Concrete Electrolyte-Based Structural Supercapacitor Reinforced With Carbon-Modified Steel Mesh

Alsulami , Rataj (School: Talented Secondary School)

Structural Supercapacitors (SCs) are electrochemical energy storage devices that utilize the abundance of cement as an electrolyte by employing its high porosity as ion transport channels toward achieving zero-energy buildings. Nonetheless, three major challenges prevent the realization of these devices, which are: 1. the contradiction between compressive strength and ionic conductivity, 2. the use of corrosive agents, and 3. the high cost of used electrode materials. Herein, steel mesh is configured as both a reinforcing agent and a current collector as an innovative approach to optimizing the mechanical and electrochemical properties. Moreover, local biomass Corchorus Olitorius-derived activated carbon is utilized as a cost-effective electrode material prepared through pyrolysis and chemical activation. The as-synthesized electrode material was characterized via FE-SEM, EDX, XRD, Raman, FTIR, and BET. The characterization confirmed successful synthesis with a 3D-hierarchal interconnected nanosheet-like structure. The cement electrolyte was constructed with only 3 wt% KOH using a designed 3D-printed mold. Afterward, the SC was fabricated and tested through CV, GCD, and EIS. The SC exhibited a high areal capacitance of 12mF/cm2, a power density of 260mW/cm2, and an energy density of 1.4mWh/cm2, which concurs with the aforementioned modifications. Simultaneously, a benchmarking compressive strength of 51.25MPa surpassing previous literature was achieved, and the cost was decreased by 13 times. The SC showed excellent durability by obtaining a capacitance retention of 83% after 1000 cycles. Lastly, a real-world application was demonstrated where the SC operated a LED paving the way for its immediate implementation to fulfill emerging demands for net-zero energy structures.

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