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Effect of Organic Solvents in Preparation of Silica-Based Chemical Gel Decontaminants for Decontamination of Nuclear Facilities

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1. Introduction

Decontamination of nuclear facilities is necessary to reduce the radiation field during normal operations and decommissioning of complex equipment such as stainless steel components, other iron-based steel and alloys, metal surfaces, structural materials and so on. Chemical decontamination technology in particular is a highly effective method to remove the radioactive contamination through a chemical dissolution or a redox reaction. However, this method has the serious drawback due to the generation of large amounts of the radioactive liquid wastes. Recently, a few literatures have been reported for the preparation of the chemical gel decontaminants to reduce the amount of the radioactive liquid wastes and to enhance the decontamination efficiency through increasing the contact time between the gels and the radioactive contaminants [1-3]. In the preparation of the chemical gels, the control of the viscosity highly depends on the amount of a coviscosifier used among the components of the chemical gels consisted of a viscosifier, a coviscosifier, and a chemical decontaminant.

In this works, a new effective method for the preparation of the chemical gel was investigated by introducing the organic solvents. The mixture solution of the coviscosifier and organic solvent was more effective in the control of the viscosity compared with that of the coviscosifier only in gels. Furthermore, the decontamination efficiency of the chemical gels measured by using the multi-channel analyzer (MCA) showed the high decontamination factor for Co-60 and Cs-137 contaminated on the surface of the stainless steel 304.

2. Methods and Results

2.1. Preparation of the chemical gels

Silica-based chemical gel for the decontamination was prepared by using the fumed silica (CAB-O-SIL M-5) as a viscosifier, 0.5 M Ce (IV) solution dissolved in concentrated nitric acid as a chemical decontamination agent, and tripropylene glycol butyl ether (TPGBE) as a coviscosifier. Here, the fumed silica, the M-5 was selected because of the stability and easy gelation in an acidic medium. Also, the TPGBE among the various PEB-based non-ionic surfactants was used owing to the chemical stability and easy dissolution. In typical procedure, the M-5 was added into the reaction bottle containing the decontaminant solution under vigorous stirring. Then, the TPGBE was slowly added after the stirring for 30 min and stirred for 3 h more at ambient condition. To investigate the effect of the organic solvent as an ethyl alcohol (EtOH) in the formation of the gels, the viscosity of the chemical gels prepared by using the mixture solution consisted of the TPGBE and EtOH was compared with that prepared without the EtOH under various experimental conditions such as the amount of the EtOH and TPGBE, the stirring time, and the stirring speed. The decontamination efficiency for Co-60 and Cs-137 contaminated on the surface of the stainless steel 304 was investigated by using the MCA.

2.2. Effect of the organic solvent

To examine the effect of the organic solvent in the preparation of the chemical gels, the viscosity properties of the gels prepared by using the mixture solution with a different volume ratio of the TPGBE/EtOH (0.1 ml/0.0 ~ 1.5 ml) exhibited in Fig. 1(a). The viscosity of the chemical gels increased with an increase of the amount of the EtOH used. On the other hand, the viscosity of the gels in the case of the use of the TPGBE only showed the sharp increase over 0.16 ml (inset Fig. 1(a)). From these results, the organic solvent played a key role as an effective dissolution solvent for the covicosifier in the preparation of the gel, resulting in a reducing of the amount of the covicosifier compared with that of the chemical gel prepared without organic solvent. This reason believed that the organic solvent contributed to the effective dissolution of the coviscosifier as well as the homogeneous mixing in the formation of the gel, while the coviscosifier in aqueous media shows the lower solubility [4].

To use the chemical gels for the decontamination of the contaminated surfaces, the gels must possess the thixotropic property, which is one of the main characteristics in the gels, and be effectively sprayed to the contaminated surface. The gels with the viscosity in the range of ca. 5.0 ~ 7.0 Pa·s are proper for a good thixotropic behavior and effective spraying. Fig. 1(b) was shown the viscosity property of the gels prepared by varying the amount of the mixture solution with a different volume ratio of the TPGBE/EtOH (0.05 ~ 0.10 ml/1.0 ml). The viscosity of the chemical gels containing TPGBE/EtOH smoothly increased with an increase of the amount of the TPGBE used compared

with that of the TPGBE only. It implies that the viscosity of the gels prepared by using the mixture solution of the coviscosifier and the organic solvent can be easily controlled more than the use of the coviscosifier only. The viscosity of the gels for the decontamination of the contaminated surfaces is very important factor for the thixotropic property and effective spraying. Also, the effect of the stirring time and speed was investigated. As shown in Fig. 2, the viscosity of the gels was nearly unaffected to the stirring time and speed.

2.3. Decontamination efficiency of the gels

The decontamination efficiency of the gels prepared in this work was investigated by using multi-channel analyzer (MCA) for Co-60 and Cs-137 contaminated on the surface of the stainless steel 304. The decontamination efficiency for Co-60 and Cs-137 showed the high decontamination efficiency of ca. 94.0 ~ 97.8 % and ca. 91.9 ~ 100 %, respectively.

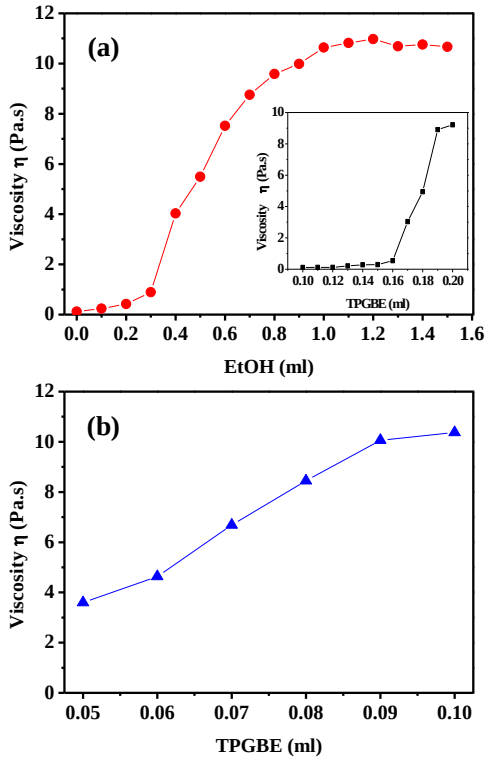

Fig. 1. (a) Viscosity property of the gels prepared by using the mixture solution with a different volume ratio of the TPGBE/EtOH (0.1 ml/0.0 ~ 1.5 ml) and the TPGBE only (Inset) and (b) Viscosity property of the gels prepared by varying the amount of the mixture solution with a different volume ratio of the TPGBE/EtOH (0.05 ~ 0.10 ml/1.0 ml).

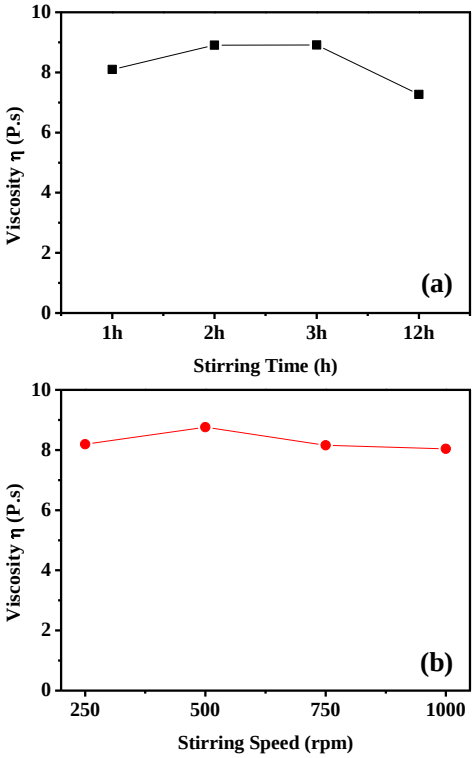

Fig. 2. Viscosity properties of the gels for (a) the stirring time and (b) the stirring speed.

3. Conclusions

The use of the organic solvent together with a coviscosifier was very effective because of the dissolution of the coviscosifier as well as the homogeneous mixing in the formation of the gel, resulting in a reducing of the amount of the covicosifier compared with that of the gel prepared without organic solvent. Also, the viscosity property of the gels was easily controlled more than the use of the coviscosifier only. The decontamination efficiency of the gels showed the high decontamination efficiency for Co-60 and Cs-137. Further research for the preparation of the gels using various organic solvents is currently under progress.

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