# DISPERSED PHASE HOLDUP IN A LIQUID-LIQUID EXTRACTION COLUMN

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Abstract — Dispersed phase holdup was measured in a liquid-liquid extraction column for the butyl alcohol-water system. The column performance has been studied using two columns of the same diameter (0.092m) but different lengths (0.70m, three stages and 0.90m, four stages). The column was operated counter-currently with several continuous and dispersed flows rates. The dispersed phase holdup was measured by the drainage method. Based on holdup data, the results were analyzed with the aim of determining the influence of flows rates and the column number of stages on the behavior of the dispersed phase holdup. An empirical correlation is proposed for estimating the dispersed phase holdup.

## *Keywords* — Hold-up, Extraction.

#### I. INTRODUCTION

Liquid-liquid extraction has been recognized as a powerful separation method for many years. Its past application on an industrial scale has been limited, however; it has been considered when separation by other methods such as distillation, evaporation, or crystallization are unsuitable. As a result of escalating energy costs, liquidliquid extraction can be an economic alternative to other separation processes.

The mass transfer between the flowing liquid phases in an extraction column depends, among other factors, on the contact interfacial area between continuous and dispersed phases. The interfacial area available for mass transfer in a counter-current extraction tower depends upon the volume fraction or holdup, of the dispersed phase, as well as on the mean droplet size. It is therefore important, at the design stage, to be able to predict the dispersed liquid holdup for a given system, column geometry and set of operating conditions.

The performance of an extraction unit operated continuously depends on the amount of solvent present in the extractor. If the amount of solvent is high compared to the feed, the solute mass transfer is favored (Zuniga-Giraldo *et al.*, 2006). From an operational point of view, knowledge of the dispersed phase holdup is also essential for inventory purposes (Batey *et al.*, 1986).

In a perforated plates extraction column the stages are separated by fixed plates with a high number of small orifices in their surface. Given the great importance of properly estimating the holdup when designing extraction equipments, many authors have published empirical correlations for several types of columns (Baird and Shen, 1984; Kumar and Hartland, 1988; Kumar and Hartland, 1997; Pratt, 1988), that may be used as reference in studies of perforated plates columns with no mechanical shaking

This paper presents a study of the influence of operational and geometrical parameters on the column's dispersed phase holdup. The influences of the dispersed phase and continuous phase flow rates are analyzed. The existence of flooding for the examined conditions is evaluated according to Thornton (1956) model, and an empirical correlation is presented to estimate the dispersed phase holdup.

#### **II. METHODS**

The extraction column used in the present work consisted of a glass tube with internal diameter of 0.092 m and height varying from 0.70 to 0.90 m. The stages were separated by perforated plates with 14.32% of free area (65 orifices with 5.5 x  $10^{-3}$ m of diameter).

The experiments consisted in feeding the dispersed phase (n- butyl alcohol) at the bottom of the column to flow upwards countercurrent to the continuous phase (water) fed at the top of the column (Fig. 1). The flow rates of the phases were fixed and the dispersed phase holdup was measured from the relative phase volume, after arresting the inflow and outflow of phases to the column (drainage method). Table 1 lists the physico-chemical data of the systems used and Table 2 presents the range of variables investigated. The experiments were conducted at room temperature,  $301 \pm 1$ K.

### **III. RESULTS AND DISCUSSION**

Figures 2 and 3 present the typical variation of the dispersed phase holdup, for columns with three and four stages, with a variation in the dispersed and continuous phase flow rates. Both figures evidence that the dispersed phase holdup increases when the dispersed phase flow rate increases.

Table 1: Physico-chemical properties of the system used (nbutyl alcohol – water)

propriety	Phases		
	Dispersed	Continuous	
$\mu x 10^3$ (kg/m.s)	2.3	1.0	
$\rho  x  10^{-3}  (\text{kg/m}^3)$	0.81	1.0	
$\sigma (N/m^2)$	2.46	7.82	
Table 2: Range of variables investigated			
Variables Studied	Operation Range		
Length of column, L (m)	0.70 m (three stages) and		
	0.90 m (	0.90 m (four stages)	
$U_{c} \ge 10^{-2} (m/s)$	0.88; 1.95; 3.00 and 4.10		
$U_d \ge 10^{-2} (m/s)$	0.29; 0.77; 1.25 and 1.74		
Number of stages	3 - 4		