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Organically Modified Low-Grade Kaolin as a Secondary Containment Material for Underground Storage Tanks

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ABSTRACT

Leaks from underground storage tanks (USTs) and its piping system can cause serious environmental problems (e.g., soil and groundwater pollutions). To prevent leaks from the USTs, five northeastern states in the U.S. (i.e., Massachusetts, Vermont, Maine, New Hampshire, and Rhode Island) require all newly installed USTs to have a secondary containment barrier.

Clay liners have been used for containment of contaminants from an UST because of their low water permeability. The permeability of organic pollutants, however, through a clay liner is 1,000-10,000 times higher than water permeability. For better containment of pollutants from an UST, organically modified clays (e.g., bentonite (organobentonite)) have replaced conventional clay liners because they are known to effectively retard the migration of nonionic organic contaminants with their organic constituents The occurrences of kaolin in Korea are common, but commercially available kaolin is relatively few in number of kind. Low-grade kaolin, which is commercially unavailable kaolin, has been abandoned. For this reason, developing application of low-grade kaolin has been taken interestingly. In this study, the mineral surface of low-grade kaolin was modified with hexadecyltrimethylammonium (HDTMA) and its performance was compared with that of HDTMA-modified bentonite. Sorption capacity and hydraulic conductivity of both HDTMA- modified clays were measured. Relative sorption capacity and hydraulic conductivity of these clays on the overall transport of benzene were also evaluated using a one-dimensional solute transport model.

Sorption isotherm of BTEX (benzene, toluene, ethylbenzene, *o*-xylene) to HDTMA-modified clays was evaluated (Fig. 1). The sorption capacity of HDTMA-modified kaolin on BTEX compounds was similar

to that of HDTMA-modified bentonite indicating that HDTMA-modified kaolin is an effective sorbent the same as HDTMA-modified bentonite. The hydraulic conductivity of two different HDTMA-modified clays decreased 2-3 orders of magnitude as the permeant liquid was changed from water to gasoline. The hydraulic conductivity of HDTMA-modified kaolin on gasoline showed 5.62×10^{-8}cm/sec that was as much as the result of HDTMA-modified bentonite, 2.53×10^{-8}cm/sec. These values were 1 order of magnitude lower than known impermeable barrier value (1×10^{-7}cm/sec) for earthen liner.

To simulate the one-dimensional (vertical) transport of benzene through the HDTMA-modified clays under study, two cases were assumed. In one case, benzene of 1,000mg/L flowed continuously into the liner 1ft thick. In this case, the concentration of benzene at the lower boundary after 10 years was expected approximately 0.2 μg/L for HDTMA-modified kaolin and 14.9 μg/L for HDTMA-modified bentonite. In the other case, where it was assumed that same concentration of benzene flowed into the liner only for 5 years, the maximum concentration (14.34mg/L) of benzene at the lower boundary of HDTMA-modified bentonite was calculated to occur 66 years later. For HDTMA-modified kaolin, benzene at the lower boundary reached maximum concentration (11.9mg/L) after 95 years.

The one-dimensional simulation of benzene transport through two different HDTMA-modified liners, HDTMA-modified kaolin and HDTMA-modified bentonite, also confirmed that HDTMA- modified kaolin more effectively retards benzene transport than HDTMA-modified bentonite. Laboratory experiments with isotherm and hydraulic conductivity studies suggest that organically modified low-grade kaolin can be used as a hydraulic barrier against advective migration of petroleum contaminants from USTs.

Key words: Underground storage tanks (USTs), secondary containment, kaolin, HDTMA, BTEX

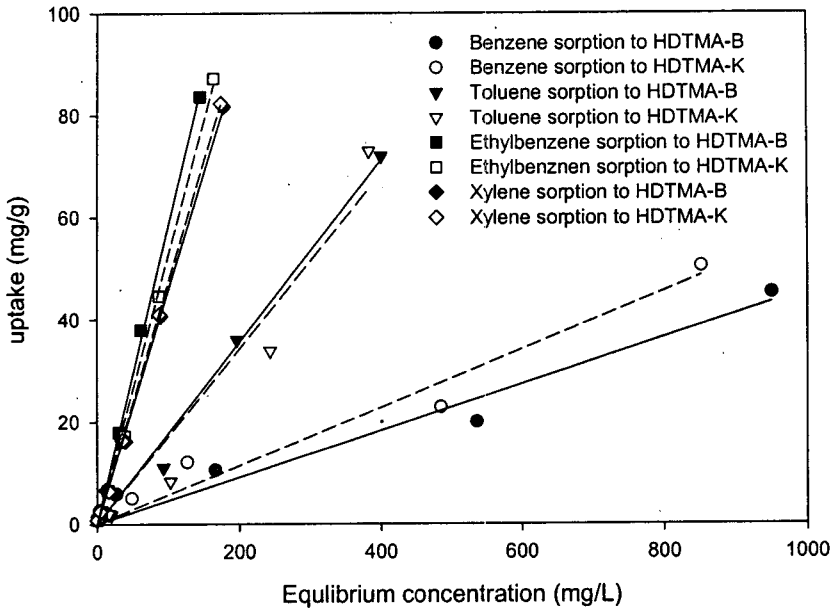

Fig. 1. Adsorption isotherm of BTEX compounds for two different HDTMA-modified clays HDTMA-B means HDTMA-modified bentonite and HDTMA-K is HDTMA-modified low grade kaolin.