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## 主 論 文 の 要 旨

論文題目 **Nanostructure-Regulated Surface Treatment by Self-Assembled Monolayers and the Applications**  
(自己組織化単分子膜によるナノ構造制御表面処理とその応用)

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## 論 文 内 容 の 要 旨

Generally, the surface properties of materials are inadequate in order to apply in the verity application. Thus, the enhancement the of surface propertied should be considers. Surface modification is the interesting process due to its simple, low cost, and great performance. Recently, surface modification process has been wildly employed to creating of the new characteristics i.e. physical, chemical or biological from the original found. Most of research focused to increasing of wettability, reactive site, corrosion resistance, compatibility, conductivity, etc. Different types of material including silica, metal, semiconductor and carbon materials can be performed. One the well know technique for surface modification is organosilane self-assembly technique. This technique is significantly great attention after first introduced since 1980 due to the low chemical and facile and low-cost preparation, energy consumption, and long-term stability. For the high performance in the application, the characteristic of raw materials should also be concerned as a major effect. Therefore, solution plasma process is introduced. Solution plasma process is the nonequilibrium plasma, which is discharge in the liquid please at atmospheric conditions. Today, it was applied to synthesized of unique carbon materials i.e. amorphous carbon, heteroatom doped carbon, carbon/metal composite, and graphene. The characteristic of carbon prepared from

solution plasma was easily controlled by the precursor selection. In this study, the novel synthesis and surface modification of materials was investigated. The obtained materials were utilized in a various purpose including binding layer for optical gas sensor, adsorbent for metal ion removal, and catalyst for proton exchange membrane fuel cell. The details of each material are expressed as follows;

**Chapter 2** The organic dye such as porphyrin for the for detect gas in the environment has been received great attention. However, the utilization of porphyrin should be fabricating porphyrin into the thin film. Nowadays, there are several techniques to prepare porphyrin as a thin film on substrate. Although, most cases have some limit such as expensive, sophisticated preparation steps, and specialized devices. In this article, a molecular self-assembly technique preparation of porphyrin thin was introduced. The meso-tetrakis(*p*-sulfonatophenyl)porphyrin (TSPP) molecules were immobilized onto the substrate through the reaction with (3-aminopropyl)triethoxysilane (APTES)-modified substrate. The effects of APTES substrate functionalization, the TSPP chemical structure, and TSPP molecular orientation to the detection of ammonia, ethanol, and acetone were studied. It was observed that the APTES-modified substrate enhance the TSPP immobilization and induced TSPP aggregation. The optical gas sensor, the free based TSPP structure provided the better sensitivity than protonated TSPP structure toward to all gases. The highest relative gas sensor response recored by our sample was found to be 2.22, 1.57, and 1.15 % for 10 ppm of ammonia, ethanol, and acetone, respectively. Furthermare, the prepared sample on exhibited a great reproducibility over fiftieth cycle measurement to all gases.

**Chapter 3** Amino-modified carbon ( $\text{NH}_2\text{-C}$ ) has been great attention to use as an adsorbent for transition metal ion capture, due to its high possibility to induce a coordinate linkage with metal ion. In this work,  $\text{NH}_2\text{-C}$  was successfully derived from a mixture of phenol and 3-Aminopropyltriethoxysilane (APTES) by liquid phase plasma, which carbonization and amination occurred at the same time. This synthesis route gets rid of the need to multiple process, as is required in the traditional process. Our synthesized  $\text{NH}_2\text{-C}$  exhibited highly incorporating of amino functional groups on both the inner pores and external surface, which was increased the adsorption efficiency. The adsorption capacity for  $\text{Cu}^{2+}$ ,  $\text{Zn}^{2+}$ , and  $\text{Cd}^{2+}$  adsorption was 144.9, 115.4, and 102.0  $\text{mg g}^{-1}$ , respectively. These adsorption values were higher than five typical  $\text{NH}_2\text{-C}$ s prepared through a traditional process. Regarding to the adsorption mechanism from adsorption kinetic, isotherm, and thermodynamic studies, the metal ion were chemisorbed on adsorbent surface in a

monolayer coverage along with endothermically and spontaneously. Furthermore, synthesized adsorbent promoted great long-term stability.

**Chapter 4** Carbon material has been generally utilized as a supporter for platinum (Pt) catalyst for proton exchange membrane fuel cell (PEMFCs). However, the pristine carbon with the hydrophobic nature is lack in the benefit owing to its limitation for the mass transportation. Therefore, the introduction of functional groups on carbon's surface should be consider in order to creating of mass transport channel. The hydrophobic/hydrophilic modification on carbon promising the great candidate to achieve the goal. In this article, a one-step preparation of platinum/amphiphilic carbon (Am-C/Pt) catalyst was successfully synthesized through a liquid phase plasma. This novel synthesis eliminates several disadvantages compared to the conventional process such as reduced multiple step, reduced chemical and energy. Results demonstrate that the PEMFCs efficiency of synthesized catalyst was depend on the number of hydrophobic/hydrophilic character on the carbon surface. At 0.6 V ( $0.3 \text{ mg Pt} \cdot \text{cm}^{-2}$ ), a single cell exhibited a maximum current density and power density of  $1.27 \text{ A/cm}^2$  and  $0.87 \text{ W/cm}^2$ , respectively, which were surprisingly  $\sim 3.2$  times higher than that of commercially available carbon-supported Pt. Furthermore, the Am-C/Pt showed the good durability after 5000 cycle tests.