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SIMULATION OF SEPARATION PROCESSES INCORPORATING MAGNETIC NANOPARTICLE RECOVERY IN CONTINUOUS MICROFLUIDIC SYSTEMS

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ABSTRACT

Research on magnetic nanoparticles (MNPs) is currently an area of intense scientific interest in a wide variety of technological areas, due to the great potential of these materials in different applications such as catalysis, wastewater treatment, design of pigments and coatings, chemical analysis, development of biomedical devices, etc. In general, MNPs exhibit enhanced physical and chemical properties, i.e. magnetic permeability, chemical reactivity, surface area, as compared to macroscopic materials and thus, their integration in existing technologies could lead to processes energetically and economically more efficient [1].

Forward Osmosis (FO) processes are receiving increasing attention in fields such as wastewater remediation, desalination, food processing, pharmaceutical industry and power generation but working with effective and reusable draw solutions still remains a challenge. The use of draw solutions formulated with magnetic nanoparticles (MNP's) and coupled with a magnetic separation stage for the draw solution re-concentration provides a clear advantage over other technical options. Draw solutions provide high osmotic pressure gradients which promote water fluxes through the membrane. In particular, MNP's used in the formulation of FO draw solutions consist of magnetite (Fe_3O_4) cores functionalized with hydrophilic polymeric moieties able to provide an effective osmotic pressure gradient by the partial solubility of the surface-grafted groups. Due to the small size of these nanocomposites (~20 nm), MNPs are superparamagnetic, and the use of a magnet provides a very simple and effective method of recovering these particles from the solution. Also, magnetic interactions are generally not affected by surface charges, pH, ionic concentrations or temperature, so this technology is very promising for the separation of magnetic materials from a fluid phase [2].

In this work, a continuous flow method capable of separating magnetic particles inside a microchannel is proposed. The advantages of this method lie in the possibility of controlling the movements of the particles under the influence of an external magnetic field and the continuous nature of the separation process, thus avoiding a possible aggregation of the

particles [3]. Particle motion is predicted using computational fluid dynamic (CFD) techniques based on a Lagrangian tracking method, being the separation efficiency evaluated through the particle trajectories inside the microfluidic separation device. Impact parameters including geometrical configuration, fluid velocity, magnetic flux density and particle size are studied.

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