博 士 論 文 の 内 容 の 要 旨

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論文題目	Study on development of highly conductive materials via electroless deposition technique for advance wearable devices (先端ウェアラブル機器のための無電解蒸着技術を通じた高伝導性材料の開発に関する研究)

（博士論文の内容の要旨）

Abstract

Study on development of highly conductive materials via electroless deposition technique for advance wearable devices

Recently, characteristics and synthesis of nanomaterials specially nanofibers into membrane are getting intensive attraction to explore potential applications that can work under mechanical deformation such as medical implants, flexible and wearable electronics, energy storage, electronic skins, sensors, biological actuators, deformable capacitors, and antennas, and point of care diagnostics. Nanofibers are being widely used because of their unique characteristics, fine diameter, high surface area and multifunctional properties such as biomedical, surgical, filtration, tissue engineering, membranes engineering, sensors, but their electrical properties such as electroconductive properties has remain challenge for researcher. In the past a wide range of polymers and facile techniques are used to fabricated high-performance conductive materials. However, in consideration of electroconductive performance, low cost, metal has remains first choice of materials.

In the view of above, the most effective approaches have been used to fabricate the conductive material. Here in, we report a versatile, novel, and easy approach to fabricate highly durable and electrically conductive aramid nanofibers (ANFs). The ANFs were firstly fabricated via electrospinning and afterward, the conductive ANFs were prepared using electroless deposition (ELD) technique. The copper (Cu) metal was used to prepare conductive ANFs due to its significant advantages i.e. conductance. During the ELD process, parameters including time and temperature were studied to optimize proper deposition and performance. The optimized ANFs samples were characterized by FE-SEM, EDX, XRD, XPS, FTIR, TGA, water contact angle, and electrical conductance. Copper (Cu) deposition on ANFs achieved high electrical conductivity. The as ANFs shows good candidate for copper

(Cu) deposition and provide good stability in terms of electrical conductance. The as-prepared Cu-ANFs could be used in various applications such as wearable electronics, flexible displays, and energy storage.

Plastic bottles are generally recycled by remolding them into numerous products. In this study, waste from plastic bottles was used to fabricate recycled polyethylene terephthalate (r-PET) nanofibers via the electrospinning technique, and high-performance conductive polyethylene terephthalate nanofibers (r-PET nanofibers) were prepared followed by copper deposition using the electroless deposition (ELD) method. Firstly, the electrospun r-PET nanofibers were chemically modified with silane molecules and polymerized with 2-(methacryloyloxy) ethyl trime-thylammonium chloride (METAC) solution. Finally, the copper deposition was achieved on the surface of chemically modified r-PET nanofibers by simple chemical/ion attraction. The water contact angle of r-PET nanofibers, chemically modified r-PET nanofibers, and copper deposited nanofibers were 140o, 80o, and 138o, respectively. The r-PET nanofibers retained their fibrous morphology after copper deposition, and EDX results confirmed the presence of copper on the surface of r-PET nanofibers. XPS was performed to analyze chemical changes before and after copper deposition on r-PET nanofibers. The successful deposition of copper one r-PET nanofibers showed an excellent electrical resistance of 0.1 ohms/cm and good mechanical strength according to ASTM D-638.

On other hand, we report the synthesis of conductive Nylon 6 nanofibers (N6 NFs) using the electroless deposition (ELD) method. We fabricated the N6 NFs by electrospinning technique and modified the surface with [2-(methacryloyloxy) ethyl] trimethylammonium chloride (PMETAC). After surface modification of N6 NFs, copper metal was successfully deposited using the ELD process. Parameters including time, temperature, volume, and pH concentration were optimized for copper deposition. SEM images revealed smooth morphology of neat N6 NFs and copper-coated N6 NFs. EDX spectrum was performed on neat N6 NFs and copper-coated N6 NFs to ensure the qualitative and quantitative presence of copper nanoparticles. Furthermore, advance characterization methods such as FTIR, XPS, water contact angle, and tensile strength were performed to analyze the successful copper deposition on N6 NFs.

One of the contributions of nanotechnology to our daily life is the preparation of a large variety of polymer-based nanofibers which could be the basis of future wearable devices. Wearable electronics are a great part of smart textiles research. Herein, we have

reported an easy method to fabricate electrically conductive cellulose nanofibers (CNFs). To fabricate CNFs, we firstly prepared cellulose acetate nanofibers (CANFs) by using the electrospinning technique and later, the deacetylation process was done to obtain the CNFs. The electroless deposition (ELD) technique was then used to create the conductive nanofibers. Copper (Cu) was used to coat the CNFs because of their high conductivity and low cost. The ELD process parameters including time, temperature, volume, and pH were optimized to obtain a nanofiber with higher conductivity. The optimized condition was temperature: 40℃, time: 10 min, volume: 600 ml, and pH: 13 to obtain a nanofiber web with 983.5 S/cm conductivity. Cu coated CNFs were characterized by Scanning Electron Microscope (SEM), Energy-dispersive X-ray spectroscopy (EDS), Fourier-transform infrared spectroscopy (FTIR), water contact angle (WCA), antibacterial activity, tensile, and electrical conductivity. The bending cycle test was performed to quantitatively demonstrate the durability and flexibility of the Cu coated nanofibers. Cu-coated CNFs exhibited great performance to be used as a conductive layer with antibacterial activity.