Thorium removal from acidic aqueous solutions
by activated biochar derived from cactus fibres

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Outline

**Background Information**

**Materials and Methods**
Preparation & characterization
Sorption experiments

**Data Presentation/Discussion**
- FTIR spectra
- pH titration curve
- Sorption data
- Comparison of sorption data

**Outlook**
Activated Biochar Fibres
Cladodes (*Opuntia Ficus-indica*) ➔
Cactus Fibres

Carbonisation and Activation of the Fibres
- 650 °C under \( O_2 \)-restricted conditions
- boiling in 12 M \( HNO_3 \) for 3 h

Characterisation Sorption Experiments
- pH titration Batch experiment
- FTIR spectroscopy 30 ml test solution
- SEM analysis 0.01 g biochar

5x10^{-6} M < [Th(IV)] < 5x10^{-3} M
Effective collection of actinides from water systems is advantageous for

- recovery and recycling of valuable resources,
- environmental remediation,
- chemical separations, and
- in situ monitoring


Biochar fibres:

*Sorbent Characteristics Affecting M(z) Sorption:*

- Compatibility (*Mechanical, Thermal, Chemical*)
- Regenerability / Reusability (*Cyclic Adsorption Applications*)
- Cost
- Kinetics (*Porosity - Intraparticle Mass Transfer*)
- Adsorption Capacity (*Texture - Surface Coverage*)
- Selectivity (*Chemical Surface Modification*)
Interaction and Sorption of Metal-ions by Activated Biochar Fibres

Preparation and characterization of the biosorbent

Bioresource Technol 159 (2014) 460
J Radioanal Nucl Chem 304 (2015) 897
Interaction and Sorption of Metal-ions by Activated Biochar Fibres

Preparation and characterization of the biomass sorbent

\[ R-COOH \xrightarrow{\text{equivalence point}} R-CO^- + H^+ \]
Interaction and Sorption of Th(IV)-ions by Activated Biochar Fibres

**Sorption experiments at pH 3**

\[ q_{\text{max}} = 0.35 \text{ mol} \cdot \text{kg}^{-1} (81 \text{ g} \cdot \text{kg}^{-1}) \]

**Solubility curve of Th(OH)\(_4\)**

\[ m \text{ Th}^{4+} + r \text{ H}_2\text{O} \leftrightarrow \text{Th}_m(\text{OH})_{8m-r}^{(4m-r)+} + r \text{ H}^+ \]

\[ \log K = 47.0 \text{ (I=0.1M)} \]

\[ \text{C Moulin et al (2001) Anal Chim Acta 441, 26} \]

hydrolysis → restricted adsorption
Interaction and Sorption of Th(IV)-ions by Activated Biochar Fibres

FTIR spectra $\rightarrow$ inner-sphere complexes

\[ \text{Th(IV)}_{\text{activated biochar, pH 3}} \]

\[ [\text{Th}]_0 = \begin{array}{c} 1 \text{ E-5 M} \\ 5 \text{ E-5 M} \\ 1 \text{ E-4 M} \\ 1 \text{ E-3 M} \end{array} \]

\[ \begin{array}{c} 4000 \text{ cm}^{-1} \quad 3500 \quad 3000 \quad 2500 \quad 2000 \quad 1500 \quad 1000 \quad 500 \end{array} \]

\[ T \text{ (\%)} \]

\[ 1713 \text{ cm}^{-1} \quad 1240 \text{ cm}^{-1} \]

\[ \text{R} \quad \text{C} \quad \text{O} \quad + \quad \text{Th} \quad \text{OH}^2+ \quad \leftrightarrow \quad \text{R} \quad \text{C} \quad \	ext{O} \quad \text{Th} \quad \text{OH} \quad + \quad 2 \text{H}_3\text{O}^+ \]
Interaction and Sorption of M(z) by Activated Biochar Fibres

Comparison of adsorption data

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Zhang et al. (2013) J Radioanal Nucl Chem 295,1201
Thank you for your attention