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The impact of ethylene glycol and hydrogen sulfide on the performance of cellulose triacetate membranes in natural gas sweetening

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Abstract

In natural gas sweetening, gas dehydration with glycols is typically carried out upstream of membrane separation of carbon dioxide. This means that when process upsets occur, these glycols can reach the membrane unit. In this work, we study the impact of two common glycols (monoethylene glycol and triethylene glycol) on the gas transport performance of CTA. We find that the glycol absorbed into the membrane initially obstructs the permeation of CH_4 and CO_2, due to pore filling or antiplasticisation effects, but the permeability then increases again, indicative of polymer relaxation and a loss of crystallinity in the polymer. The smaller helium molecule is significantly less affected by the presence of the glycols, possibly because its lower solubility within glycol limits its movement through the swollen structure. However, after removing the glycols with a methanol wash, the membrane performance recovers with only a slight residual plasticisation observed. In addition, the permeation of H_2S, a common contaminant within natural gas streams, was studied across a range of temperatures. At the partial pressures studied (up to 0.75 kPa), H_2S had very little effect on the membrane performance even in long-term exposure for up to 300 days.

Keywords: Cellulose triacetate; hydrogen sulphide; ethylene glycol; triethylene glycol; plasticization.

1. Introduction

Natural gas is a primary energy resource that will occupy over 25% of the global electricity market in the next decades, as well as acting as a transport fuel and direct heating resource [1]. The composition of raw natural gas varies widely but typically contains impurities such as nitrogen (N_2), carbon dioxide (CO_2), water (H_2O) and hydrogen sulphide (H_2S) that require removal to meet pipeline specifications. Membrane separation has been used for many decades for acid gas removal, known as natural gas sweetening, with advantages in energy efficiency, land footprint and a lack of chemical consumption [2]. Although many new membrane materials have been developed, cellulose triacetate (CTA) membranes still retain the bulk of this separation market because of their high CO_2 – methane (CH_4) selectivity, commercial readiness and acceptance as a low risk option by the industry [3, 4].