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# Evaluation of the role of the combination of bulk micro bubbles and Nano bubbles in quartz flotation

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## Abstract

Bulk micro-Nano bubbles have been shown to be effective in restoring flotation and accelerating the reaction of fine-grained minerals. However, there are currently no reports on the correlation between BMNB characteristics and flotation performance. For this purpose, the preparation time (0, 1, 2, 3, 5, and 7 minutes), the aeration rate and the aging time varied minutes). Micro bubbles and nanobubbles were characterized using focused beam reflection measurements (FBRM) and nanoparticle tracking analysis (NTA), respectively. Microfloation of quartz particles was performed using XFG cells in the presence and absence of BMNB using cetyltrimethylammonium bromide (CTAB) as a collector. Cell size characterization revealed that the diameters of bulk micro bubbles (BMB) and bulk nanobubbles (BNB) range from 1 to 10 μm and 50 to 400 nm, respectively. We have found that manufacturing parameters and aging time have a significant effect on the number of bubbles generated. When BNB and BMB coexisted, the recovery rate of fine quartz particles was significantly improved (about 7%), but when only BNB was present, the promotion of flotation recovery was not significant (2%)... This was primarily related to the bridging of aggregates and was an advantage of quartz flotation. By comparison, no aggregates were detected when only nanobubbles were present in the bulk solution.

## Introduction

BMNB has been shown to be effective in improving flotation and reaction rates of coal and minerals and a variety of acceptable bubble generation methods have been used in the flotation process. ltrasonic cavitation temperature difference compression-decompression and hydrodynamic cavitation techniques. Compared to the above methods hydrodynamic cavitation has always been considered a cost-effective method for fine flotation Hydrodynamic cavitation has been shown to have two uses for buoyancy[1,2]. The first approach is direct pulp treatment. H. Three-phase cavitation (gas-liquid solid). Another method is to treat the water / reagent solution with two-phase (gas-liquid) cavitation and then use the solution containing BMNB in the flotation process.

The application of aqueous micro Nano bubble dispersions produced by two-phase cavitation in flotation appears to be more economical than the application of three-phase cavitation in flotation. On the one hand, the concentration of BMNB produced by this method is significantly higher than that of three-phase cavitation. In addition, it avoids the high wear and high energy consumption of traditional 3-phase cavitation. Some researchers have applied high-concentration micro bubble solutions produced by hydrodynamic cavitation to the levitation of micro materials. Experimental results have shown that the inclusion of such bubbles can increase the flotation yield of fine minerals and dramatically improve the flotation rate For example; Rulyov found that processing a mixture of micro bubbles and glass beads in a flotation reactor significantly improved the recovery of glass beads in a flotation column[3,4]. This is due to the formation of coarse heteroaggregates of multiple beads and micro bubbles. Similar results were published in a Farrokhpay study However, the formation of micro bubbles also generated large nanobubbles, which was not mentioned in their study. Therefore, the mechanism of these high concentrations of micro and nanobubbles in particle flotation is still unknown. Recently, some researchers have systematically studied the effects of operating parameters on the properties of BMNB and Pourkarimi et al found that increasing the flow rate of dissolved air increased the diameter of the nanobubbles, and increasing the pressure inside the Nano bubble generator decreased the diameter of the nanobubbles. Zhou found that the size and number of micro bubbles and Nan bubbles are greatly affected by the preparation parameters. However, studies on the correlation between BMNB characteristics and flotation performance are not available in existing literature. Therefore, by investigating the characteristics of bulk micro bubbles (BMB) and bulk nanobubbles (BNB) in various operation settings and their effects on flotation performance, the role of bubbles of various sizes in improving flotation performance.

## Methodology

### Materials and reagents

The flotation experiment was carried out on a high-purity quartz sample from Jiangsu Province, China. The particle size distribution was measured using a laser particle size analyser (GSL-1000, Liaoning Institute, Dandong City, China) According to Figure 1, the d50 of the quartz sample was 15.54 μm. X-ray diffract meters (XRD, Brokers, Bremen, Germany) have shown that quartz is the main component of the sample (Figure 2). Analytical grade cetyltrimethylammonium bromide (CTAB) was obtained from Sino pharm Chemical Reagent Co., Ltd. in Shanghai, China. Used as a collector. All experimental work used deionized water with a conductivity of 18.2 MΩ [5,6,7].

### Preparation and characterization of aqueous dispersions

Using a fine bubble generator (Natsunoharu Environmental Protection Technology Co Ltd Kunming, China), fine bubbles were generated by hydrodynamic cavitation. More information on operating parameters and their mechanisms can be found elsewhere. The generator works by mixing a combination of water and air through a pump and venture tube and releasing a uniform BMNB from a fine bubble nozzle to form an “emulsion-like” gas-liquid mixture. .. Five litters of ultrapure water circulated through the system to create micro and Nano bubbles. Aqueous solutions with different properties were prepared by adjusting the preparation time (1-10 minutes) and aeration rate (0-2 L / min) prior to the flotation experiment[8,9]. All tests were performed at room temperature (25 ° C).

## Results

Shows qualitative observation of the prepared aqueous solution and bubble size measurement as a function of aging time. It is noteworthy that the aqueous solution was clearly clear before the dispersion was prepared. Immediately after preparing the solution with aging time = 0, it turned milky white at this point, the aqueous dispersion contained high concentrations of both micro bubbles and Nano bubbles. As the aging time increased to 1 minute, the lower layer of the aqueous dispersion gradually became clear and the upper layer remained milky white. As you can see, the milky white colour of the solution gradually disappeared as the aging time increased from 3 minutes to 10 minutes. Therefore, due to the short life of the micro bubbles in the bulk solution, the aqueous dispersion remained clear even after a ripening time of more than 3 minutes. In fact, the presence of a large amount of high-concentration micro bubbles greatly contributed to the milky white colour of the aqueous dispersion. As the aging time progresses, the micro bubbles gradually move to the surface, burst due to their low stability, and the solution becomes transparent[10,11]. The same phenomenon was observed in a study reported by Nazari and Hassanzadeh However, due to their high stability and longevity, bulk Nano bubbles remained in the bulk solution Table 1 shows the number of bulk micro bubbles as a function of aging time. As you can see, the concentration of these bubbles decreased over time and disappeared after 3 minutes of aging.

### Effect of BMNB water treatment conditions on flotation performance

The flotation yield is plotted in Figure 12 as a function of aeration rate. Increasing the aeration rate from 0 to 2 L / min increased the flotation yield and then decreased. Correspondence between highest flotation yield (78%, aqueous dispersion prepared at 0.5 L / min) and lowest flotation yield (75%, 0 L / min) when producing BMNB water at different aeration rates There was a difference between the solutions). Less than 3%. In particular, the change in buoyancy recovery was the same as that of BMB. This further showed that the flotation yield was sensitive to the number of BMBs.

### Effect of aging time of micro / Nano bubble water on flotation performance

Figure 10 shows the quartz flotation yield as a function of aging time. Froth flotation recovery was shown to decline gradually as BMNB water ages, but was always greater than without BMNB in the system. In particular, when a fresh aqueous dispersion (i.e. 0 minute aging time) was used for flotation, the recovery of foam products was about 79%. Yield increased by 7% (about 72%) compared to traditional flotation. With a ripening time of 0.5 minutes, the flotation yield was about 76%. The flotation yield was then maintained at about 73% by extending the aging time to 5 and 10 minutes. Compared to the results of traditional flotation tests, the recovery rate at this point has increased by only about 2%. In other words, the effect of BMNB on levitation performance gradually diminished with increasing aging time compared to traditional conditions.

## Discussion

As already mentioned, the main bubble groups in BMNB water are bubbles with a diameter of 1-10 μm and 50-400 nm. The composition of the BMNB group, such as the number and size distribution of bubbles, is the manufacturing conditions and aging time. Bubble count is more sensitive to operating parameters than bubble size. For example, the concentration of BNB changed significantly with changes in preparation time and aeration rate, increasing by up to 400%. The size distribution of the BMB did not change much when the operating parameters were changed. Only the size of the BNB changed, but the range of variation was less than 100 nm and the distribution range of the BNB was relatively concentrated[12,13]. Therefore, the variation in levitation results under different conditions was primarily due to variations in the number of bubbles on different scales. To further investigate the effect of BMB and BNB on quartz particle agglomeration, quartz particle agglomeration was observed in the presence of BMB and BNB (aging time 0 minutes) and BNB alone (aging time> 3 minutes). As can be seen in Figure 16, when BMB and BNB were present at the same time (i.e., aging time was 0), many flocs bridged by micro bubbles appeared in the pulp. However, no flakes were found in the presence of BNB alone. Although the number of BNBs was much higher than the number of BMBs, the effect on particle aggregation induction was relatively weak. This is because on the micro scale, the smaller the bubble size, and the more likely it is that the particle will collide with the bubble[14,15].

## Conclusions

The present work initially investigated the synergetic effect of bulk micro-Nano-bubbles on the flotation of quartz particles. Bubble size distribution and stability for both ranges were studied using FBRM and NTA. The results revealed that the preparation parameters and aging times had a considerable impact on the number of bubbles with different sizes. The bubble size ranges of the BMNB-containing dispersion were obtained between 0 and 100 microns. Bubbles with diameters of 1–10 nm and 50–200 nm were predominate among them. With an increase in the aging time, the micro-bubbles were essentially vanished after 3 min, leaving just BNBs in the solution. It was demonstrated that in the presence of BMNBs, the improvement of flotation recovery was affected by the synergistic effect of bubbles with various scales in the aqueous dispersion. Compared with the size distribution of BMNBs, the flotation recovery was more sensitive to the variation in the number of bubbles on different scales. The flotation tests with BMBs and BNBs showed higher recoveries in comparison with those tested in the absence of BMBs. When both micro and Nano-bubbles existed at the same time, the yield of fine-grained quartz increased by about 7%, while when there were only BNBs, the promotion of flotation recovery was about 2%. Thus, the existence of BMBs was a key factor in promoting the flotation of fine quartz particles. As a result of forming these bubble sizes simultaneously, many flocks were bridged by BMBs in the pulp.

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