Transactions of the Korean Nuclear Society Spring Meeting
Taebaek, Korea, May 26-27, 2011

Silica-based Chemical Gel for Decontamination of Cs and Co

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

1. Introduction

Chemical decontamination technology represents a highly effective decontamination effect through chemical dissolution or a redox reaction. However, the generation of large amounts of waste limits its use as an in-situ technology. Therefore, to avoid the well-known disadvantages of chemical decontamination techniques while retaining their high efficiency, it is necessary to develop processes using chemical gels instead of chemical solutions [1-3]. This method is effective in situations where long contact times are required, and the need to minimize waste exists.

A chemical decontamination gel can be prepared by adding gelling agents composed of a viscosifier and coviscosifier to chemical decontamination agents used in traditional decontamination processes.

A chemical gel decontamination process consists of applying a gel by spraying it onto any vertical or complex surface of the large area components to be decontaminated. The gel adheres to the surface due to its thixotropic properties and operates by dissolving the radioactive deposit, along with a thin layer of gel support, so that the radioactivity trapped at the surface can be removed. Upon drying, this gel forms a strong film that can be peeled from the surface.

This work investigates the decontamination behaviors including rheological and drying behaviors of an inorganic-based chemical gel for SS 304 metallic surfaces contaminated with Co and Cs radioactive materials.

2. Methods and Results

Chemical decontamination agents were prepared by dissolving 0.5M Ce (IV) in concentrated nitric acid. The gelling agents were composed of a viscosifier and coviscosifier. Pyro Si, which is stable in an acidic medium, and is easily gellated at small amounts compared to Al, was selected as a viscosifier and used in the 5-10 wt.% concentration during the experiment. As a coviscisifier, tripropylene glycol butyl ether (TPGBE) and tripropylene glycol dodecyl ether (TPGDDE) were selected among PEG-based non-ionic surfactants that are chemically stable and easily dissolved, and were tested within a range of 0.1-1.0 wt.%.

A chemical decontamination gel was sprayed onto the surface of an SUS 304 specimen contaminated with Co-60 and Cs-137 radionuclides. The gel adheres to the surface of the specimen 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. The efficiency of the radioactivity removal from the surface of the sample, expressed by the decontamination factor (DF) were calculated by measuring the radioactivity concentration of Co and Cs radionuclides using MCA(Canberra, 2025).

Thixotropy, defined as a decrease in apparent viscosity under stress, followed by a gradual recovery at rest, is a rheological phenomenon. 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.

The shear rates before and after the injection of the gel were simulated to 500/s and 1/s, and the rheological properties were measured in accordance with the concentration of the viscosifier, as shown in Fig. 1. The viscosity increased with an increase in concentration, regardless of the type of viscosifier used.

A low viscosity of less than 500cP at a high shear rate of 500/s results in effective spraying to the surface, while a high viscosity of 7,000 cP (TPGBE), 4,000 cP (TPGDDE) or more showed the proper surface adhesion characteristics at low shear rates of 1/s. Thixotropy, which is one of the main characteristics in chemical gels, is characterized by a re-build time when the gel structure evolves from a breakdown into a recovery state. As shown in Fig.1, a rebuild time of under around 3 seconds was achieved for the various gels tested, and the effective thixotropic behavior was observed.

The drying and detachment characteristics of the gel containing radioactive nuclides after decontamination were investigated using various concentrations of viscosifier and coviscosifier, and are shown in Fig. 2. Gel containing radionuclides after decontamination were completely dried within 6 hours, regardless of the viscosifier and coviscosifier concentration.

Fig. 2 shows the surface of the SUS 304 specimens after drying and detachment, revealing that the gel products have been effectively removed from the surface through the formation of a uniform crack of 2-3 mm on the surface after drying.

The decontamination factor for Co and Cs (Fig. 3) shows that DF increased for both radionuclides depending on the viscosifier concentration, with a high decontamination effect within a DF range of 100 to 800.

Using a gel formulation containing TPGBE as a coviscosifier, the decontamination factor for Co and Cs radionuclides were in the range of 200-520 and 180-700, respectively. The decontamination factor for Co

and Cs radionuclides using a TPGDDE or TPGBE coviscosifier increased depending on the concentration of the viscosifier. In particular the DF increased greatly at a viscosifier concentration of 6 and 7 wt.%, and ranged from 810 to 820 for Co, and from 700 to 810 for Cs, respectively.

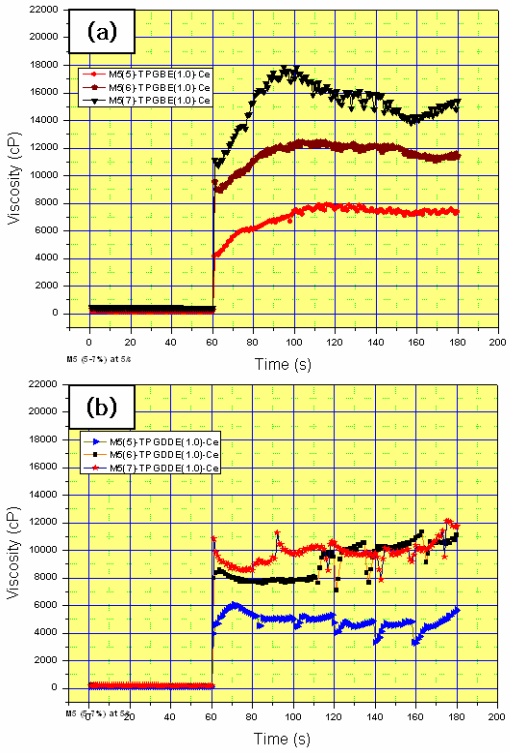

Fig. 1. Schematic rheograms of various gels (a : Tripryrylene glycol butyl ether, b: Tripropylene glycol dodecyl ether).

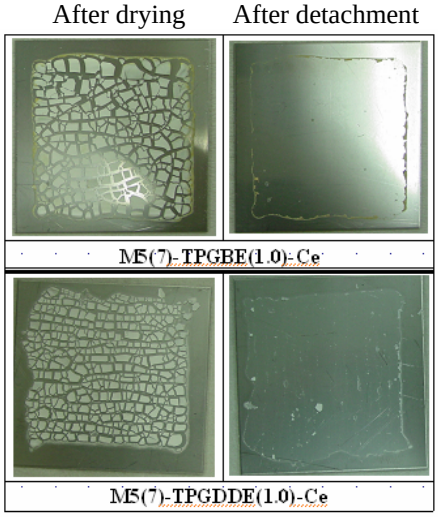

Fig. 2. Photographs of SUS 304 surface after drying and detachment.

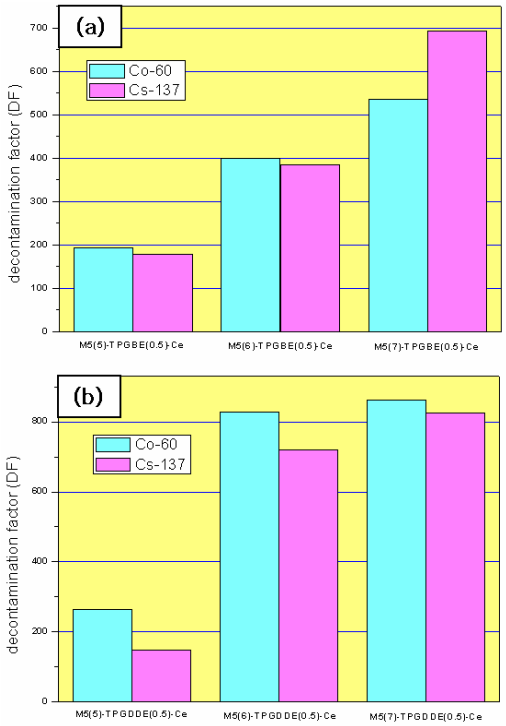

Fig. 3. DF with variation in gel formulation (a : Tripryrylene glycol butyl ether, b: Tripropylene glycol dodecyl ether).

3. Conclusions

The appropriate combination of viscosifier and coviscosifier is a very important factor in the control of the viscosity and adhesion properties of chemical decontamination gels.

A pyro Si-based chemical decontamination gel was prepared by adding gelling agents composed of a pyro Si viscosifier and PEG-based non-ionic coviscosifier (TPGBE and TPGDDE) into a Ce (IV) solution in concentrated nitric acid, and the decontamination and rheological behaviors, along with the drying behaviors of a chemical gel for SS 304 metallic surfaces contaminated with Co and Cs radionuclides were investigated.

A chemical gel containing a 0.5 wt% TPGDDE coviscosifier was more effective in terms of the rheological and drying-detachment properties, and the radionuclide decontamination effectiveness in particular, compared to TPGBE.

REFERENCES

[1] S. Faure, "Innovative Processes for nuclear decontamination solids" Exchange meeting between KAERI-CEA, 2008.
[2] A. Purohit et. al., "Method for the decontamination of metallic surfaces" US 650407, 2003.
[3] G. Jean-Paul, et. al., "Gel decontamination et son utilisation pour la decontamination radioactive de surfaces" FR-A-2656949, 1990.