Separation of C_2-C_4 Hydrocarbons from Methane by Zeolite MFI Hollow Fiber Membranes Fabricated from 2D Nanosheets

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Abstract

Separation of higher hydrocarbons from methane is an important and energy-intensive operation in natural gas processing. We present a detailed investigation of thin and oriented MFI zeolite membranes fabricated from 2D MFI nanosheets on inexpensive α-alumina hollow fiber supports, particularly for separation of n-butane, propane, and ethane ("natural gas liquids") from methane. The present MFI membranes display high permeances and selectivities for C2-C4 hydrocarbons over methane, driven primarily by stronger adsorption of C2-C4 hydrocarbons. We study the separation characteristics under unary, binary, ternary and quaternary mixture conditions, including the pressure dependence. The membranes are highly effective in quaternary mixture separation at elevated feed pressures, for example allowing n-butane/methane separation factors of 170–280 and n-butane permeances of 710–2700 GPU in the 1-9 bar feed pressure range. Furthermore, we parametrize and apply multicomponent Maxwell-Stefan transport equations to predict the main trends in separation behavior over a range of operating conditions.

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