Transactions of the Korean Nuclear Society Autumn Meeting
Jeju, Korea, October 21-22, 2010

Chemical Gel for Surface Decontamination

Chong Hun Jung*, J. K. Moon, H. J. Won, K. W. Lee, C. K. Kim
Korea Atomic Energy Research Institute,
Decontamination & Decommissioning Research Dept.
**nchjung@kaeri.re.kr*

1. Introduction

Many chemical decontamination processes operate by immersing components in aggressive chemical solutions. In these applications chemical decontamination technique produce large amounts of radioactive liquid waste [1-2]. Therefore it is necessary to develop processes using chemical gels instead of chemical solutions, to avoid the well-known disadvantages of chemical decontamination techniques while retaining their high efficiency [3].

Chemical gels decontamination process consists of applying the gel by spraying it onto the surface of large area components (floors, walls, etc) to be decontaminated. The gel adheres to any vertical or complex surface due to their thixotropic properties and operates by dissolving the radioactive deposit, along with a thin layer of the gel support, so that the radioactivity trapped at the surface can be removed (Figure 1).

Important aspects of the gels are that small quantities can be used and they show thixitropic properties : liquid during spraying, and solid when stationary, allowing for strong adherence to surfaces.

This work investigates the decontamination behaviors of organic-based chemical gel for SS 304 metallic surfaces contaminated with radioactive materials.

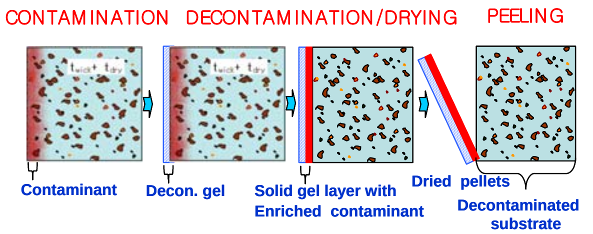

Fig. 1. Surface decontamination using chemical gel.

2. Methods and Results

2.1 Preparation of the gels

Chemical gels can be formulated by adding the gelling agents composed of polymeric gelator and surfactant, to chemicals used for traditional decontamination processes. Polyvinyl alcohol(PVA) was selected as the gelator that can form synergitic emulsifying combinations with surfactant. To obtain a tensile strength for peelability, PVA with molecular weight of higher than 20000g/mol was purchased from SIgma. Surfactant is used to further lower surface tension for easy application, and to stabilize the chelating agent used as a decontamination chemical in the gel for longer life. Among the most frequently used chelating agents, diethylenetriaminepentaacetic acid (DTPA) was chosen based on their chelating efficiency and safety to the environment. 12.5 % to 17.5% of PVA relative to the total weight of the gel was mixed with demineralized water and heated in a silicone oil bath to about 90 C until PVA was fully dissolved. The mixture was then cooled to room temperature. A surfactant (1.5wt%-3.0wt%) and DTPA with concentration of 1.0wt% to 2.0wt% were added to the mixture. The gel was then neutralized with 10wt% KOH solution to about pH of 7.0.

2.2 Surface decontamination and Rheography

To examine the decontamination properties of the chemical gel, a non-radioactive surrogate compound, cesium chloride was chosen as the radionuclide surrogate Cs137. An aqueous stock solution prepared at the concentration of 10wt% was uniformly distributed on SS 304 plate with a dimension of 7cm X 7cm. After the solution had evaporated, chemical gel containing DTPA was applied to the SS plate. After 3hrs, dehydrated gel was peeled off. The SS plate was rinsed with distilled water to dissolve any residual salt. The rinsing solutions was dried in the oven at 80C for 48hrs. By weighing the residual salt, the removal efficiency was determined.

Thixotropy defined as a decrease in apparent viscosity under stress, followed by gradual recovery at rest, is a rheological pheonema. The rheogram curves at various shear rates according to the gel formulations were obtained using a viscometer(Brookfield Eng. & Lab. Inc., RVDV-ⅢU) and Rheocalc 32 software..

2.3 Decontamination test results

Figure 2 shows the removal of Cs with variation of CsCl & PVA concentration at constant surfactant concentration of 2 wt.%. The removal % of Cs is about 99.5% and 99.0% with variation of PVA concentration (12.5-17.5%) at a Cs salt concentration of 0.01 g/cm^2 and 0.0025 g/cm^2, respectively. The chelating gel containing DTPA was effective in removing cesium.

The main characteristic in chemical gel exists in their thixotropic properties. Thixotropy is characterized by a re-build time when the gel structure evolves from breakdown to recovery states.

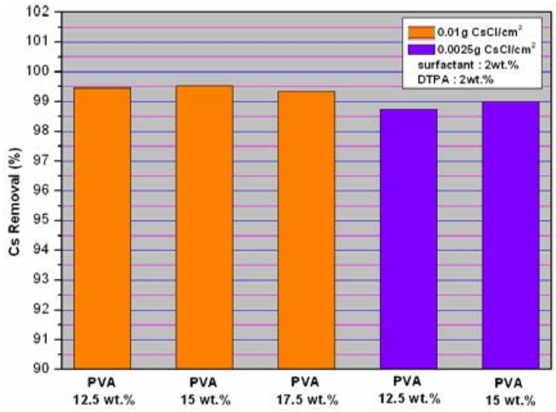

Fig. 2. Removal of cesium with variation of CsCl and PVA concentration.

Figure 3 represents schematic rheograms at various PVA-based gels and shows the effects of the formulation on the rheological properties. After shearing for 120s at a shear rate ofn15 s^{-1} and a consecutive shear rate of 1.7 s^{-1} representing a stationary state are imposed. The equilibrium viscosity at 1.7 s^{-1} vary depending on the gel formulations. It is reported that the equilibrium viscosity has an effect on the amount of gelator, chelating agent concentration, the type and concentration of surfactant and the salinity and electrolyte properties of the medium [4]. The viscosity at 1.7 s^{-1} ranges from 8000 to 9500 cP depending on the gel formulation but the re-build time of about 4 second for various gels tested. When a surfactant and DTPA chemicals are added, the viscosity and re-build time attain satisfactory value. But viscosity at a shear rate of 15 s^{-1} was so high for spraying.

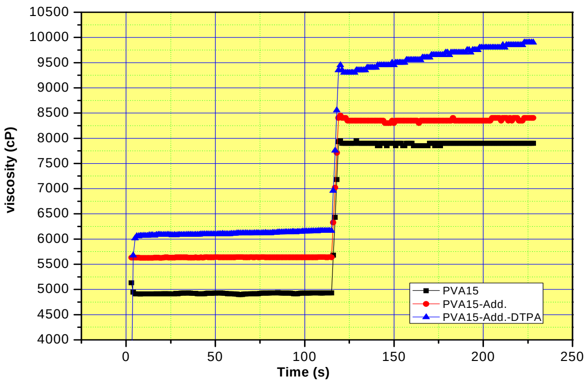

Fig. 3. Rheograms of various gels: shearing for 120s at a shear rate of 15/s ollowed by a shearing for 120s at 1,7/s.

3. Conclusions

The PVA-based organic gel containing DTPA was effective in removing a cesium contaminants from SS 304 metallic surface.

Approximately 99.5% removal was achieved with a cesium concentration of 0.01 g/cm^2 whereas 99% removal was attained with 0.0025 g/cm^2 of the cesium contaminations.

When a surfactant and DTPA are added to the PVA gelator, the viscosity and shear rate after adherence to the surface is satisfactory without leakage.

REFERENCES

[1] Anibal L. Taboas, A. Alan Moghissi and Thomas S. LaGuardia, "The decommissioning handbook", ASME, 4-22 (2004).
[2] IAEA, "State of the art technology for decontamination and dismantling of nuclear facilities", IAEA in Austria (1999).
[3] Feltcorn, "Technology Reference Guide for Radiologically Contaminated Surfaces", U.S. Environmental Protection Agency (2006).
[4] Nunez, Luis and Kaminski, Michael Donald, "Foam and gel methods for the decontamination of metallic surfaces", US patent No. 7166758 (2007).