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SEPARATION OF GASES BY SUPPORTED LIQUID MEMBRANES

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Biogas, seems to be a very good candidate for the replacement of depleting fossil fuels. The raw biogas is created by the decomposition of waste through the process of anaerobic digestion and has to be purified in order to reach a fuel quality. Unwanted impurities such as CO2 or acidic gases have to be removed while the others impurities with concentrations lower than 1 vol. % are marginal for the biogas upgrading. The recent breakthrough in biogas upgrading represents the membrane separations with water-swollen thin polymer (skin) layer composite membranes when the presence of water vapor in raw biogas assists in the effective gas separation. For this reason, pre-treatment such as water vapor removal is avoided and a raw biogas feed is directly in contact with the composite membrane.

Two swollen polyamide thin-film composite membranes were tested for effective CO2/CH4 separation. It was found that the water wettability has a key role for the separation of binary mixture representing a raw biogas, i.e. containing CO2 and CH4. The transport properties were analyzed by means of a mathematical model simulating gas permeation. A new modification of the mass transport coefficient model provided the concentration profiles of individual components on both sides of the membrane (inaccessible in experiments). Furthermore, the model enabled the evaluation of the mass transport coefficients of the gases in the mixture under varying stream flow rates and arrangements with respect to the membrane separation cell size. Therefore, the possibility of scale-up was discussed for both membranes and flow cell arrangement. Although the mathematical model was developed for a flat sheet membrane configuration, the results can be applied for a real spiral wound module with a wider surface.

The mass transfer coefficients of CO2 and CH4 in the Koch membrane as well as in the Sterlitech membrane were evaluated directly from experiments and by the developed permeation model for each individual experimental case. The final values of the mass transfer coefficients for CO2 and CH4 were evaluated as the averages and were used for the prediction model. The differences in CO2 permeate molar fractions between the experimental data and prediction model were in the range from -19 to +10 % for Koch membrane and from -5 to +4 % for Sterlitech membrane, respectively.
The Sterlitech membrane showed CO2 mass transfer coefficients of approximately one order of magnitude higher than the Koch membrane. On the other hand, the ratio of the CO2 and CH4 mass transfer coefficients was only fivefold in the case of the Sterlitech membrane, where as, in the Koch membrane, the difference was more than twentyfold. Based on our results, a real biogas upgrading plant can be designed. It should consist of

the dual module arrangement with the first, highly permeable Sterlitech membrane module and the second selective Koch membrane module.

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