

CO₂ and H₂ selectivity properties of PDMS/PSf membrane prepared at different conditions

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Abstract The effects of different solvent/water coagulation mediums, different coagulation bath temperatures (CBT) and different coagulants on the performance, morphology and thermal stability of polysulfone membranes were investigated. The CO₂/CH₄, H₂/CH₄ and H₂/N₂ separation performance of the membranes were studied by gas permeation. Changing the *N,N*-dimethyl acetamide (DMAc)/water coagulation medium ratio from pure water to 90/10 vol%, resulted in a complete disappearance of the macrovoids throughout the polysulfone (PSf) polymeric matrix. The PSf membrane prepared in a CBT of 25°C showed the best gas separation performance with ideal selectivities of 46.29, 39.81 and 51.02 for H₂/CH₄, CO₂/CH₄ and H₂/N₂ respectively, and permeances of 25 and 21.5 GPU for H₂ and CO₂ at 25°C and 10 bar respectively. By increasing the amount of solvent in the gelation bath, the selectivities of H₂/CH₄, CO₂/CH₄ and H₂/N₂ were dramatically reduced from 46.29, 39.81 and 51.02 to 16.08, 20.2 and 18.5 respectively at 25°C and 10 bar. Reducing the CBT from 80°C to 5°C led to a complete elimination of macrovoids. Using methanol as a coagulant resulted in a less selective membrane compared with membranes from ethanol and water coagulants. The H₂ and CO₂ permeances were respectively about 3 and 9 times more than those for ethanol and water coagulants. Coated membranes were heated at different temperatures to investigate the suppression of undesirable CO₂ plasticization. The membranes were stabilized against CO₂ plasticization by a heat-treatment process.

Keywords gas separation, PDMS/PSf membrane, synthesis parameters, CO₂ selectivity

1 Introduction

Membrane separations are a technology of interest in natural gas sweetening. They have also been used in the removal of CO₂ in landfill gas recovery processes and for the removal of CO₂ in enhanced oil recovery applications (EOR). Membrane systems for applications in these areas have become more competitive compared to traditional separation processes such as amine scrubbing. At present, natural gas is a vital energy source and is produced in large quantities that often contain excess CO₂. The content of CO₂ must be reduced to meet pipeline specifications, i.e., 2 mol-% or less [1]. Separation processes using asymmetric polymeric membranes assist in the reduction of CO₂ concentration for upgrading low-quality natural gas [2,3].

Hydrogen is a promising energy source for space heating and electric power generation, and as a transportation fuel. These potential uses have resulted in a huge increase in the demand for hydrogen. Separation of hydrogen from nitrogen in ammonia purge gas streams was the first large-scale commercial application of membrane gas separations. The process, launched in 1980 by Monsanto, was followed by a number of similar applications, such as hydrogen/methane separation in refinery off-gases [4]. The other major current application of H₂ separation membranes is the separation of hydrogen from methane in ammonia plants. During the production of ammonia from nitrogen and hydrogen, methane enters the reactor as an impurity with the hydrogen. The methane impurity accumulates until it represents as much as 15% of the gas in the reactor. To control the concentration of these components, the reactor must be continuously purged. The hydrogen lost with this purge gas can represent 2%–4% of the total hydrogen consumed. These plants are very large, so recovery of the hydrogen for recycle to the ammonia reactor is economically worthwhile. Hence it is crucial to use a membrane system for the recovery of hydrogen from an ammonia plant purge gas stream. Hydrogen recovery was among the first commercial applications of mem-

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