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Engineering of size-controlled magnetic nanoparticles for use as a draw solution in a forward osmosis process

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ABSTRACT

Forward osmosis (FO), an osmotically driven process, is a promising technique for nutrients and organic matter recovery from urine and wastewater. Its efficiency is highly dependent on the differential osmotic pressure between feed and draw solutions. Therefore, the choice of draw solution is of great significance for successful operation of FO units. While inorganic salts solutions generate high osmotic pressure, their recovery is difficult and energy intensive. An easy to recover draw solution is therefore needed. Recently, few researchers reported that an easy to recover draw solution made of coated magnetic nanoparticles (MNPs) could be engineered. However, synthesis of coated MNPs for use as draw solution is not yet well mastered and not well understood. It is assumed that the size, dispersion, coating ratio and properties of coated MNPs are crucial important factors affecting the performance of the draw solution. In this study, we investigate the effect of several parameters exemplified by synthesis temperature, introduction of MNPs sonication, and timing of coating material addition (separate or simultaneous co-precipitation and coating) as well as initial MNP to coating agent ratio on the size and coating ratio and properties of coated MNPs. Chemical precipitation was adopted for the synthesis of MNPs. The coated nanoparticles were characterized using SEM, coating ratio and osmotic pressure and flux generation. Findings show that by heating at 80°C during the coating process, an increase in the particle size distribution and coating ratio was confirmed. Moreover, by separating the co-precipitation process and the coating process, the coating ratio increased and the particle size distribution became uniform with a small particle size. By introducing ultrasonic treatment after washing the magnetite particles, it was confirmed that the coating ratio increased and the particle diameter decreased. However, introducing sonication after coating stage will lead to smaller particle size, but lower coating ratio as the kinetic energy of sonication will peel off the coating agent from MNPs. With respect to initial MNP to coating agent ratio, coating ratio will increase with increasing the initial ratio. It is worth mentioning that FO tests revealed that the osmotic pressure shows a linear relationship with the coating ratio. Moreover, at similar amounts the generated osmotic pressure is larger in the MNP coated than in the bare sodium poly-acrylate.

Keywords: Forward osmosis; Magnetic nanoparticles; Draw solution; Coating

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