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Concentration of Salt Solution by High Pressure Reverse Osmosis Membrane and Properties of Scale Formation on the Membrane Surface

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Summary

In the crystallization with reverse osmosis (RO) membrane the crystals grow at the concentration polarization layer formed on the membrane surface. For establishing the crystallization method with RO membrane the prediction and control of behaviors of the concentration polarization layer will be required because properties of crystals will depend on the time profile of solute concentration during the crystallization process. In this study the concentration properties of some solutes including amino acids and soluble salts with RO membrane and crystals formed at RO membrane were observed. For the prediction and control of the concentration polarization layer a mathematical model was developed.

L-glutamic(L-Glu) acid were used as a typical solute for the RO membrane crystallization. The concentration was performed with RO membrane (ES-20, Nitto Denko) by dead-end mode with a HPLC pump. The pressure drop and rejection of the solute were monitored during the concentration. The crystals formed after the concentration at membrane surface was observed by SEM images. The effects of operation conditions including feed solute concentration, temperature, membrane type were studied. The solutes including L-histidine(L-His) acid, NaCl, KCl, $BaCl_2$, $SrCl_2$ were also studied.

From the observations a concentration mechanism of L-Glu with RO membrane was proposed. In the early stage of the concentration the L-Glu was concentrated at membrane surface over the saturated solubility without crystals. Then the nucleation and growth of crystal were occurred at membrane surface. When the membrane surface completely covered with the grew crystals the pressured drop increased steeply because the back diffusion of L-Glu was hindered by the crystal layer and osmotic pressure would increase. Finally the RO membrane was destroyed by the osmotic pressure. Same concentration pattern was observed for L-His while no crystals were observed on the membrane surface for NaCl, KCl, $BaCl_2$, $SrCl_2$.

A mathematical model for the concentration polarization layer was developed by accounting the mass balance of solute at membrane surface including crystallization of solute. The developed model could be fitted to the experimental results and was useful to predict the behaviors of solute at the membrane surface.