Influence of Hydrophilic/Hydrophobic Interface on Formation of Micto Bubbles

賴俊翰、鄭江河

E-mail: 346166@mail.dyu.edu.tw

ABSTRACT

Micro-Bubble formation at submerged orifices has wide-spread applications in various technological processes; including distillation, oxidation, absorption, flotation, chemical processing, biochemical operations and waste water treatment, etc. However, the some applications of advance industries are often limited in the micro-bubble generator size. For example, the size of bubble oxygenator is need small size. In this study aims on design and fabrication of small size micro-bubble generator, The goal of this study is to design a proper system to formed micro-bubbles used for increasing the oxygen concentration in blood and keeping the blood oxygen content saturated. The nozzle plate with multi-orifice was fabricated by nickel electroforming process on a stainless steel substrate. In order to control hydrophilic of the nozzle plate, we used sputter machine on the surface of nozzle plate substrate to sputtering a thin Pt layer with super-hydrophilic film. The sizes and formation process of the bubbles depend on the fluid properties and constant flow velocity, the size of the orifice, the oxygen pressure and flow rate, and the nozzle plate surface contact angle and surface tension characteristics. During the experiment, a flow visualization setup employs a high magnification microscope and a high speed charge coupled device (CCD) camera to photograph the time evolution of meniscus shape of gaseous bubbles dispensed from the micro-bubble generator. The bubble formation process and size is also discussed in the study.

Keywords : Micro-bubble generator、Hydrophilic、Nozzle plate、Micro electroforming

Table of Contents

REFERENCES

[1]林聰得，“水中載具減阻技術之實驗研究”，中原大學機械工程研究所94博士班論文.

[2]林俊明，“邊界層附近減阻氣泡之特性”，國立成功大學系統及船舶機電工程學系92碩士班論文.

[3]謝志明，“微泡減阻技術在船模上的應用研究”，國立台灣大學工程科學與海洋工程學系92碩士班論文.

[4]劉驥佑，“微泡減阻技術之基礎研究”，國立台灣大學工程科學與海洋工程學系91碩士班論文.

[5] 嚴祖煦，“微氣泡技術在減阻上之研究”，國防大學中正理工學院造船工程研究所89碩士班論文.

[6]張維剛，“微氣泡產氣模組參數設計對水下潛體減阻影響研究”，國防大學中正理工學院造船工程研究所95碩士班論文.

[7]陶德容，“微氣泡減阻技術應用於水面艦之效能評估”，國防大學中正理工學院造船工程研究所92碩士班論文.

[8]林俊成，“微氣泡對潛體阻力之研究”，國防大學中正理工學院造船工程研究所91碩士班論文.

[9]葉婉凌，“應用實驗計劃法對微氣泡減阻參數分析”，國防大學中正理工學院造船工程研究所94碩士班論文.

[10] Madavan, N. K., Merkle, C. L. and Deutsch, S.,“Numerical investigations into the mechanisms of microbubble drag reduction,” Journal of Fluids Engineering, Vol.107, 1985, pp. 370-377.

[11] B. Bustgens, W. Bacher, W. Menz, W. K. Schomburg,“Micropump Manufactured by Thermoplastic Molding,” Micro Electro Mechanical Systems, MEMS, Proceedings, pp. 18-21,1994.

[12]張淵竣，“廣用型血氧濃度儀系統初探:以視網膜為例”，私立中原大學電機工程學系93碩士班論文.
[13]A. Vogel, W. Lauterbrorn and R. Timm,“Optical and acoustic investigations of the dynamics of laser-produced cavitation bubbles near a solid boundary,”J. Fluid Mech. Vol. 206, pp. 299-338, 1989.
[14]侯文祥、陳威光，“應用氣泡柱於循環水養鰻系統中去除顆粒之效率評估”，台灣水產學會刊，25（2）:117-127，1998.
[15]甘連正，“微氣泡技術在減阻上之研究”碩士論文，臺灣大學生物環境系統工程學研究所，2004.
[16]蘇揚根，“奈米微氣泡浮除技術於半導體工業化學機械研磨廢水處理之應用”碩士論文，國立交通大學環境工程系所，2003。
[17]Burns S.E., Yiacoumi S. and Tsouris C.“Microbubble generation for environmental and industrial separations”, Separation and Purification Technology, Vol. 11, pp. 221-232, 1997.
[18]李春宏，“工業廢水處理曝氣裝置之試製及其性能分析之研究”碩士論文，國立成功大學土木工程研究所，1979.
[19]Smith,J.S.et al.,“Bubble Column Reactors for Wastewater Treatment.Theory and Modeling of Continuous Countercurrent Solvent Sublation,”Ind.Eng.Chem.Res., 35, 1688-1699, 1996.
[20]G. Korpanty, P. A. Grayburn, R. V. Shohet and R. A. Brekken,“Targeting vascular endothelium with avidin microbubbles,”Ultrasound Med. Biol., Vol.31, pp. 1279-83, 2005.
[21]李承翰，“高頻超音波血流成像”，碩士論文，國立台灣大學電機工程學研究所，2005.
[22]E. Unger, T. O. Matsunaga, P. A. Schumann and R. Zutshi,“Microbubbles in Molecular Imaging and Therapy,”Medicanumdi, Vol. 47, pp. 58-65, 2003.
[23]K. Ferrara, R. Pollard, M. Borden,“Ultrasound microbubble contrast agents: fundamentals and application to gene and drug delivery,”Ann. review of biome. eng., Vol. 9, 415-44, 2007.
[24]G. Korpanty, J. G. Carbon, P. A. Grayburn, J. B. Fleming, R. A. Brekken,“Monitoring response to anticancer therapy by targeting microbubbles to tunor vasculature,”Clinical Cancer Research, Vol. 13, 323-330, 2007.
[25]Hooke R.“An account of an experiment made by R Hooke of preserving animals alive by blowing air through their lungs with bellows,”Philosophical Transactions of the Royal Society; 2: 539. 1667.
[26]LeGallois J.J.C. Expe’riences sur le principe de la vie. Notamment sur Celui des Mouvemens du Coeur, et Sur le Sie’ge dece Principe; Suivies du rapport fait a’la premie’re classe de l’Institt surcelles relatives aux movemens du Coeur. Paris: D’Hautel, 1812.
[27]Brown-Sequard E. Du sang rouge et du sang noir, et de leurs principaux elements gazeuse, l’oxygene et l’acide carbonique. Journal of Anatomie (Paris) 1858; 1: 95.
[28]Von Schro··der W. Uber die Bildungsta··tte des Harnstoffs. Archiv Fur Experimentelle Pathologie und Pharmakologie 1882;15: 364-402.
[29]Von Frey M, Gruber M. Studies on metabolism of isolated organs. A respiration-apparatus for isolated organs. Untersuchungen uber den stoffwechsel Isolierter organe. Einrespirations-apparat fur isolierte organe (German). Virchows Archiv fur Physiologie 1885;9: 519-32.
[30]Gibbon J.H. Jr. Application of a mechanical heart and lung apparatus to cardiac surgery.Minnesota Medicine 1954;37: 171-85.
[31]Hill J.D. O'Brien TG, Murray JJ, et al. Prolonged extracorporeal oxygenation for acute post-traumatic respiratory failure (shock-lung syndrome). Use of the Bramson membranelung. N Engl J Med 1972;286:629-34.
[32]Burgess; Mike, Hall; Cyril I.,“Blood oxygenator,”US Patent 4396584, 1983.
[33]Nunn J.F. Nunn’s Applied Respiratory Physiology, 4th edn. Oxford: Butterworth Heinemann,1993.
[34]Galletti P.M. Colton C.K. Artificial lungs and blood-gas exchange devices. In: Bronzion JD, eds. The Biomedical Engineering Handbook, Chapter 125. Boca Raton: CRC Press, 1995.
[35]James Andrew Senkiw,“Microbubbles of oxygen,”US Patent 6689262, 2004.
[36]Wilkinson, P. M., and van Dierendock, L. L.,“A theoretical model for the influence of gas properties and pressure on single bubble formation at an orifice,”Chem. Eng. Sci., Vol. 49, pp. 1429-1438. 1994.
[37]J. N. Lin, f S. K. Banerji, and H. Yasuda,“Role of Interfacial Tension in the Formation and the Detachment of Air Bubbles. 1. A Single Hole on a Horizontal Plane Immersed in Water,”Langmuir Vol. 10, pp. 936-942, 1994.
[38]J. N. Lin, f S. K. Banerji, and H. Yasuda,“Role of Interfacial Tension in the Formation and the Detachment of Air Bubbles. 1. A Single Hole on an Inclined Plane Immersed in Water,”Langmuir Vol. 10, pp. 943-948, 1994.
[39]A.V. Byakova, S.V. Gnyloskurenko, T. Nakamura, O.I. Raychenko,“Influence of wetting conditions on bubble formation at orifice in an inviscid liquid Mechanism of bubble evolution,”Colloids and Surfaces A: Physicochem. Eng. Aspects 229 (2003) 19-32.
[40]S.V. Gnyloskurenko, A.V. Byakova, O.I. Raychenko, T. Nakamura,“Influence of wetting conditions on bubble formation at orifice in an inviscid liquid. Transformation of bubble shape and size,”Colloids and Surfaces A: Physicochem. Eng. Aspects 218 (2003)73-/87.
[41]G. Corchero, A. Medina, and F.J. Higuera,“I Effect of wetting conditions and flow rate on bubble formation at orifices submerged in water,”Colloids and Surfaces A: Physicochem. Eng. Aspects 290 (2006) 41-49.
[42]鄭江河、蘇玉如，“壓電式氣泡產生裝置”，台灣專利，新型專利M313017，2007.
[43]C-H Cheng, T-H Chiang, and B-C Liu,“Application of Piezoelectric Micro Bubble Generator to Blood Oxygenation,”The 13th International Symposium on Flow Visualization, July 1-4, 2008, Nice, France.
[44]鄭江河、古天雄、江宗星、邱士哲、陳昭閔、張佳倫，2007，“壓電式微米氣泡產生器應用於血氧濃度之研究”，第二十四屆機械

工程研討會論文集，台灣中壢，中原大學。
[45]Chiang-Ho Cheng, Chia-Lan Chang and Tsung-Hsing Chan,“ Gas Bubble Sizes Formed in Liquids at Different Resonant Frequencies, ” Advanced Materials Research, Vol.74, pp. 105-106, 2009.