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Replacement of trichloroethylene in the extraction of crude caprolactam

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Caprolactam is the precursor to Nylon 6, a widely used synthetic polymer. Most of the world's caprolactam production involves its synthesis from cyclohexanone via the Beckmann rearrangement. The purity requirements for caprolactam are stringent, as even trace amounts of impurities can significantly affect the physical and mechanical properties of Nylon 6. Due to the presence of both polar and nonpolar impurities in crude caprolactam, purification traditionally includes forward extraction with a nonpolar solvent such as trichloroethylene, followed by back-extraction with water and multistage distillation.

This study focuses on the search for safer, non-carcinogenic alternatives to trichloroethylene in caprolactam extraction. Since a high distribution coefficient of caprolactam in the forward extraction process is undesirable for subsequent back-extraction with water, the alternative solvent should exhibit a distribution coefficient for caprolactam similar to that of trichloroethylene. Additionally, low mutual solubility with water, favorable physical properties, a low distribution coefficient for impurities, and acceptable cost are further requirements.

Suitable solvents were estimated using Hansen solubility parameters. Experimental liquid-liquid equilibrium data, along with key physical properties affecting mass transfer (density, viscosity, and interfacial tension), were determined for the design of Karr extraction columns with reciprocating plates, as used in caprolactam refining. The model was further validated through performance trials with an actual extraction unit employing trichloroethylene in caprolactam refining.

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