# SYNTHESIS OF POLY (METHYL METHACRYLATE/$SiO_2$ NANOCOMPOSITE

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**Abstract**

**In this research, $SiO_2$ nanoparticles were incorporated in Poly (methyl methacrylate) (PMMA) via sol-gel method using tetraethoxysilane as a precursor and trichloroethylene as a solvent. The morphological study was carried out using Surface electron microscopy (SEM). The study reveals that the particles are of spherical shape and are of nanometer size. The synthesis of particles is also confirmed through Fourier Transform Infrared Spectroscopy, Which shows the presence of Si-O-Si bond.**

**Keywords: nanoparticles, polymer nanocomposite, SEM**

## Introduction

Nanotechnology[1] deals with nano-meter sized objects. It is expected that nanotechnology will develop at several levels: materials, devices and systems. Nanotechnology has more applications in electronics, optics, optoelectronic devices, solar cells, fuel cells, food, water pollution treatment, chemical and biological sensors. In the last 20 years, there has been a strong emphasis on the development of polymeric nanocomposites, where at least one of the dimensions of the filler material is of the order of a nanometer. The transition from microparticles to nanoparticles yields drastic changes in physical and chemical properties.

Inorganic and organic mixed materials are modern materials and present the properties, which are not exhibited by individual materials.[2] There are number of methods for the synthesis of polymer nanocomposites.

Optical polymers are clear plastic materials that provide excellent light transmission.[3] In photonic applications, they offer advantages over optical glasses. They are light weight as compared to glass materials and they can be molded into spherical, aspheric and symmetrical shapes. Poly(methyl methacrylate) (PMMA), polycarbonate (PC) and polystyrene (PS) are important transparent materials used in optical and photonic applications. Optical polymers are used in lenses[4] for video cameras, compact disc drives, projection televisions, light-emitting diodes[5], diffractive optics, printers and bar-code readers, optical films, ophthalmic lenses, wave-guide materials, high-density optical storage media, flat panel displays[6] and optical fibers.

Poly (methyl methacrylate) (PMMA) is an excellent thermoplastic material which is prepared by the polymerization of methyl methacrylate.

It is highly transparent in the visible region and widely used in optical fibers, optical disks and lenses.[7] It is a light weight material, which is good alternative of glass. It is also used as a sheet glazing material and fluorescent solar collections because of its optical clarity. PMMA as a polymeric waveguide has attracted much attention for its use as optical component and in optoelectronics devices due to their low cost and volume productivity.

Since 1970, visible-light-cured dental composites have been used extensively in dentistry due to their aesthetic characteristics and their particular properties. Nanosilica filler is typical filler used in dental composites. $SiO_2$ nanoparticles are also used in fabrication of optical fibers and display applications. Amorphous $SiO_2$ nanoparticles are used in fabrication of electronic substrates, thin film substrates, electrical insulators, thermal insulators, humidity sensors etc.[8]

## Experimental

### *Material*

Poly(methyl methacrylate) (PMMA) (Commercial grade), Tetraethoxy silane (TEOS) (Himedia, 98.00%, density- 0.933 gm/cc), $HNO_3$ (Rankem, AR grade), Ethanol (Merck, AR grade, 99.9 %, density- 0.79 gm/cc), Trichloroethylene (Rankem, 99.5%, AR grade, density-1.46 gm/cc)

### *Method*

TEOS was used as a precursor for *in-situ* synthesis of $SiO_2$ nanoparticles in PMMA matrix.

**Preparation of Polymer Solution-**

1 gm of PMMA was dissolved in 20 ml of trichloroethylene in a RB flask and stirred for 3 hours at room temperature.

**Preparation of Sol-**

TEOS was dissolved into equal amount of ethanol and nitric acid was added into the above solution in the molar ratio of TEOS:$HNO_3$ = 1:0.5. This solution was stirred for half an hour to obtain clear solution.

**Preparation of PMMA/$SiO_2$ Nanocomposite Film -**

The transparent sol prepared by above method was added in polymer matrix so as to obtain 0.5, 0.75, 1.0, 1.5 and 2.0 wt% nano $SiO_2$ in PMMA. The above solution was stirred for 24 hours at room temperature under continuous stirring and heated at 60 °C for 1 hour to complete the reaction of hydrolysis. The solution was then poured in a petri dish and kept at 40°C for 1 hour. The film was removed from the petri dish and then analyzed.

## Results and Discussion

PMMA/$SiO_2$ nanocomposite thin films were synthesized by sol gel method. The films are studied with the help of various instrumental techniques and conclusions are drawn from SEM, UV-visible spectroscopy and IR spectroscopy.

**Morphological Study**

Morphological study was carried out using JEOL, Model JSM 5600 scanning electron microscope**.** Figure 1 shows the SEM micrograph of PMMA/$SiO_2$ nanocomposites having 0.5 wt% nanoparticles.

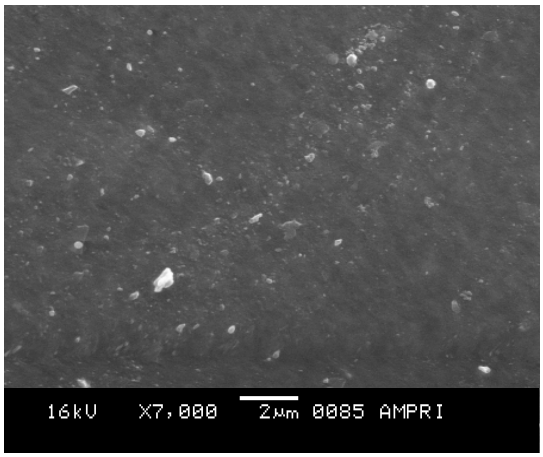


**Fig. 1 SEM micrograph of PMMA/$SiO_2$(0.5 wt%) nanocomposite**

It is clear from the SEM image that size of particles is in nanometre range and particles are well distributed in PMMA but in some places agglomeration is also observed.

**FTIR study**

FTIR spectra of pure PMMA and PMMA/$SiO_2$ nanocomposite thin films were recorded in transmission mode by using FTIR spectrometer BRUKER TENSAR 27 in the range of 500-4000 $cm^{-1}$ at resolution of 4 $cm^{-1}$

Figure 2 (A) and (B) shows the FTIR spectra of pure PMMA and PMMA/$SiO_2$ nanocomposite thin films, respectively.

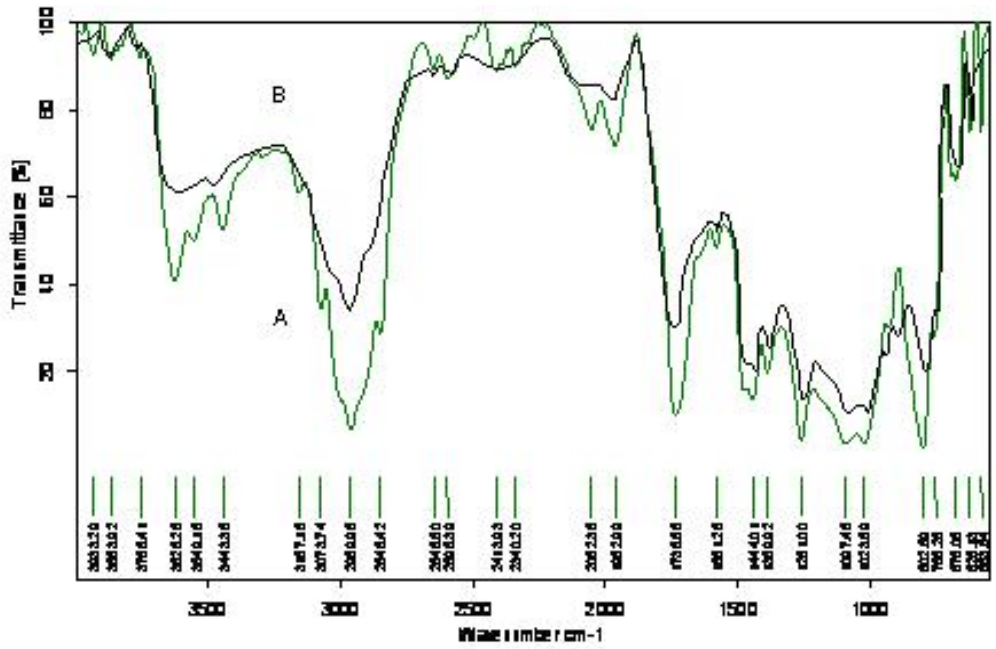


**Fig. 2. FTIR spectra of (A) pure PMMA and (B) PMMA/$SiO_2$ nanocomposite films**

The characteristic stretching vibration bands of the C=O and C–H stretching in the PMMA segment appeared at 1737, 2960 and 2848 $cm^{-1}$ respectively. The asymmetric stretching band at 2959 $cm^{-1}$ exhibits noticeable change in position and intensity. The peak intensity decreases with the nano addition. A broad peak at 802 $cm^{-1}$ is due to C–C stretching of PMMA. The –CH deformation vibrations are observed at 1444 $cm^{-1}$ and 1386 $cm^{-1}$. The peak at 1261 $cm^{-1}$ is assigned to the stretching vibration of the =C–O–C– bond of ester group in PMMA. The bands at 1023 and 1097 $cm^{-1}$ are observed due to C-O stretching vibrations. An additional small peak at around 900 $cm^{-1}$ is observed due to Si-O-Si stretching vibration. A broad absorption band at around 3400 $cm^{-1}$ is also observed due to vibration of Si-OH bond.

**Optical Study**

The optical study was carried out using UV-visible absorption spectroscopy. UV-visible absorption measurements were carried out on Shimadzu 1800 spectrophotometer. The spectra were recorded at wavelength range between 200-800 nm at room temperature. The UV-visible spectra of PMMA nanocomposites show that incorporation of $SiO_2$ did not increase the absorption of pure PMMA considerably.

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