

Preparation and Characterization of Core-shell Polymer Emulsion for Radioactive Contamination Measurement

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1. Introduction

The decontamination of the surface in the nuclear facilities has been widely studied with particular emphasis on small and large surfaces [1]. So, it is important to monitor the radioactive contamination level of the nuclear facilities for the determination of the decontamination method, the establishment of the decontamination planning, and the worker's safety. But it is very difficult to measure the surface contamination of the floor and wall in the highly contaminated facilities. In this paper, the detecting material for contamination monitoring of the large area such as the floor and wall of the building was prepared. The core-shell polymeric emulsion for measurement of the radioactive contamination was prepared.

2. Methods and Results

2.1 Materials

The monomer, styrene (St, Aldrich) and ethyl acrylate (EA, Aldrich) were washed three times with a 5 % sodium hydroxide solution and then three times with distilled water to remove their inhibitors and dried over calcium chloride and stored at 0°C. Ammonium persulfate (APS), sodium dodecyl sulphonate (SDS), 2,5-diphenyloxazole (PPO) and 1,4-bis[5-phenyl-2-oxazol]benzene (POPOP) from Aldrich Co. were used without further purification.

2.2 Synthesis of poly[(styrene)-co-(ethyl acrylate)]s

The preparation of core-shell composite polymer particles was performed by two-step polymerization method. The ingredients and reaction conditions were shown in Table 1. In a typical polymerization, the seed was first prepared by emulsion polymerization in a three-necked glass reactor equipped with a condenser, a mechanical stirrer, and a gas inlet to maintain a nitrogen atmosphere. Monomers in distilled water were pre-emulsified in the presence of SDS by stirring at 85°C for at least 20 min, before addition of APS to start the polymerization reaction. Then, the organic scintillator, PPO and POPOP in the St were dissolved. The used organic scintillator was 2,5-diphenyloxazole (PPO) as a first solute and 1,4-bis[5-phenyl-2-oxazol]benzene (POPOP) as a second solute which was a wave shifter. The reaction was maintained at 85°C for at least 4 h. In the second stage of the reaction, quantitative EA was

added into the seed latex emulsion. This mixture was kept under a nitrogen atmosphere and stirred 300 rpm for 5h. The system was cooled in the room temperature and the final latex was obtained without any post preparative treatments.

Table 1. Ingredients and Conditions for the Synthesis of polystyrene (PS) Seed Latex and the poly(St-co-EA) Composite Polymer

	PS seed latex	Poly(St-co-EA) composite particles
St (g)	5-15	
EA (g)		2.5
Seed latex emulsion (g)		5
DI water (g)	200	250
APS (g)	0.1	0.025
SDS (g)	0.004	
PPO (g)	0.05-0.35	
POPOP (g)	0.0025-0.0175	

2.3 Characterization of Core-shell Polymer

The products are characterized by FT-IR spectroscopy, Differential Scanning Calorimetry (DSC), Thermogravimetry Analysis (TGA) to show the structure, the glass transition temperature (T_g), the thermal stability of the prepared polymer respectively. Also the radiation detection ability of the polymeric emulsion was evaluated with the organic scintillator contents.

2.4 Properties of the Emulsion

Fig. 1 shows the spectrum of the PS and poly(styrene-co-ethyl acrylate) [poly(St-co-EA)]. The C-H aromatic stretching vibration at 3060 cm^{-1} and the phenyl ring stretching vibration at 1610, 1493, 1448 and 702 cm^{-1} where the typical absorption band for polystyrene were clearly observed. The IR spectrum of the poly(styrene-co-ethyl acrylate) was shown in Fig. 1b. Bands found at 1638, 1490 and 1450 cm^{-1} , attributed to stretching vibrations of the substituted benzene rings, are almost in the same position as in the polystyrene spectrum. Moreover, the intensity band at 3400 cm^{-1} can be seen resulting from the presence of -OH functional groups.

Fig. 2 is the spectrum of the beta particles with the organic scintillator contents. The total counts of the

beta particles increase with the organic scintillator contents in emulsions.

[1] O. A. Bernaola, A. Filevich, Fast Drying Strippable Protective Cover for Radioactive Decontamination, *Health Physics* Pergamon Press 1970. Vol.19(Nov.), p.687-690.

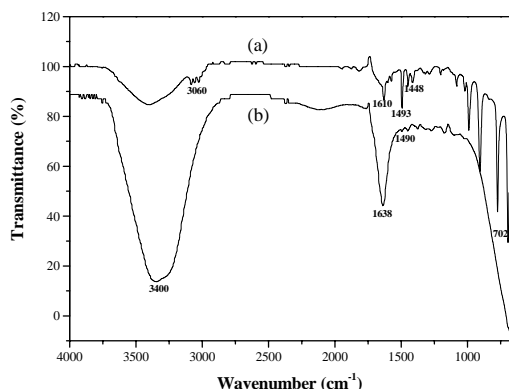


Fig. 1. FT-IR spectrum of polystyrene(a) and poly(St-co-EA) (b).

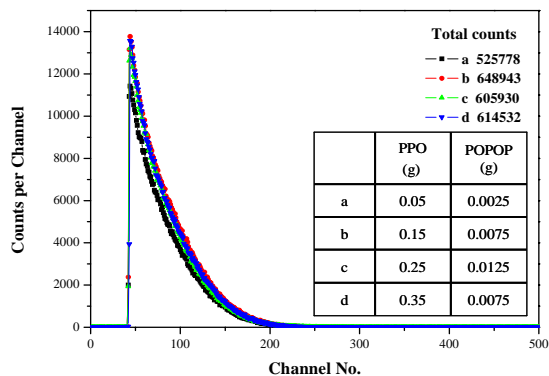


Fig. 2. Pulse height spectrum of poly(St-co-EA) emulsions with the variation of the organic scintillator contents (beta emitting source : Sr-90).

3. Conclusions

In this work, the spray type counting materials for radioactive contamination of the large surfaces were prepared via emulsion polymerization. The spray can be applied to horizontal and vertical surfaces without dripping problems. The products were contained emulsions of copolymer (styrene, ethyl acrylate) and organic scintillator (PPO, POPOP) with core-shell structure. The process of the chemical transformations was monitored with absorption spectroscopy (FT-IR). The radiation detection properties were evaluated with contents variation of the copolymer emulsions. The maximum detection efficiency was found at organic scintillator (PPO, POPOP) contents showed 0.15 and 0.0075 wt%, respectively. It was found that these properties were very dependant on the organic scintillator contents.

REFERENCES