The transport of vapor through anodic alumina membranes under conditions of capillary condensation

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The flow of isobutane vapors through an anodic alumina membrane[1] with a pore diameter of 20 nm is described. Three different models are used: An isothermal description, a fully adiabatic description and a description of the flow that assumes a heat flux from the downstream side of the membrane such that the downstream temperature is equal to the upstream temperature, $T_1 = T_2$.

A vapor close to saturation that flows through a porous medium with small pore sizes may condense due to capillary condensation. In isothermal descriptions[2] the large pressure differences at the strongly curved menisci between the condensate and the vapor, which increase the mass flux, are taken into account. In the fully adiabatic description,[3] in addition, account is taken of the release and the consumption of the enthalpy of vaporization and of the real fluid properties of the vapor, i.e., the Joule-Thomson effect is recovered. Hence, the temperature varies within and in front of the membrane. In the fully adiabatic description, it is assumed that there is zero heat flux to and from the membrane. However, the mass flow of vapor and hence the flow of enthalpy is so small that this latter assumtion may be easily disturbed. Therefore, in the third description, a heat flux from the downstream side is imposed such that the downstream temperature is equal to the upstream side. The real fluid properties of the vapor and the enthalpy of vaporization are still taken into account.

Figure 1(a) shows the measured permeance J reported in literature[1] and the permeance as computed from the three different descriptions. For $p_1/p_{\mathrm{sat}} = 0.98$, the temperature distributions for the fully adiabatic description and for the description with $T_1 = T_2$ are shown in Figure 1(b).

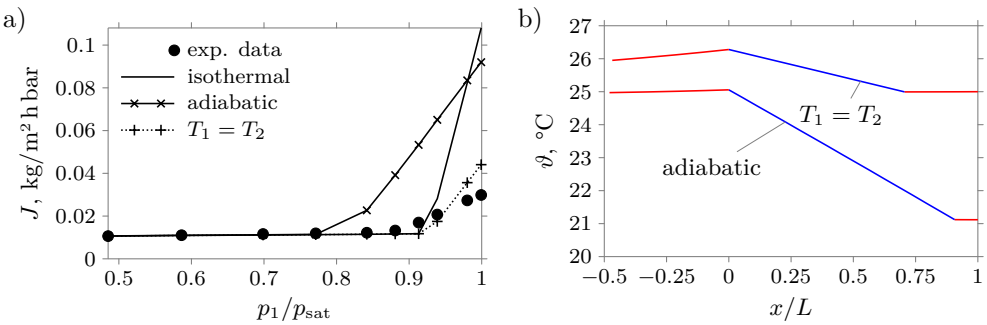

Figure 1: (a) Permeance J versus relative upstream pressure. (b) Temperature distribution in front of and within the membrane for $p_1/p_{\mathrm{sat}} = 0.98$ according to the adiabatic description and for $T_1 = T_2$. Vapor is indicated by red, liquid by blue, respectively.

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[1]Petukhov et al. *J. Phys. Chem. C* **120**, 10982 (2016).
[2]Lee and Hwang, *J. Colloid Interf. Sci.* **110**, 544 (1986).
[3]Loimer et al., *J. Membr. Sci.* **383**, 104 (2011).