ABSTRACT:

Membrane-Based Strategies to Obtain Pure or Concentrated H2 from Gas Streams

P.F. Zito
National Research Council - Institute on Membrane Technology “Enrico Drioli”, via P. Bucci, cubo 17C, 87036, Rende, IT.

Hydrogen is well known to be an important energy vector and reactant in many industrial processes. Even today, it is mainly obtained from fossil fuels (i.e., about 96%) by steam methane reforming and coal gasification, while only a small fraction from electrolysis [1]. Renewable sources, such as solar and biomass, represent an important challenge in moving toward clean and sustainable H2 production processes (e.g., photocatalytic conversion of CO2 and H2O in hydrogen liquid carriers, water electrolysis using solar energy, biomass gasification etc.). Once produced, H2 has to be purified from other components often present in the mixtures, such as CO2, CH4, CO, H2O etc. Conventional methods for H2 separation include pressure swing adsorption and cryogenic distillation; however, membrane technology has been gaining attention in recent years. In this work, membrane-based processes were simulated for the treatment of gas mixtures, focusing on various types of materials and configurations that allowed the simultaneous purification of multiple components, as recently reported in the literature [2]. Polymer and zeolite membranes were used here for H2 concentration while purifying other species like CO2, CO and CH4, which are often present in real industrial streams (e.g., syngas, biogas, coke oven gas etc.). An ultrapure H2 product was achieved by installing Pd-based membrane modules before/after the concentration stages. The cost-benefit analysis of various simulated plants predicted positive economic potentials and profits, making membrane technology a possible solution for real applications.

[1] T. Capurso, M. Stefanizzi, M. Torresi and S.M. Camporeale, Energy Convers. Manag., 251, 114898 (2022).
[2] P.F. Zito and A. Iulianelli, Energy Convers. Manag., 347, 120538 (2026).
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