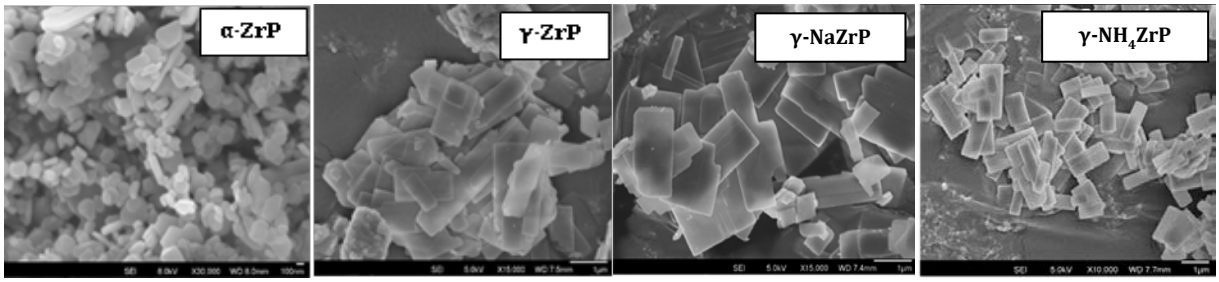
Zirconium Phosphate as Radioactive Sorbents

Market Need

Radioactive materials are used in medicinal radiotherapy, agriculture, archaeology (carbon dating), aerospace, law enforcement, geology (including mining), automotive, ionizing smoke detectors, and energy generation.
As energy demands continues to increase, governments of different countries turn to alternative sources of power to supplement current fossil fuels and yet-to-mature renewables thwart with technical challenges to provide on par performance. Fission power plants have been established in many countries like France, US, China, Japan, South Korea, Eastern Europe to supply over 30% of energy needs. While nuclear energy is efficient, risk of accidents (demonstrated historically) has dire consequences. Handling and treatment of spent radioactive materials from nuclear power plant demands good sorbents that can contain such environmental contaminants.

Solution

A new species of nanoplatelet zirconium phosphates (nano-ZrP) from a proprietary process presents tunable morphology controllable particle sizes. The species includes: - **α-ZrP, γ-ZrP, γ-NaZrP, γ-NH_4ZrP**, See SEM image of the species.



These new species presents good ion-exchange capabilities against known amorphous (Gel) ZrP as shown in **Tables 1**.

Table 1. Total ion exchange capacity of sorbents

Sorbents	IEC (mmeq./g)
Gel-ZrP	5.86[a]
α-ZrP	6.64[b]
γ-ZrP	6.27[b]
γ-NaZrP	6.02[b]

[a]based on titration. [b]based on chemical formulae.

From **Table 2**, the 3 multi-element solutions, having initial concentration of each ionic species at 1 mmol/L, shows the relative affinity of α-ZrP and γ-ZrP towards alkali and alkaline-earth metal ions. Notably, γ-ZrP exhibit significantly higher removal efficiency for caesium (Cs^+) than α-ZrP.

Table 2. Removal efficiency of α-ZrP and γ-ZrP

Solution	Cations in solution (each at 1mmol/L)	Removal Efficiency (%)	
		α-ZrP	γ-ZrP
#1	Na^+	2.56	3.03
	K^+	3.63	12.68
	Cs^+	9.27	**97.33**
#2	Mg^{2+}	1.11	3.04
	Ca^{2+}	6.96	27.86
	Sr^{2+}	5.7	26.45
#3	Cs^+	5.82	**94.72**
	Sr^{2+}	3.37	15.13

Comparative studies on sorption and kinetics of these new species is presented in **Figure 1** and **2**:

The sorption amount against time in **Figure 1** (below) shows the sorption kinetics of K^+ (at

10mmol/L) by 4 ZrP sorbents. The (highest) sorption rate is achieved by γ-ZrP, significantly higher than known amorphous (gel)-ZrP

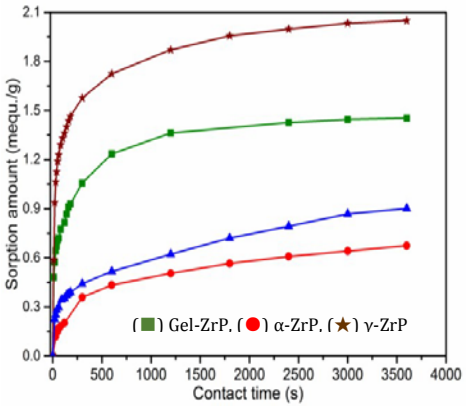
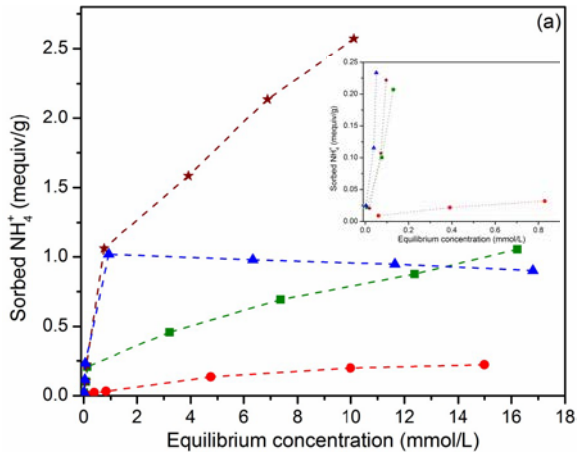


Figure 1. *Sorption kinetics of K^+ on (■) Gel-ZrP, (●) α-ZrP, (★) γ-ZrP and (▲) γ-NaZrP.*

The sorption of ammonium (NH_4^+) and potassium (K^+) ions were tested in aqueous NH_4NO_3 (pH 5.3) and KCl (pH 5.7) solutions with the initial concentrations of 0.1-20 mmol/L. **Figure 2** shows results where sorption of ammonium and potassium ions decreased as follows: α-ZrP > γ-NaZr P > Gel-ZrP > γ-ZrP. However, at low concentrations (< 1 mmol/L), the sorption of ammonium and potassium ions was higher for γ-NaZrP than γ -ZrP. See respective insets (chart) (a) and (b), in **Figure 2** below.



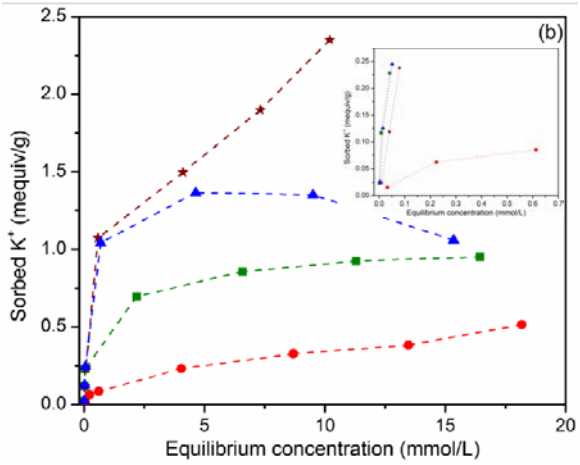


Figure 2. *Sorption isotherms of (a) NH_4^+ and (b) K^+ on (■) Gel-ZrP, (●) α-ZrP, (★) γ-ZrP and (▲) γ-NaZrP.*

Application and advantages

Through the proprietary process the lesser known γ-ZrP and alternative species of nano-ZrP can now be produced in high yield for development in different applications.

Keywords

Tunable morphology, micron size, compact, high pick-up of ionic species.

Contact:

Reference: 2017-175; Email: triciachong@nus.edu.sg; Phone: +65-65166446

Technology Readiness Level

Material transfer for application development on request

Principal Inventor

Prof. Chuah Gaik-Khuan