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Effect of frothers on bubble size

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Abstract

The size of bubbles in flotation cells was measured using the UCT bubble size meter and the HUT bubble size analyser. While both methods provided similar critical coalescence concentration (CCC) values for the three tested frothers, they also revealed important differences. Using the HUT bubble size analyser, which does not impose any lower bubble size limit, it was possible to find differences in bubble size measured for three frothers at concentrations exceeding the corresponding CCC values.

Frothers affect both the break-up phenomena in the impeller/stator zone in flotation cell, and bubble coalescence. While longer chain polyglycols (e.g. DF-1012) are able to produce larger stable bubbles than the short chain DF-250 and DF-200 polyglycols, the CCC values for DF-1012 are lower than those for DF-250 and DF-200.
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1. Introduction

Flotation frothers are used to facilitate air dispersion into fine bubbles, and to stabilize the froth. According to Leja–Schulman's penetration theory (Leja and Schulman, 1954; Leja, 1956/57), frothers accumulate preferentially at the water/gas interface and interact with collector molecules adsorbed onto solid particles in the particle-to-bubble collision and attachment. The most dramatic effect of the frothers on flotation come from their effect on bubble size. The first-order flotation rate constant is linearly related to S_b, the bubble surface area flux, which in turn is inversely related to the bubble size.

The effect of frothers on bubble size has recently been extensively studied (Cho and Laskowski, 2002a,b; Laskowski et al., 2003; Laskowski, 2003). It was found that the effect of frothers on bubble size results from their ability to prevent bubble coalescence. As shown schematically in Fig. 1, with increasing frother concentration, the degree of bubble coalescence decreases and at a particular concentration (critical coalescence concentration, CCC), the coalescence of the bubbles is completely prevented. As Fig. 1 explains, the CCC values are obtained by finding the intersection of the horizontal asymptote to

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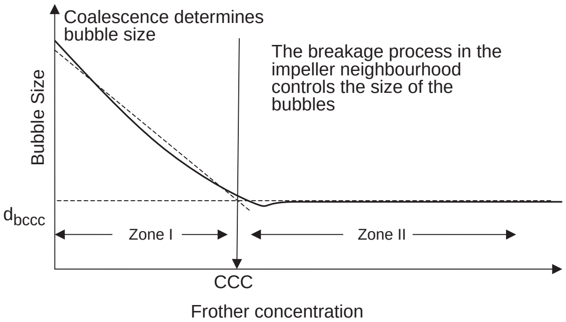

Fig. 1. Schematic diagram of the effect of the frother concentration upon bubble size in a flotation cell.

the bubble size–concentration curves at higher concentrations with the sloped line approximating the curve at lower concentrations. Further increase of the frother concentration above the CCC value does not affect the bubble size.

In the experiments discussed in this paper, the bubble size was determined with the use of the UCT (University of Cape Town) bubble size meter and the HUT (Helsinki University of Technology) bubble size analyser. In the UCT technique, bubbles are suctioned into a capillary tube, where the length and velocity of movement of each bubble are measured. The size of the capillary tube imposes a lower bubble size limit. In addition, the suction rate and the inner diameter of the capillary tube seem to impose a maximum bubble size limit. Grau and Heiskanen (2002) observed that bubbles greater than 3 mm in diameter broke when entering a capillary tube of 1 mm in inner diameter. Since large number of the experimental data have been generated using the UCT bubble size meter, and since the critical coalescence concentration for many frothers has been given based on such measurements, in this project, the bubble size was also measured using a visual technique developed at the Helsinki University of Technology (HUT method, Grau and Heiskanen, 2002) to verify how reliable are the CCC values obtained with the use of the UCT bubble sizer.

2. Experimental

The tests were carried out with three commercial Dow Frothers (Table 1). The acronym DF stands for the trade name Dowfroth.

Table 1
List of tested frothers

Common name	Chemical formula	Molecular weight
DF-200	$CH_3(OC_3H_6)_3OH$	206.29
DF-250	$CH_3(OC_3H_6)_4OH$	264.37
DF-1012	$CH_3(OC_3H_6)_{6.3}OH$	397.95

Two series of tests were carried out: one at the Helsinki University of Technology using Outokumpu flotation cell, and the other one at the University of British Columbia using an Open-Top Leeds lab flotation cell. In the former the HUT bubble size analyser was utilized, while the UCT bubble meter was used in the latter.

The *HUT bubble size analyser* (HUT BSA) consists basically of a sampler tube, a viewing chamber and image acquisition system as shown in Fig. 2. The sampler tube is partially immersed in the liquid phase, below the froth–liquid interface. The sampler tube is used to collect rising air bubbles, which are drawn into the viewing chamber. The function of the chamber is to expose the bubbles to a monochrome CCD camera which is connected to a personal computer, where the visual information is stored and processed. The images captured during sampling are automatically processed using commercial image analysis software and in-house visual basic user-interface. The operation of the HUT bubble size analyser has been described in detail by Grau and Heiskanen (2002, 2003). Bubbles captured by the HUT BSA are shown in Fig. 3.

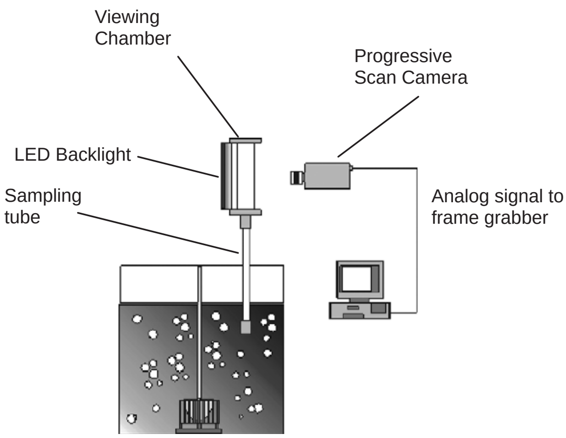

Fig. 2. Schematic diagram of the HUT bubble size analyser.

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