Investigating the Impact of Dip Coating on the Performance of Graphene Nanoplatelet-Coated Electrodes with Cellulose Binder for Organic Flow Batteries

Taha Yasin Eken[1,2], Cantekin Kaykılarlı[1], Ali Tuna[2], Pekka Peljo[2],Ebru Devrim Şam Parmak[1], Deniz Uzunsoy[1]

[1]Department of Metallurgical and Materials Engineering, Faculty of Engineering and Natural Science, Bursa Technical University, 16310, Yıldırım, Bursa, Türkiye

[2]Research Group of Battery Materials and Technologies, Department of Mechanical and Materials Engineering, Faculty of Technology, University of Turku, 20014 Turun Yliopisto, Finland

Organic flow batteries (OFBs) are a promising technology for large-scale and long-duration energy storage. They utilize organic compounds as the active material and are known for their high energy density, flexibility in design, and low cost. The unique characteristics of OFBs make them a highly promising technology for large-scale and long-duration energy storage, making them an area of active research and development. Unlike traditional batteries, OFBs offer customizable configurations, allowing for tailored solutions that can meet specific energy storage requirements. This adaptability extends to various sectors, such as renewable energy integration, grid stabilization, and off-grid applications.

Electrodes are important components of OFBs, and their performance affects the overall efficiency of the battery. Electrodes act as the interface where the electrochemical reactions take place, facilitating the flow of electrons and ions during charge and discharge cycles. The most common electrode used for OFB applications are graphite felts due to their high porosity and electrical conductivity properties. Various materials are currently under investigation to enhance the performance of graphite electrodes. Graphene, a two-dimensional carbon material, has emerged as a highly promising candidate since it exhibits exceptional electrical conductivity, mechanical strength, and chemical stability. Its unique structure and large surface area allow for efficient electron transfer and enhanced electrochemical reactions within the OFB system. Various binding agents or matrix materials are used for graphene-graphite binding in the literature. Polyvinyl alcohol (PVA), Polymethyl methacrylate (PMMA), and polymeric resins are some of the well-known binders used for this purpose. Cellulose is a natural polymer that also serves as an effective binder for graphene and graphite materials. Its remarkable compatibility with graphene and graphite makes it a commonly employed binding material. The inclusion of cellulose-based binders enhances the adhesion between the layers of graphene and graphite, resulting in improved mechanical strength and overall stability.

In this study, the performance of graphene-coated electrodes with cellulose as a binder for OFB applications was characterized. Pristine and 1- and 5-times dip-coated PAN-based carbon-felt electrodes were used as the electrode material. Different organic molecules were tested and TEMPO, (2,2,6,6-Tetramethylpiperidine-1-oxyl)-type air stable aminoxyl radical derivatives were used as the electroactive material. Electrochemical tests such as cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) were used to evaluate the electrochemical performance. Surface area analysis and characterization were performed using Brunauer-Emmett-Teller (BET) and scanning electron microscopy (SEM). According to the current literature, our work is the first study to investigate using cellulose as a binder for carbon-felt coating with graphene for OFBs. Figure 1 depicts the CV results of the pristine, 1- and 5-times dip-coated electrodes for a scan rate of 100 mV/s. The results show that with the increase in dipping times, the CV capacitance increased as well as all demonstrates the feasibility of using graphene-coated electrodes with cellulose binder for OFBs and the potential for improving their performance through multiple dip coatings.

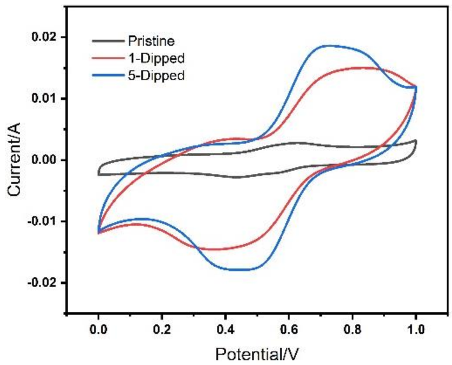

Figure 1. CV graph of pristine, 1- and 5-dipped graphite felts. Scan rate: 100 mV/s.

References

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Taha Yasin EKEN is currently associated with the Department of Metallurgical and Materials Engineering at Bursa Technical University. After completing his undergraduate studies at Middle East Technical University in 2016, he earned his M.Sc. degree in 2018 from Bursa Technical University. Since then, he has been pursuing his Ph.D. studies at the same university. His research focuses on organic redox flow batteries.

Taha Yasin EKEN, e-mail: yasin.eken@btu.edu.tr ;tel: +90 224 300 34 62