Transactions of the Korean Nuclear Society Autumn Meeting
Pyeongchang, Korea, October 30-31, 2014

Fixation of Soil Using PEC and Separation of Fixed Soil

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1. Introduction

Radioactive contaminants have been released into the environment by the nuclear accident at the Fukushima nuclear power station in 2011. The radioactive contaminants were spread to a residential area, forest, agricultural field by wind and water. Radioactive cesium (Cs-137) is the most apprehensive element due to its long half-lives, high solubility in water, and strong radiation emission in the form of gamma rays.

Because the radioactivity is localized within topsoil, soil surface on topsoil should be fixed to prevent the spreading of the contaminated soils by wind and water erosion. Many methods have been developing for soil fixation to remove radioactive contaminants in soil and prevent to diffuse radioactive materials. Various materials have been used as fixatives such as clays, molecular sieves, polymer, and petroleum based products.

One of the methods is a soil fixation or solidification using polyelectrolyte[1-3]. Polyelectrolytes have many ionic groups and form the polyelectrolyte complex (PEC) due to electrostatic interaction of anion and cation in an aqueous solution. polyelectrolyte complex can fix soil particles by flocculation and formation of crust between soil. The method can prevent a spread of radioactive material by floating on a soil surface. Recently, polyelectrolyte complex was used the solidification of soil near the Fukushima nuclear power plant in Japan [4]. The decontamination efficiency of the surface soils reached about 90%, and dust release was effectively suppressed during the removal of surface soils. However it has a problem that the removed soil must separate soil and polymer to treat as the waste.

In this study, the fixation of soil by polyelectrolyte complex to suppress the spread of contaminant and the separation method of soil and polymer was investigated.

2. Methods and Results

Cationic polymer, Polydiallyldimethyl ammonium chloride (PDADMAC, 200,000 ~350,000, 20 wt% in water, Aldrich), and anionic polymer, Polyacrylic acid (PAA, 250,000, 30wt%, Aldrich) were used for formation of polyelectrolyte complex. Potassium chloride (KCl) and sodium hydroxide (NaOH) were used for the adjustment of salt concentration and pH, respectively.

To prepare the PEC solution, KCl and NaOH dissolved in water and 10wt% PDADMAC and then 10wt% PAA solution is adding to 10wt% PDADMAC solution slowly with stirring. When 10wt% PAA solution is adding to 10wt% PDADMAC solution, PAA agglomerate was formed due to low pH of PAA

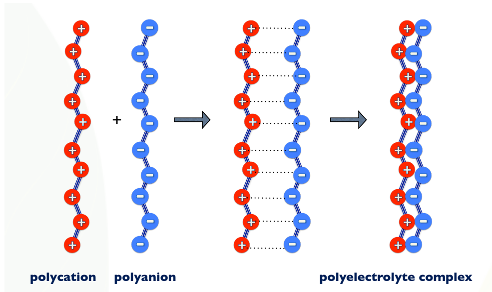


Fig. 1. Formation of polyelectrolyte complex by polycation and polyanion

In order to fix soil by polyelectrolyte complex solution, 20 ml of polyelectrolyte complex solution was spread to 150 g of sea sand (Junsei) and dried at room temperatures. In case of a low KCl concentration soil was partly fixated from the results of soil fixation, The low capacity of soil fixation was caused by low contents of polymer due to the precipitation of polyelectrolyte complex. Therefore, a content of salt is a very important to the application of polyelectrolyte complex for the soil fixation. The measurement for physical strength of fixed soil was performed in order to the investigation of stability of fixed soil. To prepare fixed soil samples with polymer molecular weight, each 6ml of polyelectrolyte complex solution with different molecular weight was added to 16g of soil and then was dried at room temperature during two week.

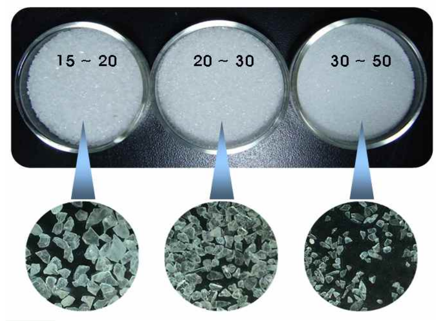
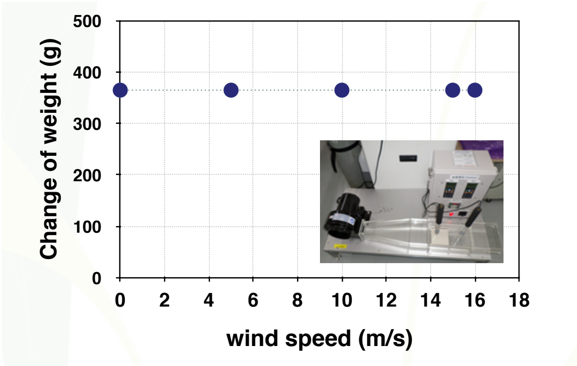


Fig. 2. Image of soil (sea sand) used to the fixation

Physical strength of fixed soil was determined by universal testing machine. As the increasing the contents of polyelectrolyte complex, numbers of adding, and the molecular weight of polyelectrolyte the physical strength of fixed soil sample increased. From the results, physical strength of fixed soil is affected to numbers of adding polyelectrolyte complex solution more than a molecular weight of polymer. Wind erosion tests were carried out with a crust prepared by a high salt concentration polyelectrolyte complex solution.



From the results of the wind erosion test, wind erosion was not detected up to a flow rate of 15m/s.

Fig. 3. The change of weight by wind erosion

In order to separate soil and polyelectrolyte complex from the fixed soil, 15g of fixed soil soaked in 20 ml of 1M KCl solution at room temperatures. And then Fixed soil was separated soil and polymer by washing KCl solution. The method is a good application for the separation of soil and polyelectrolyte complex.

3. Conclusions

The properties of polyelectrolyte complex solution and the stability of fixed soil by polyelectrolyte complex were investigated. The concentration of salt in the polyelectrolyte complex solution is a very important parameter for the soil fixation. The physical strength of fixed soil was increased with increasing amount of polyelectrolyte complex solution and molecular weight of polymer. The separation method of fixed soil was found.

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