Cost-effective Ultrasound Utilization on Cement-Based Composites for Scalable Fabrication of Bifunctional All-solid-State Ultracapacitors

Alghannam, Latifa (School: KFUPM Schools)

In response to immense international energy demands, the industrial sector must witness a historic alteration for bulk energy storage with a wide range of up-scaling spectra for commercial utilization. Due to its scalable, porous, durable, and abundant availability, concrete cement has emerged as a scalable material for efficient ultracapacitors, yet it is not conductive. Herein, highly conductive cement-based composites were uniquely prepared from a self-synthesized polypyrrole conducting polymer utilizing the novel probe ultrasonication technique. Additionally, for the first time in scalable cement-based ultracapacitors, the fabricated ultracapacitor indicated a full-solid-state structure with liquid-free electrolyte, which reduced the leakage, inclined the potential window, and thereby increased the stability. Large pores were captured through SEM magnifications, which logically indicates the vast surface area, whereas EDX alongside XPS identified the cement integrity/purity. After many experimental trials, an exceptional specific capacitance of 101.2F/g was calculated through the CV and GCD analysis at a wide potential window of 2V retaining a notable 92% of the total capacitance after 5000 cycles maintaining superior stability/strength. Such fascinating findings outperformed similar reports with an impressive 148% efficiency-enhancement and 82% cost decline. This research introduced bifunctional cement properties as it simultaneously functions as a construction/building material and as a bulk storage unit for practical/scalable implementation. This project contributes a key-step towards large-scale commercial ultracapacitors for utilization in miniaturized and large-scale intermittent power supplies and reinforce the attainment of a sustainable circular economy.

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