293e Macromolecular Separation Based on Unique Microscale Transport

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A unique feature of microscale flow, that has been demonstrated experimentally, is multi-phase laminar flow of perfectly miscible incompressible fluids. Moreover, it is known that colloidal solutes or macromolecules are transported across the common interface, of such multi-phase flows, by diffusion only. We employ this phenomenon, to develop a multistage microscale separation scheme to separate multicomponent mixtures of macromolecules or colloidal particles. Analytical and numerical solutions are obtained, for the steady and unsteady state transport of solutes in a single stage contactor. This provides insights into the parameters affecting the non-equilibrium partitioning of solutes between two phases. It is shown that a set of stages can be used to obtain a single split in the multicomponent mixture with each phase containing an enriched fraction of solutes. The separation theory is further developed by devising a number of contacting schemes that allow the enrichment of a desired fraction, from an equimolar, multicomponent mixture of solutes. We show that: (1) Enrichment of smaller solutes can be achieved with few stages. (2) The yield decreases with increasing number of stages. (3) Selectivity or sharpness of the split for larger solutes is poor. Owing to dependence of partitioning and selectivity on flow rate, it is possible to flow-tune the separation of smaller solutes without changing any other parameters. This method may be especially suitable for bioseparation applications involving aqueous media. Some limitations of this method and the current theory are discussed. This method may be combined with other specific or nonspecific interactions to yield highly selective and rapid separations in the microscale.