（第３号様式）(Form No. 3)

学 位 論 文 要 旨
Dissertation Abstract

氏名：
Name　白米 優一

学位論文題目：
Title of Dissertation　Molecular Biology and Materials Engineering of Poly-γ-Glutamate
（ポリ-γ-グルタミン酸の分子生物学と材料工学）

学位論文要旨：
Dissertation Abstract

Poly-γ-glutamate (PGA) is biopolymer obtained from natto mainly. This polymer consists of nylon4-like backbone with linked carboxyl residues. Moreover, it has many abilities about biodegradation, coating and biocompatible materials. Although application of PGA to industries is focused, there are still many problems. Through my doctoral thesis, I reported molecular biology and materials engineering of PGA.

In caper1, our investigations into the unique chromosomal DNA maintenance (EDM) system of *B.subtilis* have identified two crucial factors, FliF and EdmS. Among over 30 structural genes in the *B. subtilis* fla/che operon, the *fliF* gene was found to be essential for the EDM process. This finding indicated that FliF has two independent functions, namely FliF-dependent EDM and flagellation, similar to EdmS that also displays two distinct functions, namely EdmS-dependent EDM and PGA production. In this case, the “one gene, one protein (or function)” hypothesis is not applicable. Instead, the theory of moonlighting proteins, in which one gene does not necessarily encode only one protein with a single role, becomes accepted as an alternative hypothesis. To our knowledge, this is the first observation of the moonlighting role of FliF in DNA maintenance.

Although the extremolyte-like (versatile) function of archaeal L-PGA has been revealed, it remains unclear whether this archaeal polymer can bind to critical metals. In chapter2, L-PGA was found to prefer trivalent metal ions (Ga^{3+}, In^{3+}, Dy^{3+}) and to discriminate against divalent metal ions (Co^{2+}, Ni^{2+}, Mn^{2+}), and these properties could be used to develop a selective polymer for the collection of valuable (multivalent) metal ions. In this sense, the fact that L-PGA afforded a sigmoidal curve for its metal adsorption represents a considerable advantage, because a process for metal desorption could also be established using facile manipulation steps, which would have very little impact on the adsorption capability of the polymer. In contrast, PAC exhibited hyperbolic behavior, which would be more suitable for the removal of metal ions rather than their collection. Overall, this chapter highlights the potential of L-PGA as a useful metal adsorbent.

In chapter3, the supra-molecular plastics of PGA ion complex (PGAIC) were effectively synthesized from archaeal, stereo-regular L-PGA using some cationic surfactants, viz. PGA/HDP, PGA/DDP, PGA/BZA, and PGA/BZT. These PGAICs possessed versatile coating performance to create bioactive (anti-*staphylococcal* and anti-*Candida*) surfaces on different materials with no additional treatments for the stabilization. Interestingly, PGA/HDP-coated surfaces showed significant anti-influenza

activities, while they were safe (non-toxic) for human cells. We are therefore hopeful that PGAICs generate considerable interest among researchers seeking to develop advanced polymer coatings for infection prophylaxis.

In chapter4, we focused on the performance of PGAIC as an antimicrobial coating material and succeeded in the development of PGAIC-ACs for effective bacterial elimination. Viable *E. coli* cells were virtually eliminated (> 99.9%) from the laboratory model of highly contaminated water ($\sim 2.0 \times 10^4$ CFU/mL) using our PGAIC-AC–embedded column. We hope that the PGAIC-AC system serves to regenerate the resources of water from such undesirable (polluted) conditions, and the large-scale manufacture of PGAIC-AC products would now be required for in situ water purification.

In chapter5, using a fine (sustainable) polymer from extremophiles, we have succeeded in developing a novel antimicrobial coating, showing the antithetical qualities of extreme durability and briefly controllable removability. This archaeal polymer, namely stereoregular PGA, possesses a peculiar functionality that enables it to bind cooperatively to various cationic compounds such as some critical metals (chapter2) and organic surfactants. PGAICs can be transformed into versatile nanofiberplastics and safe dispersants to create antimicrobial surfaces, and they may be used to contribute to hygienic control and infection prophylaxis in various public facilities such as schools, hospitals, hotels, and transportation, resulting in a decreased risk of airborne infections, contagions, and serious pneumonia, which are often fatal. Engineering advanced functional (e.g., controlled capture– killing) coatings would eventually prevent unforeseen epidemics caused by new contagions.