4dc Chemical Separations Based on Spatially Controlled Phase Transformations in Thermotropic Liquid Crystalline Materials

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Membrane separation technologies generally rely on an externally applied driving force, usually a concentration or pressure gradient, to induce mass transfer across the membrane. The application of such a driving force generally requires ancillary process equipment, such as evaporators or compressors, increasing both energy requirements and capital costs. As such, the development of membrane that takes advantage of the physical properties of the membrane material to drive the mass transfer of a solute could provide a more efficient means of separation. The solubility and transport properties of minor components dissolved in thermotropic liquid crystalline (LC) materials vary from phase to phase (smectic, nematic, isotropic.) LC materials also often exhibit significant responsiveness to applied stimuli. This sensitivity allows the alteration of the sorption and diffusion properties of the material through a LC-isotropic phase transition induced by slight changes in temperature, the application of electric fields, or through light irradiation The application of external stimuli in a spatially controlled manner would result in phase transformations proceeding in sequence across the bulk of a LC sample and forcing a dissolved component across the sample in the absence of an external pressure or concentration gradient. Finite element calculations have been performed that confirm the theoretical feasibility of this approach for cross-membrane transport. Initial experiments targeted the transport of gases across a LC sample contained in a microfluidic device. Electrodes embedded in the microchannels serve as individually addressable heating elements to thermally induced phase changes across the sample. Further work will include the exploitation of light-induced phase changes in photo-isomerizable LC materials and efforts to separate components from liquid streams.