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Catalytic dehydrogenation of methylcyclohexane (MCH) to toluene in a palladium/alumina hollow fibre membrane reactor

Abstract

A compact multifunctional Pd/alumina hollow fibre membrane reactor (HFMR) has been developed and used for the catalytic dehydrogenation of methylcyclohexane to toluene. The developed HFMR consists of a thin and defect-free Pd membrane of 5 um coated directly onto the outer surface of analumina hollow fibre substrate. The substrate, was prepared by a phase inversion/sintering method, possess a unique asymmetric structure which can be characterised by a very porous inner surface from which finger-like voids extend across approximately 80 % of the fibre cross-section with the remaining 20 % consisting of a denser sponge-like outer layer. A 50 wt% Ni/Al2O 3 catalyst is directly deposited into the asymmetric support, with a fraction of catalyst particles distributed uniformly in the finger-like macro-voids while the others on the lumen surface forming a "filter- cake"-like layer. A significant increase in gas permeation resistance occurs due to this "filter-cake"-like catalyst layer when the catalyst loading (weight per unit fibre length) is above 2.3 mg-cm-1. Methylcyclohexane conversion increases with the increasing temperatures, because of the endothermic nature of the reaction; while decreases with the higher sweep gas flow rates due to the more serious catalyst deactivation in the HFMR. For a HFMR with 1.0 mgx-1 of catalyst loading, methylcyclohexane conversion of approximately 26% can be achieved at 610 °C with the sweep gas flowrate of 20 ml min-1, while for a porous membrane reactor and a fixed-bed reactor the methylcyclohexane conversion of 50% and 25% can be achieved at identical operating temperature.

Keywords

Asymmetric structure; Catalyst; Membrane reactor; Methylcyclohexane dehydrogenation; Pd membrane