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Evaluation of activation of mesoporous carbon produced with biomass on the electrochemical performance of lithium-sulfur batteries

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In a world increasingly demanding new and efficient energy storage devices, lithium-sulfur (Li-S) batteries are a great alternative due to its high theoretical capacity (1675 mA h g-1) and the low cost of sulfur. However, the device still presents challenges such as the shuttle effect and the formation of intermediate species in the reaction. One of the alternatives to overcome these problems is the use of a conductive host with a high contact area and the capacity to retain polysulfides. Therefore, here we present two sustainable mesoporous carbons obtained through the solvent-free method, one of which has an additional physical activation step with CO2, to be used as hosts in Li-S batteries. The objective of this work is to study the influence of surface area and pore distribution of the carbon materials on sulfur incorporation and electrochemical tests. Mesoporous carbon (MC) was obtained through the mechanochemical synthesis of the precursors tannin extract, Pluronic F127 and terephthalaldehyde in a 1:1:0.5 ratio, respectively (800°C). Mesoporous activated carbon (MCA) was obtained through MC activation conducted under a CO2 atmosphere at 900°C. The incorporation of sulfur (S) was carried by the melt-diffusion method using a 1:1 carbon:S ratio, thus obtaining the MCS and MCAS composites. The carbon materials presented specific BET areas of 539 and 1370 m2 g-1 for MC and MCA, respectively. For the materials with sulfur, as expected, the area suffered a drastic reduction due to pore filling, dropping to 15 and 156 m2 g-1 for MCS and MCAS, respectively. The thermal analysis of MCS and MCAS, showed 39% and 43% sulfur content, respectively. The TG and DTG curves for the two materials differ from the curve for elementary sulfur, showing an increase in thermal stability associated with the interaction of sulfur with the host and its porous structure. This is even more pronounced for the MCAS sample, indicating species incorporated into the material's internal pores, an effect that has benefits in polysulfide retention. Galvanostatic tests reveal that MCAS have higher specific capacity (790 mAh g-1) compared to MCS (620 mAh g-1) at a current density of 0.1C. This difference corroborates the greater sulfur-host matrix interaction in MCAS, evidenced by thermal analyses. The mesoporous structure for both materials, which aims to improve ionic diffusion, resulted in excellent performance in high-rate capacity retention. Operating at 4C, MCAS and MCS maintain specific capabilities of 470 and 380 mAh g-1, respectively. Considering cyclic stability, experiments were conducted with MCAS at 0.2C for 250 cycles. As a result, the maintenance of specific capacity around 70% is observed, attesting to the quality of the composite materials for the retention of polysulfides.