学位論文の要旨

Abstract of Thesis

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学位論文題目 Title of Thesis（学位論文題目が英語の場合は和訳を付記）

Synthesis and properties of water vapor sensing carbon nanohorn - cellulose sheets and nanometals.
（カーボンナノホーン - セルロースシート水素センサーおよびナノメタルの作製と特性）

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In Nanoscience and Nanotechnology, nanomaterials and fabrication techniques are key components in designing a device or an application. In such an effort, the synthesis route of nanomaterials plays an important role in tailoring the properties. Nanomaterial synthesis can be done in many varieties and methods, from the top-down approach to bottom-up approach, chemical, physical so forth.

Carbon nanohorns (CNHs) are mixed with cellulose to make freestanding thin-film conductive sheets. CNHs, at different ratios (5, 10, 25, 50 wt%), form composites with cellulose (hydroxyethylcellulose). Freestanding cellulose–carbon nanohorn (CCN) sheets were fabricated using a 100 μm-thick metal bar coater. Surfactants or any other chemical treatments to tailor the surface properties of CNHs were avoided to obtain composite sheets from pristine CNHs and cellulose. Utilizing the hygroscopic property of hydroxyethylcellulose and the electrical conductivity of CNHs paved a path to perform this experiment. The synthesis technique is simple, and the fabrication and drying of the sheets were effortless. As the loading concentration of CNH increased, the resistance, flexibility, and strength of the CCN composite sheets decreased. The maximum loading concentration possible to obtain a freestanding CCN sheet is 50 wt%. The resistance of the maximum loading concentration of CNH was 53 kΩ. The response of the CCN sheets to water vapor was 4 sec and recover time was 13 sec, and it is feasible to obtain a response for different concentrations of water vapor.

To fabricate wearable, portable, flexible, lightweight, inexpensive, and biocompatible composite materials, carbon nanohorns (CNHs) and hydroxyethylcellulose (HEC) were used as precursors to prepare CNH-HEC (Cnh-cel) composite sheets. Cnh-cel sheets were prepared with different loading concentrations of CNHs (10, 20 50,100 mg) in 200 mg cellulose. The obtained sheets are conductive (1.83×10^{-5} S) and bio-compatible with human skin. To fabricate the bio-compatible sheets, a pristine composite of CNHs and HEC was prepared without any pretreatment of the

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materials. Analysis for skin-compatibility was performed for Cnh-cel sheets by h-CLAT in vitro skin sensitization tests to evaluate the activation of THP-1 cells. It was found that THP-1 cells were not activated by Cnh-cel; hence Cnh-cel is a safe biomaterial for human skin. It was also found that the composite allowed only a maximum loading of 100 mg to retain the consistent geometry of free-standing sheets of < 100 μm thickness.

Synthesis of metal nanomaterials using unconventional route was used to obtain silver and copper nanomaterial by thermal evaporation — a simple approach to synthesize metal nanoparticles(nps) using High vacuum thermal deposition (HVTD) by reverse engineering of thin films to nps. Metal nps were synthesized by a top-down approach from bulk metals of silver and copper wires. High-vacuum thermal deposition is a commonly used technique for thin film deposition in many applications. Synthesis of metal nps by HVTD is simple and efficient as particle size control is effortless. The metals are deposited as thin films by thermionically evaporating and depositing on to a pre-coated thin layer of polyethylene glycol (PEG) on a glass substrate (Petri dish). The deposited metal thin film is removed along with the PEG coating into a liquid medium and subjected to sonication and stirring and deoxidation. Controlling the particle size is one prominent factor by HVTD technique and providing the feasibility of reusing bulky particles as a precursor after synthesis is a unique vantage point.

Assembling and synthesis nanomaterials such as carbon nanorods, hybrid carbon nanoparticles, metal nanomaterials and growth conditions of carbon nanotube arrays and their applications, properties are discourse in this thesis.

Self-Assembly is a novel synthesis technique which can successfully synthesize fullerene-based nanorods and hybrid carbon nanoparticles using different carbon allotropes. Carbon nanostructures (nanorods) synthesized via liquid-liquid interface precipitation method (LLIP) with its application in field effect transistor as a gate terminal. The carbon nanorods were synthesized by supersaturating and shape-shifting Bucky ball fullerene into nanorods. The nanoparticles synthesis process is fast, efficient and the reaction is carried out in 24hrs.

Synthesis of Hybrid Carbon nanoparticles using Multi-walled carbon nanotubes and Fullerene via self-assembly in this experiment a simple and efficient method to develop hybrid carbon nanoparticles employing Multi-walled carbon nanotubes (MWCNTs) and fullerene are conducted. Ultra-sonicated Precipitation technique was used to stack MWCNTs with fullerene in toluene as the saturated solution and methanol as the alcohol solution containing MWCNTs. This reaction of saturated solution reacting with rough alcohol increases the amount of carbon in the solution causing it to super saturate and forming nanoparticles.