Development of high-performance fluorescent magnetic beads - Making it possible to diagnose diseases within 5 minutes -

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[Background]
Innovative technology development through interdisciplinary researches such as nanobiotechnology has achieved the improvement of people’s quality of life (QOL). In recent years, people have become so health conscious that they want the development of very quick and highly sensitive disease diagnosis technology. Such technology will make it possible not only to make a definitive disease diagnosis in several minutes but also to diagnose cancer metastasis within a few minutes during an operation.

[Results]
Our research group has developed functional magnetic beads (FG beads) composed of ferrite, a magnetic iron oxide, as core and polystyrene and poly(glycidyl methacrylate) as shell. We have also developed high performance affinity FG beads through fixing a drug on the surface of the FG beads. Based on the affinity FG beads, we have established a powerful and innovative screening system that can very efficiently isolate and purify a target protein toward the drug in a single step. These developments have led to the opening up of chemical biology (Fig. 1).

Very recently, by giving fluorescence to the FG beads, we have also created novel fluorescent magnetic beads (FF beads), which possess dual function: quickly magnetic collection by an external magnetic field and highly sensitive fluorescence.

The FF beads contain several ferrites and more than $1 \times 10^5$ fluorescent europium complexes and show strong fluorescence intensity (Fig. 2). When FF beads fixing antibodies to detect disease markers are quickly collected with a magnetic field (a magnet) on a substrate on which antigens are fixed as the disease markers, the antigen-antibody reaction is significantly accelerated. So, the FF beads can be said to be epoch-making sensing probes for detecting various disease markers very speedily. We have also developed technology to form biocapsules containing ferrite through a combination of our original ferrite modification/processing technology and self-assembling technology of virus capsid protein (Fig. 3).

[Outlook]
The FF beads on which various antibodies are fixed promote the antigen-antibody reactions through quick magnetic collection with an external magnetic field. Therefore, highly sensitive measurement of their fluorescence will lead to development of a highly speedy and accurate detection system of various disease markers based on use of the FF beads. Such a detection system is expected to be able to detect disease markers for 3 to 5 minutes. We aim to develop a speedy, highly sensitive, and accurate disease diagnosis equipment that can help doctors to complete their diagnoses quickly either during a medical examination or even during an operation. Our developed methodology will revolutionize modern medicine drastically. Besides, we think that our biocapsule formation technology based on self-assembling of virus capsid protein could be applied to development of a carrier of an innovative drug delivery system (DDS).

Fig. 1 Affinity magnetic beads (FG beads)

Fig. 2 Highly functionalized fluorescent magnetic beads (FF beads)

Fig. 3 Creation of a functional biocapsule based on virus capsid protein

Related Grants-in-Aid for Scientific Research:
FY2007-2008 Grant-in-Aid for Scientific Research (A): "Creation and application of high performance nanocapsules"
FY2009-2011 Grant-in-Aid for Scientific Research (A): "Development of high performance nanocarrier for next-generation medicine"