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Ultrasound-Mediated Separation of Ethanol, Methanol, and Butanol from Their Aqueous Solutions

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Abstract : Ultrasonic atomization (UA) is a useful technique for producing a liquid spray for various processes, such as spray drying. Ultrasound generates small droplets (a few microns in diameter) by disintegration of the liquid via cavitation and/or capillary waves, with low range velocity and narrow droplet size distribution. In recent years, UA has been investigated as an alternative for enabling or enhancing ultrasound-mediated unit operations, such as evaporation, separation, and purification. The previous studies on the UA separation of a solvent from a bulk solution were limited to ethanol-water systems. More investigations into ultrasound-mediated separation for other liquid systems are needed to elucidate the separation mechanism. This study was undertaken to investigate the effects of the operational parameters on the ultrasound-mediated separation of three miscible liquid pairs: ethanol-, methanol-, and butanol-water. A 2.4 MHz ultrasonic mister with a diameter of 18 mm and rating power of 24 W was installed on the bottom of a custom-designed cylindrical separation unit. Air was supplied to the unit (3 to 4 L/min.) as a carrier gas to collect the mist. The effects of the initial alcohol concentration, viscosity, and temperature (10, 30 and 50°C) on the atomization rates were evaluated. The alcohol concentration in the collected mist was measured with high performance liquid chromatography and a refractometer. The viscosity of the solutions was determined using a Brookfield digital viscometer. The alcohol concentration of the atomized mist was dependent on the feed concentration, feed rate, viscosity, and temperature. Increasing the temperature of the alcohol-water mixtures from 10 to 50°C increased the vapor pressure of both the alcohols and water, resulting in an increase in the atomization rates but a decrease in the separation efficiency. The alcohol concentration in the mist was higher than that of the alcohol-water equilibrium at all three temperatures. More importantly, for ethanol, the ethanol concentration in the mist went beyond the azeotropic point, which cannot be achieved by conventional distillation. Ultrasound-mediated separation is a promising non-equilibrium method for separating and purifying alcohols, which may result in significant energy reductions and process intensification.

Keywords : azeotropic mixtures, distillation, evaporation, purification, seperation, ultrasonic atomization
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