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Drop size distribution and mean drop size in a pulsed packed extraction column

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ABSTRACT

Drop size distribution and mean drop size are used for calculation of interfacial area available for mass transfer. In this study, the drop size distribution and Sauter mean drop diameter (d_{32}) have been investigated using three different liquid systems in the absence of mass transfer in a pilot plant pulsed packed column. The drop size was measured at four different points along the active column height. Three operating variables have been studied including the pulse intensity (*af*) and flow rates of both liquid phases. The effect of liquid properties and height of the active column were also investigated. A combination of the pulse intensity and interfacial tension had the largest effect on the drop size distribution while none of the flow rates were of significance. The height of the column played an important role at the bottom of the active column, but the associated effect was reduced with increase of the height. Finally, a normal probability function of number density was proposed for prediction of the drop size distribution with an Average Absolute Relative Error (AARE) of 8.8% for their optimized constant. Furthermore, two correlations were presented involving height or flow rates of the two phases along with operating variables and physical properties of the liquids. These correlations had AARE values of about 8.5 and 7.8%, respectively.

Keywords: Pulsed packed column; Sauter mean drop diameter; Drop size distribution; Pulse intensity

1. Introduction

Liquid–liquid extraction is one of the useful techniques applied in various separation technologies including chemical, petroleum, food, hydrometallurgy, nuclear, and many other applications (Tsouris et al., 1994). In design of an extraction column, height and diameter of the column have to be specified for a desired mass transfer and allowable flow rates in all phases. Drop size has an important effect on the dispersed phase holdup and the maximum throughput. Furthermore, the interfacial area of mass transfer can be determined using drop size and holdup together (Kumar and Hartland, 1996). The knowledge of drop size distribution is a key parameter to scaleup of the system (Maaß et al., 2011), and obviously contains more information than a mean drop size alone because different drop size distributions might have the same mean drop size while having different interfacial areas.

Pulse intensity can affect the drop size: the drop breakup is enhanced with increasing pulse intensity due to enhaced collisions between the dispersed liquid drops and the internal wall (Ousmane et al., 2011). The drop size distribution curve becomes wider when *af* is lower. An increase of *af*, on the contrary, makes the curve trends to represent a uniform size (Jones, 1962). Some investigations have been carried out on the effect of the column geometry in pulsed extraction columns (Spaay et al., 1971; Lorenz et al., 1990; Yadav and Patwardhan, 2008). The column diameter has almost no effect on the drop size, but the first 2–3 sieve plates affect the drop size: thay bring about a breakage of the drops while in the rest of the column the drop size varies only slightly (Lorenz et al., 1990).

The volumetric flow rates of the continuous and dispersed phases also slightly change the drop size (Jones, 1962) especially when the phase velocities are too smaller than *af* (Boyadzhiev and Spassov, 1982). Yadav and Patwardhan (2008) presented a review on the drop size in the pulsed sieve plate columns. Usman et al. (2009) investigated the effect of the pulse intensity, and the dispersed phase and continuous phase velocities on the Sauter mean diameter. Drop size

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