Project for a Master Thesis

Investigation of Transport of Nanoparticles through Ion Exchange Resin Beds by Magnetic Resonance Imaging and Acoustic Particle Counter

Motivation

Nanoparticles are ubiquitous in waterbodies, such as surface waters, drinking water, and can cause negative health and eco-toxicological effects. A nanoparticle typically has a size of 1 – 100 nm [1, 2]. Due to their small size, they are difficult to remove from water by conventional water treatment technologies [3]. In order to deionize water in water treatment, ion exchange resins in e.g. mixed bed filters, are widely used and their ability to reject nanoparticles is poorly studied, mainly due to analytical limitation for nanoparticle monitoring [4].
Ion exchange is also of high relevance for industrial water purification, as for example in ultrapure water production for electronics industry. Ultrapure water (UPW) is purified water with most of the quality parameters below the detection limit of the most advanced analytic technologies. Nanoparticles should be removed from the UPW down to < 1000 particles/L at 10 nm size at the point of entry for wafer fabrication [5]. In the UPW sector, but also in other water fields, there is an urgent need for strategies to detect and control nanoparticle release [6-8].

Aim of the master thesis

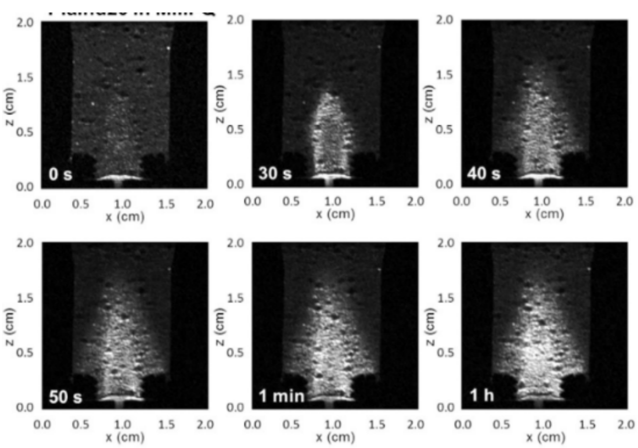

Figure 1: Nanoparticle transport through a sand column analysed by MRI (Cuny et al. 2015).

This master thesis work aims for the quantification of **the capacity of ion exchange resin beds to reject synthetic nanoparticles in a size range of 5-200 nm.** High purity cationic and anionic ion exchange resins in UPW will be used. An innovative analytical approach will be applied by combining **magnetic resonance imaging** (MRI) and **acoustic particle counter** (APC).
Differently sized and composed model nanoparticles with magnetic cores serve as MRI contest agents. The particle shell is out of polymers and/or silica to simulate a variety of nanoparticles in target water bodies.

Nanoparticle transport and behaviour within the resin column will be detected by MRI in real time. This approach has been proven, for example by Cuny et al. (2015) using quartz sand bed [9] (figure 1). MRI enables to **spatially trace nanoparticle transport**, estimate local concentration and analyse the column properties. Complementary to MRI, **nanoparticle breakthrough** will be quantitatively investigated by online particle measurement by APC. APC will provide nanoparticle concentrations and size distributions (4 size channels). The results will contribute to a better understanding of nanoparticle behaviour in advanced water treatment.

The tasks of the master thesis

- Conducts a **state-of-the-art literature research** on nanoparticle occurrence and rejection by ion exchange resins and analysis with MRI

- **Trace different magnetic nanoparticles in ion exchange resins columns** using MRI in order to identify mechanisms for transport and rejection
    - Image ion exchange resins bed for contrast optimization
    - Calibrate paramagnetic relaxation enhancement in MRI (relativities etc.)
    - Detect nanoparticle rejection patterns within the resin beds (cationic and anionic)
    - Improve data analysis tools (numerical image analysis)
- **Conduct breakthrough experiments** to elucidate the rejection and washout of different nanoparticles by online particle concentration monitoring using APC
    - study the impact of particle size.
    - study the impact of cationic and anionic ion exchange resins.
    - study the impact of flow on particle behaviour in resin bed.
- **Assessment of the results and evaluation of technical improvements** for nanoparticle rejection in water treatment

Type of thesis:	mainly experimental work
Target student group:	chemical engineering, chemistry, environmental engineering,
Start of the project:	immediate or flexible

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Literature:

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