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Design of porous carbon electrodes for energy storage systems

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Electrochemical capacitors (ECs) electrode materials are usually carbons with a well-developed surface area. In general, the activation process of carbon precursors does not allow for control of properties such as pore size distribution and graphitization degree. Therefore, a facile and sustainable method called salt-templating has been proposed to fabricate functional carbons. It is possible for inorganic salts to simultaneously regulate the porosity and graphitization degree of carbon materials [1,2]. The different eutectic mixtures of alkali metal chlorides (LiCl, NaCl, KCl, and CsCl) have been employed as salt-templates in the current work. In contrast to other methods that typically require independent carbonization and activation steps, this approach permits a single-step templating and activation process (during annealing). The advantage of chlorides, as salt-templates, is the fact that water can be used easily for their removal.

Several physicochemical techniques were used to analyze the structure and porosity of prepared carbons (XRD, Raman spectroscopy, N_2/CO_2 adsorption, TEM). It was possible to prepare ideal carbon materials with different degrees of graphitization and specific surface area ranging from 1450 to 2640 m^2 g^{-1} by using LiCl/NaCl and CsCl templates, respectively. Moreover, TPD-MS was utilized to evaluate the amount and types of oxygen-containing surface groups, what is usually neglected. Electrochemical testing of ECs included techniques such as cyclic voltammetry, galvanostatic charge/discharge, and electrochemical impedance spectroscopy. Accelerated ageing based on floating procedure was applied to investigate the long-term performance of assembled systems. Lithium sulfate (1 mol L^{-1}) as a cost-effective and environmentally friendly electrolyte enabled ECs to operate at 1.6 V. Excessive specific capacitance values (125 – 250 F g^{-1}) have been recorded. Furthermore, the longest floating time has been reported for LiCl/KCl carbon-based EC (288 h). Analyzing the structural, textural, and surface chemical features of salt-templated carbons in connection to specific capacitance values and floating time, significant correlations were found.

References

[1] C. Nita, M. Bensafia, C. Vaulot, L. Delmotte, C. Matei Ghimbeu, Carbon, 109 (2016) 227-238.

[2] A. Platek-Mielczarek, C. Nita, C. Matei Ghimbeu, E. Frackowiak, K. Fic, ACS Appl. Mater. Interfaces, 13 (2021) 2584-2599.