150c Standing Wave Design of Carousel Ion-Exchange Processes for the Removal of Zinc Ions from a Protein Mixture

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Chelex 100 is a highly effective adsorbent for the separation of metal ions from proteins for three reasons; it has a high affinity for metal ions; proteins with molecular weight of 1,000 or higher are excluded from the particle pores; it also allows high flow rates because it can stand a pressure drop up to 100 psi. In this study, a carousel process based on Chelex 100 has been developed for the removal of zinc ions from insulin in a buffer solution. The intrinsic parameters for the carousel design were estimated from a series of single column experiments, which showed that Chelex 100 has a high selectivity for zinc ions in 1 N acetic acid and it can be effectively regenerated using 0.1 N HCl. The exchange mechanisms between Zn2+ and H+ on Chelex 100 were studied and considered in rate model simulations. The effective zinc isotherm was found to be unfavorable in 1 N acetic acid. A design method based on the Standing Wave Analysis for unfavorable isotherm systems has been developed in this study to ensure high product purity and high yield in carousel ion-exchange processes. Computer simulations and several lab-scale carousel experiments showed that the design method and the proposed carousel process can achieve high product purity (100%) and high product yield (>99%). Compared to a batch size-exclusion chromatography process described by Xie et al.,1 a three-zone carousel process based on Chelex 100 has more than 600 times the throughput per bed volume, requires only 63% of the mobile phase, and has a 50 times smaller residence time.