Biogeochemical Alteration of KJ-II Bentonite Under Alkaline-Reducing Conditions

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1. Introduction

Bentonite has been used as buffer or backfill materials for deep geological repositories of high-level radioactive wastes. The bentonite can react with the cement used as construction materials in the repositories [1]. They may cause alkaline conditions. When bentonite and cement interacts, OH^- and Ca^{2+} can move into bentonite and pH rises to 10~13 in bentonite pore water. In this process, a dissolution of bentonite can occur, and secondary minerals may precipitate [2]. Therefore the study on the alteration of bentonite under alkaline condition is needed. Furthermore, the alteration of bentonite may be related with the behavior of radionuclides.

In the study, we investigated the alteration of KJ-II (Gyeongju) bentonite based on microbial activity under alkaline-reducing conditions. This work was focused on the effect of indigenous microbe in the bentonite, NaCl, and corrosion products of disposal materials on the alteration of KJ-II bentonite.

2. Experimental

2.1 Material

The bentonite used in this study was taken from Gyeongju. We named it as "KJ-II bentonite". It is a Ca-type bentonite that has montmorillonite content of about 65% with the ratio of CaO : Na_2O as 5.5:1 [3]. To examine the effect of corrosion products for the bentonite alteration, Cu_2S, FeS, and Fe_2O_3 powders were mixed with KJ-II bentonite (10% w/w).

2.2 Methods

2.2.1 Bentonite. KJ-II bentonite was mixed with corrosion products, and then distilled water that was sterilized was added to make a solid-liquid ratio (S/L) of 1g/30ml in 50ml centrifuge tubes. To remove some oxygen remaining in the bentonite, it was previously shaken for 3 days (120 rpm, 30°C). Finally, the supernatant was removed after a centrifugation (10,000 rpm, 5 minutes), and the centrifuge tubes containing the materials were placed in a glove box filled with N_2 gas.

2.2.2 Solutions. Solutions were prepared by adding some reagents to water using a clean bench. Before addition of the reagents, they were sterilized by 0.20 μm filtration (ADVANTEC). To investigate the effect of indigenous microbe in KJ-II bentonite, distilled water, distilled water+10mM Na-lactate, and distilled water+10mM Na-lactate+2mM sulfate were prepared respectively. To investigate the effect of salt water, 0.5M NaCl and 2.0M NaCl solutions were used. All solutions were purged with N_2 gas for 40 minutes to remove oxygen in solution and then immediately placed in a glove box.

2.2.3 Experiments. All experiments were carried out in the glove box filled with N_2 gas (anaerobic condition). The prepared solutions were poured into centrifuge tubes containing bentonite mixed with corrosion products (FeS, Fe_2O_3 and Cu_2S). NaOH solution was used to adjust the pH of the media as 9, 10, and 11, respectively. The experimental conditions are summarized as follows (Table 1).

Table 1. Experimental conditions in our study

Case	Type of bentonite	Solutions	pHs
1	KJ-II bentonite	distilled water	9, 10, 11
2	KJ-II bentonite	distilled water+10mM Na-lactate	9, 10, 11
3	KJ-II bentonite	distilled water +10mM Na-lactate +2mM sulfate	9, 10, 11
4	KJ-II bentonite	0.5 M NaCl	9, 10, 11
5	KJ-II bentonite	2.0 M NaCl	9, 10, 11
6	KJ-II bentonite +FeS(10% w/w)	distilled water	9, 10, 11
7	KJ-II bentonite +Fe_2O_3(10% w/w)	distilled water	9, 10, 11
8	KJ-II bentonite +Cu_2S(10% w/w)	distilled water	9, 10, 11

3. Results and discussion

The bentonites that were incubated in anaerobic condition showed visual changes (Fig. 1). In particular, case 3 showed that the color of bentonite was changed for 2 months regardless of its pH conditions. It is assumed that this phenomenon is caused by the indigenous bacteria that are active in the bentonite, if some electron donors (e.g., lactate) are supplied. The sulfate that was initially injected into the tube may be reduced to sulfide that is black as combined with metals (e.g., Fe).

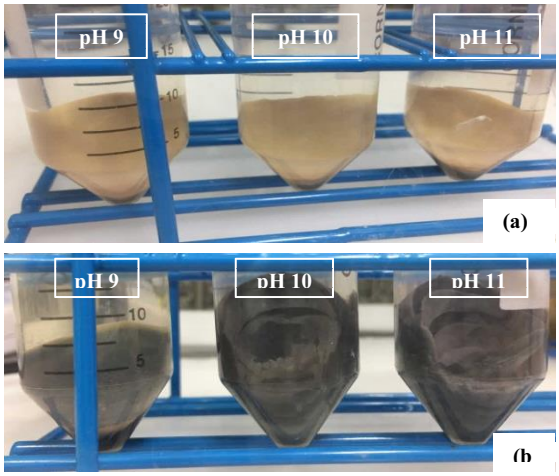

Fig. 1. Some KJ-II bentonites with different pHs; (a) after 1 week, (b) after 2 months.

4. Conclusion

The effect of microbial activity under alkaline-reducing conditions was investigated experimentally. In the study, the color of bentonite was changed by the indigenous bacteria that are active in the bentonite under the alkaline condition. When KJ-II bentonite is used as buffer material, bentonite alteration may be caused by the microbial activity in deep geological repositories of high-level radioactive wastes.

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