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KOH ACTIVATION OF TANNIN-DERIVED ORDERED MESOPOROUS CARBONS FOR SUPERCAPACITOR DEVICES

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Introduction

Activated carbons (ACs) are widely used as main materials in electrodes for supercapacitors (SCs). Thanks to their high surface area, ACs are indeed able to store energy through an electric double layer (EDL) formed by the accumulation of ions on the carbon surface. As the EDL mechanism does not involve Faradaic reactions, supercapacitors can deliver the stored energy at high power outputs. Although a high surface area is needed, it is generally agreed that mesopores are also important because they favour ion access to the micropores, and hence they may significantly improve the electrochemical performances. Thus, in spite of their usually moderate surface areas, ordered mesoporous carbons (OMC) have attracted interest in the field of electrochemical applications due to the possibility of controlling both pore size and structure. In the present study, the synthesis of OMCs was carried out and the effect of KOH activation on their textural properties and electrochemical performances was analysed.

Materials and Methods

The OMCs were synthesized by a surfactant- and water-assisted mechanochemical mesostructuration (SWAMM) method using mimosa tannin as carbon precursor.[1] KOH-activation was performed by two routes: (i) impregnation of the OMC with KOH aqueous solution and (ii) physical mixing of dry KOH pellets with the OMC. Different KOH to OMC weight ratios, *w*, were tested and samples were labelled IMP-*w* or PM-*w* depending on the activation route: impregnation or physical mixing, respectively.

N_2 and CO_2 adsorption (at -196 and 0°C, respectively) measurements were used to calculate textural parameters such as surface area (S_{NLDFT}), pore volumes and pore size distribution (PSD). Selected samples were used to assemble SCs and their electrochemical performances were tested through cyclic voltammetry (CV), galvanostatic charge-discharge (GCD) and electrochemical impedance spectroscopy (EIS) in aqueous electrolyte (1 mol L^{-1} H_2SO_4).

Results and Discussion

The OMC proved to be more resistant to KOH-activation by impregnation, as high values of *w* were needed to obtain the same surface areas as those obtained with lower ratios by physical mixing, as shown in **Figure 1a**. In order to observe if the activation route had an impact on the electrochemical performance, samples with similar textural properties from each series were

selected. The chosen materials were separated into two pairs with approximately the same surface area and PSD (see **Figure 1b**): PM-3 and IMP-4 on the one hand, and PM-5 and IMP-7 on the other hand.

The CV tests at different scan rates, shown in **Figure 2a** revealed that the samples activated at a higher *w* reached higher values of capacitances due to their higher surface area, as expected. In addition, EIS measurements showed that PM-3 and IMP-4 exhibited high equivalent distributed resistance (EDR) explaining their low performance when compared to PM-5 and IMP-7. Furthermore, the lower EDR of this second pair of activated samples in combination with its high surface area and adequate PSD resulted in quasi-rectangular CV curves (**Figure 2c**) indicating ideal supercapacitor behaviour. Finally, samples from the PM series outperformed those from the IMP series in both cases and for all tested scan rates.

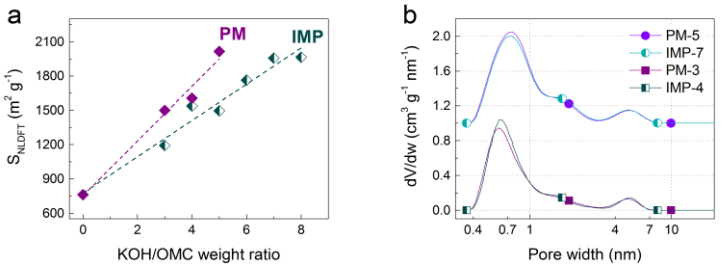

Figure 1. (a) Surface area as a function of KOH/OMC weight ratio for the two series of samples activated by impregnation (IMP) and physical mixing (PM). (b) PSD of the four samples with similar textural properties selected for further electrochemical tests.

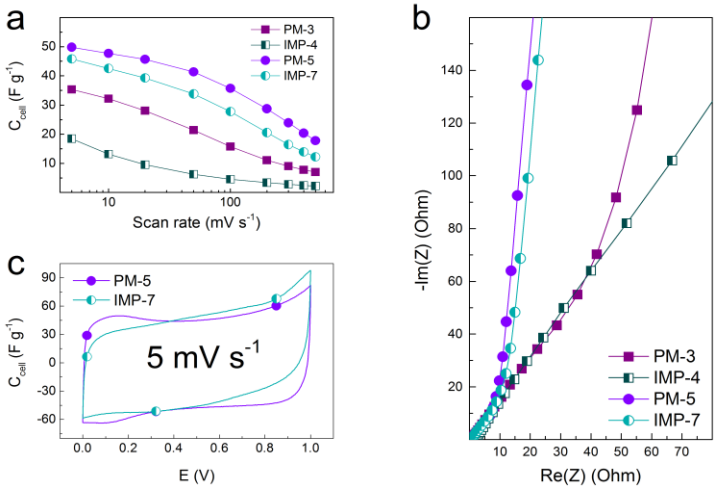

Figure 2. Electrochemical performance of selected samples: (a) cell capacitance as a function of scan rate; (b) EIS measurements; and (c) CV curves at 5 mV s^{-1} for PM-5 and IMP-7.

Conclusion

KOH-activation of OMCs resulted in high surface area materials. It was shown that tannin-derived OMCs are more resistant to activation by impregnation than by physical mixing. Among the activated materials, PM-5 and IMP-7 exhibited the highest electrochemical performances. In addition, the physical mixture route resulted in lower EDR materials.

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References

1. Castro-Gutiérrez, J. *et al.* (2018). Synthesis of perfectly ordered mesoporous carbons by water-assisted mechanochemical self-assembly of tannin. *Green Chemistry* **20**, 5123–5132.