

Cloud point extraction of lanthanide(III) ions via use of Triton X-100 without and with water-soluble calixarenes as added chelating agents

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Abstract

The use of water-soluble calixarenes: *p*-sulfonato thiacalixarene (ST), tetra-sulfonatomethylated calix[4]resorcinarene (SR), calix[4]resorcinarene phosphonic acid (PhR) as chelating agents in cloud point extraction (CPE) of La(III), Gd(III) and Yb(III) ions using Triton X-100 as non-ionic surfactant is introduced. The data obtained indicate that both complexation ability and structure of calixarenes govern the extraction efficiency of lanthanides. In particular ST and SR, forming 1:1 lanthanide complexes with similar stability in aqueous media, exhibit different extractability when used as chelating agents in CPE. First synthesized PhR was found to be the most efficient chelating agent exhibiting pH-dependent selectivity within La(III), Gd(III) and Yb(III) in CPE.

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1. Introduction

Calixarenes are well documented as efficient extractants of metal ions in liquid–liquid extraction, in particular of 4f- and 5f-ions [1]. Their application in liquid–liquid extraction requires both high complexation ability towards metal ions and high lipophilicity in order to provide sufficient solubility of the extractant and extracted complexes in organic phase. In turn the insertion of polar substituents (particularly, the ionized groups) into calixarene matrix may result in an enhanced solubility in aqueous phase, which restricts the applicability of calixarenes as extractants. For example calixarenes, bearing sulfonate [2] or phosphonate groups [3,4] on their rims and thus exhibiting high complexability towards metal ions, are water soluble and can not serve as extractants in traditional liquid–liquid extraction.

An interesting alternative to traditional liquid–liquid extraction is the micelle-mediated extraction, firstly developed by Watanabe and Tanaka [5]. Micelles of such well-known non-ionic surfactants as Triton X-100 or -114, have a non-polar core and extended polar layer, where both extractants and extracted complexes can be solubilized [6–9]. The separation of aqueous and micelle-enriched phases can be achieved by heating the solution. This simple procedure called cloud point extraction (CPE) [6–10] enables to avoid hazardous organic solvents and allows to achieve a much higher concentration of recovered metal ions than in the case of liquid–liquid extraction, because the micellar phase volume is about 10–100-fold less than the volume of an aqueous phase [7]. Accordingly, any metal ions that either directly interact with micelles or after prerequisite binding with hydrophobic chelating ligand, can be extracted from the parent solution by CPE procedure. The first example of the lanthanides(III) separation through CPE technique with 8-hydroxyquinoline as chelating ligand and Triton X-114 as non-ionic surfactant was published recently

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