Innovative disinfection for dental and surgical therapies combined with the plasma treated water and the reduced pH method

<u>Katsuhisa Kitano</u>¹, Satoshi Ikawa², Atsushi Tani³, Hiromitsu Yamazaki⁴, Tomoko Ohshima⁴, Kazuhiro Kaneko⁵, Masaaki Ito⁵, Takeshi Kuwata⁵, Atsushi Yagishita⁵

¹ Graduate School of Engineering, Osaka University, Suita, 565-0871, Japan

² Technology Research Institute of Osaka Prefecture, Izumi, 594-1157, Japan

³ Graduate School of Science, Osaka University, Toyonaka, 560-0043, Japan

⁴ Graduate School of Dental Medicine, Tsurumi University, Yokohama, 230-8501, Japan

⁵ National Cancer Center Hospital East, Kashiwa, 277-8577, Japan

E-mail: kitano@plasmabio.com

With the intention of disinfecting human bodies in dental and surgical applications, sterilization experiments in water have been conducted with low-temperature atmosphericpressure plasmas. For the disinfection in the body fluid, we have successfully developed the reduced pH method that efficient bactericidal activity can be achieved if the solution is sufficiently acidic [1]. It is interesting that a critical pH value of about 4.7 exists for the bactericidal activity. The critical pH value may be associated with pKa of the dissociation equilibrium between superoxide anion radicals (O_2^{-}) and hydroperoxy radicals (HOO), which is known to be approximately 4.8. $O_2^{-\bullet}$ of reactive oxygen species generated in gas penetrate into liquid via plasma-air-liquid interactions [2, 3]. For the enough long lifetime of $O_2^{-\bullet}$ in gas as air ion, $O_2^{-\bullet}$ can be supplied into liquid by non-contact plasma. The non-contact plasma with 400 cm extra tube has strong bactericidal activity only with the reduced pH method. In addition, we found that the plasma treated water has strong bactericidal activity for a few minutes with the reduced pH method, as shown in Figure 1. This suggests that the disinfection can be done by the plasma treated water which contains short-lived active species (cannot supplied by chemical reagent) and it would bring safety plasma medicine considering usual contact or non-contact plasmas to human body. Currently, animal experiments for root canal therapy in dentistry [4] and surgical site infection prevention in surgery have been done with indirect plasma disinfection techniques of non-contact plasma and plasma treated water.



Figure 1: Bactericidal activity of the plasma treated water with the reduced pH method.

References

- [1] S. Ikawa, K. Kitano, and S. Hamaguchi, Plasma Process. Polym., 7, 33 (2010).
- [2] K. Kitano, S. Ikawa, A. Tani et al., Proc. of ISPC20, Philadelphia, 270, July, (2011).
- [3] E. Takai, K. Kitano, J. Kuwabara, K. Shiraki, Plasma Process. Polym., 9, 77-82, (2012).
- [4] H. Yamazaki, T. Ohshima, et al., Dental Mat. Journal, 30, 384 (2011).