Removal of carbon dioxide out of mixtures of carbon dioxide and hydrogen with amino-functionalized polymeric membranes

Abstract

Aim of this work is to investigate the suitability of a membrane process for the removal of carbon dioxide from carbon dioxide/ hydrogen - mixtures. As an example for an application a hydrogen storage unit on the base of formic acid is selected. By catalytic decomposition of formic acid a mixture of carbon dioxide and hydrogen at pressures between 1-3 MPa is generated. Carbon dioxide is selectively separated by membranes and hydrogen is generated under pressure for further use without the need of compressing. The examined membranes contain amino functionalisations for the facilated transport of carbon dioxide. The work gives as an overview of the state of the art of hydrogen storage and preferred carbon dioxide permeable membranes. Furthermore an macroscopic model for the description of the transport of carbon dioxide in carrier membranes including the function of water is developed. As amino-functionalized polymers for membrane separation layers of cation- and anion-exchange polymers are synthesised. As basic polymer polyetherketons, polyvinyl alcohol and epichlorhydrin polymers are used. The pressure and temperature dependent permeation rates in the range of 283-353 K and 0-4 MPa of the manufactured membranes are determined.
It was shown, that a the removal of carbon dioxide out of carbon dioxide hydrogen mixtures is feasible. The reachable separation factors depend greatly from carbon dioxide partial pressure in feed. At partial pressures < 0.5 MPa separation factors up to 25 at permeabilities of 1000 barrers are found. At higher partial pressures saturation of the carrier positions leads to reduced selectivity. Only separation factors of 5 (but also in the presence of water vapor) can be reached. A hydrogen storage unit based on formic acid for the production of hydrogen >95 vol% under pressure can be realised with an two stage membrane system.

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