Mobile Iodine Retention in the Compacted Bentonite for a Long-Term Period

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1. Introduction

The spent fuel derived from the nuclear reactor facilities may be disposable into a deep underground below 500 m [1]. It would be surrounded by a metal canister, and it usually consists of uranium in majority with its minor decay products such as iodine and technetium, which are typical anionic radionuclides. In particular, radioiodine is one of very important nuclides because of its higher mobility from its deposit source. It has been known that it could freely pass through a compacted bentonite that is a potential barrier to be used to retard some nuclides' migration from the inside canister. We experimentally installed a small miniature apparatus that is similar to the underground repository site in an anaerobic glove box to evaluate the iodine migration from compacted bentonite. In our study, we additionally tried to develop a new design to retard iodine migration from the compacted bentonite for a long-term period. This is a new approach applicable to the disposal site to effectively suppress iodine mobility.

2. Methods and Results

2.1 Methods

We made a small and compact repository miniature apparatus (Fig. 1) by using a granite column with 5 cm height and 5.2 cm diameter that was cut around the center, where the inside part was also excavated in a dimension of 2 cm height and 3 cm diameter as a purpose for putting a compacted bentonite into it later on. The granite used was a boring core obtained from the KURT (Kaeri Underground Research Tunnel) site. The bentonite that was used as a compacted buffer material was originated from Kyongju, Gyeonsang province. Some portion of it was modified by exchanging the interlayer cations with copper(II) ions as much as 1 CEC (cation exchange capacity). The prepared bentonite was compacted by a density of 1.6 g/cm^3 in column (2 cm height and 3 cm diameter), where iodine powder, NaI (45 mg), was put into the center as a replica of radioiodine waste. The prepared compact apparatus was immersed into a plastic container with an anaerobic solution containing $NaHCO_3$ (1 mM), Na_2SO_4 (2 mM), and Na-lactate (10 mM). The whole apparatus was placed in the glove box filled with N_2 gas. Some aqueous solution was periodically sampled from it and measured for pH, Eh, and dissolved ions such as iodine during 5 months. After the experiment, the solid bentonite sample was cross-cut and examined for the iodine diffused over it using microprobe analyzer.

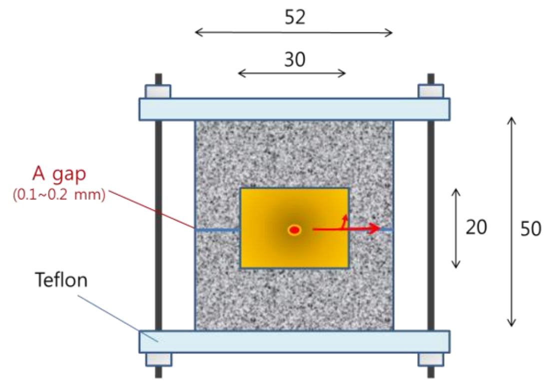

Fig. 1. A small apparatus that consists of KURT granite and compacted bentonite with iodine in its center was used in the experiment, which conceptually represents a specific radwaste geological disposal site. The scale is millimeter.

2.2 Iodine Diffusion from the Compacted Bentonite

The solution pH and Eh were initially 6.5 and 190 mV, respectively, exhibiting a little acidic and anaerobic condition. The initial pH value was little changed, but a significant change for Eh was observed for the case of presence of aqueous sulfate, displaying its decline from 190 to 74 mV during 5 months.

The iodine powder in the compacted raw bentonite was gradually dissolved and released to the surrounding solution as it became saturated with water. Its release rate was initially fast and then became slow with time in a buffer solution of $NaHCO_3$ alone (Fig. 2). However, in a specific condition both with Cu-exchanged bentonite and aqueous sulfate, the releasing rate of iodine was relatively slower and nearly zero at the late stage. It means that the leaching of iodine from the compacted bentonite may be retarded and strongly influenced by the copper and aqueous sulfate. The sulfate can be reduced to sulfide by SRB (sulfate-reducing bacteria) living in the bentonite, probably affecting the iodine diffusion and migration in the system. In general, bentonite could have some indigenous bacteria including SRB [2], which have been recognized as regulating agents to be able to change the geochemical properties in the bentonite.

For the Cu-exchanged bentonite with sulfate, soluble iodine was transformed to a solid phase, which was identified by X-ray diffractometer and electron microscopy. The concentration of iodine in the solid phase was significantly high and mostly coexisted with copper component in the bentonite. It means that in a specific condition the highly mobile iodine can be effectively immobilized as a crystal phase, which will be stable for a long time in natural environments.

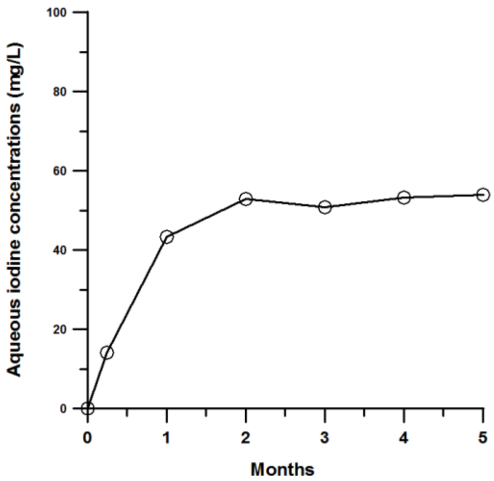

Fig. 2. Release of iodine from the compacted raw bentonite to the aqueous solution with time.

3. Conclusions

We found an effective way to limit the iodine diffusion and migration from the compacted bentonite. This specific condition designed can be achievable by exchanging the bentonite interlayer cations with copper ions in the presence of sulfate. In that case, soluble iodine can be easily immobilized as a solid phase by combining with copper component via the role of indigenous SRB in bentonite.

REFERENCES

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