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Development of Ferric Citrate Complex Draw Solute and Its Application for Liquid Product Enrichment through Forward Osmosis

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Abstract : Forward osmosis is an emerging technology for separation and has great potential in the concentration of liquid products such as protein, pharmaceutical, and natural products. In pharmacy industry, one of the very tough talks is to concentrate the product in a gentle way since some of the key components may lose bioactivity when exposed to heating or pressurization. Therefore, forward osmosis (FO), which uses inherently existed osmosis pressure instead of externally applied hydraulic pressure, is attractive for pharmaceutical enrichments in a much efficient and energy-saving way. Recently, coordination complexes have been explored as the new class of draw solutes in FO processes due to their bulky configuration and excellent performance in terms of high water flux and low reverse solute flux. Among these coordination complexes, ferric citrate complex with lots of hydrophilic groups and ionic species which make them good solubility and high osmotic pressure in aqueous solution, as well as its low toxicity, has received much attention. However, the chemistry of ferric complexation by citrate is complicated, and disagreement prevails in the literature, especially for the structure of the ferric citrate. In this study, we investigated the chemical reaction with various molar ratio of iron and citrate. It was observed that the ferric citrate complex (Fe-CA2) with molar ratio of 1:1 for iron and citrate formed at the beginning of the reaction, then Fecit would convert to ferric citrate complex at the molar ratio of 1:2 with the proper excess of citrate in the base solution. The structures of the ferric citrate complexes synthesized were systematically characterized by X-ray diffraction (XRD), UV-vis spectroscopy, X-ray photoelectron spectroscopy (XPS), Fourier transform infrared spectroscopy (FT-IR) and Thermogravimetric analysis (TGA). Fe-CA2 solutions exhibit osmotic pressures more than twice of that for NaCl solutions at the same concentrations. Higher osmotic pressure means higher driving force, and this is preferable for the FO process. Fe-CA2 and NaCl draw solutions were prepared with the same osmotic pressure and used in FO process for BSA protein concentration. Within 180 min, BSA concentration was enriched from 0.2 to 0.27 L using Fe-CA draw solutions. However, it was only increased from 0.20 to 0.22 g/L using NaCl draw solutions. A reverse flux of 11 g/m²h was observed for NaCl draw solutes while it was only 0.1 g/m²h for Fe-CA2 draw solutes. It is safe to conclude that Fe-CA2 is much better than NaCl as draw solute and it is suitable for the enrichment of liquid product.

Keywords : draw solutes, ferric citrate complex, forward osmosis, protein enrichment
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