Control of nanoparticle synthesis using physical and chemical dynamics of gas-liquid interfacial non-equilibrium plasmas

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Plasmas generated in liquid or in contact with liquid [1] have attracted much attention as a novel reactive field in the nano-bio material creation [2,3] because the brand-new chemical and biological reactions are yielded at the gas-liquid interface, which are induced by the physical actions of the non-equilibrium plasmas.

In this study, first, size- and structure-controlled gold nanoparticles (AuNPs) covered with DNA for the application to next-generation drug delivery systems are synthesized using a pulse-driven gas-liquid interfacial discharge plasma (GLIDP) [4]. The size and assembly of the AuNPs are found to be easily controlled by changing the plasma parameters and DNA concentration in the liquid as shown in Fig. 1 [5]. Furthermore, the synthesized AuNP-DNA conjugates are forced to be encapsulated into carbon nanotubes (CNTs) by applying a positive DC electric field which is superimposed on the pulse electric field.

Second, highly-ordered structures of the AuNPs are formed by transcribing the plasma structure to the surface of the liquid, where the spatially selective synthesis of the AuNPs is realized. The steep gradients of the electron density and temperature are generated using a ring electrode under the strong magnetic fields up to 4 tesla. The ring structure of the nanoparticles is found to be formed in accordance with the cylindrical density gradient region. Furthermore, expansion and contraction of the nanoparticle structure are also realized using the converging and diverging magnetic fields. At present, it is attempted to form nano- or micro-scale periodic structures of the AuNPs based on the self-organizing behavior of turbulent plasmas generated by the nonlinear development of plasma fluctuations at the gas-liquid interface.

Fig. 1: Synthesized DNA-AuNPs conjugates as a function of DNA concentration.

References