



Microscopic insights into the temperature-dependent adsorption of Eu(III) onto titanate nanotubes studied by FTIR, XPS, XAFS and batch technique

Guodong Sheng^{a,b,*}, Huaping Dong^a, Runpu Shen^a, Yimin Li^a

^a School of Chemistry and Chemical Engineering, Shaoxing University, Huanheng West Road 508, Shaoxing, Zhejiang 312000, PR China

^b Key Laboratory of Novel Thin Film Solar Cells, Institute of Plasma Physics, Chinese Academy of Sciences, P.O. Box 1126, Hefei 230031, PR China

HIGHLIGHTS

- Eu(III) interaction is promoted at higher temperature.
- Eu(III) interaction is a spontaneous and endothermic process.
- Eu(III) interaction is controlled by outer-sphere surface complexation at low *T*.
- Eu(III) interaction is controlled by inner-sphere surface complexation at high *T*.
- The results are important to understand Eu(III) physicochemical behavior.

ARTICLE INFO

Article history:

Received 14 August 2012

Received in revised form 3 October 2012

Accepted 5 October 2012

Available online 10 November 2012

Keywords:

Eu(III)
Titanate nanotubes
Spectroscopic technique
Interaction mechanism
Microstructure

ABSTRACT

This work investigated the effects of reaction temperature on Eu(III) interaction mechanism and microstructure at the titanate nanotubes (TNTs)/water interface by batch and spectroscopic (FTIR, XPS, XAFS) technique. Batch adsorption results showed that the adsorption of Eu(III) onto TNTs is promoted at higher temperature, and is an endothermic and spontaneous interfacial process. The adsorption isotherms at three different temperatures can be described by the Freundlich model better than the Langmuir model did. The spectroscopic analysis results suggested that Eu(III) interaction with TNTs is mainly controlled by outer-sphere surface complexation at *T* = 293 K, which is a reversible adsorption process, whereas Eu(III) interaction is mainly controlled by inner-sphere surface complexation at *T* = 313 K and *T* = 343 K, which is an irreversible adsorption process. The findings in this work can help us to better understand the physicochemical behavior of Eu(III) and related radionuclides in natural environment. The results of this work also show the great potential importance of TNTs as novel nanomaterials in the near future of nuclear waste management.

© 2012 Elsevier B.V. All rights reserved.

1. Introduction

Recently, the interfacial behavior and effective remediation of lanthanides and actinides have received increased attention in nuclear waste management [1–4]. In order to study the interfacial behavior of lanthanides and actinides and their potential pollution towards the natural water and soil environment, the understanding of interaction mechanism and microstructure of lanthanides and actinides at the solid/water interface are of great importance [1–3]. Eu(III), which is a trivalent lanthanide and also a chemical homologue to trivalent actinides, has been widely used as a model

element to study the interaction mechanism and microstructure of lanthanides and actinides at solid/water interface due to the similar interfacial behavior between Eu(III) and other lanthanides and actinides [3–5]. Therefore, the interaction mechanism and microstructure of Eu(III) at the solid/water interface have been extensively studied largely based on various macroscopic and spectroscopic measurement methods [1–7]. The results indicated that Eu(III) interaction is generally affected by solution pH, while is more or less dependent on ionic strength, and the microstructure mainly includes the formation of outer-sphere or inner-sphere surface complexes depending on solution chemistry [6,7].

Since their discovery by Kasuga et al. [8,9], titanate nanotubes (TNTs) have come under intense multidisciplinary studies due to their one-dimensional nanostructure, excellent physicochemical property and versatile applications such as solar cells, catalyst supports, photocatalysis, sensors, novel adsorbents and electrolumi-

* Corresponding author at: School of Chemistry and Chemical Engineering, Shaoxing University, Huanheng West Road 508, Shaoxing, Zhejiang 312000, PR China. Tel.: +86 551 5591368; fax: +86 551 5591310.

E-mail address: gdsheng@mail.ustc.edu.cn (G. Sheng).