

論 文 の 要 旨

題 目: SYNTHESIS AND FUNCTIONALIZATION OF NANOSTRUCTURED ELECTRICALLY
CONDUCTIVE FINE PARTICLE FOR ENERGY STORAGE AND CONVERSION
(エネルギー貯蔵・変換のための電気導電性ナノ構造体微粒子の合成と機能化)

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Fuel cells and supercapacitors emerge as alternative energy supplying devices in response to the problems related to the utilization of internal combustion engine: Fossil fuel shortage and environmental issue due to the emitted greenhouse gasses. To date, continuous improvement on these devices is still required to achieve high performance. Possible approaches for the improvement include functionalization and optimization on the electrode structure, which are commonly composed of carbon particles.

The research covered in the scope of this dissertation is aimed to investigate the structure of carbon particles suitable for the improved device's performance and their functionalization. Two methods were employed for the nanostructuring and functionalization, *i.e.* aerosol and liquid phase method. As a continuation of the carbon-related studies, this dissertation also investigates an alternative material for carbon substitute in response to the durability problem suffered by carbon. In detail, the contents of this dissertation is as the followings.

Chapter 1 summarizes the recent trend of carbon nanostructuring and functionalization, the opportunity for improvement towards highly functional carbon particles for fuel cells and supercapacitor, and the alternative material in response to the problem suffered by carbonaceous materials. This summary and problem statements lead to the motivation of the researches covered within the scope of this dissertation.

Chapter 2 discusses the effects of carbon particle morphology as electrocatalyst support on oxygen reduction reaction performance after being deposited with Pt nanoparticles. A dual polymer precursor, comprising phenolic resin and polystyrene latex (PSL), was used as the starting materials for the spray pyrolysis process. Phenolic resin to PSL ratios and PSL surface charge were varied to produce carbon particles with various morphology, *i.e.* dense, hollow, and porous. After Pt deposition, oxygen reduction reaction activity of the electrocatalyst was evaluated to obtain the optimum morphological structure to perform the reaction. It was found that a combination between meso- and macropores is important for a good oxygen reduction reaction activity. The results were confirmed using a computational fluid dynamic simulation.

Chapter 3 focuses on in-situ functionalization of hollow-structured carbon particles and its effects on the capacitance. 3-aminophenol was used as both nitrogen and carbon source. Polymerization of 3-aminophenol was assisted by microwave irradiation. Addition of PSL into the precursor created the hollow structure. The shell thickness was controlled by varying the ratio between PSL and 3-aminophenol. A high nitrogen content of up to 15.62% was observed in the synthesized hollow carbon. A combination of the nitrogen doping and hollow structure contributes to a capacitance of 16.3 F cm⁻³, higher than that of activated carbon.

In **Chapter 4**, Magneli phases TiO_x nanoparticles were synthesized from micron-sized TiO₂ particles using thermal induced plasma method. The synthesized nanoparticles were heat-treated in a mildly reducing atmosphere at 550 °C for rearrangement of the crystal structure, resulting in the highly conductive TiO_x

nanoparticles despite comprising many TiO_x phases. Durability of these nanoparticles was evaluated by performing 1000-cycle cyclic voltammetry and an accelerated corrosion test in hydrochloric acid solution. Results of this evaluation show a high stability and corrosion resistance in a strongly oxidizing environment.

Chapter 5 provides a summary of all chapters and suggestions for future research.