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# Stabilization/solidification of nitrobenzene contaminated soil based on hydrophobilized CaO

S.Yu[a], R.Xu[a], L.Hou[a], M.Song[a], J.Liu[a, *]

[a]*School of Environment, Tsinghua University, Beijing, 100084, China*

**Abstract**

Lime, one of the common binders used in Solidification/Stabilization (S/S), is not adequate to immobilize toxic organic compounds of high-concentration released into soil by accidents in petrochemical and chemical industries. CaO, the main composition of lime, was hydrophobilized with stearic acid (SA) and silane coupling agent (KH570) to improve its fixation of nitrobenzene in S/S remediation of contaminated soil in present work, and the effect of hydrophobilized CaO on toxic organic compound encapsulation was evaluated through leaching and volatilization tests. Results showed that the binder composed of 20% SA hydrophobilized CaO together with 10% original CaO could reduce nitrobenzene's volatilization ratio to 0.096% and leaching ratio to 8.79%, while the nitrobenzene's volatilization ratio is 0.413% and leaching ratio is 35.48% with 30% original CaO as the binder.



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*Keywords:* Calcium oxide; hydrophobic modification; toxic organic compounds; contaminated soil; Solidification/Stabilization;

## 1. Introduction

With the rapid development of China, Sites are prone to be contaminated by high-concentration toxic organic compounds because of frequent pollution accidents in petrochemical and chemical industries. The common

* Corresponding author. Tel.: +86-010-6278-2029; fax: +86-010-6278-2029.
E-mail address: jgliu@tsinghua.edu.cn


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pollutants in soil include phenol, petroleum, polycyclic aromatic hydrocarbon(PAH), organic pesticide[1] To prevent compounds from doing harm to air, river and underground water after emergency, rapid immobilization is demanded to control their migration.

Solidification/Stabilization (S/S) is one of most widely used soil remediation methods[2,3]. Ordinary S/S usually uses lime, whose main element is CaO, as binder and focuses on heavy metal[4,5]. However, encapsulation of original CaO is not adequate to immobilize toxic organic compounds from polluted soil. It cannot ensure the long-time stability or prevent the volatilization of toxic organic compounds because of different chemical polarity between CaO and toxic organic compounds. Organic compounds are lipophilic and are hard to combine tightly with CaO, which results in the low fixation ratio in S/S of toxic organic compounds contaminated soil. Hydrophobic modification of CaO has been taken to enhance the ability to capture and fix toxic organic compounds as the surface modification makes CaO powder hydrophobic and lipophilic.

Hydrophobic modification has been studied for a long time[6] over the world and those studies concentrated mainly on chemical catalyze domain[7]. Hiromi Matsuhashi prepared solid base catalysts composed of CaO covered with 5-20% of $Al_2O_3$ by decomposition of $Al(OCH(CH_3)_2)_3$ over an $Ca(OH)_2$ surface in an ethyl acetate solution for a retro-aldol reaction to convert diacetone alcohol into acetone[8]. Sneha E. Mahesh modified CaO powder into hydrophobic using potassium bromide as catalysts for extracting biodiesel from waste cooking oil[9]. Kamegawa Takashi achieved hydrophobic modification of sulfonic acid-functionalized meaoporous silica for improvement of the catalytic performance in Fiedel-Crafts alkylation[10].In the present work, we investigated wet processes for hydrophobic modification of CaO powder with stearic acid (SA) and silane coupling agent (KH570).

In this work, hydrophobic modification technology, which is used in chemical catalyze domain widely，was applied to Solidification/Stabilization to enhance organic compounds' adsorption, in order to improve the fixation of toxic organic compounds in soil in emergency treatment after accidents. A systematic S/S experiment using hydrophobilized CaO and original CaO together to immobilize the high-concentration nitrobenzene, which was selected as a representative of toxic organic compounds, has been taken to study the effects of hydrophobic CaO in S/S. Three indicators, including volatilization ratio, leaching ratio and fixation ratio, have been thought to evaluating the effect of immobilization.

## 2. Materials and methods

### *2.1. Materials*

In this work, the main materials including CaO(AR), SA(AR), KH-570(AR), Nitrobenzene(AR), Methyl tertiary butyl ether (MTBE)(GR), Concentrated nitric acid(AR),Concentrated sulfuric acid.

The hydrophobilized CaO was produced in our lab experiment before, using SA or KH570 as a modifier. The optimum conditions for SA modification of CaO is 5% of SA (mass fraction) at 30 ℃ and with 30min, and the optimum conditions for KH570 modification of CaO is 0.02mL KH570 / g CaO at 30 ℃and with 40min.

We used the soil from Tsinghua university campus, after 105℃ drying, screen-through 2 mm sieve. In this work we chose 10000mg nitrobenzene/kg soil as the experiment concentration, which is 100 times of standard for Class B in "Standard of Soil Quality Assessment for Exhibition Sites"(HJ350-2007). Nitrobenzene acetone solution, which is prepared at a certain amount, was poured into the drying soil. The mixture of soil and nitrobenzene acetone solution was putted in fume hood for 48h after what all acetone was volatilized. The contaminated soil sample was transferred to the brown bottle. Testing the concentration of nitrobenzene in soil before the experiment, the result is the initial concentration of nitrobenzene of contaminated soil sample

### *2.2. Equipment*

Cement mixer (JJ-5, China); GC-MS (QP2010Plus, Shimadzu Japan); Air sampler (QC-1S, Beijing China); XRD (D8-Advance, BRUKER Germany); SEM (MERLIN VP Compact, Carl Zeiss Jena); FTIR (VERTEX 70v, BRUKER Germany).