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Dodecanethiol-capped gold nanoparticles could spread on water subphase and be transferred by LB technique. The superlattice structure of gold nanoparticles multilayer was discussed.

Keywords: superlattice; gold nanoparticles film; Langmuir-Blodgett technique

INTRODUCTION

In recent years a growing number of methods has been utilized for organizing two-dimensional superlattices of metal and semiconductor nanoparticles due to their electronic and optical properties, including self-assembly [1] and field-induced methods [2] etc.. LB technique is the most convenient to form lamellar multilayer films for one-dimensional or three-dimensional superlattices[3]. Fendler [4] and coworkers have reported the preparation of surfactant-stabilized nanoparticulate film on air-water interface and deposited multilayer films of Ag and CdS nanoparticles using LB technique. The another approach on nanoparticles-surfactant alternating LB films [5] was carried out by using

nanoparticulate hydrosols as the subphase. In this paper, we fabricated monolayer and multilayer gold nanoparticles films deposited by LB technique. It' s supperlattice structure are first demonstrated by the results of transmission electron microscopy(TEM) and small-angle X-ray diffraction(XRD).

EXPERIMENTAL SECTION

Dodecanethiol was purchased from Aldrich. Dodecanethiol-capped gold nanoparticles were fabricated according to the method of Brust et al. [6]. The precipitate was dissolved in chloroform with the concentration of 0.5 mg/ml. We spread the solution on air-water interface of a LB trough(KSV 5000 system). The water subphase was treated by millipore system, it' s pH value is 6.2±0.5 and temperature 25°C. When the surface pressure was stabilized at 10 mN/m, we transferred monolayer and multilayer films of gold nanoparticles onto solid substrates(copper grids and glass) with Z-type. TEM was investigated by JEOL-2100 electron microscope, the sample was supported on PVF-covered 230-mesh copper grids, the mean diameter of gold nanoparticles is 22Å, of which per particulate weight is 78878 g/mol on basis of the formulas deduced by Leff et al.[7]. XRD was taken with Rigaku D/max RA X-ray diffractionmeter by Cu-Kα radiation.

RESULTS AND DISCUSSION

Surface pressure(π) vs area(A) per nanoparticles isotherm is shown in FIGURE 1, where are two transition at the surface pressure of 15 and 22.5 mN/m respectively, which demonstrates when the surface pressure higher than 15 mN/m nanoparticulate monolayer has partially fold up. In contrast, a steep

and ideal monoparticulate layer that has an average area per nanoparticle of 1592 Å^2. According to the theory of Leff et al.[7], n gold atoms are stabilized by

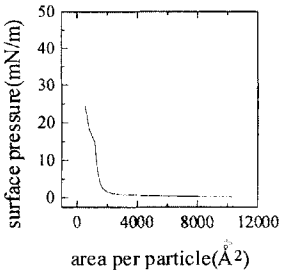

FIGURE 1 π-A isotherm of dodecanethiol-capped gold nanoparticles on water subphase.

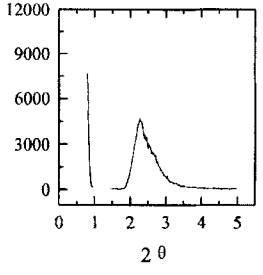

FIGURE 3 XRD pattern of a 7-layer gold nanoparticles LB film.

n_{thiol} dodecanethiol molecules for a nanoparticle, here $n=4\pi(D/2)^3/51$, $n_{thiol}=4\pi(D/2)^2/21.4$, D is Au partcle diameter, gold atoms on gold nanoparticulate surface bind with dodecanethiol molecules via Au-S bond. So each gold nanoparticle has a mass: $M=n\cdot m_{gold}+n_{thiol}(m_{thiol}-1)$, where m_{gold} and m_{thiol} are the mass of gold atom and dodecanethiol molecule, respectively. It was calculated that 22 Å^2 gold nanoparticle has a mass of 78878 g/mol corresponding to a monoparticulate area of 1592 Å^2 on the air-water interface, this value is about a half of the theoretical nanoparticle sectional area of 3017 Å^2. Hence it is concluded that those dodecanethiol molecules situated between

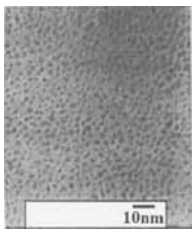

FIGURE 2 TEM image of gold nanoparticles monolayer LB film.

adjacent gold nanoparticles are interlocking.

FIGURE 2 shows TEM image of close-packed gold nanoparticles monolayer LB film. Analysis of the image yields an average particle diameter of 22±5Å and an average interparticle distance(center to center) of 42±8Å. The average interparticle spacing is approximately 20Å corresponding to the length of one dodecanethiol molecule[5], which is in accord with the analysis of π-A isotherm. FIGURE 3 is the XRD pattern of a 7-layer dodecanethiol-capped gold nanoparticles LB film dipped on a glass substrate, there is only the first order Bragg peak corresponding to a periodic length of 42Å. As above mentioned, a dodecanethiol molecular length is 20Å and mean gold nanoparticles diameter 22Å, whose sum agree favorably with the periodic length from XRD, so the 7-layer dodecanethiol-capped gold nanoparticles film can be considered as one-dimensional superlattice perpendicular to substrate.

Acknowlegements

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References

[1] R. P. Andres, J. D. Bielefeld, J. I. Henderson, D. B. Janes, V. R. Kolagunta, C. P. Kubiak, W. J. Mahoney, R. G. Osifchin, Science, **273,** 1690 (1996).
[2] M. Trau, D. A. Saville, I. A. Aksay, Science, **272,** 706 (1996).
[3] T. Ivanova, T. Gutberlet, M. Kastowsky, H. Bradaczek, Thin Solid Films, **299,** 165 (1997).
[4] J. H. Fendler, F. C. Meldrum, Adv. Mater., **7,** 607 (1995).
[5] X. G. Peng, Y. Zhang, J. Yang, B. S. Zou, L. Z. Xiao, T. J. Li, J. Phys. Chem., **96,** 3412 (1992).
[6] M. Brust, M. Walker, D. Bethell, D. J. Schiffrin, R. Whyman, J. Chem. Soc., Chem.Commun., 801 (1994).
[7] D. V. Leff, P. C. Ohara, J. R. Heath, W. M. Gelbert, J. Phys. Chem., **99,** 7036 (1995).