Ultra-Low-Defect Graphene Composites of High-Voltage Supercapacitors for power grid energy stroage system

Byung Jun Park[1]
Younghee Lee[1], Jeseok Shin[1], Subin Kim[1], Young Hee Han[1], Yeoheung Yoon[1]
[1]*Flexible Energy Team, Convergence Technology Lab, Korea Electric Power Corporation Research Institute (KEPCO Research Institute), Daejeon, Rep. of Korea*
bjpark@kepco.co.kr

Graphene derivatives, with their high electrical conductivity, large surface area, and mechanical stability, have emerged as promising electrode materials. However, conventional graphene structures often suffer from stacking and edge defects, which limit ion transport and reduce electrochemical stability at high voltages[1]. Overcoming these challenges is crucial for developing high-voltage supercapacitors with enhanced energy storage capacity.

In this study, an ultra-low-defect graphene composite was developed to enable high-voltage operation (>3.0V) of supercapacitors using conventional quaternary ammonium electrolytes. By applying an ultra-fast electric pulse(UFEP) to a mixture of graphene powder and a graphitizable polymeric compound(GPC), atomic and structural defects in the graphene were healed, restoring the sp^3 carbon sp^2 network. These UFEP treatments allowed discrete graphene grains to seamlessly merge *via* the GPC matrix, minimizing defect sites and preventing stacking issues commonly found in activated carbons(ACs) and reduced graphene oxide(rGO) electrodes.

Electrochemical characterization demonstrated a high working voltage of 4.0 V, with excellent electrochemical stability over 40,000 cycles. These results highlight the potential of UFEP-method-based graphene composite electrodes with ultra-low defects for next-generation high-energy-density supercapacitors, such advancements could significantly improve the efficiency and lifespan of energy storage systems in renewable power grids, reducing reliance on conventional batteries and enhancing overall grid stability.

References

[1] Nomura, et, al."4.4V supercapacitors based on super stable mesoporous carbon sheet made of edge-free graphene walls" Energy Environmetal Science 12.5(2019)1542-1549

Figures

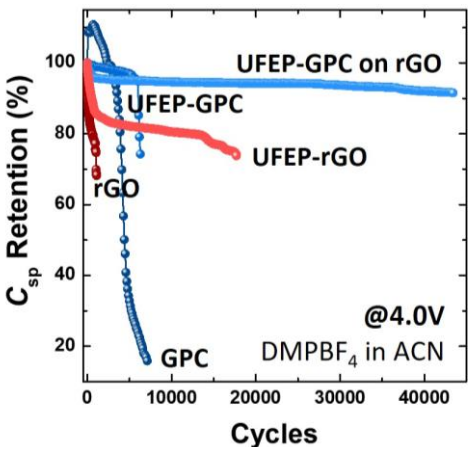

Figure 1: Electrochemical stabilities of UFEP-Graphene based supercapacitor