Parameters Influencing Size of Micro Nano Bubble

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***Abstract*: Micro Nano Bubble (MNB) have been researched widely for their potential use in different applications such as disinfection, removal of toxic material from water, separation etc. Various parameters such as water temperature, system operating pressure, gas types and gas flow rates contribute in the size of the MNB generated. This research illustrates the influence of various parameters and their significance in size of MNBs generated. Experiments conducted showed that feed gas as a vital parameter for generating bubbles in nano size.**

***Keywords* : Micro nano bubble, water treatment, bubble size**

I. INTRODUCTION

A bubble is a globule of one substance in other, generally air in water. Their stability is inversely proportional to their size. The size of bubbles depends upon the amount of air trapped inside of it. The way they behave in the immersed substance depends upon their sizes. Larger spherical bubbles follows zig-zag path and larger ellipsoidal bubbles follows a spiral path. In case of the smaller bubbles, they follow rectilinear path [1]. Bubbles form, and coalesce, into globular shapes, because those shapes are at a lower energy state. Due to this lower energy states they have a wide range of applications. Generally, the size of a bubble is in range of few hundred mili meters. But in special conditions the sizes can be reduced. By experimentation, the sizes can be reduced to micrometers as well as nano meters. The stability of these micro-nano bubbles (MNB's) is quite good and hence they are used for special purposes. Earlier researches have shown the application of MNB in medical systems for better drug delivery systems. Such as they have been reported to be used in reversal of hypoxia, which results from low inadequate supply of oxygen. This is major cause of concern in cancer treatment as it reduces the efficiency of the chemotherapy and radiotherapy.

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The oxygen concentration was increased in hypoxic areas by using oxygen micro-nanobubbles which were prepared by using different methods.

The results indicated the degradation of HIF-1α after the introduction of ONBs [2]. They were also reported to be used in different imaging methods for medical applications. Such as they were used a new way for imaging and detection of any structural and functional anomalies in tissues which has been referred as photo acoustic imaging. The MNBs can be trapped with high absorbing optical contrast agents like gold nanoparticles, etc [3]. Others have used these micro nanobubbles with ultrasound contract agents for tumor imaging [4]. They were also used in field of aquaculture and irrigation so that water wasted due to improper irrigation methods can be reduced. Some researchers have shown the application of MNBs in agriculture wherein micro nano bubble ozonated water was used to control the spread of airborne diseases in greenhouses in place of chemical fungicides. But more usage of these chemical fungicides leads to accumulation of toxic residue on water and soil surface. So, development of these noble approach is very useful for both humans as well as environment. Again, ozone gas was used for this purpose because ozone is strong oxidant and disinfectant which leaves no chemical residue after usage. The dissolved oxygen concentration (DOC) of the micro nano bubbles and mixing pump water increased with the increase in mixing time. Results showed that treatment efficiency of *Cladosporium fulvum conidia* suspensions by using ozonated micro nanobubbles was good [5]. Some of the researches carried out have shown that MNBs are effective in cleaning, again reducing the waste of water. The major studies in MNB has been performed for treatment of water, especially for treatment of grey and black water and seawater. Researches have shown the application of micro bubbles for desalination of sea water by the process of reverse osmosis (RO) and also for de-fouling of water [6]. They are also been used for ground water remediation process. Researchers are performed showing the use of micro-nano bubbles in removal of contaminants from groundwater [7]. Also nanobubbles were used in the removal of Naproxen, a commonly found from the wastewater. It is most commonly used, nonsteroidal anti-inflammatory drug which is found in drinking water. Conventionally used methods to remove this from drinking water are not able to remove it fully. In the study [8] a combination of ozonated micro bubble with H_2O_2 was used for analyzing the removal efficiency of Naproxen.

This many applications of such tiny and generally ignored object make it worthy to be explored more. Nanobubble has been used for detergent-free cleaning, ultra-sound imaging and intracellular drug delivery like one research has showed their application in drug release in intracellular hyperthermia [9], enhanced drug susceptibility of cancer cells [2], and mineral processing for dispersing Kaolinite and talc in aqueous solution [10] etc.For the last few decades this technology has seen a steep rise. This technology holds really good potential and more and more experimentation and research should be done. This study will help to provide an insight to explore MNBs by summarizing different ways to produce MNB's and how their sizes can be varied.

In this study the parameters effecting the bubble size is illustrated.

II. EXPERIMENTAL PROCEDURE

For determination of bubble size Malvern N90S particle size analyzer which works on the principle of dynamic light scattering system was used. The system developed is a laboratory model as shown in figure 1. It is comprised of a bubble generator (Nikuni KTM) working on the principle of pressurized dissolution method, a needle valve (Parker, N800) which further splits the bubbles generated into much smaller size.

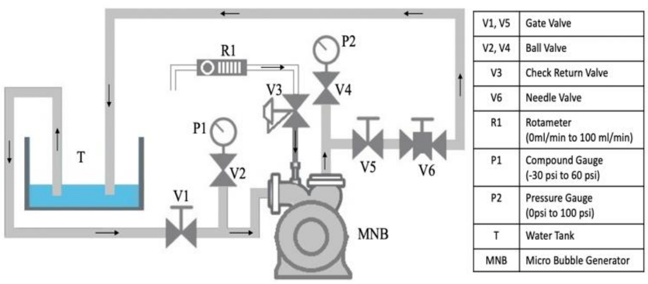

Fig 1: Schematic diagram of system

Experiment were classified for two different operating pressure limits in presence of different feed gases as described in the table1. Further to test for reproducibility of bubble size each analysis of experiments was carried out for 10 runs of each test parameter. Other system operating settings illustrated in table 1 were kept constant as they dint show much interference in determining bubble size.

Table 1: System operating conditions for experimentation

Parameter	Value
Input pump pressure	-9 psi
Feed gas rate	30 ml/min
Feed gas pressure	1.3 bar
Feed gas type	Compressed Air
	Oxygen
	Ozone
Water type	Distilled water
Volume of water	10 L
Inner dimension of tank	42.9L X 29.2W
No. of Runs per experiment	10
Bubble generation time	5 mins
Output Operational Pressure	60 psi
	80 psi
Operating Temperature	20°C, 25°C, 30°C, 35°C

III. RESULTS AND DISCUSSIONS

The readings taken for repeated sets of experiments are presented in this section. Each cycle of experiment was performed at continuous bubble generation for a duration of 5 mins after which the system was turned off for an interval of 10 mins to prior starting the next cycle/run. This buffer time helped the bubbles to completely rise to the surface and clear from the water. During each cycle, color of the water served as an indicator for the presence and absence of the bubble, which turned the color of water from milky white (presence of bubble) to colorless (absence of bubble). MNB generation was carried out in recirculating mode for a fixed volume of 30L of distilled water at a flow rate of 4L/min [11]. Prior conducting experiments, the complete setup was cleaned using distilled water and acetone to avoid presence of any dust particle which could disrupt the determination of bubble size. The flow of gases required for generating bubbles were passed at a constant flow of 30ml/min through a rotameter at 1.37bar. It was observed that temperature of water used to increase and hence only

It was observed that at an operating pressure of 60 psi, the bubble ranged in micrometers from 1.1μm to 4μm in size shown in Fig 2. Several studies have shown that bubbles ranging in micrometer size were capable of removing toxic metal ions, dye stuff etc. Further O_3 bubbles could be used as an alternative disinfectant for removal of bacterial contaminates from swimming pool instead of using chlorine.

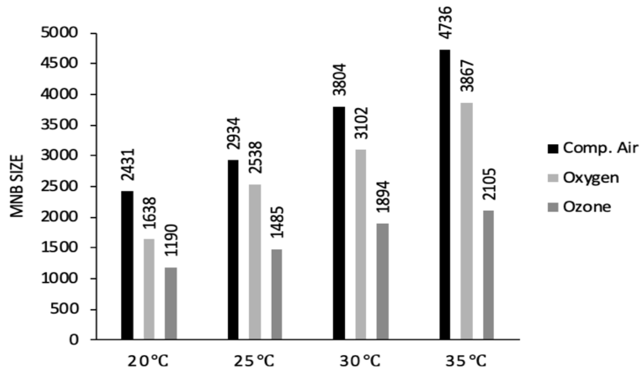

Fig 2: Size of MNBs under different operational conditions at 60 PSI

While conducting experiments at 80psi reduction in bubble size ranging from 809 nm to 4μm shown in figure 3. Bubbles of this size can be of potential use in applications where longer residual and oxidation is necessary. Studies with MNBs in nanometer range have resulted in greater removal efficiencies.

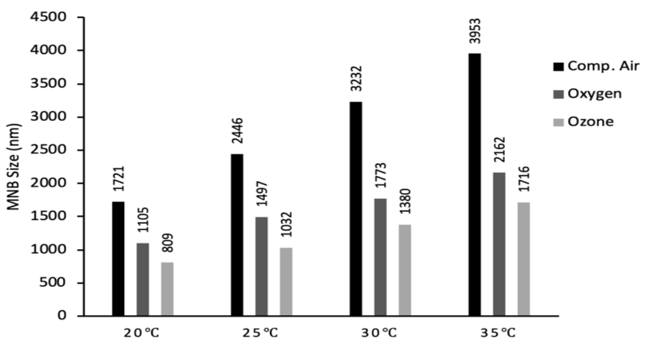

Fig 3: Size of MNBs under different operational conditions at 80 PSI

Table 2 illustrates the importance of individual parameters effecting bubble size using the apparatus shown in fig 1.

Table 2: Parameters effecting bubble size

Parameter	Importance
Temperature	+ + +
Output Pressure	+ +
Gas Flow Rate	+ + +
Input Pressure	+
Gas type	+ + + +

IV. CONCLUSION

This study describes the hierarchy of parameters majorly contributing towards generation of MNBs. Various experiments were conducted with multiple combinations of system operating parameters. The results of the study shows that the feed gas used for generating MNB is a significant factor in reduction of bubble size. A reduction of 51% in size of MNB was observed while using O_3 gas. Another contributing factor, temperature showed an increasing influence in the size of MNB with rise in temperature. Whereas increase in gas flow rate resulted in increase in size of MNB.

REFERENCES

1. Wu, M., & Gharib, M. (2002). Experimental studies on the shape and path of small air bubbles rising in clean water. Physics of fluids, 14(7), L49-L52
2. Khan, M. S., Hwang, J., Seo, Y., Shin, K., Lee, K., Park, C., ... & Choi, J. (2018). Engineering oxygen nanobubbles for the effective reversal of hypoxia. Artificial cells, nanomedicine, and biotechnology, 46(sup3), S318-S327.
3. Xu, R. X. (2011). Multifunctional microbubbles and nanobubbles for photoacoustic imaging. Contrast media & molecular imaging, 6(5), 401-411.
4. Xing, Z., Wang, J., Ke, H., Zhao, B., Yue, X., Dai, Z., & Liu, J. (2010). The fabrication of novel nanobubble ultrasound contrast agent for potential tumor imaging. Nanotechnology, 21(14), 145607.
5. He, H., Zheng, L., Li, Y., & Song, W. (2015). Research on the feasibility of spraying micro/nano bubble ozonated water for airborne disease prevention. Ozone: Science & Engineering, 37(1), 78-84.
6. Gwenaelle, M. P. O., Jung, J., Choi, Y., & Lee, S. (2017). Effect of microbubbles on microfiltration pretreatment for seawater reverse osmosis membrane. Desalination, 403, 153-160.
7. Li, H., Hu, L., Song, D., & Al-Tabbaa, A. (2014). Subsurface transport behavior of micro-nano bubbles and potential applications for groundwater remediation. International journal of environmental research and public health, 11(1), 473-486.
8. Patel, S., Majumder, S. K., Das, P., & Ghosh, P. (2019). Ozone microbubble-aided intensification of degradation of naproxen in a plant prototype. Journal of Environmental Chemical Engineering, 7(3), 103102.
9. Wen, D. (2009). Intracellular hyperthermia: Nanobubbles and their biomedical applications. International Journal of Hyperthermia, 25(7), 533-541.
10. Zbik, M., & Smart, R. S. C. (2002). Dispersion of kaolinite and talc in aqueous solution: nano-morphology and nano-bubble entrapment. Minerals Engineering, 15(4), 277-286.
11. Pinisetti Swami Sairam, Ravi Gunupuru, Jitendra K Pandey. (2019). Machine Learning Based Decision-Making Model to Determine Size of Micro Nano Bubble. International Journal of Recent Technology and Engineering, 8(3), 8062-8064.

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