The Effect of Type and Dosage of Frothers on Coarse Particles Flotation

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ABSTRACT: *Frothers have a profound effect on bubble size and also flotation efficiency. In present study the effect of type and dosage of frothers on the flotation response of coarse particles of quartz was investigated. Therefore, flotation response of coarse particles using frothers such as MIBC, pine oil, poly propylene glycol with concentration of 0, 25, 50 and 75 g/t, was obtained respectively. For all used frothers, maximum recovery was obtained around frother dosage of 25 g/t and with increasing frother dosage, flotation recovery decreased. With increasing frother dosage, bubble diameter, d_{32}, decreased and when Poly Propylene Glycol, MIBC and Pine Oil were used as frother, bubble diameter increased. Maximum bubble diameter was obtained around Pine Oil and frother dosage of 25 g/t and minimum bubble diameter was obtained around Poly Propylene Glycol and frother dosage of 75 g/t. As the particle size increased, the probability of collision increased and with using Poly Propylene Glycol, MIBC and Pine Oil, probability of collision increased, respectively. Maximum collision probability was obtained around 65.46 % with Poly Propylene Glycol dosage of 75 g/t and particle size of 545 microns and minimum collision probability was obtained around 1.43 % with Pine Oil dosage of 25 g/t and particle size of 256 microns.*

KEY WORDS: *Flotation, Coarse particle, Frother, Collision probability.*

INTRODUCTION

The importance of frothers in flotation is widely acknowledged, particularly in terms of their role with respect to bubble size and the stability and mobility of the froth phase. This factor plays a significant role in the kinetic viability of the process and the overall recovery and grade that can be achieved from a flotation cell [1].

As summarized by *Booth* and *Frey Berger* [2], flotation processing involves three main steps: (I) selective chemical modification of specific mineral surface to effect hydrophibicity/hydrophilicity, (II) contact between and adherence of hydrophibic mineral particles to air bubbles and (III) separation of the flotable and nonflotable particles. They pointed out that frothers play their most important role in the second and third

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steps by influencing bubble/particle contact and by effecting frother separation of attached hydrophilic mineral particles from entrained hydrophilic mineral particles by draining in the froth [3].

Many investigators examined the influence of physically and chemical variables on bubble size and they extensively studies the influence of several commercial frothers on bubble size in flotation cell [4-6].

This study focused on the effect of type and dosage of frother on the coarse particle recovery in laboratory flotation cell. These two parameters were influence on bubble size distribution and bubble size which an important parameter, and has a strong influence on the flotation rate constant and flotability of coarse particles. So, influence of some frothers such as MIBC, Pine Oil and Poly propylene glycol on coarse particles flotation of quartz has been investigated.

MATERIALS AND METHODS

In this study, quartz particles were used with specific gravity of 2.65 g/cm^3 of four size classes: -300+212, -420+300, -500+420 and -590+500 microns for flotation tests. Oleic acid with 1000 g/t as collector and MIBC (Methyl Isobutyl Carbonyl), Pine Oil and Poly propylene glycol (A_{65}), with concentration of 0, 25, 50 and 75 g/t were used as frother, respectively. Flotation tests were carried out at pH=12.5 in which anionic flotation of quartz in this pH attribute to calcium ion present and activation of quartz surface with this hydroxy ion in a self-aerated Denver laboratory flotation cell. An impeller diameter of 0.07 meter was used for pulp agitation and a cell with square section was used that its length and height were 0.12 and 0.1 meters, respectively. In turbulence conditions, the Reynolds number changes between 10^5 and 10^6 (maximum turbulence) [7]. So, for increasing flotation response, all the experiments were carried out when impeller speed and Reynolds number were 1100 rpm and 89800, respectively.

RESULTS AND DISCUSSION

The Effect of type and dosage of frothers on coarse particles flotation

The effect of type and dosage of frothers on flotation response of quartz particles in four classes has been shown in Fig. 1. According to these results, for all of

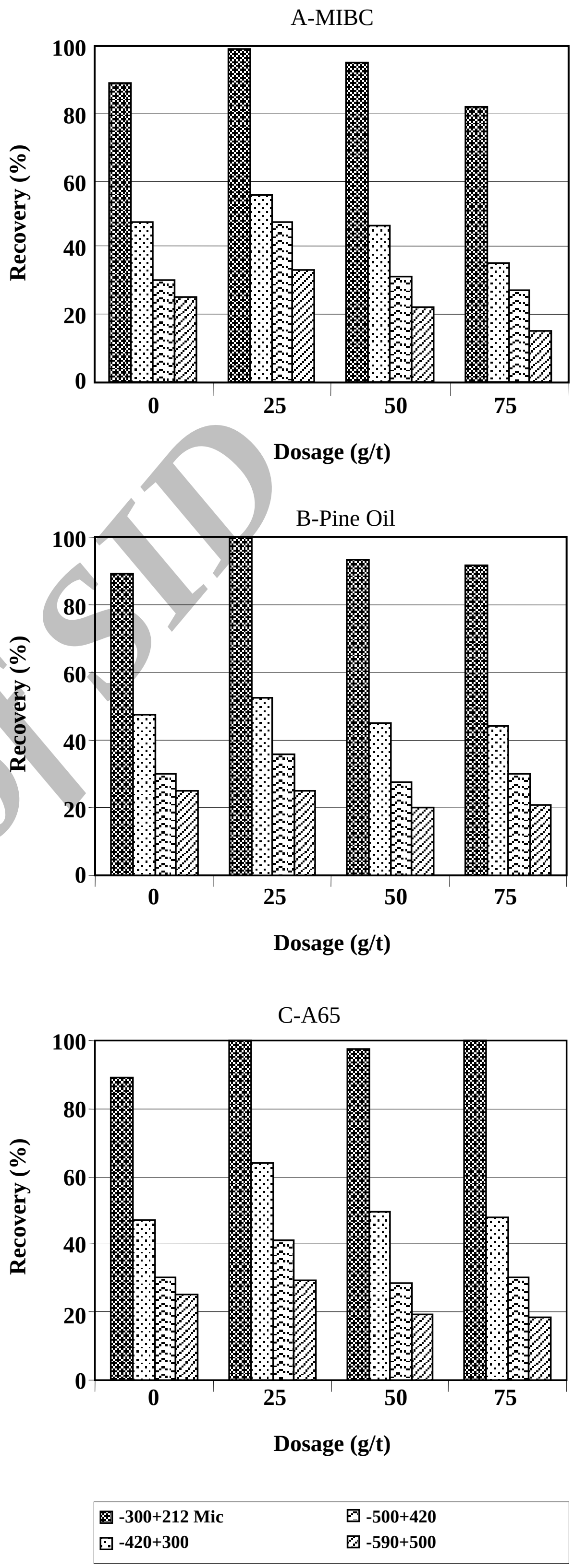

Fig. 1: The effect of type and dosage of frother on recovery of coarse particles.

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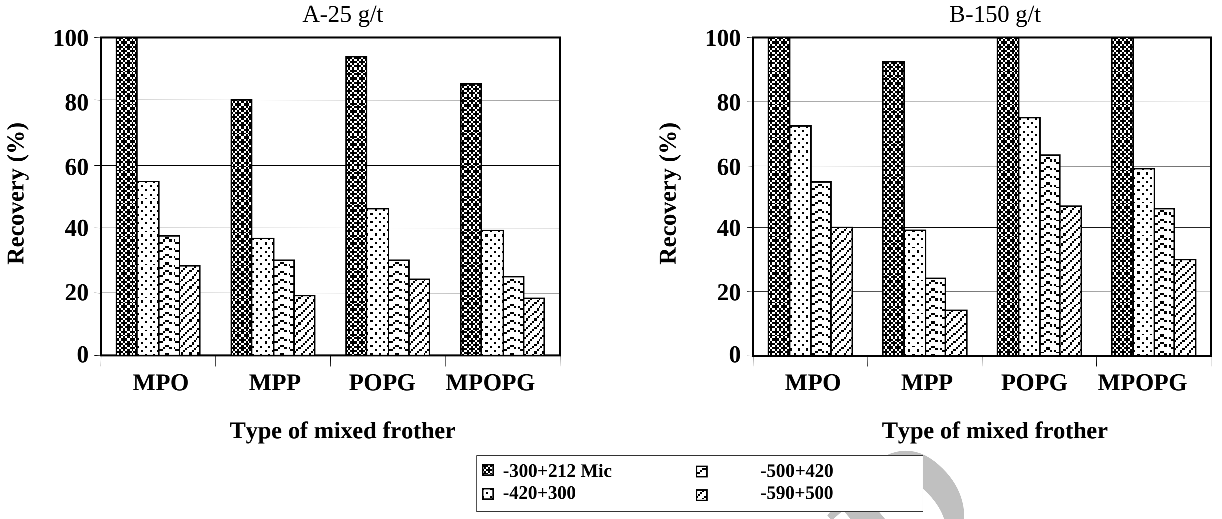

Fig. 2: The effect of type and dosage of mixed frothers on recovery of coarse particles.

frothers maximum recovery was obtained around frother dosage of 25 g/t and with increasing frother dosage, flotation response of quartz particles decreased. Furthermore, results have been shown that the best recovery was obtained using MIBC.

Some flotation tests have also been carried out using mixed frothers in equal proportions like MIBC and Pine Oil (MPO), MIBC and Poly Propylene Glycol (MPP), Pine Oil and Poly Propylene Glycol (POPG) and MIBC and Poly Propylene Glycol and Pine Oil (MPOPG). According to Fig. 2a, Quartz particles presented a maximum recovery using MPO (25 g/t) as compared with other mixed frothers, but flotation recovery using MPO was less than MIBC. In these conditions, with using MPP, the recovery decreased to minimum.

According to Fig. 2b with increasing frother dosage from 25 g/t to 150 g/t, flotation recovery increased steadily. This sudden increase of recovery may result due to mutual acting of frother and collector.

Bubble size distribution

In this research, bubble size distribution was measured similar to McGill bubble viewer [8]. The mean bubble diameter adopted was the Sauter diameter, calculated by the Eq. (1) [9]:

$$d_{32} = \frac{\sum n_i d_i^3}{\sum n_i d_i^2} \qquad (1)$$

Where: n, is number of bubbles and d, is bubble diameter. The effect of type and dosage of frothers on bubble size distribution and Sauter mean bubble diameter has been shown in Fig. 3 and table 1, respectively. With increasing frother dosage, bubble diameter, d_{32}, decreased and when Poly Propylene Glycol (A_{65}), MIBC and Pine Oil were used as frother, bubble diameter increased, respectively. Maximum bubble diameter was obtained around Pine Oil and frother dosage of 25 g/t and minimum bubble diameter was obtained around Poly Propylene Glycol and frother dosage of 75 g/t. So, with increasing frother dosage, bubble diameter and coarse particles flotation response have been decreased.

Table 1: Bubble diameter at various type and dosage of frothers.

Frother	Dosage g/t	d_{32} (mm)	d_{max} (mm)
MIBC	0	1	1.65
	25	0.84	1.45
	50	0.61	1.05
	75	0.64	0.90
Pine Oil	0	1	1.65
	25	1.75	2.15
	50	1.27	1.75
	75	1.31	1.85
A_{65}	0	1	1.65
	25	0.61	1.15
	50	0.59	1.05
	75	0.55	1.05

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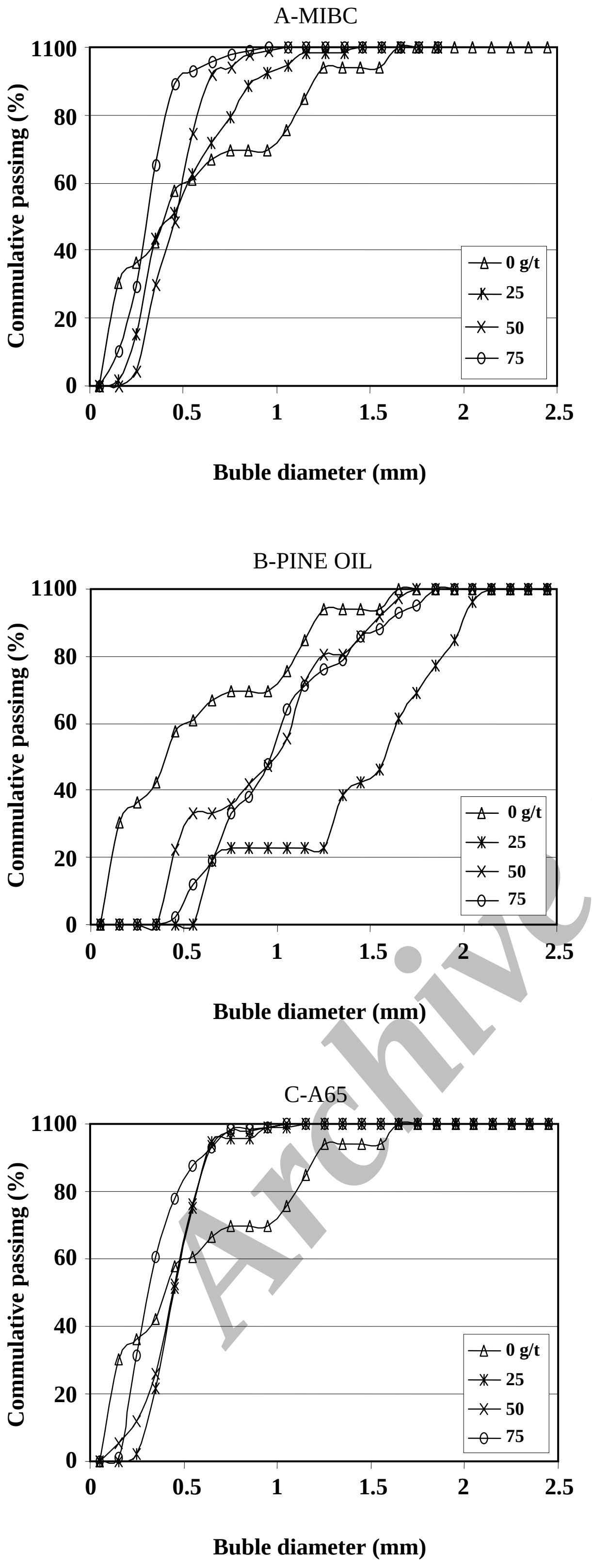

Fig. 3: Bubble size distribution at various type and dosage of frothers.

Furthermore, MIBC, Pine Oil and Poly Propylene Glycol was mixed together in equal proportion and bubble diameter, d_{32}, was obtained using Eq. (1). According to table 3 and Fig. 4, when MPO (25 g/t) was used for flotation tests, bubble diameter and flotation recovery was more than other mixed type frothers. With increasing frother dosage to 150 g/t, the bubble diameter decreased.

Collision probability

The probability (P) of a particle being collected by an air bubble in the pulp phase of a flotation cell can be given by [10]:

$$P = P_c P_a (1 - P_d) \qquad (2)$$

Where: P_c is the probability of bubble particle collision P_a is the probability of adhesion and P_d is the probability of detachment. There is a generalized equation for calculation $P_c$as given below [10]:

$$P_c = A\left(\frac{d_p}{d_b}\right)^n \qquad (3)$$

where: d_p is the diameter of particle, d_b is the diameter of bubble and A and n are the parameters that vary with Reynolds numbers. Table 2 gives these values for the three different flow regimes considered, i.e., Stokes, intermediate and potential flows.

Probability of collision was calculated for all of flotation tests using Stokes and Potential equations. When collision probability was calculated using potential equation, amount of collision probabilities was exaggerated but Stokes equation can estimate probability of collision. So, Stocks equation has been used for discussions.

According to Fig. 5, as the particle size increased, the probability of collision increased but with using Poly Propylene Glycol, MIBC and Pine Oil, probability of collision increased, respectively. Maximum collision probability was obtained around 65.46 % with Poly Propylene Glycol dosage of 75 g/t and particle size of 545 microns and minimum collision probability was obtained around 1.43 % with Pine Oil dosage of 25 g/t and particle size of 256 microns.

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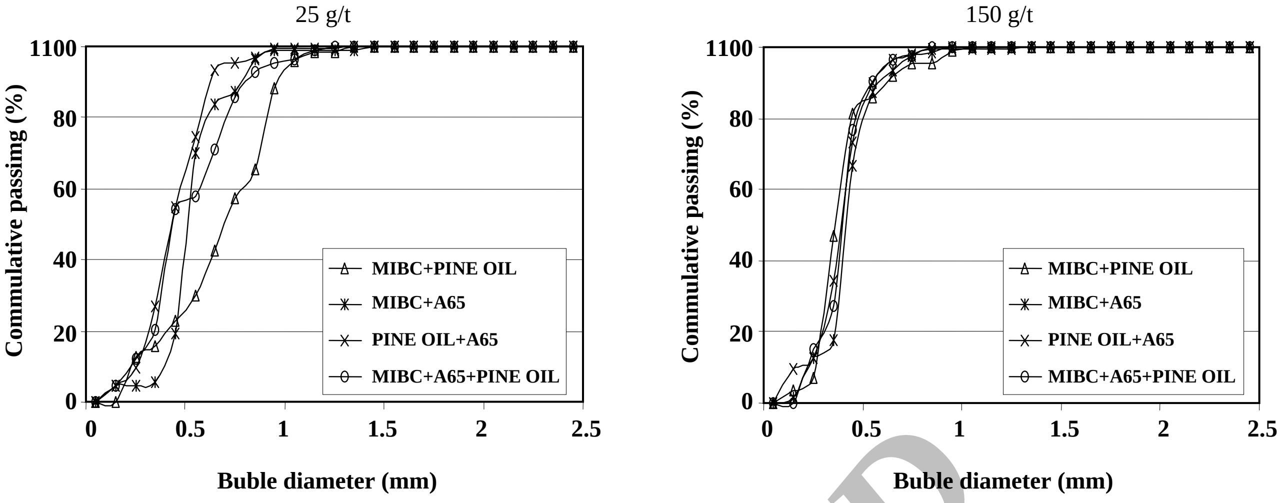

Fig. 4: Bubble size distribution at various type and dosage of mixed frothers.

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Table 2: Values of A and n for different flow conditions [10].

Flow Conditions	A	n
Stokes [11]	2/3	2
Intermadiate I [12]	$\left[\frac{3}{2}+\frac{4\,\mathrm{Re}^{0.72}}{15}\right]$	2
Intermadiate II [13]	$\frac{3}{2}\left[1+\frac{(3/16)\mathrm{Re}}{1+0.249\,\mathrm{Re}^{0.56}}\right]$	2
Potential [14]	3	1

Table 3: Bubble diameter at various type and dosage of mixed frothers.

Frother	Dosage (g/t)	D_{32} (mm)	D_{max} (mm)
MIBC+ Pine Oil (MPO)	25	0.89	1.35
	150	0.59	1.05
MIBC+A_{65} (MPP)	25	0.70	1.45
	150	0.56	0.95
Pine Oil+A_{65} (POPG)	25	0.63	1.35
	150	0.57	1.35
MIBC+A_{65}+Pine Oil (MPOPG)	25	0.75	1.25
	150	0.52	0.85

According to Fig. 6, when frother dosage was 25 g/t, using MPO, MPOPP, MPP and POPP as frothers, collision probability increased, respectively and when frother dosage was 150 g/t, using MPO, POPP, MPP and MPOPP as frothers, collision probability increased, respectively. When mixed frothers was used for flotation tests, maximum collision probability was obtained around 73.23 % with MPOPP, frother dosage of 150 g/t and particles size of 545 microns and minimum collision probability was obtained around 5.52 % with MPO, frother dosage of 25 g/t and particles size of 256 microns.

CONCLUSIONS

In this research, the effect of type and dosage of frothers on coarse particles flotation of quartz was investigated fallow conclusions were made:

- For all of frothers maximum recovery was obtained around frother dosage of 25 g/t and with increasing frother dosage, flotation response of quartz particles decreased. Furthermore, results have been shown that the best recovery was obtained using MIBC.

- Quartz particles presented a maximum recovery using MPO (25 g/t) as compared with other mixed frothers, but flotation recovery using MPO was less than MIBC. In these conditions, with using MPP, the recovery decreased to minimum.

- With increasing frother dosage from 25 g/t to 150 g/t, flotation recovery increased steadily. This sudden increase of recovery may result due to mutual acting of frother and collector.

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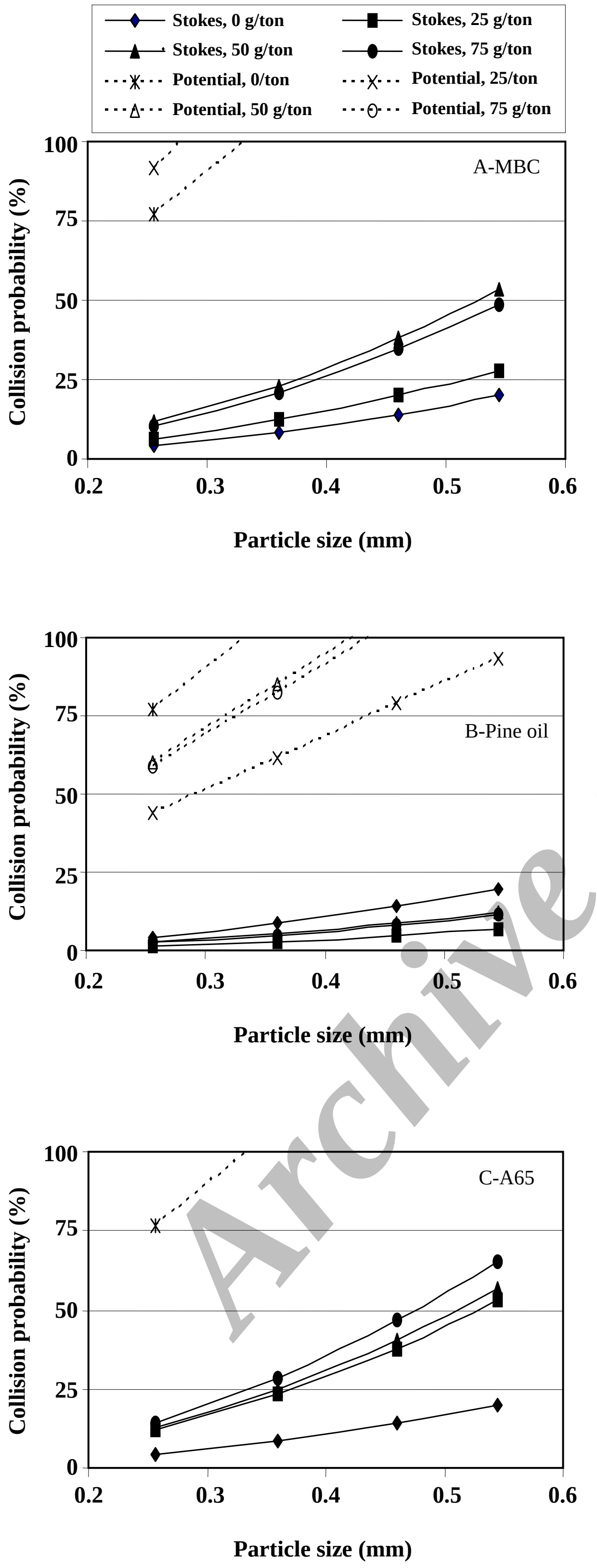

Fig. 5: Collision probability at various type and dosage of frothers and particle size.

- With increasing frother dosage, bubble diameter, d_{32}, decreased and when Poly Propylene Glycol (A_{65}), MIBC and Pine Oil were used as frother, bubble diameter increased, respectively.

- Maximum bubble diameter was obtained around Pine Oil and frother dosage of 25 g/t and minimum bubble diameter was obtained around Poly Propylene Glycol and frother dosage of 75 g/t. So, with increasing frother dosage, bubble diameter and coarse particles flotation response have been decreased.

- When MPO (25 g/t) was used for flotation tests, bubble diameter and flotation recovery was more than other mixed type frothers. With increasing frother dosage to 150 g/t, the bubble diameter decreased.

- As the particle size increased, the probability of collision increased but with using Poly Propylene Glycol, MIBC and Pine Oil, probability of collision increased, respectively. Maximum collision probability was obtained around 65.46 % with Poly Propylene Glycol dosage of 75 g/t and particle size of 545 microns and minimum collision probability was obtained around 1.43 % with Pine Oil dosage of 25 g/t and particle size of 256 microns.

- When frother dosage was 25 g/t, using MPO, MPOPP, MPP and POPP as frothers, collision probability increased, respectively and when frother dosage was 150 g/t, using MPO, POPP, MPP and MPOPP as frothers, collision probability increased, respectively.

- When mixed frothers was used for flotation tests, maximum collision probability was obtained around 73.23 % with MPOPP, frother dosage of 150 g/t and particles size of 545 microns and minimum collision probability was obtained around 5.52 % with MPO, frother dosage of 25 g/t and particles size of 256 microns.

Nomenclatures

MIBC	Methyl Isobutyl Carbonyl
A_{65}	Poly Propylene Glycol
MPO	MIBC+ Pine Oil
MPP	MIBC+A_{65}
POPG	Pine Oil+A_{65}
MPOPG	MIBC+A_{65}+Pine Oil
d_{32}	Sauter diameter

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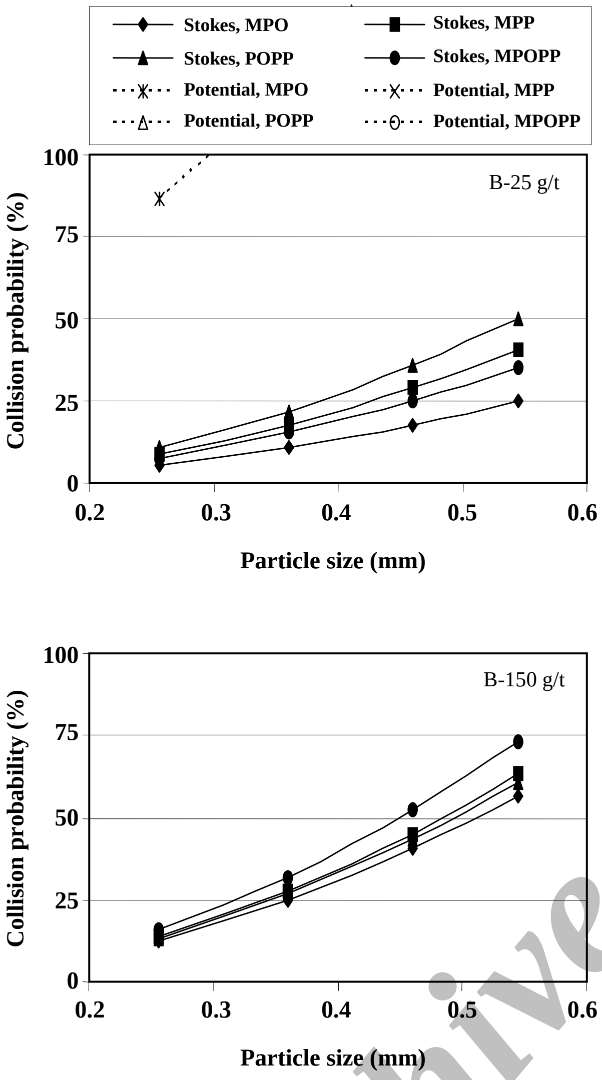

Fig. 6: Collision probability at various type and dosage of mixed frothers and particle size

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