Fiscal Year 2019, Tokyo Institute of Technology ASPIRE League Research Grant

Selected Research Project for Type 1 in FY2019

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| Subject | Functional Design of Protein Cage for Sustainable Bio-nanomaterial | |

## Summary of the research project

Protein assemblies have recently become recognized as potential molecular scaffolds for applications in materials science and bio-nanotechnology. Efforts to design protein assemblies for construction of protein-based hybrid materials with metal ions, metal complexes, and nanomaterials now indicate a growing field with a common aim of providing novel functions and mimicking natural functions. However, the important roles of protein assemblies in sustainable materials science have not been systematically investigated and established.

Protein cage is one of the most useful scaffolds among protein assemblies with nano-sized structures, such as tube, wire, and two-dimensional array, because the cage has a various range of diameter from several to hundreds nm, and can be conjugated with natural and synthetic functional molecules on both the inside and outside surfaces. Many researchers reported functionalization of protein cages for the broad range of applications and implications focusing on the medical and biotechnology sectors. However, there is a limitation on development of drug delivery and imaging reagent due to low stability to conjugate various composites involving inorganic materials. Thus, highly robust protein cages are required to encapsulate and display inorganic materials with bionano functions, such as drug delivery and imaging.

We therefore propose to design and construct new types of sustainable protein cages conjugated with inorganic compounds for medical and bionano-applications. Ferritin (Fr), which plays the role of an iron storage protein, is known to accommodate various metal ions/complexes and is suitable for catalytic reactions conducted in an aqueous medium. From a protein engineering point of view, the effective preparation, yield, and stability make the Fr cage suitable for use as molecular templates to accumulate metal ions, complexes, and nanoparticles for construction of sustainable biomaterials to deliver metal drug and metal imaging reagents, such as gold and silver nanoparticles, and gadolinium complexes, into living cells. The accumulation of the inorganic compounds with desired size, number and position in the Fr cage is required for the accurate functions promoted in living cell. Thus, in the research project, we pursue the following objectives to establish the new research field of sustainable bio-nanomaterials :

**(1) Computational design of the Fr cage**

**(2) Incorporation and preparation of inorganic materials in the Fr cage and surface modification of the composite**

**(3) Evaluation of the functions toward medicinal and biomaterial applications**