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Structural and thermal properties of the Poly(styrene-ethyl acrylate) polymeric scintillation material for surface radioactive contamination measurement

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1. Introduction

Emulsion polymerization is a unique chemical process widely used to produce waterborne resins with various colloidal and physicochemical properties. These emulsion polymers find a wide range of applications such as synthetic rubbers, thermoplastics, coatings, adhesives, binders, rheological modifiers, plastics pigments, standards for the calibration of instruments, polymeric supports for the purification of proteins and drug delivery system, etc [1]. Polystyrenes are widely employed as matrices in order to dope scintillating dyes for alpha and beta radiation sensors [2]. For example, BC-400 (Bicron Direct Saint-Gobain, MA), a polyvinyltoluene-based scintillator doped with PPO and POPOP, is the best existing plastic scintillator for alpha particle detection [3].

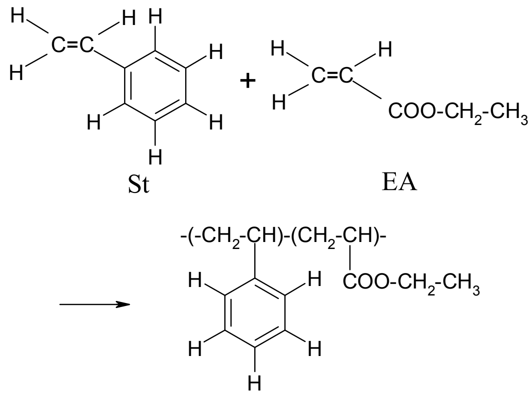
Using emulsion polymerization technique described in a previous communication [4], experiments have been performed to investigate the detection performance with the scintillators contents. In this paper, the properties of the polymer for radioactive contaminant measurement observed under various condition of polymerization and variously EA contents.

2. Methods and Results

2.1 Emulsion Polymerization

The morphology of the poly(St-EA) composite emulsion particle was core-shell structure, with polystyrene (PS) as the core and poly(ethyl acrylate) (PEA) as the shell. Core-shell polymers of styrene (St)/ethyl acrylate (EA) pair were prepared by sequential emulsion polymerization in the presence of sodium dodecyl sulfate (SDS) as an emulsifier using ammonium persulfate (APS) as an initiator. The polymer was made by impregnating organic scintillators, 2,5-diphenyloxazole (PPO) and 1,4-bis[5-phenyl-2-oxazol]benzene (POPOP). A liquid scintillator consists of a solvent, a primary solute (PPO) and, sometimes, a secondary solute (POPOP). The preparation of core-shell composite polymer particles was performed by a two-step polymerization method as shown in scheme 1.

2.2 Characterization and properties testing



Scheme 1. Scheme for the synthesis of poly(St-EA) polymer

The core-shell polymeric emulsion for measurement of the radioactive contamination was prepared using emulsion polymerization. Fourier Transform Infrared Spectroscopy (FTIR), Differential Scanning Calorimetry (DSC), Thermogravimetry Analysis (TGA), Transmission Electron Microscopy (TEM) were employed to investigate the structures and properties of the composite polymers.

2.3 Thermal properties and radioactive detection test

Thermogravimetric analysis (TGA) were carried out in order to evaluate the thermal stability of poly(St-EA). Fig. 1 shows the thermograms for (a) PS and (b) poly(St-EA), respectively. Primary thergrams were obtained by plotting the percentage residual weight against the temperature. The PS had no residual weight above 430 ℃. However, residual weight percentage for the poly(St-EA) were obtained. The final stable residue content of poly(St-EA), between 450℃ and 500 ℃, are 12 wt%. The thermal stability of the PEA polymerized poly(St-EA) has been found to be higher in comparison to the pure PS as clear from the TGA curves.

Fig. 2 represents the effect of monomer concentration on the particle size. The particle size has shown the increasing trend on increasing the monomer concentration. In the EA concentration range of 3-13 wt%, the particle size apparently increased as the EA concentration grew because the local EA concentration, and this helped the diffusion of the monomer molecules to the macroradical sites on the PS backbone.

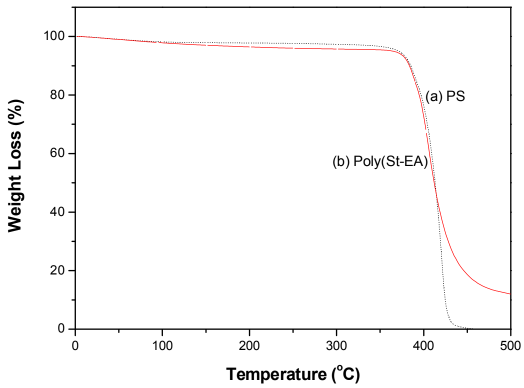


Fig. 1 Primary thermograms of (a) pure PS and (b) poly(St-EA)

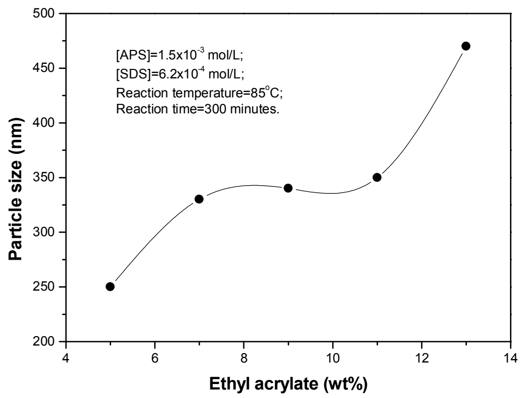


Fig. 2 Effect of monomer concentration on particle size

Also the radiation detection ability of the polymeric emulsion was evaluated with the organic scintillators contents. The radiation detection ability of the emulsion is adequate enough to measure the radioactive contamination.

3. Conclusions

The poly(St-EA) core-shell composite polymer for measurement of the radioactive contamination was synthesized by the method of emulsion polymerization. FTIR spectra of the poly(St-EA) confirmed the existence of a chemical link between the PS and PEA. Polymerizing PEA chains enhanced the thermal stability of the PS backbone. The particle sizes were strongly dependent on the variations in polymerization condition.

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