博 士 論 文 の 内 容 の 要 旨

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論文題目	Study on fabrication of nanofibers with multifunctions for textile, water filtration, and biomedicine (濾過および生物医学の為の多機能ナノファイバー製造に関する研究)

（博士論文の内容の要旨）

When the fiber diameters started to reduce from micrometers to nanometers, new fascinating features were introduced, for instance, large surface area to volume ratio, surface functionalities, and superb mechanical properties. There are several methods to prepare fibers at the nanoscale, including template synthesis, drawing, phase separation, and electrospinning. The latest has the potential to be developed at a mass-production scale from a wide range of different polymers. The setup utilizes electrostatic force to elongate single or multiple jets of polymer solution onto a collector. The jets become dry on the way traveling by the evaporation process. Eventually, nanofibers were gathered in regular sheet form and ready for further applications.

Water and air pollutions are the problems that humankind has to deal with. Harmful aqueous pollutants, including heavy metals or toxic organic compounds, can contaminate water resources; whereas, in the atmosphere, bacteria and viruses can lead to respiratory diseases and degrade human well-being. Conventional treatments for wastewater include three levels of treatment, which are primary, secondary, and tertiary treatments. The primary and secondary treatments remove coarse solids and organic matters. Tertiary treatment or the final treatment stage can remove pathogens and persistent contaminants. Expensive and advanced techniques, such as activated carbon and reverse osmosis, are usually used in this stage. For avoiding aerial pollutants, masks are usually worn. However, for fine particles and viruses smaller than 0.3 μm, regular masks do not remove or effectively protect against those particles and pathogens.

Varied materials have been utilized to speed up the healing process of wounds by preventing contamination and proving suitable environments. With the new developments of bioactive materials incorporated into nanofibers, the natural polymers with biodegradable or biocompatible characteristics, the deposition of healthy tissues is accelerated. Besides, growth factors, vitamins, and natural substances particularly plant-derived compounds were integrated into nanofibers for the production of novel composite nanofibers with enhanced properties. Honey, one of the natural substances, has been very appealing material due to its

antimicrobial and anti-inflammatory effects. For centuries, silver and copper have played the roles of antibiotics, due to antibacterial properties. Antibacterial resistance has been one of the major problems needing to be overcome in the field of biomedicine. Silver is a very potent antibacterial agent and has been used in the form of silver sulphadiazine or metallic silver. In recent years, silver finds its applications in silver-based wound dressings and medical devices. The mechanistic actions of silver have been suggested by numerous studies which comprise of oxidization, diffusion, and penetration. Whereas, copper promotes cell and tissue regeneration yet exhibits strong toxicity toward bacteria.

The main aim of my research is to promote the development of a nanofiber system with multiple functions, applied in antibiotic applications or water filtration. By adding new substances and compounds into the nanofibrous scaffolds, new composite materials can be introduced with fascinating and unexpected features.

In Chapter 2, we evaluated the adsorption capacity of the hybrid nanofibers of chitosan and cellulose for removing copper, lead, and arsenic in an aqueous environment. The system seemed to improve in mechanical characteristics owing to the tenacious nature of chitosan. The system also exhibited a stable nanofibrous structure during adsorption tests.

Chapter 3 discusses the mechanistic actions of different silver species against gram-negative and gram-positive bacteria. The arguments over the mechanisms of silver against bacteria have been a hot topic, and with multiple theories about the actions, the insights upon the silver exerting bactericidal activities have been more controversially complicated. Chapter 3 dealt with this prominent issue with the hope of contributing a different perspective of silver actions under the influences of chloride ions.

In chapter 4, we tried to bring the antibacterial activities on cellulose nanofibers by adhering silver and copper to the nanofibrous platform. Cellulose is an abundant natural polymer that has attracted more and more interest from academia and industry. The work introduces two different methods to decorate cellulose nanofibers with metal nanoparticles and assesses the antibacterial effects of the resulted composite nanofibers.

Chapter 5 is the combination of natural antibiotic - hinokitiol and synthetic nanoparticles - zinc oxide for the antibacterial application and dye removal. Hinokitiol played the role of a coating substance to secure zinc oxide nanoparticles staying firmly on the surfaces of nanofibers. Furthermore, this chapter presents novel research upon synergistic actions of hinokitiol and zinc oxide against gram-positive bacteria. The blue and red dyes were removed effectively from the aqueous solutions by the composite membrane.