79b Implementation of an on-Line Optimization Based Control Scheme on a Laboratory Simulated Moving Bed Plant

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Most of the chromatographic techniques were originally developed for analytical purposes but their separation power and ease of use have been a motivation to develop large-scale chromatographic applications. Introduction of simulated moving bed (SMB) chromatography has been considered as a breakthrough in chromatographic applications, because it can provide the benefits of countercurrent continuous operation without the problems associated with the continuous movement of the solid adsorbent. SMB chromatography has been widely studied by both industry and academia, and it has been shown that the possible gain from optimization of SMB processes is significant. On the other hand, regardless of their complexity, the performance of optimization algorithms is limited by the quality of the available physical data. Unfortunately, it is also a fact that the precise characterization of the separation system is a rather difficult task. Another issue is the significant dependency of the optimal conditions on the operating parameters, i.e., feed concentration/composition, and the physical parameters of the system, i.e., the adsorption isotherm and column properties, which are both subject to change. Therefore, it is hard to discuss a set of a priori fixed optimal operating conditions for SMB units. Re-characterization of the system and re-optimization of the process are required to account for the changes. Thus, the automatic control of SMB units presents itself as a dynamic optimization problem rather than a simple regulation or tracking problem, and integration of feedback control and on-line optimization is desirable to exploit the full economic potential of the SMB technology. We have recently proposed a control strategy that requires minimal information about the system, i.e., linear isotherm information regardless of the type of adsorption isotherm characterizing the separation and average porosity of the columns, and integrates the on-line optimization and feedback control of the SMB process in order to address the difficulties mentioned above [1,2,3]. The internal flowrates in four sections and the concentration levels in the outlet streams are chosen as the manipulated and the measured variables, respectively. The control concept makes use of an explicit model of the process and optimizes the performance of the plant over a defined future time window based on its current state. The process and product specifications, e.g. the average purity of the product outlets, are considered explicitly as constraints in the optimization problem which is solved on-line and yields the optimal changes in the flowrates. This work presents the experimental implementation of the developed control concept on the high purity separation of nucleosides (uridine, guanosine) with an eight-column four-section SMB unit arranged in a 2-2-2-2 configuration. Several experimental scenarios are considered in which the SMB unit is subjected to different types of disturbances, e.g., pump instabilities, and it is shown that the controller is capable of delivering the optimal separation performance regardless of not only the imposed disturbances but also uncertainities in the system characterization. An important aspect refers to the robustness of the developed control scheme to the frequency of the concentration measurements. It has been verified experimentally that the control performance remains quite satisfactory when the on-line measurements are replaced by cycle-to-cycle monitoring, which essentially can be regarded as off-line measurements.

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