Electrochemical Conditioning of Graphene Supercapacitors via Controlled Accelerated Aging

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Abstract

Supercapacitors are faced with the universal aging phenomenon of increasing equivalent series resistance (ESR) and a reduction in capacitance over time. Though in organic systems, this is more pronounced owing to higher operating voltages and electrolyte sensitivity to impurities [1]. Accelerated aging, conventionally employed to measure device reliability, applies controlled electrical and thermal stress to induce the aging process. Although seemingly counterintuitive, such stress can be harnessed to prolong device integrity. In this work, we demonstrate that accelerated aging can be systematically employed as an electrochemical conditioning step to stabilize graphene supercapacitors. In a temperature-controlled environment, the supercapacitors are charged to near rated-voltage conditions. Following the accelerated-aging protocol, the electrochemical performance is monitored through the evolution of ESR and capacitance. Qualitative assessment of device bulging and gas evolution is also carried out. The controlled accelerated aging promotes early consumption of residual reactive species and thereby aids in stabilization of the electrode-electrolyte interfaces. This leads to a measurable reduction in gas evolution and improved ESR stability. On the contrary, aggressive aging conditions can result in irreversible degradation, highlighting the importance of defining safe conditioning windows. Overall, these findings reposition accelerated aging from a failure-inducing process to a deliberate conditioning strategy, offering a practical pathway to improve the reliability and operational stability of graphene supercapacitors.

References

[1] E. Pameté; L. Köps; F. A. Kreth; S. Pohlmann; A. Varzi; T. Brousse; A. Balducci; V. Presser, *Adv. Energy Mater.*, vol. 3 29, 2023, 3-6.

Figures

Figure 1: Process Flow for Electrochemical Conditioning and Stabilization.