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modular designed particles

Technological Applications

Publications and Reviews

magnetic micro- and nanoparticles

Implementation in Life Sciences

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Product overview

	Size range (10 nm – 100 nm – 1 µm – 10 µm – 100 µm)	Product matrix
Magnetic particles	20 nm – 500 nm	dextran
	80 nm – 100 nm	bionized nanoferrite
	2 - 12 µm	polystyrene
	30 µm - 100 µm	poly(lactic acid)
	350 nm - 6 µm	silica
	150 nm	poly(ethylene imine)
	150 nm	chitosan
	50 - 250 nm	iron oxide
Fluorescent particles	10 nm – 20 µm	silica
	25 nm – 6 µm	polystyrene, polymethacrylate
	250 nm – 100 µm	poly(lactic acid)
	250 nm	albumin
Fluorescent magnetic particles	100 nm - 300 nm	dextran
	100 nm	bionized nanoferrite
	30 µm - 100 µm	poly(lactic acid)
White particles	10 nm – 20 µm	silica
	25 nm – 100 µm	polystyrene, polymethacrylate
	250 nm – 100 µm	poly(lactic acid)
	300 nm	latex
	250 nm	albumin
Colored particles	100 nm – 100 µm	silica
	1 µm - 12 µm	polystyrene
	250 nm – 100 µm	poly(lactic acid)

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11 Magnetic silica particles for radionuclide extraction

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The recovery of lanthanides and actinides from high level nuclear waste is an area of world-wide concern. Current approaches are based on the TRUEX process which utilizes the highly efficient, neutral, organophosphorous ligand octyl phenyl N,N-disobutyl carbamoylmethyl phosphine oxide (CMPO). Such CMPO moieties were incorporated at the wide rim of calix[4]arenes. This preorganization of the chelating CMPO ligands at the cup-shaped calixarene lead to a 100 fold increase in extraction efficiency combined with an enhanced selectivity for actinides and lighter lanthanides [1]. Solvent extraction methods using either simple or calix[4]arene-based systems, despite being highly efficient, do not lead to a marked decrease in waste volume and require large volumes of organic solvents. The application of magnetic particles has a high potential to circumvent these drawbacks. With a special surface design magnetic particles combine the selectivity of a solvent exchange ligand system with improved separation using the magnetically assisted chemical separation (MACS). After binding radionuclides the magnetic particles can be separated with a magnetic system, stripped to enable re-use, or vitrified.

Our 6 µm sicastar®-M particles were conjugated to calix[4]arenes bearing four CMPO moieties at the wide rim. The comparison of the extraction capacity for europium, americium and cerium of the CMPO-calix[4]arene bearing particles in comparison to particles with the same amount of simple CMPO ligands showed a significantly higher level of extraction of all radionuclides studied. This demonstrates the importance of pre-organization of the chelating ligands on a suitable macrocyclic scaffold, prior to their attachment at the particle surface [2].

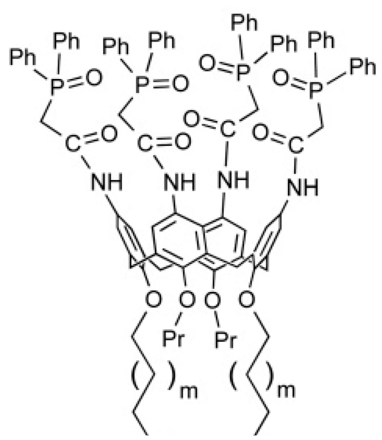

Figure 1. sicastar®-M particles with CMPO-bearing calix[4]arenes on the surface

Highly porous sicastar®-M particles with a diameter of 100 µm have a larger area for the immobilization of the chelator per g of particles than the non-porous particles. Therefore porous sicastar®-M particles were specially developed and conjugated to CMPO-containing calix[4]arenes via different spacer lengths between calixarene and particle surface (Figure 1).

In comparison to solvent extraction methods a more efficient extraction of americium and europium from simulated nuclear waste conditions has been achieved [3]. In addition surprisingly high levels of cerium could be extracted with the magnetic particles. It was also demonstrated that shorter spacer lengths of three to five carbon atoms lead to a more efficient extraction of europium and americium than the highly flexible spacer of 10 carbon atoms due to additional intermolecular interaction between CMPO units of neighboring calixarenes. But the increasing spacer length to C10 results in an increasing selectivity of the sicastar®-M particles for americium over europium due to complex formation with the CMPO units of single calixarenes. Thus the optimal spacer length for calixarene attachment on a particle surface must prevent interactions between the CMPO units of different calixarenes for a complete exploitation of the pre-organization effect of the CMPO chelators [4] The possibility of recycling the magnetic particles was demonstrated for back extraction of europium from the particle surface. The complexation capacity of the particles did not change within four complexation-back extraction cycles, that makes the magnetic particles interesting for economic industrial nuclear waste water cleaning [3,4].

Another strategy for the design of magnetic particles for an efficient binding of radionuclides is the attachment of dendrimers with a high number of terminal amino groups on the surface of our porous 100 µm sicastar®-M particles. The dendrimer-coated magnetic particles were used as a universal platform for the covalent binding of CMPO (Figure 2)[5], tripodal CMPO compounds and other selective chelators for radionuclides [6]. The introduction of the dendrimer spacers led to a 50 to 400-fold increase in europium and americium extraction in comparison with corresponding chelator-coated particles without the dendrimer spacers.

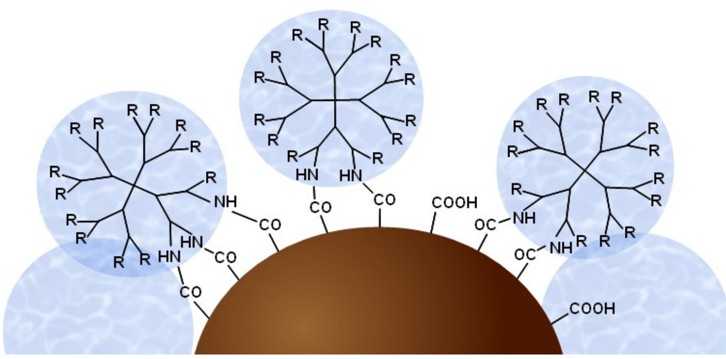

Figure 2. sicastar®-M particles with CMPO-bearing dendrimers on the surface (R=CMPO)

Back-extraction experiments with CMPO-bearing dendrimer-coated sicastar®-M particles demonstrated the possibility of multiple particle use, which also makes the application of CMPO-dendrimer coated particles an interesting alternative to conventional liquid-liquid extractions [5].

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