Transactions of the Korean Nuclear Society Spring Meeting
Pyeongchang, Korea, May 27-28, 2010

Radiological decontamination strippable coatings using PVA and PVP based core-shell polymeric scintillation materials

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1. Introduction

Strippable coatings are innovative technologies for decontamination that effectively reduce loose contamination. These coatings are polymer mixtures, such as water-based organic polymers that are applied to a surface by paintbrush, roller or spray applicator. In this study, the core-shell composite polymer for decontamination from the surface contamination was synthesized by the method of emulsion polymerization and blends of polymers. The strippable polymer emulsion is composed of the poly(styrene-ethyl acrylate) [poly(St-EA)] composite polymer, poly(vinyl alcohol) (PVA) and polyvinylpyrrolidone (PVP). The morphology of the 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. Related tests and analysis confirmed the success in synthesis of composite polymer. The products are characterized by FT-IR spectroscopy, TGA that were used, respectively, to show the structure, the thermal stability of the prepared polymer. Two-phase particles with a core-shell structure were obtained in experiments where the estimated glass transition temperature and the morphologies of emulsion particles. Decontamination factors (DF) of the strippable polymeric emulsion were evaluated with the polymer blend contents.

2. Methods and Results

2.1 Preparation of Poly(St-EA) Core-Shell Polymer

The preparation of core-shell composite polymer particles was performed by a two-step polymerization method. 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. St monomer in distilled water were pre-emulsified in the presence of SDS by stirring at 85℃ for at least 20 min, before addition of APS to start the polymerization reaction. The reaction was maintained at 85℃ 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 for 5h. The reaction mixture was stirred at a constant rate to avoid the adverse effect of stirring on polymerization.

2.2 Preparation of Polymer Blends

The poly(St-EA) polymer latex and PVA and PVP were blended with a mechanical stirrer. The blending was performed 85-90℃, employing a mechanical stirrer speed of 200 rpm. The system was cooled to room temperature and the final polymer 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 PS seed latex and the poly(St-EA)/PVA/PVP composite polymer

	PS seed latex	Poly(St-EA)/PVA/PVP composite particles
St (g)	5	
EA (g)		2.5
Seed latex emulsion (g)		5
DI water (g)	200	250
APS (g)	0.1	0.025
SDS (g)	0.004	
PVA (g)		12.5-37.5
PVP (g)		7.5-37.5

2.3 Determination of decontamination factors

The strippable polymer emulsion is composed of poly(St-EA) composite polymer, PVA and PVP. Decontamination factors for strippable coating materials were preformed as follow: Several aluminum disks (5 cm diameter) were prepared by adding contaminant solution (Sr-90). Each contaminated disks were analyzed via Low Background Counting System before being treated with strippable coating. All coatings were allowed complete dry for 24 h. The coatings were removed from disks, and the disks were again analyzed via Low Background Counting System. Using the count rates before and after decontamination, decontamination factors were calculated using equation 1, where β_1 is the β count before decontamination and β_2 is the β count after decontamination.

$$\text{Decontamination Factors} = \beta_1 / \beta_2$$

2.4 Decontamination

The results for these coating are shown in Table 3. The decontamination factors obtained for Sr-90 on the disk plate studies were observed to decrease as the amount of contaminant on the disk increased. This was probably due to a conflict between the time required for the larger amounts of contaminant to permeate into the polymer and the drying time of the coating; in other words, it is likely that the coating dried before the larger amount of Sr-90 was drawn into it. It was shown the DF values of 8.9 to 12.8 at all the polymer composition. Poly(St-EA)-PVA-PVP coating have the ability to contamination for the contaminant.

Table 2. Decontamination factors for the decontamination of Sr-90 contaminated disk using poly(St-EA)-PVA-PVP

Polymeric Composition (wt%)		Initial (Bq/sample)	Final (Bq/sample)	DF	Stripp -ability
Poly (St-EA)	PVA 5 PVP 3	1138	111	10.3	Bad
	PVA 7 PVP 5	1042	107	9.7	Good
	PVA 8 PVP 6	1039	81	12.8	Good
	PVA 9 PVP 7	1187	92.4	12.8	Good
	PVA 10 PVP 8	1169	124	9.4	Good
	PVA 15 (without PVP)	1155	129	8.9	Good
	PVP 15 (without PVA)	1965	211.7	9.3	Bad (brittle)

3. Conclusions

Organic polymer coatings had developed that are capable of both detecting and removing contaminants from surfaces. These coatings consist of strippable polymeric compositions containing blends of polymers, copolymers and safe water-based materials. Furthermore, strippable polymeric coatings are polymeric solutions or dispersions that can be applied to a surface by brushing or spraying. Upon curing or drying, these coatings form strong films that can easily be peeled or stripped from the surface.

REFERENCES

[1]. M.A. Ebadian, Susan C. Madaris, Carmen Alicia Aponte, Assessment of strippable coatings for deactivation and decommissioning, U.S. Department of Energy, 1999.