

# **Final Report**

## **The Aqueous Thermodynamics and Complexation Reactions of Anionic Silica and Uranium Species"**

**Award Register No. 15023  
9/10/02 – 9/14/06**

During this contract period, a number of papers were published. The papers prior to this report have been reported in earlier annual reports. This final report covers the 2005 & 2006 publications which have been published as well as the last few which have been submitted, but are still under review for acceptance for publication. The titles and Abstracts of the papers are presented in Section A, and the full published papers in Section B.

## Section A.

### Abstracts of Published and Submitted Papers

#### Complexation / speciation studies of $\text{Ni}^{2+}$ ion with *ortho* silicic acid in perchlorate media

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(Received May 17, 2005)

##### Abstract

The complexation behavior of  $\text{Ni}^{2+}$  with *ortho*-silicic acid (*o*-SA) has been studied as a function of ionic strength (*I*) from 0.20 to 1.00M ( $\text{NaClO}_4$ ) at  $\text{pH } 4.55 \pm 0.05$  and  $25^\circ\text{C}$  by a solvent extraction technique with bis(2-ethylhexyl) phosphoric acid (HDEHP) as the extractant. The stoichiometry of the extracted species was determined to be  $\text{Ni}(\text{DEHP})_2(\text{HDEHP})_2$ .  $\text{Ni}^{2+}$  forms a 1:1 complex,  $\text{Ni}(\text{OSi}(\text{OH})_3)^+$ , as the predominant species with concentrations of  $1.00 \times 10^{-3}$  to  $1.00 \times 10^{-2}$ M *o*-SA. The stability constant ( $\log \beta_1$ ) values for  $\text{Ni}(\text{OSi}(\text{OH})_3)^+$  complex formation decrease with increased ionic strength. These values have been fitted with the extended Debye-Huckel expression to obtain the value of  $\log \beta_1 = 6.34 \pm 0.03$  at  $I = 0.00\text{M}$ . The data allowed the calculation of speciation of the  $\text{Ni}^{2+}$ -silicate system as a function of ionic strength.

#### Complexation Studies of $\text{Co}^{2+}$ ion with Orthosilicic Acid

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(Received June 6, 2005)

##### Abstract

The complexation behavior of  $\text{Co}^{2+}$  with *ortho*-silicic acid (*o*-SA) has been studied as a function of ionic strength (*I*) from 0.20 to 1.00M ( $\text{NaClO}_4$ ) at  $\text{pH } 4.96 \pm 0.03$  and  $25^\circ\text{C}$  by a solvent extraction technique with bis(2-ethylhexyl) phosphoric acid (HDEHP) as the extractant. The stoichiometry of the extracted species was determined to be  $\text{Co}(\text{DEHP})_2(\text{HDEHP})_2$ .  $\text{Co}^{2+}$  forms a 1:1 complex,  $\text{CoOSi}(\text{OH})_3^+$ , as the predominant species with *o*-SA concentrations of  $3.00 \times 10^{-4}$  to  $4.00 \times 10^{-3}$ M. The stability constant ( $\log \beta_1$ ) values for  $\text{CoOSi}(\text{OH})_3^+$  complex decrease with increase in ionic strength. These values were fitted with the extended Debye-Huckel expression to obtain the value of  $\log \beta_1$  at  $I = 0.00\text{M}$ . The effect of aging time of the *o*-SA solution on  $\log \beta_1$  values for  $\text{CoOSi}(\text{OH})_3^+$  complex was investigated and compared with those of the  $\text{UO}_2\text{OSi}(\text{OH})_3^+$  complex.

## **Sorption Studies of europium(III) on hydrous silica**

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(Received September 22, 2005)

### **Abstract**

Sorption behavior of europium,  $\text{Eu}^{3+}$ , on  $\text{SiO}_2 \cdot x\text{H}_2\text{O}$  (silica gel) has been investigated as a function of time, the amount of silica gel,  $\text{Eu}^{3+}$  concentration, the ionic strength, and pH (in absence and in presence of carbonate). The sorption data were fitted to Freundlich, Langmuir and Dubinin-Radushkevich (D-R) isotherms. The sorption capacity of silica gel was determined to be in the range  $2.62\text{--}8.00(\times 10^{-7})$  mol/g at pH  $5.30 \pm 0.05$  and  $0.20\text{ M NaClO}_4$ . The mean energy of sorption was calculated to be  $13.50 \pm 0.05$  kJ/mol from the D-R isotherm, suggesting the involvement of ion exchange reactions in the sorption process. Sorption of  $\text{Eu}^{3+}$  decreased with increased ionic strength. A gradual decrease in pH with increased ionic strength supports the involvement of an ion exchange mechanism in the sorption process. The diffusion coefficient of  $\text{Eu}^{3+}$  ion on silica gel was calculated as  $3.98(\pm 0.12) \times 10^{-13} \text{ m}^2 \text{ s}^{-1}$  under the particle diffusion-controlled conditions.

## **Kinetic and thermodynamic studies on cesium(I) sorption on hydrous silica**

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(Received December 13, 2006)

### **Abstract**

Batch sorption experiments of cesium,  $\text{Cs}^+$ , on  $\text{SiO}_2 \cdot x\text{H}_2\text{O}$  (silica gel) have been conducted with variable times of equilibration, amounts of silica gel ( $0.10\text{--}1.00$  g), cesium concentrations ( $5.00 \times 10^{-5}\text{--}2.40 \times 10^{-3}$  M), ionic strengths ( $0.20\text{--}1.40$  M  $\text{NaClO}_4$ ), pH's ( $2.50$  to  $7.70$ ), and temperatures ( $273$  to  $333$  K). The diffusion coefficient of  $\text{Cs}^+$  ion was calculated to be  $9.19(\pm 0.86) \times 10^{-11} \text{ m}^2 \text{ sec}^{-1}$  under particle diffusion-controlled conditions. The sorption rate was  $3.94(\pm 0.65) \times 10^{-3} \text{ sec}^{-1}$  at  $298$  K, pH  $7.70(\pm 0.05)$  in  $0.20$  M  $\text{NaClO}_4$ . The sorption data fits the Freundlich, Langmuir and Dubinin-Radushkevich (D-R) isotherms. Cesium sorption on  $0.20$  g silica gel decreased with ionic strength from  $40.42(\pm 0.34)\%$  in  $0.20$  M  $\text{NaClO}_4$  to  $6.35(\pm 0.40)\%$  in  $1.40$  M  $\text{NaClO}_4$ , at pH<sub>(initial)</sub>  $8.20(\pm 0.05)$ . A gradual decrease in pH with increased ionic strength is consistent with a cation exchange mechanism. Sorption of  $\text{Cs}^+$  on silica gel decreased with increased temperature, indicating an exothermic enthalpy. The presence of anions such as fluoride, carbonate, phosphate and oxalate in the aqueous medium did not influence the cesium sorption profile.

## **Nickel(II) sorption on hydrous silica: A kinetic and thermodynamic study**

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(Received October 20, 2005)

### **Abstract**

Sorption of nickel,  $\text{Ni}^{2+}$ , on  $\text{SiO}_2 \cdot x\text{H}_2\text{O}$  (silica gel) has been studied as a function of time, amount of silica gel (0.10–1.00 g), nickel concentration ( $5.00 \times 10^{-5}$ – $1.20 \times 10^{-3}$  M), ionic strength (0.20–1.40 M  $\text{NaClO}_4$ ), pH (6.50 to 8.50), and temperature (273–318 K). From kinetic data, the diffusion coefficient of  $\text{Ni}^{2+}$  ion was calculated to be  $1.28(\pm 0.07) \times 10^{-11} \text{ m}^2 \text{ sec}^{-1}$  under particle diffusion-controlled conditions. The sorption rate was determined as  $3.79(\pm 0.35) \times 10^{-3} \text{ sec}^{-1}$  at 298 K, pH 8.40 in 0.20 M ( $\text{NaClO}_4$ ). The sorption data were fitted to Freundlich, Langmuir and Dubinin-Radushkevich (D-R) isotherms. Nickel sorption on 0.20 g silica gel decreased with ionic strength from 77.70( $\pm 0.70$ )% (0.20 M  $\text{NaClO}_4$ ) to 16.12( $\pm 0.37$ )% (1.40 M  $\text{NaClO}_4$ ) at pH (initial) 8.50( $\pm 0.05$ ). A gradual decrease in pH with increased ionic strength suggests an ion exchange mechanism. Sorption of  $\text{Ni}^{2+}$  on silica gel increased with temperature indicating an endothermic enthalpy. The effect of different ligands such as fluoride, carbonate, phosphate and oxalate on  $\text{Ni}^{2+}$  sorption on silica gel was studied.

## **Thermodynamic study of metal silicate complexation in perchlorate media**

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(Received August 18, 2005)

### **Abstract**

The thermodynamic parameters of formation of the o-silicate complexes of  $\text{UO}_2^{2+}$ ,  $\text{Cm}^{3+}$  and  $\text{Eu}^{3+}$  have been measured in the temperature range 5 – 45°C in an aqueous medium of 0.20M ( $\text{NaClO}_4$ ) ionic strength. Solvent extraction with bis(2-ethylhexyl) phosphoric acid (HDEHP) was used to measure the stability constant ( $\log \beta_1$ ) values of the silicate complexes as a function of temperature to obtain the enthalpies and entropies of complexation. The complexation reactions are entropy driven and opposed by the enthalpy. These thermodynamic values are consistent with the formation of an inner sphere complex.

## Kinetics and thermodynamics of cobalt(II) sorption on hydrous silica

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(\*Accepted for publication in J. Radioanal. Nucl. Chem.)

### Abstract

Sorption of  $\text{Co}^{2+}$  on  $\text{SiO}_2 \cdot x\text{H}_2\text{O}$  (silica gel) has been investigated as a function of time, amount of silica gel (0.10-1.00g), cobalt concentration ( $5.00 \times 10^{-5}$  -  $1.20 \times 10^{-3}$  M), ionic strength (0.20-1.40 M  $\text{NaClO}_4$ ), pH (~6.80-10.80), and temperature (273-318 K). Based on kinetic studies, the diffusion coefficient of  $\text{Co}^{2+}$  ion was calculated to be  $6.86(\pm 0.44) \times 10^{-12} \text{ m}^2 \text{ sec}^{-1}$  under particle diffusion-controlled conditions. The sorption rate was determined to be  $2.61(\pm 0.19) \times 10^{-3} \text{ sec}^{-1}$  at 298 K, pH 6.70( $\pm 0.05$ ) and 0.20 M  $\text{NaClO}_4$  using the Lagergren equation. The sorption data were fitted to Freundlich, Langmuir and Dubinin-Radushkevich (D-R) isotherms. Cobalt sorption decreased with increased ionic strength. A gradual decrease in pH with increased ionic strength supported the sorption of  $\text{Co}^{2+}$  by an ion exchange mechanism. Effect of different ligands such as  $\text{CO}_3^{2-}$ ,  $\text{F}^-$ ,  $\text{H}_2\text{PO}_4^-$  and  $\text{C}_2\text{O}_4^{2-}$  on the sorption of  $\text{Co}^{2+}$  was studied in the pH range 6.50 to 8.50. Temperature variation experiments gave an endothermic enthalpy for sorption of cobalt on silica gel which becomes more spontaneous as the temperature increases.

## Sorption of $\text{Am}^{+3}$ Cations on Suspended Silicate: Effects of pH, Ionic Strength, Complexing Anions, Humic Acid and Metal Ions

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(\*Submitted: Inorg. Chim. Acta)

### Abstract

Sorption of tracer  $\text{Am}^{+3}$  to silicate particles was studied as a function of pCH (4 to 9) and of ionic strength (0.20 M to 1.50 M ( $\text{NaClO}_4$  at 298 K. The sorption increased with increased pCH from 4 to 6 above which saturation was observed. The insensitivity of  $\text{Am}^{+3}$  sorption to increased ionic strength indicates inner-sphere complexation with the surface silicate sites. The effects of different complexing anions such as carbonate, acetate, oxalate, phosphate, citrate, EDTA and humic acid, on  $\text{Am}^{+3}$  sorption were investigated. Synergistic enhancement in  $\text{Am}^{+3}$  sorption was observed in the presence of phosphate ( $4 \leq \text{pCH} \leq 7$ ) and acetate ( $4 \leq \text{pCH} \leq 5$ ) ligands at 0.20 M ( $\text{NaClO}_4$ ). The presence of the other ligands inhibited  $\text{Am}^{+3}$  sorption in the order: EDTA > citrate > oxalate > carbonate.  $\text{Am}^{+3}$  sorption in the presence of HA (25.00 mg/L) increased in the pCH range of 4.0 to 5.5, then decreased. Increased ionic strength enhanced  $\text{Am}^{+3}$  sorption in the presence of 25.00 mg/L HA for  $4 \leq \text{pCH} \leq 9$ . The sorption increased in the presence of a mixture of HA (25.00 mg/L) and phosphate ( $1.00 \times 10^{-3}$  M) as compared to that of HA (25.00 mg/L) alone. The presence of  $\text{Fe}^{3+}$  ( $1.00 \times 10^{-3}$  M) enhanced  $\text{Am}^{+3}$  sorption at pCH ~ 4 but suppressed it from pCH of 5 to 9;  $1.00 \times 10^{-4}$  M of  $\text{Ca}^{2+}$  and of  $\text{UO}_2^{2+}$  ions had no effect on the sorption profile.

## **Sorption of Neptunyl(V) Cations on Suspended Silicate: Effects of pH, Ionic Strength, Complexing Anions, Humic Acid, and Metal Ions**

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(Submitted: J. Radioanal. Nucl. Chem.)

### **Abstract**

Sorption of  $\text{NpO}_2^+$  on silicate (10.00 g/L) particles dispersed in sodium perchlorate media was studied as a function of pH and ionic strength at 298 K. The sorption increased with increased pH in the range of ~ 6.5 to 9.2, above which saturation was observed. An increase in ionic strength from 0.20 M to 1.00 M ( $\text{NaClO}_4$ ) increased the  $\text{NpO}_2^+$  sorption, which then decreased at 1.50 M ( $\text{NaClO}_4$ ) for  $7 < \text{pH} < 8.5$ . The effects of different types of ligands on the sorption of  $\text{NpO}_2^+$  to suspended silicate were investigated. The types of ligands included: (i) inorganic anions (fluoride, carbonate, phosphate) (ii) N-donors (ethylenediamine, 1,10 phenanthroline) (iii) carboxylic acids (oxalic acid, citric acid, iminodiacetic acid, ethylenediaminetetraacetic acid) and (iv) humic acid. A synergistic enhancement in sorption to the suspended silicate was observed for phosphate, oxalate, ethylenediaminetetraacetic acid, ethylenediamine, 1,10 phenanthroline ( $5 < \text{pH} < 8$ ) and humic acid ( $6.5 < \text{pH} < 8.8$ ). This behavior was attributed to the formation of ternary  $\text{NpO}_2^+$ /silicate/ligand complexes. The effects of  $\text{Ca(II)}$  ( $1.00 \times 10^{-3}$  M) and  $\text{Eu(III)}$  ( $1.00 \times 10^{-4}$  and  $1.00 \times 10^{-3}$  M) ions on  $\text{NpO}_2^+$  sorption to suspended silicate were also investigated.

## **Polymerization and complexation behavior of silicic acid: a review**

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### **Abstract**

The role of dissolved silica (silicic acid) in the migration of radionuclides has been of interest for several decades. Studies have shown that the interaction of silicic acid with the metal cations is complicated due to a tendency to polymerize which is dependent on pH, ionic strength, temperature, etc. of the system. While polymerization of silicic acid has been studied in detail, uncertainty remains on the effect of these changes on cations in environmental systems. The nature and the role of silicate species in the environmental behavior of cationic radionuclides is the focus of this review. The interaction of metal cations such as  $\text{UO}_2^{2+}$ ,  $\text{Eu}^{3+}$ ,  $\text{Cm}^{3+}$  and  $\text{Cu}^{2+}$  with polymeric silica is discussed. The effects of different experimental parameters (e.g., pH, ionic strength, temperature, acids, fluoride and hydroxyl anions, organic compounds, etc.) on the polymerization behavior of silicic acid are reviewed. Monomeric silicic acid is most stable at ca. pH 2 and most unstable at pH 7-8. Polymerization increases with increased ionic strength, temperature, and the aging time of the silicic acid solutions. Hydroxyl and fluoride ions catalyze the polymerization of silicic acid. The presence of metal ions, (e.g., aluminium, beryllium, thorium and iron) inhibits the polymerization process through complexation with hydroxyl and fluoride ions.

## **Effect of complexing anions on europium sorption on suspended silica: A TRLFS study for ternary complex formation**

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(Submitted: Radiochimica Acta)

### **Abstract**

The sorption of europium, Eu(III), on suspended silica was studied in perchlorate media under varying concentrations of Eu(III) and silica, at pH 4 to 8, and ionic strength from 0.20 to 1.40 M NaClO<sub>4</sub> at 298 K. The complexing anions, carbonate, acetate, citrate, oxalate, phosphate and EDTA, affected the sorption of Eu(III). A synergistic enhancement in the sorption of Eu(III) was observed for oxalate and phosphate ligands. Other anions suppressed the sorption in the order: acetate < carbonate < citrate < EDTA. The results of TRLFS studies were consistent with ternary Eu/silica/ligand complexation for oxalate and phosphate anions.

## **Silicate complexation of NpO<sub>2</sub><sup>+</sup> ion in perchlorate media**

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(Submitted: J. Radiochimica Acta)

### **Abstract**

Complexation behavior of NpO<sub>2</sub><sup>+</sup> with *ortho*-silicic acid (o-SA) has been studied at ionic strengths (I) from 0.10 to 1.00 M (NaClO<sub>4</sub>) at pcH 3.68±0.08 and 25°C using solvent extraction with bis-(2-ethylhexyl) phosphoric acid (HDEHP) as the extractant. The stability constant value (log β<sub>1</sub>) for the 1:1 complex, NpO<sub>2</sub>(OSi(OH)<sub>3</sub>), were found to decrease with increase in ionic strength of the aqueous phase [6.83±0.01 at I=0.10M to 6.51±0.02 at I=1.00 M]. These values have been fitted with the extended Debye-Huck expression and compared with similar values of complexation of the metal ions Am<sup>3+</sup>, Eu<sup>3+</sup>, UO<sub>2</sub><sup>2+</sup>, PuO<sub>2</sub><sup>2+</sup>, Np<sup>4+</sup>, Ni<sup>2+</sup>, and Co<sup>2+</sup>. The speciation of NpO<sub>2</sub><sup>+</sup>-o-silicate/carbonate system has been calculated as a function of pcH under ground water conditions.

## **Sorption of Uranyl(VI) Cations on Suspended Silicate: Effects of N-donors Ligands, Carboxylic Acids, Humic Acid, Metal Ions and Organic Cosolvents**

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(Submitted: Radiochimica Acta)

### **Abstract**

Sorption of uranyl ion,  $\text{UO}_2^{2+}$  on silicate particles (3.00 g/L) was studied in sodium perchlorate solution as a function of pH and ionic strength at 298 K. The effects of different ligand types (e.g. N-donors, carboxylic acids, humic acid) on the uranyl sorption were investigated. A synergistic enhancement in uranyl sorption was observed in the presence of the N-donor ligands such as 1,10 phenanthroline, ethylenediamine and humic acid in the pH range 3 to 4. Carboxylic acids inhibited the sorption in the order: citric acid > malonic acid > nitrilotriacetic acid > iminodiacetic acid > sulfosalicylic acid > succinic acid > glycolic acid. The presence of organic cosolvents such as dimethylsulfoxide, glycerol and tetrahydrofuran had no significant influence on the uranyl sorption profile. Uranyl sorption decreased marginally in the presence of  $1.00 \times 10^{-3}$  M Eu(III).

## **Sorption of uranyl ion on hydrous silica: effects of ionic strength and ethylenediaminetetraacetic acid (edta)**

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(Submitted: Radiochimica Acta)

### **Abstract**

The effects of ionic strength and of ethylenediaminetetraacetic acid (EDTA) on the sorption of uranyl ion,  $\text{UO}_2^{2+}$  to  $\text{SiO}_2 \cdot x\text{H}_2\text{O}$  (silica gel) were investigated. It was observed that pH and the ions present in the supporting electrolytes influence the ionic strength effects. The presence of different sodium salts in the concentration range (0.20 to 1.40 M) suppressed the sorption of  $\text{UO}_2^{2+}$  in the order:  $\text{NaNO}_3 < \text{NaClO}_4 < \text{NaCl} < \text{NaOCOCH}_3 < \text{NaSO}_4$  (pH 2.75( $\pm 0.05$ )), while the presence of perchlorate salts of  $\text{Li}^+$ ,  $\text{Na}^+$  and  $\text{Ca}^{2+}$  (0.20 to 1.40 M) promoted the sorption of  $\text{UO}_2^{2+}$  on silica gel in the order:  $\text{LiClO}_4 \sim \text{NaClO}_4 < \text{Ca}(\text{ClO}_4)_2$  at pH 2.80( $\pm 0.05$ ). The ionic strength effect on  $\text{UO}_2^{2+}$  sorption was studied in presence of EDTA ( $0-1.00 \times 10^{-3}$  M) in the pH range 2.90 to 5.57. The sorption data and speciation calculation suggest negligible complexation of  $\text{UO}_2^{2+}$  with EDTA at  $I \geq 1.00$  M  $\text{NaClO}_4$ .



## Polymerization study of $\alpha$ -Si(OH)<sub>4</sub> and complexation with Am(II), Eu(III) and Cm(III)

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(Submitted: Inorg. Chim. Acta)

### Abstract

The formation of 1:1 complexes of  $\text{Am}^{3+}$ ,  $\text{Cm}^{3+}$ , and  $\text{Eu}^{3+}$  with ortho-silicate,  $\alpha$ -OSi(OH)<sub>4</sub>, at pH 3.50 in ionic strengths of 0.20 to 1.00 M ( $\text{NaClO}_4$ ) was studied by solvent extraction with di-(2-ethylhexyl) phosphoric acid (HDEHP) in heptane as extractant. The stability constant ( $\log K$ ) values decrease with increased ionic strength from 0.20 to 1.00 M ( $\text{NaClO}_4$ ) for silicic acid concentrations from 0.002 to 0.02 M. The extended Debye-Hückle expression was used to analyze these values of the  $\log K$  values to calculate the stability constants at  $I=0$  (IV). Increasing the concentration of silicic acid above 0.02 M increased the amount of M extracted into the organic phase, contrary to the trend usually observed for increased ligand concentration in solvent extraction. This reversed trend is likely due to the extraction of cationic species of silicic acid by HDEHP. Aging time (60 to 300 min) had no effect on the stability constant of these metal ions for 0.002-0.02 M silicic acid at pH 3.50 and  $I=0.20$  M ( $\text{NaClO}_4$ ). The fraction of polymeric silicic acid present in solutions of 0.20 to 4.50 M  $\text{NaClO}_4$  solutions at pH 3.0 to 10.0,  $T=0-60^\circ\text{C}$  and aging time = 5 to 300 min. was measured for determination of the silicomolybdate reactions to ascertain the proper conditions to study metal +  $\alpha$ -silicate complexation.

**Section B.**  
**Published Papers**

## **Publications**

Complexation / speciation studies of  $\text{Ni}^{2+}$  ion with ortho silicic acid  
in perchlorate media,

P. N. Pathak and G. R. Choppin, **J. Radioanalyt. and Nucl. Chem.**, 267, No. 1; 175-182 (2006)

Complexation Studies of  $\text{Co}^{2+}$  ion with Orthosilicic Acid,

P. N. Pathak and G. R. Choppin, **J. Radioanal. Nucl. Chem.**, 267, No. 2; 309 -314 (2006)

Sorption Studies of europium(III) on hydrous silica,

P. N. Pathak and G. R. Choppin, **J. Radioanal. Nucl. Chem.**, 270, No. 2; 277-283, (2006)

Kinetic and thermodynamic studies on cesium(I) sorption on hydrous silica,

P. N. Pathak and G. R. Choppin, **J. Radioanal Nucl. Chem.**, 270, No. 2; 299-305 (2006)

Nickel(II) sorption on hydrous silica: A kinetic and thermodynamic study,

P. N. Pathak and G. R. Choppin, **J. Radioanal Nucl. Chem.**, Vol. 268, No.3; 467-473 (2006)

Thermodynamic study of metal silicate complexation in perchlorate media

P. N. Pathak and G. R. Choppin, **Radiochim. Acta** 94, 81-86 (2006)

Kinetics and thermodynamics of cobalt(II) sorption on hydrous silica

P. N. Pathak and G. R. Choppin, **accepted for publication in J. Radioanal. Nucl. Chem.**

Sorption of  $\text{Am}^{+3}$  Cations on Suspended Silicate: Effects of pH, Ionic Strength,  
Complexing Anions, Humic Acid and Metal Ions

P. N. Pathak and G. R. Choppin, **(submitted: Inorg. Chim. Acta)**

Sorption of Neptunyl(V) Cations on Suspended Silicate: Effects of pH, Ionic  
Strength, Complexing Anions, Humic Acid, and Metal Ions

P. N. Pathak and G. R. Choppin, **(submitted: J. Radioanal. Nucl. Chem.)**

Polymerization and complexation behavior of silicic acid:a review

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Effect of complexing anions on europium sorption on suspended silica:  
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Silicate complexation of  $\text{NpO}_2^+$  ion in perchlorate media

P. N. Pathak and G. R. Choppin, **(submitted: J. Radiochimica Acta)**

Sorption of Uranyl(VI) Cations on Suspended Silicate: Effects of N-donors Ligands, Carboxylic Acids, Humic Acid, Metal Ions and Organic Cosolvents

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Sorption of uranyl ion on hydrous silica: effects of ionic strength and ethylenediaminetetraacetic acid (edta)

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Polymerization study of  $\text{o-Si(OH)}_4$  and complexation with Am(II), Eu(III) and Cm(III)

P. Thakur, D.K. Singh and G. R. Choppin, **(submitted: Inorg. Chim. Acta)**