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# Separation of ethylene/ethane and propylene/propane by cellulose acetate–silica nanocomposite membranes

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ABSTRACT

The separation of olefin–paraffin mixtures is one of the most important and expensive processes in petrochemical industries. In this research, the performance of cellulose acetate–silica nanocomposite membranes in the separation of ethylene/ethane and propylene/propane has been studied. Silica nanoparticles were prepared via hydrolysis of tetraethoxysilane (TEOS). Membranes were prepared by the solution-casting method. The prepared membranes were characterized using FT-IR, SEM and TGA analyses. Pure gas permeation experiments were performed by the constant volume/variable pressure method at 2 bar feed absolute pressure and 35 °C. The results showed the permeability of ethylene and propylene increased from 0.052 barrer and 0.046 barrer in pure cellulose acetate to 0.11 and 0.098 barrer in the composite membrane containing 30 wt% silica particles, respectively. The comparison of the selectivities of $C_2H_4/C_2H_6$ and $C_3H_6/C_3H_8$ indicates an increase from 2.16 and 2.55 in pure cellulose acetate to 4.07 and 6.12 in composite membrane containing 30 wt% silica particles. The diffusion coefficients of prepared hybrid membranes were determined by the time lag method. The solubility coefficient was calculated indirectly from permeability and diffusivity coefficients. The results showed an increase in the solubility coefficient and a decrease in the diffusion coefficient of gases while increasing the silica mass fraction. To investigate the possible plasticization phenomena, the effect of feed pressure on gas permeability and $O_2/N_2$ selectivity, before and after exposure of membranes with propylene, was studied. The results showed no plasticization effects up to 8 bar feed pressure.



## 1. Introduction

It is common to divide petrochemical industry into two general sections, Olefins and Paraffins with their derivatives [1]. The most important olefins are ethylene and propylene. Olefins are mainly used for production of plastics like polyethylene and polypropylene as well as chemicals such as ethylene oxide, propylene oxide, acetaldehyde, acrylonitrile and acrylic acid. Ethylene is produced primarily by steam cracking of hydrocarbon feedstock with propylene as a byproduct. Propylene is produced by the on-purpose method including fluid catalytic cracking, propane dehydrogenation, methanol to olefin and olefin conversion. Olefin (ethylene and propylene) purification is the most significant and difficult section of olefin production. Currently purification of olefins is carried out by distillation. The separation of propane from propylene requires more than 200 trays if a grade of propylene with more than 99.5% purity is required. This process is highly energy intensive due to the low relative condensability of the components (1.09–1.15) [1–3]. Due to the complexity and difficulty of the separation process, several attempts have been made to develop different separation methods such as extractive distillation, adsorption, absorption and membrane. Polymeric membranes are attractive alternatives for conventional separation methods because of some advantages like low cost, good mechanical stability and ease of processing [4,5]. But the separation factor of membranes, especially rubbery polymers, for olefin/paraffin separation is low and should be improved. Facilitated transport membranes have high selectivity but they have a stability problem and separation process has to be carried out under humid conditions [6].

Ito and Hwang [7] studied the separation of propane and propylene through cellulose acetate, polysulfone and silicon rubber hollow fiber membranes. The ideal selectivity of 3.8 and 0.88 for propylene over propane was reported in the cellulose acetate membrane at 40 °C and −17 °C respectively. Lee and Hwang [8] reported the ideal selectivity factor of 15 for propylene over propane in the polyimide hollow fiber membrane based on BPDA. Tanaka et al. [9] studied the separation performance of

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