Critical adsorption in nanochannels

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We study the flow of a near-critical binary mixture through a nanopore in contact with two material reservoirs. When the pore walls interact favorably but weakly with one of the mixture components and the fluid velocity approaches zero we recover the well-known picture of critical adsorption [1]. However, when the fluid velocity through the pore increases, the interplay between advection and the mixture components inter-diffusion, or Péclet number, leads to two intriguing flow regimes. Initially, we find that the pore acts a membrane. The inlet stream cannot supply the favored component fast enough leading at steady-state to a depletion of this component at the inlet reservoir and an excess of it at the outlet reservoir. Upon further increase of the fluid velocity advection becomes dominant leading to a depletion of the pore composition, long-range dispersion in the outlet reservoir, and back flow within the pore. These phenomena depend almost exclusively on the Péclet number, and hence could be easily and reversibly controlled by the application of an external pressure.

References

[1] M. E. Fisher and P. G. de Gennes, C. R. Seances Acad. Sci., Ser. B **287**, 207 (1978).