L.12: Trans-stilbene polymer composites for x-ray imaging applications

Trans-stilbene (TSB) is an important organic scintillator material for detection of x-rays, gamma and neutrons. TSB can be grown in single crystal form, however growing large cross-section crystal is difficult and costly, therefore attention has been given to develop this material in composite form. Due to several advantages of polymers, a poly-methyl methacrylate (PMMA) based composite having varying concentration of TSB has been developed for x-ray imaging applications. PMMA was chosen as the host matrix due to its high transparency in the desired spectral range, high mechanical strength, chemical stability, and favourable processing conditions. In addition, its density and refractive index at room temperature are 1.18 gm/cc and 1.49 (at 589.3 nm), which are close to that of TSB crystal (1.16 gm/cc and 1.62 at 589.3 nm).

The first step in synthesis of TSB/PMMA composites was purification of commercially available TSB chemical (98%, Alfa-Aesar) by zone-refining process. The purified TSB chemical was dissolved in methyl methacrylate (MMA) solvent and then the solution was degassed at 70 °C. Thereafter, a small amount of initiator azobisisobutyronitrile (AIBN) was added to the solution to initiate free radical chain reaction between the MMA molecules, and left for polymerization process at 68 °C. This results in formation of TSB/PMMA composite material. Using this procedure, TSB/PMMA composite elements of diameter 25 mm and 0.5 mm thickness having TSB concentrations of 5, 10, 15, 20 and 25 wt% were prepared. Figure L.12.1 shows the TSB/PMMA composites.

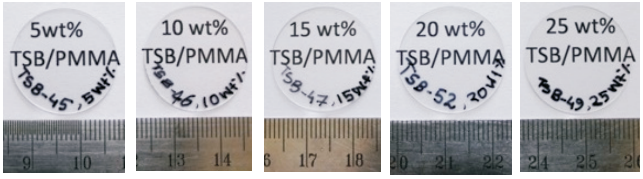

Fig. L.12.1: TSB/PMMA composites with 5, 10, 15, 20 and 25 wt% TSB concentration.

The UV-Vis-NIR transmittance spectra for the synthesized TSB/PMMA composites are shown in Figure L.12.2. The transparency was 75% in the spectral range of 350 - 450 nm, and 85% in the range 450 - 1500 nm. The bandgap energy of the composites was calculated from the UV cutoff wavelength, and it was found to decrease with increasing TSB concentration. The photoluminescence spectra for 5, 15 and 25 wt% TSB/PMMA composite sample for excitation at 240 nm are shown in Figure L.12.3. PL spectra shows a broad peak centred at 374 nm and the peak value increases with increasing TSB concentration.

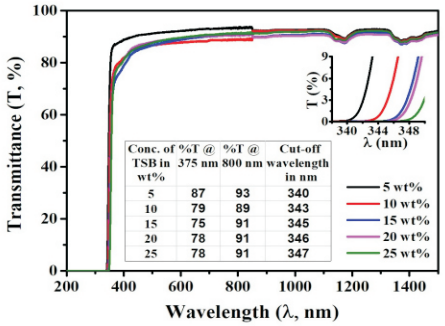

Fig. L.12.2: UV-Vis-NIR transmittance spectra of 5, 10, 15, 20 and 25 wt% TSB/PMMA composites.

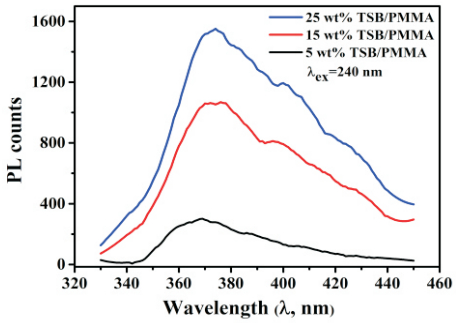

Fig. L.12.3: PL spectra of 5, 15 and 25 wt% TSB/PMMA composites.

The TSB/PMMA composites were used for x-ray imaging using the Imaging Beamline (BL-04) of Indus-2 SR facility. The scintillation image was grabbed using CCD camera (PCS2000) coupled to the beamline. An object in the form of wire-mesh with wire diameter 100 μm was imaged using x-rays of 10 keV energy and illumination time of 180 s. Object features of 100 μm were clearly resolved in the images. The effect of TSB concentration on imaging was also investigated. The results show increase in scintillation count as well as improved image contrast as the TSB concentration increases from 5 wt% to 25 wt% (Figure L.12.4(a-e)). However, the image quality was found to deteriorate on increasing the sample thickness with same TSB concentration.

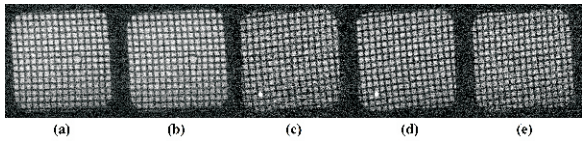

Fig. L.12.4: Images of wire mesh using TSB/PMMA composites of (a) 5 wt%, (b) 10 wt%, (c) 15 wt%, (d) 20 wt%, and (e) 25 wt% TSB concentration. The wire diameter is 100 μm and the spacing between adjacent wires in the mesh is 225 μm.

Reported by:
C. Debnath (cdebnath@rrcat.gov.in)