

# Graphene-polypyrrole hybrid supercapacitor electrode by electron beam irradiation

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## 1. Introduction

Supercapacitors which have highly large capacitance have attracted to energy researchers due to their rapid charging/discharging rate, high power density, and long life cycle. Supercapacitors are divided into two types according to the energy charging method; they are electrical double layer capacitors (EDLC) and pseudocapacitors.

EDLC stores energy through physical adsorption and desorption of ions or activating materials and has a very long charging/discharging life cycle. In addition, although the manufacturing cost is relatively low, there is a disadvantage that the energy density is low. EDLC mainly uses carbon-based materials because they have a large surface area and a low price. Various carbon-based materials, such as active carbon, carbon ion, graphene, and carbon nanotube, have been reported to be used as EDLC electrode materials. Among them, graphene has excellent electrical conductivity and low density, making it a very attractive material as an electrode material [1].

On the other hand, pseudocapacitors store energy through faraday redox reaction and have high energy density. Conductive polymers or transition metal oxides are mainly used as electrode materials, however these materials show low thermal and chemical stability. In addition, they have a poor level of charging/discharging life cycle.

Recently, a hybrid supercapacitor combining two types of electrode materials has been reported in many studies to dramatically improve the capacitance and compensate for each of the shortcomings. The important factors to manufacturing hybrid supercapacitor is to increase the bonding strength between two types of electrode materials and to increase the thermal stability of the pseudocapacitor material [2].

In this study, the hybrid supercapacitor electrode is manufactured using graphene, the main ingredient of EDLC, and polypyrrole (Ppy), a pseudocapacitor material. Fabricated hybrid electrode is irradiated with electron beam to enhance the binding strength and thermal stability of PPy.

During irradiation process on polymer, scission which are breaking chain and crosslinking that is creation of chain are proceed in polymer. Scissioning and crosslinking of polymer produce the aromatic ring which enhance the thermal stability and electrical conductivity. Furthermore, irradiation process is eco-

friendly modifying method since it doesn't need complicated process and harmful chemicals. Electron beam of 50 keV is used to enhance the property of electrode. In this study, we present and design the synthesis of hybrid supercapacitor electrode.

## 2. Methods

### 2.1 Fabrication of graphene-PPy hybrid electrode

Graphene particles are prepared by electrochemical decomposition in 1M KCl aqueous solution. Graphene particles and polyvinylidene fluoride (PVDF) in a weight ratio of 9:1 are mixed. The mixture is molded in N-methyl-2-pyrrolidone and coated on Cu foil (t: 1mm) and dried in vacuum oven at 80 °C for 1 hr [3].

Graphene-PPy hybrid electrode is synthesized by electrochemical deposition using a cyclic voltammetry method at a potential window of -0.6 to 1.0 V with a scan rate of 20mVs<sup>-1</sup>. Electrolyte is an mixed aqueous electrolyte with 0.1M pyrrole monomer and 0.2M sodium-potassium hydrant tartrate (Fig. 1).



Fig. 1. Image of fabricated graphene-PPy hybrid electrode

### 2.2 Electron beam irradiation on hybrid electrode

In this paper, 50keV electron beam device produced in our lab is used. The hybrid electrode is fixedly placed in the electron beam irradiator, and then the inside of the irradiator is evacuated. At this time, the degree of vacuum is maintained at 10<sup>-6</sup> Torr by using a rotary pump and a turbo pump. Then, electron beam is irradiated to the hybrid electrode by controlling the current and the electron beam irradiation time in each experimental condition.

### 2.3 Characterization

As prepared hybrid electrode is characterized by Raman, scanning electron microscopy, and transmission electron microscopy. Electrochemical properties of hybrid electrode is measured with cyclic voltammetry and galvanostatic charge-discharge method using SP-200 instrument (Biologic, France) (Fig.2).



Fig. 2. Electrochemical measurement instrument for hybrid electrode (SP-200, biologic)

### **3. Conclusions**

Hybrid supercapacitors have in attention as next-generation supercapacitors due to their large capacities and various advantages. This study designed a method for manufacturing hybrid supercapacitors using electron beam irradiation. Electronic beam irradiation is expected to dramatically improve the binding strength and capacitance of hybrid supercapacitors. It is expected that this research would expand the application of radiation to the energy fields.

### **REFERENCES**

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