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Flow formation in gas and liquid by cold atmospheric plasmas

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A recent development of cold atmospheric plasmas has opened up the application using plasma in biomedical field because they can produce reactive nitrogen and oxygen species relevant to biological reactions [1,2]. The treatment using cold atmospheric plasmas is contact-free and it is possible to treat sensitive surfaces including biological tissues without thermal damage. One typical application in the biomedical filed using the cold atmospheric plasma is sterilization/disinfection for wound care [3]. There are already several clinical studies conducted and it has been already reported that the bacterial load in wounds was reduced significantly [3,4].
To spread the usage of plasmas for biomedical applications, an optimization of the biological effects is of quite importance. Since the reactive species are transported from the plasma production region to the surface of biological samples by flow and diffusion, the investigation of flow driven by plasmas is crucial. In this contribution, two examples of flow formation are presented and discussed.
The first example of flow formation was observed in gas and liquid using a pin-to-water-surface discharge as shown in Fig. 1 [5]. In this discharge system, the plasma discharge was produced between the edge of pin electrode and water surface. It was found that a gas flow from the edge toward the surface was driven by the discharge through the collisions between neutral gas molecules/ atoms and ions accelerated by a present electric field. The velocity of gas flow reached 28 m/s. Moreover, it was observed that the velocity was strongly dependent on the electrical property of water. Higher gas velocity was seen with lower conductivity of water. Different water properties gave the change in electric field between the needle electrode and water surface since charge relaxation time in water depends on its electrical conductivity. The flow in water was generated by the gas flow over the water surface accordingly and it was observed that the reactive species are distributed following the water flow.
The second example is a plasma-effect for the transport of albumin (protein) in albumin solution [6]. Figure 2 shows a schematic of treatment on albumin solution using atmospheric helium plasma jet. When the plasma was applied to the albumin solution in a cuvette, an agglomerated albumin was observed at the treated point. There was a dissolution process from this agglomerate and Schlieren visualization found that a high-density albumin region moved downward through the dissolution (an example of Schlieren photo for dissolution process is shown in Fig. 2). By applying the plasma onto the surface of albumin solution, it was found that the downward movement of high-density albumin region was decelerated from 0.7-0.9 mm/s to 0.2 mm/s. It seems the transport of albumin (albumin flow) is related to the deposition of charged particles on solution surface. In the conference, further experimental details will be discussed.

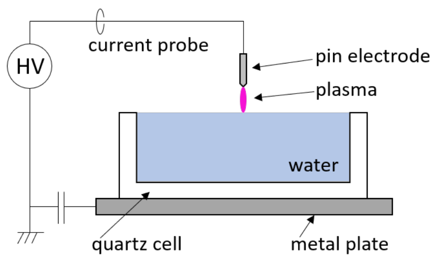

Figure 1. Schematic of pin-to-water-surface discharge system.

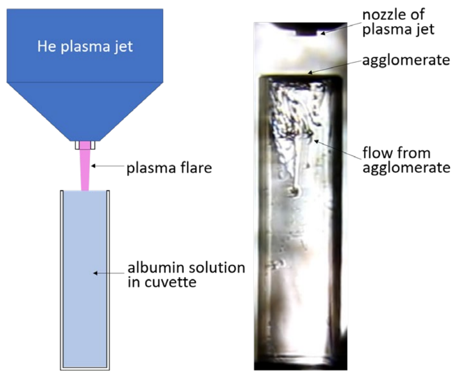

Figure 2. Schematic of plasma treatment on albumin solution and Schlieren photo showing a dissolution process from the albumin agglomerate.

References

[1] M. G. Kong, G. Kroesen, G. E. Morfill, T. Nosenko, T. Shimizu, J. van Dijk, and J. L. Zimmermann , New J. Phys. **11**, 115012 (2009).
[2] T. Shimizu and Y. Ikehara, J. Phys. D: Appl. Phys. **50**, 503001 (2017).
[3] T. Shimizu, Jpn. J. Appl. Phys. **59**, 120501 (2020).
[4] G. Isbary, G. E. Morfill, H.-U. Schmidt, M. Georgi, K. Ramrath, J. Heinlin, S. Karrer, M. Landthaler, T. Shimizu, B. Steffes, W. Bunk, R. Monetti, J. L. Zimmermann, R. Pompl, and W. Stolz, Br. J. Dermatol., **163**, 78 (2010).
[5] T. Shimizu, K. Kishimoto, T. Sato, J. Electrostat. **104**, 103422 (2020).
[6] T. Shimizu, H. Yamada, M. Fujiwara, S. Kato, Y. Ikehara, H. Sakakita, AIP Advances **10-12**, 125216 (2020).