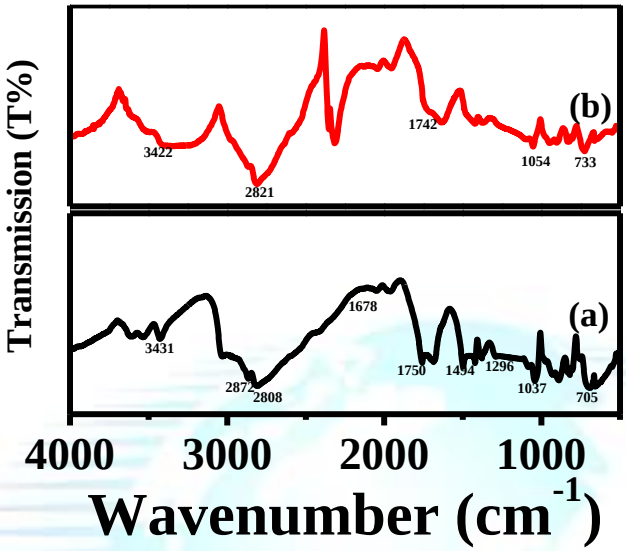

Fig. 3: FTIR spectra of (a) pure PMMA (b) Ag (0.013 wt%)-PMMA nanocomposite films.

Conclusions

Ag-PMMA nanocomposites have been synthesized and characterized using optical and structural studies. The optical absorption spectra indicate SPR band at around 420 nm in Ag-PMMA nanocomposite. TEM investigations reveal that Ag nanoparticles have spherical shape with average diameter 5.4 nm and are uniformly distributed in the PMMA polymer matrix. FTIR spectra show shifting of characteristics peaks of various functional groups in PMMA after addition of silver nanoparticles.

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