Solution-plasma synthesis of a gold-nanoparticle-containing polymer membrane on aqueous solution

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We have generated dielectric barrier discharge (DBD) of argon gas on $HAuCl_4$ aqueous solution for synthesizing gold nanoparticles. If we add gelatine to $HAuCl_4$ aqueous solution, we obtain a wine-red coloured membrane on the aqueous solution by the DBD. The membrane has fibrous structure composed of polymerized gelatine, which has been confirmed through optical microscope observation and infrared absorption spectroscopy of the membrane. In addition, we have confirmed that dispersed gold nanoparticles are incorporated in the membrane, which has been confirmed through energy dispersive X-ray spectroscopy of the membrane and transmission electron microscope observation of the edge of the membrane. Gold nanoparticles in the membrane are dense and have fairly uniform size distribution depending on the position in the membrane.

1. Introduction

Solution plasma can be used for various applications including nanoparticle synthesis and liquid treatment [1]. However, there are few reports on thin film formation using solution plasma [2]. In this work, we report that we can synthesize a free-standing and gold-nanoparticle-containing gelatine membrane by using dielectric barrier discharge (DBD) on aqueous solution.

2. Experimental setup

The aqueous solution was $HAuCl_4$ (0.3 mM) aqueous solution with gelatine. Gas gap was 2 mm. Applied voltage was bipolar pulse voltage (amplitude 4 kV, frequency 40 kHz, pulse width 4 μs). Typical discharge time was 10 min. Discharge gas was argon**.**

3. Results and discussion

A wine-red coloured membrane is formed on the surface of aqueous solution in contact with DBD as shown in Fig. 1. Infrared absorption spectra of the membrane and energy dispersive X-ray spectra have indicated that the membrane is made of polymerized gelatine and gold. Figure 2 shows a transmission electron microscope (TEM) image of the sample

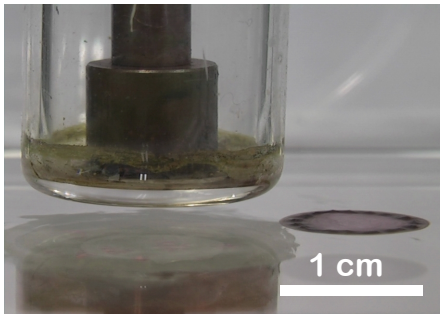

Fig. 1 The membrane formed on the $HAuCl_4$/gelatine aqueous solution by Ar DBD exposure.

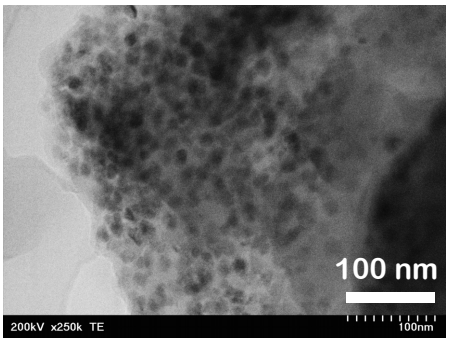

Fig. 2 A TEM image of the edge of the membrane.

taken from the outer edge of the membrane, which indicates that gold nanoparticles are formed in the membrane, and that they are dense and have uniform size distribution. Such size regulation may be explained in terms of immediate capture of reduced gold near the outermost edge of the laterally growing membrane. This method may be useful for preparing size-regulated nanomaterials because the particle size may be controlled by adjusting rates of reduction and membrane growth.

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References

[1] T. Shirafuji, J. Ueda, A. Nakamura, S.-P. Cho, N. Saito, and O. Takai, Jpn. J. Appl. Phys. **52**, 126202 (2013).

[2] H. Furusho, D. Miyamoto, Y. Nagasaki, K. Kitano, and S. Hamaguchi, J. Photopolym. Sci. Technol. **20**, 229 (2007).