Characterization of Polymer Emulsion for Radioactive Contamination Measurement Using Inorganic Scintillator

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1. Introduction

Decontamination of the contaminated facility surface which is imbrued with radioactivity security division environmental effect pollution level about under considering confronts to the detection, the removing, preventing and accessing method of contaminants is essential. These decontamination methods were to establish for safely radiological contamination properties. The relation with the decontamination planning, research on the decontamination has been needed, both methodologies and techniques. In this paper, the properties of the polymer for radioactive contaminant measurement observed under various condition of polymerization and variously inorganic scintillator contents.

2. Methods and Results

2.1 Materials

All the chemicals used were of analytical purity. The monomers, styrene (St, Aldrich) and methyl methacrylate (MMA, Aldrich) were washed three times with a 10 % sodium hydroxide solution and then three times with distilled water to remove their inhibitors and dried over calcium chloride and stored at 0℃. Ammonium persulfate (APS), sodium dodecyl sulphonate (SDS), ZnS(Ag) inorganic scintillator from Aldrich Co. were used without further purification. Deionized water was used throughout the study.

2.2 Preparation

Before the polymerization was started, water, surfactant and monomer were fed to the reactor; the stirred speed was set at the desired value. 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. In a St monomer dopant ZnS(Ag) are mixed. Monomer in distilled water were pre-emulsified in the presence of SDS by stirring at 80-85℃ for at least 30 min, before addition of APS to start the polymerization reaction. The reaction was maintained at 85℃ for at least 5 h. In the second stage of the reaction, quantitative MMA was added into the seed latex emulsion. This mixture was kept under a nitrogen atmosphere and stirred 250 rpm for 5h. The system was cooled to room temperature and the final latex was obtained without any post preparative treatments. The ingredients and reaction conditions were shown in Table 1.

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

	PS seed latex	Poly(St-MMA) polymer
St (g)	5-15	
EA (g)		5-10
Seed latex emulsion (g)		10
DI water (g)	200	200
APS (g)	0.1	0.1
SDS (g)	0.004	
ZnS(Ag)	0.2-1	

2.2 Mechanism in Inorganic Scintillator

Stage one: The ionization event creates an inner shell hole and an energetic primary electron, followed by radiative decay (secondary X-rays), nonradiative decay (Auger processes-secondary electrons), and inelastic electron-electron scattering in the time domain of ~10^{-15}-10^{-13} s. Typically it takes two to seven times the band gap energy of the crystal to create an electron– hole pair [1, 2]. In some crystals the number of pairs created varies with recoil electron energy and this nonlinearity can limit the energy resolution for the detection of gamma rays by multi-step absorption.

Stage two: When the electron energy becomes less than the ionization threshold, hot electrons and holes thermalize by intraband transitions and electron-phonon relaxation. The charge carriers can remain as diffuse band states in the case of semiconductors, become trapped on defects and impurities, become self-trapped by the crystal lattice, or form free and impurity-bound excitons, all in a time scale of ~10^{-12}-10^{-11} s. During this
stage luminescent centers may be excited by impact excitation by hot electrons, sequential electron-hole capture or sequential hole– electron capture, and sensitizer-activator energy transfer processes over a

time scale ranging from $<10^{-12}$ to $> 10^{-8}$ s. Depending on carrier mobility, this time is responsible for the intrinsic rise time of the scintillation light.

Stage three: The excited luminescent species return to the ground state by nonradiative quenching processes or by emitting a photon. The radiative process can be as short as 10^{-9} s for electron-hole recombination, free and bound exciton emission, and core-valence recombination, or can take many minutes for the case of highly forbidden processes [3].

2.3 Characterization

The radio detection materials was made by impregnating inorganic scintillators [ZnS(Ag)] in polymer. Polymers of styrene(St) and ethyl acrylate (EA) pair were polymerized by a sequential emulsion polymerization. These scintillator sheets were characterized by fourier transform infrared spectra (FTIR), transmission electron microscopy (TEM), scanning electron microscopy (SEM), thermogravimetric analyses (TGA), and the amount of scintillation, formed by the interaction between the ZnS(Ag) scintillators and the alpha-particles deposited onto the film specimen, was counted using a photo multiplier tube (PMT).

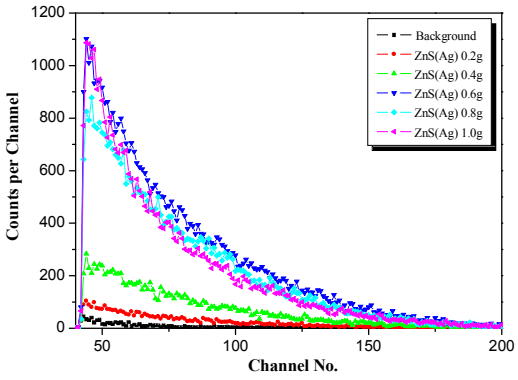

Fig. 1. Pulse height spectrum of polymer emulsions impregnated inorganic (beta emitting source : Sr-90)

2.4 Radioactive detection test

As shown in Figure 1, the detection efficiency was improved with the increase of the scintillator content in the scintillation paste. This is due to the increase in the overall scintillation events with the increase of the total amount of ZnS(Ag). The stability of the active layer, however, was decreased with the scintillator content, since too many scintillators result in a reduction of the adhesion strength due to the lack of a binding polymer.

3. Conclusions

In this work, the spray type counting materials for radioactive contamination using ZnS(Ag) inorganic scintillators. The radio detection materials was made by impregnating inorganic scintillator in polymer by emulsion polymerization. These scintillator sheets were characterized by FTIR, TEM, SEM, TGA and the amount of scintillation by the interaction between the ZnS(Ag) inorganic scintillators and the organic polymer, was counted using a PMT. The detection efficiency was improved with the increase of the scintillator content in the scintillation paste. The detectable capacity of organic-inorganic composite polymer emulsion showed a good performed for radioactivity.

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