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Studies on Adsorbent Development for the Separation of Ca/Sc

Jun Sig Lee, Ul-Jae Park, Hyemin Jang
Korea Atomic Energy Research Institute

Introduction

➢Purpose of Study

- Develop a proper adsorbent for the separation of scandium and calcium from aqueous solutions

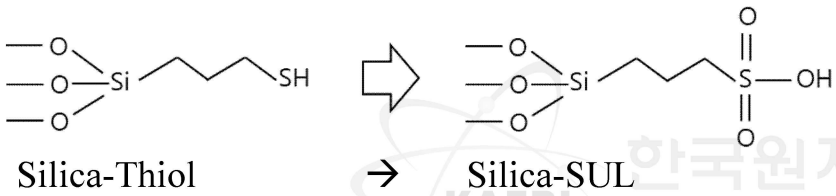
➢Background

- As a matched pair of radionuclides
  - Sc-44 for PET imaging
  - Sc-47 for therapy
- Calcium isotopes are target materials of both Sc-44 and Sc-47
  - Proton Irradiation: $^{44}Ca(p,n) \rightarrow {}^{43}Sc$
  - Neutron Irradiation: $^{46}Ca(n,\gamma)^{47}Ca \rightarrow {}^{47}Sc$
- Separation technology is required.-> Adsorbent Development

Proposed Adsorbents

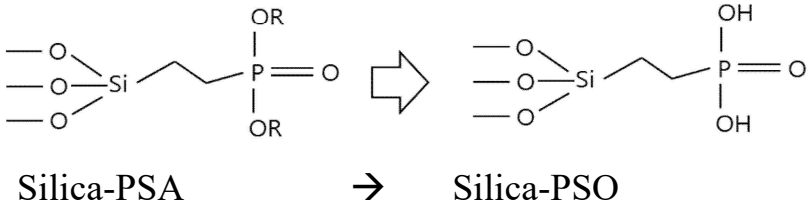
➢Silica-SUL (Molar ratio : Si : S = 5 : 1)

- Sol-gel processed silica having sulfonic acid groups



➢Silica-PSO (Molar ratio : Si : P = 5 : 1)

- Sol-gel processed silica having phosphonic acid groups



Ligand Density of Synthesized Adsorbents
(Based on EA results)

Adsorbent	Element Weight % From EA		Ligand Density(mmol/g)	
	C	S	EA*	Mole/Wt*
Silica-Thiol	10.2	6.7	2.1[*1]	1.9
Silica-SUL	9.0	6.1	1.9[*1]	N/A
Silica-PSA	14.9	N/A	2.1[*2]	2.0
Silica-PSO	6.4	N/A	1.8[*2]	N/A

* EA: Calculated from the results of elemental analysis for carbon ([*1]) and sulfur ([*2])
* Mole/Wt: moles of the precursor / weight of resulting adsorbent

FtIR Studies for Adsorbents

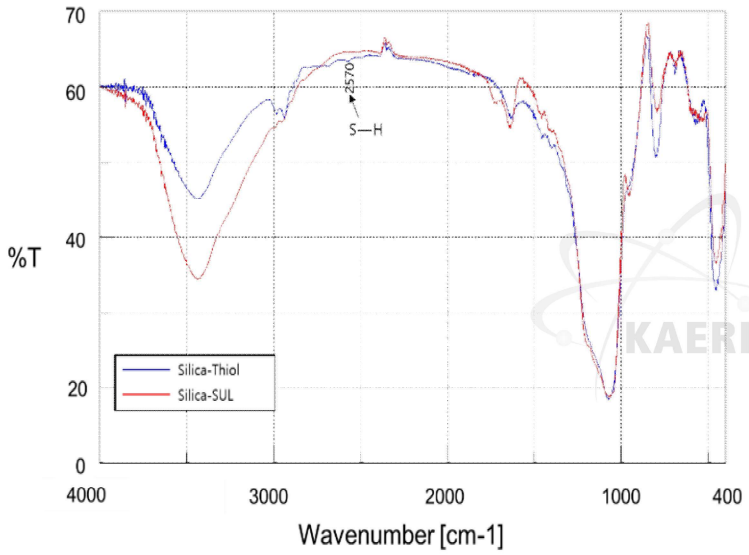


Figure : FtIR spectra of Silica-Thiol and Silica-SUL

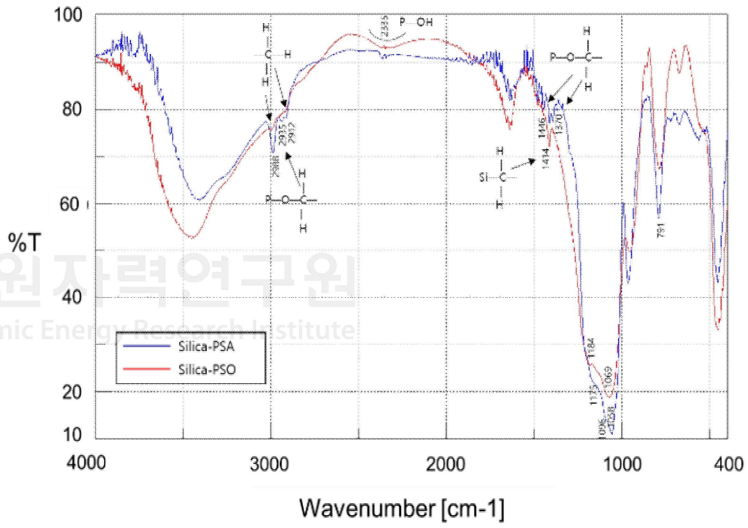


Figure : FtIR spectra of Silica-PSA and Silica-PSO

Chemical Speciation of Scandium in Aqueous Solutions

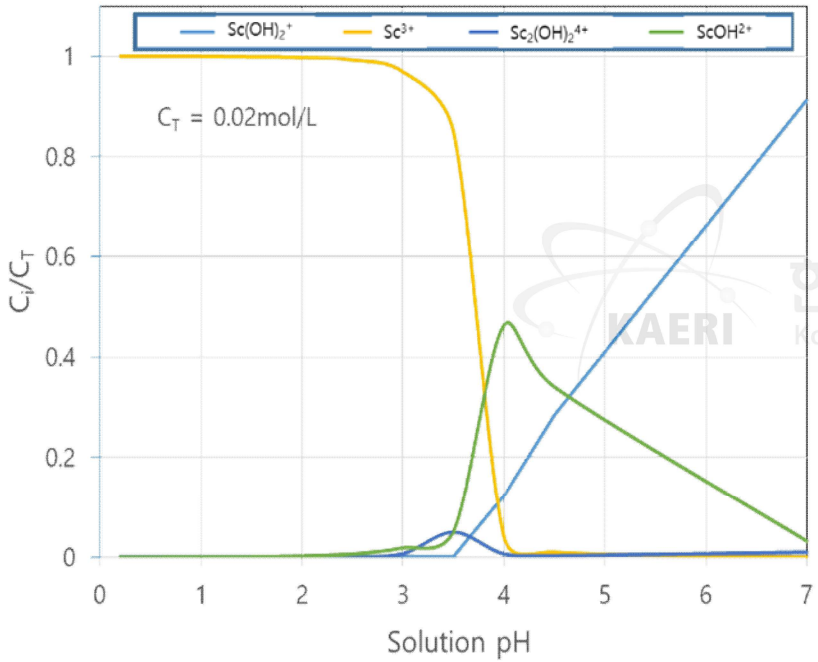
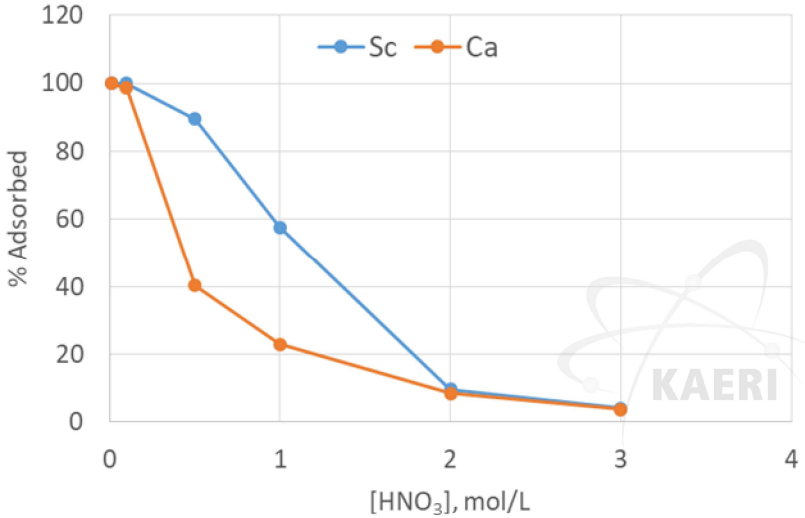


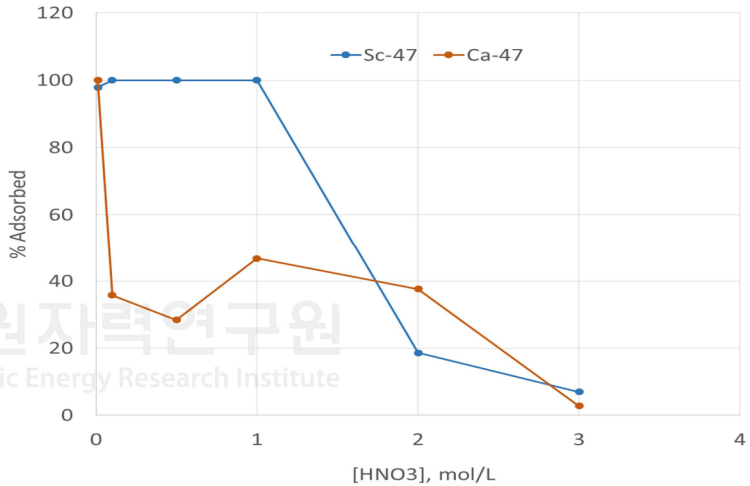
Figure : Chemical Speciation of Scandium in Aqueous Solutions - Calculated by Using MINEQL®

- In the Solution,
  - Calcium exists a billion times more than scandium.
- Calcium Ions?
  - Exist only in the form of Ca^{2+} within the given pH (pH ≤ 7)
- Scandium Ions
  - Oxy-complexes forms when pH ≥ 2
- Required : an adsorbent that has an extreme selectivity on Sc over Ca at a certain solution pH (preferably less than 2).

Results of Batch Extraction

Batch Experiments at With Adsorbent, Silica-SUL





Initial Concentration (Sc and Ca both) = 50mg/L

Initial Concentrations (Sc & Ca, respectively) = 10 and 220 ug/L

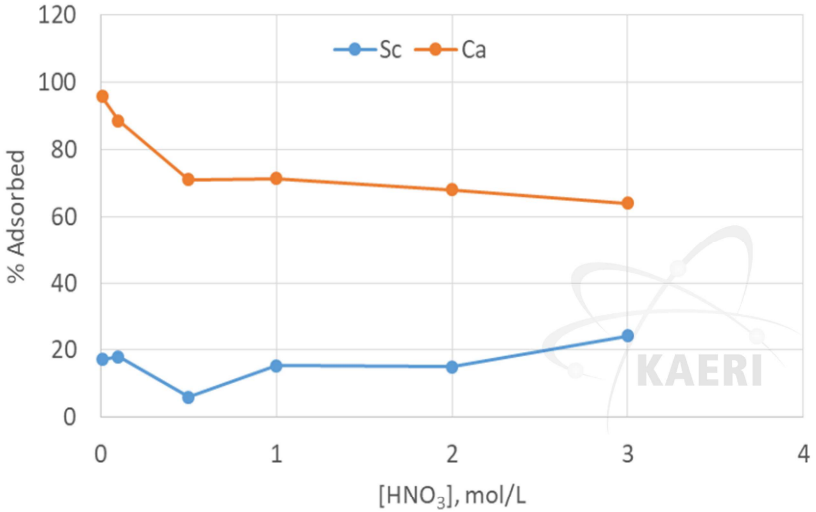
Experimental Conditions at a High Concentration

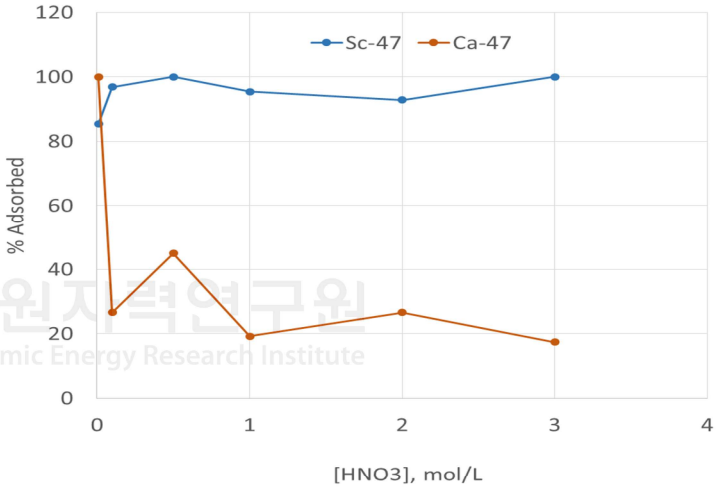
- Amount of adsorbent/sample = 0.2g
- Volume of solution/sample = 20mL
- Contact time = 3hours
- HNO_3 concentration = varies from 0.001 ~ 3M

Experimental Conditions at a Low Concentration:

- Amount of adsorbent/sample = 0.25g
- Volume of solution/sample = 25mL
- Contact time = 2hours
- HNO3 concentration = varies from 0.001 ~ 3M
- Radiotracer (Ca-47/Sc-47) was spiked
- Gamma Counting at 154.9keV for Sc-47 and 1297keV for Ca-47

Batch Experiments at With Adsorbent, Silica-PSO





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Discussion and Conclusions

- Sulfonic acid functionalized silica (Silica-SUL) shows the same trend for the affinity to Sc and Ca with respect to the acid concentration for both tested concentration levels (mg/L and ug/L)
- However, phosphonic acid functionalized silica (Silica-PSO) shows higher affinity for Ca than that for Sc at a high concentration (50mg/L) but reversed at low concentration (ug/L level)
  - Strong binding between phosphonic acid and scandium
  - On the other hand, limited availability of the ligands for trivalent association rather than for divalent association –> Probable reason
- Even though further study is required, Silica-SUL has better characteristics for the separation of Sc and Ca because it has high affinity for Sc and presumably expected a mild stripping condition.

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