Abstract

Understanding the behavior of hydrophobic membranes is important for applications where separating a gas from a liquid-gas mixture is beneficial. For example, vapor extraction can be implemented in microscale heat sinks to improve heat transfer and flow stability. Gas and liquid-gas combinations of air, liquid water and water vapor were experimentally studied flowing through flexible polytetrafluoroethylene (PTFE) nanofiber membranes.

For single-phase flow such as superheated vapor and air, structural changes such as compaction affect membrane properties dependent on membrane thickness which can restrict the flow rate. Two types of existing models accounting for compaction and reduced extraction area are insufficient to predict gas extraction flow rates from two-phase mixtures. For certain situations, the effective extraction area insufficiently accounts for bubble kinetic energy, membrane surface characteristics and thin liquid films. The thin liquid film must be ruptured to open membrane pores to extract the gas in the bubbles. At greater applied pressure differences, film rupture and three phase contact are accelerated resulting in a greater effective extraction area. If the bubbles have too much energy associated with them, it may take multiple collisions with the membrane for the bubble to form stable three phase contact. In the case of liquid-air mixtures with high void fractions, bubbles are not completely extracted due to hydrodynamics outside of the membrane. For saturated liquid-vapor studies, full extraction is achieved even at high void fractions due to differences in bubble energy and size. One implication with liquid-vapor mixtures is that permanent changes in the membrane permeability can be induced. Empirical models are developed to predict the dependence of gas extraction on temperature, fluid type and applied pressure differences across the membrane.