MMC

MICROMACHINE

2003 10

MMC Activities

Reports on Research Conducted under the 9th Micromachine Technology Research Grants (Part 2)

The research grant program began inviting applications in 1993 as a part of the independent activities of MMC. The purpose of the program is to assist college and university staff engaged in basic research on micromachines, and to promote further development of micromachine technology and communication between academics and people in the industrial world.

Of the 9 themes selected for the 9th (2001) research grants, summaries are provided below of the research results for 2 projects carried over from fiscal 2000 and 3 projects newly selected for fiscal 2001.

NO.	Subjects	Leader and Co-Worker	Affiliations	Period
Carried-Over Projects Granted for Fiscal 2000				
5	Creation of PEGylated Gold Nanoparticles for New Diagnostic System	Prof. Yukio Nagasaki	Professor, Department of Materials Science, Science University of Tokyo	2 Years
6	Surface Micromachining on Three-Dimensional Bulk Si Structures	Dr. Minoru Sasaki	Associate Professor, School of Engineering, Tohoku University	2 Years
Research Projects Newly Selected for Fiscal 2001				
1	Basic Study for Microactuator Controled by Wetting and Driven by Capillary Force between Liquid-Liquid-Gas Interfaces	Prof. Izumi Hirasawa	Professor, Department of Applied Chemistry, Waseda University	1 Year
		Dr. Masato Sakurai	Senior Researcher, Space Technology Research Center, National Aerospace Laboratory of Japan	
2	Study on a Cuff Microelectrode Using MEMS Technology	Dr. Shoji Takeuchi	Associate Professor, Center for International Research on Micromechatronics (CIRMM), Institute of Industrial Science (IIS), The University of Tokyo	1 Year
3	Study on Heart-Emulating Microactuators Using Self-Oscillating Gel	Dr. Ryo Yoshida	Associate Professor, Graduate School of Engineering, The University of Tokyo	1 Year

Affiliations as of May, 2003

Creation of PEGylated Gold Nanoparticles for New Diagnostic System

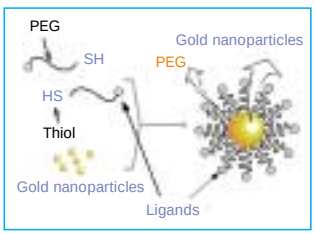
Yukio Nagasaki, Professor, Department of Materials Science, Science University of Tokyo

It is known that small gold particles on the order of several to tens of nanometers can be generated by reducing a chloroauric acid ($HAuCl_3$) using a reducing agent, such as citric acid. Gold nanoparticles obtained in this way disperse stably in an aqueous solution because like particles do not aggregate due to an ion-ion repulsion from the citric acid adsorbed on the surface of the gold nanoparticles. However, under the severe conditions of high ion concentrations or the like, the ionic repulsion of these adsorbed molecules generates an electrostatic shield that remarkably reduces dispersion, facilitating agglutination. In order to improve stability, we performed an experiment to add starch or other water-soluble polymers to form a protective colloid. Murray, et al., succeeded in coordinating a very stable particle dispersion by adding polyethylene glycol having a mercapto group (PEG-SH) to the surfaces of the gold nanoparticles. However, this method suffers from many problems including a drop in stability when investigating functionality, due to the conflicting relationship between stabilizing nanoparticle dispersion and surface functionality.

From the conventional perspective of biomaterial surface treatment, the authors synthesized polyethylene glycol (HeteroPEG) with a different functional group on both ends (Scheme 1). The gold nanoparticles were stabilized using HeteroPEG having a highly configurable mercapto group and polyamine chain on the surface of the gold particles (Scheme 2). Since the PEG was coordinated in a brush formation on the surface layer of the gold nanoparticles and the opposing end possessed a functional group in which a ligand can be introduced, this compound holds promise as a tool for resolving the above problems.

We attempted to functionalize particles using sugar and lectin or biotin and avidin, which are well known for use in specific molecular recognition. Fig. 2 shows photos of a solution of dispersed lactose-conjugated gold nanoparticles when an RCA lectin protein was added to selectively interact with galactose therein. The dispersed nanoparticles agglutinated by the interaction between lactose on the particle surface and lectin, turning the solution a purple color. When free galactose is added to this form, the solution returns to a pink color, indicating that this interaction is reversible. Fig. 3 is a graph showing the relationship between the concentration of RCA_{120} lectin and changes in absorbency for two nanoparticles prepared with lactose and mannose introduced onto the PEG terminals of the respective gold nanoparticles. While the gold nanoparticles modified with mannose, which does not show interaction with the RCA_{120} lectin, do not indicate any changes in absorbency, the lactose-conjugated gold nanoparticles were confirmed to change dependent of concentration. Based on the results of Figs. 2 and 3, this system enables the confirmation of molecular recognition with the naked eye and an accurate assessment of concentration using a simple spectroscope. This novel material will allow us to perform bedside diagnoses of today's extremely serious infectious diseases and highly sensitive diagnoses that were impossible before now.

Scheme 1



Scheme 2

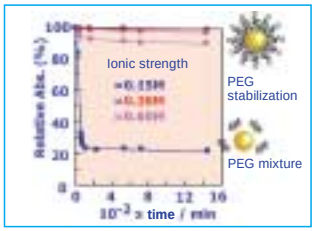


Fig. 1 Dispersion stability of PEGylated gold nanoparticles

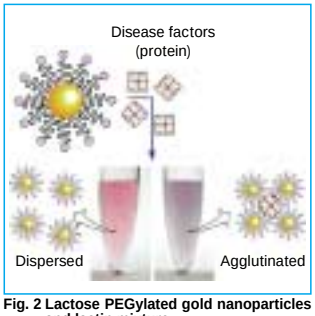


Fig. 2 Lactose PEGylated gold nanoparticles and lactin mixture

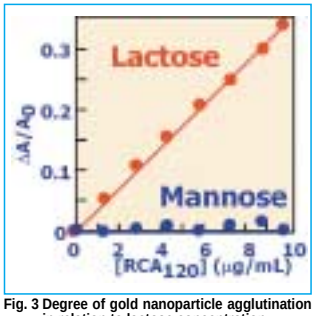


Fig. 3 Degree of gold nanoparticle agglutination in relation to lactose concentration