79h Parallel Two-Zone and Four-Zone Hybrid Smb System for the Separation of *P*-Xylene

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Demand for *p*-xylene has increased greatly over the past five years to meet rapidly growing markets. At present, there are three main industrial purification processes based on simulated moving bed (SMB) adsorption. In 1971 UOP first commercialized the Parex process to produce high purity *p*-xylene from the isomer mixture. Other alternatives are Toray's Aromax and IFP's Eluxyl. An economical solution to increasing capacity is to debottleneck existing *p*-xylene production units.

A two-zone simulated moving bed (SMB) system with a storage tank has been developed for binary separation (Jin and Wankat, *Ind. Eng. Chem. Res.* 2005, *44*, 1565-1575). The two-zone SMB uses a two-step process. First, feed is introduced between zones I and II while some desorbent is recycled from zone I to zone II and the remaining desorbent (equal to the feed rate) exiting zone I is stored in the tank. In the second step (without feed) fresh desorbent and desorbent recycled from the tank is used to produce products. The raffinate product is withdrawn from zone I and the extract product from zone II. At the end of the second step, the ports are switched and the process repeats. A "parallel two-zone SMB" system that couples two two-zone SMB systems, does not require a storage tank and the feed and products are continuous. Previous results show that two-zone SMB and parallel two-zone SMB systems are comparable to the four-zone SMB with one column per zone. When the systems operated under the same total pressure drop and product purities, the productivity of a parallel two-zone SMB is 30% higher than a four-zone SMB.

In this research we simulate debottlenecking existing *p*-xylene separation units by placing a parallel two-zone SMB in front of an existing four-zone SMB. The impure *p*-xylene is pre-purified in the high-productivity parallel two-zone SMB with low desorbent-to-feed ratio (*D/F*). The pre-purified extract product is fed to the four-zone SMB for final purification. Since the feed to the four-zone SMB now has a much higher *p*-xylene purity, the feed and extract rates can be increased and desorbent rate can be reduced while retaining the desired *p*-xylene purity. The raffinate product streams from both parallel two-zone and four-zone SMBs can be fed to the raffinate distillation column. The typical C_8 aromatics feed to the four-zone SMB contains no desorbent, but after the pre-purification the feed for the four-zone SMB will be diluted. Despite this, with a much higher *p*-xylene purity in the feed for the four-zone SMB, the productivity can be increased significantly.

Published simulations from an SMB similar to UOP's Parex process are used as an example. Simulations were done with Aspen Chromatography® v12.1 for the purification of *p*-xylene for the hybrid SMB system.

The feed is a C_8 aromatics mixture with 23.6% *p*-xylene, 49.8% *m*-xylene, 12.7% *o*-xylene, and 14% ethylbenzene. The desorbent used is *p*-diethylbenzene. After pre-purification in the parallel two-zone SMB at *D/F*=1, *p*-xylene purity was increased to 78% in the extract product, while the *p*-diethylbenzene content was 72%. In the four-zone SMB (24-column system with 3-6-3-9 configuration), using a 40% increase in feed rate and 38% increase in extract product rate, the *p*-xylene purity was 99.92% (compared to the 99.91% without pre-purification). Optimized results will be reported. In this scenario, the distillation columns may also require debottlenecking.

Since the feed of the four-zone SMB was diluted in this hybrid SMB system, a promising alternative scenario is to concentrate the extract product from the parallel two-zone SMB by removing *p*-diethylbenzene in a new distillation column before feeding this stream to the four-zone SMB. A much higher feed rate to the four-zone SMB can be expected, and the load of the extract distillation column will be reduced.