

Comparisons of Reverse Osmosis and Pervaporation Membrane Processes I. Theoretical Interpretations

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The pressure in RO leads to a concentration difference across the membrane, while the concentration difference in PVAP across the membrane is achieved by applying a vacuum to the downstream compartment. Therefore, it could be possible to compare this two processes using the solution-diffusion mechanism.

The relationship between the activities in the solutions and just within the membrane can be expressed as [1,2]

$$a_{i0}^m = a_{i0}^s \quad (1)$$

$$a_{i1}^m = a_{i1}^s \exp[-V_1(P_0 - P_1)/RT] \quad (2)$$

Furthermore, the activity of component i can be derived from the Flory-Huggins equation and the rubber elasticity theory :

$$\ln a_{i1}^m = \ln(1 - v_{r1}) + v_{r1} + \chi_1 v_{r1}^2 + [V_1 \cdot \nu_e / V_0 (v_{r0}^{4/3} / v_{r1} - v_{r1} / 2)] \quad (3)$$

Combinations of Eqs.(2) and (3) gives finally

$$\begin{aligned} -V_1(P_0 - P_1)/RT = & \ln(1 - v_{r1}) + v_{r1} + \chi_1 v_{r1}^2 \\ & + [V_1 \cdot \nu_e / V_0 (v_{r0}^{4/3} / v_{r1} - v_{r1} / 2)] \end{aligned} \quad (4)$$

If the solubility is known from the swelling equilibrium measurement, the concentration profile in the membrane can be estimated from the following relationship:

$$1 - v_1 = (1 - v_{10})[(1 - v_{11})/(1 - v_{10})]^{x/l} \quad (5)$$

And also, combined with Fick's law, it gives the volumetric flux

$$n_1 V_1 = (D/l) \ln[(1 - v_{11})/(1 - v_{10})] \quad (6)$$

In this paper, using the above theoretical background, it is discussed how the solubility and activity are affected by the applied pressure in RO and PVAP for the binary systems, i.e., rubber membrane-hexane, rubber membrane-benzene, polyethylene film-hexane, and polyethylene film-benzene systems.

References

- [1] D.R. Paul and O.M. Ebra-Lima, J. Appl. Polym. Sci., 14 (1970) 2201.
- [2] D.R. Paul and O.M. Ebra-Lima, J. Appl. Polym. Sci., 15 (1971) 2199.

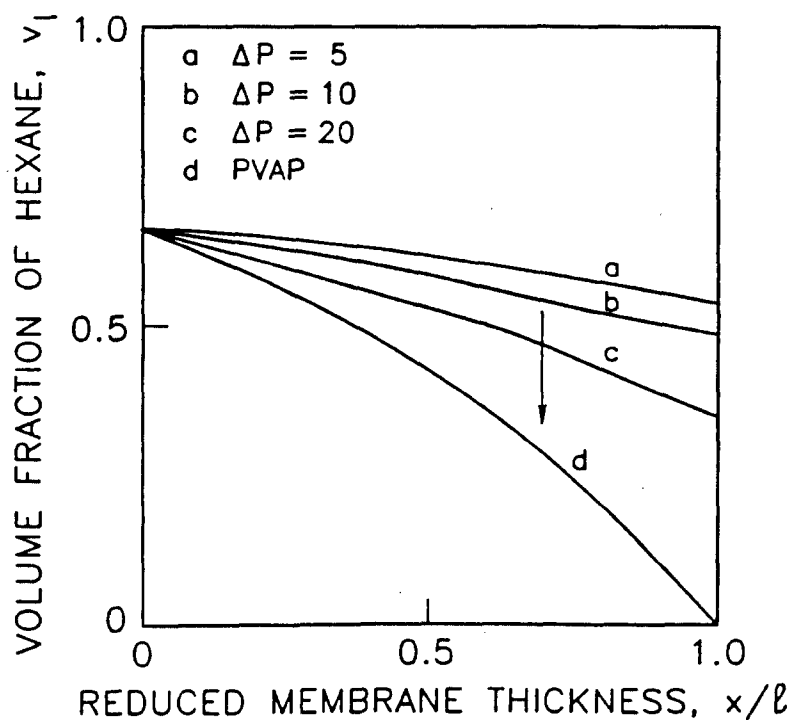


Figure. Calculated concentration profile of hexane in the rubber membrane at various pressures (atm) in RO(a,b,c,) and PVAP(d).