Microscale Heat and Mass Transport of Evaporating Thin Film of Binary Mixture

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Analytical and computational studies are presented to examine the effect of binary mixture (pentane/decane) on the microscale heat and mass transport of an evaporating meniscus formed inside a two-dimensional slotted pore. Mass conservation in the liquid film is combined with the momentum equations, energy balance, and normal stress balance and then scaled yielding two constitutive equations: 1) a fourth-order, nonlinear, ordinary differential equation for thin-film profile [Eq. (27)] and 2) a first-order, linear, ordinary differential equation for concentration profile [Eq. (30)]. The numerical results showed that the magnitude of distillation-driven capillary stress due to the composition gradient of a binary mixture can be larger than the thermocapillary stress due to temperature gradient while they are acting in opposite direction. Henceforth, the proof-of-concept has been established in that the binary mixture could facilitate improvement of the evaporating thin-film stability. It was also shown that the resulting stress elongated the length of the evaporating thin-film region without degradation of heat transport effectiveness.