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Tuning Functional Groups in Reduced Graphene Oxide Electrodes for Enhanced Performance in Indigo Carmine-Additivated Supercapacitors

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The integration of redox mediators into supercapacitors (SCs) presents a cost-effective strategy to meet concurrent high energy and power demands [1]. Critical to this approach is the selection of electrodes with high specific surface areas for capacitive charge accumulation and efficient adsorption of redox species at high concentrations. Reduced graphene oxides (rGOs) are particularly advantageous due to their extensive surface area and favorable electrosorption capacity. However, optimizing the content of functional groups on rGOs is crucial as it affects material conductivity and electrolyte wettability. In this study, we investigate how functional group content influences the performance of rGOs as electrodes in indigo carmine (IC)-additivated SCs. rGOs with varying degrees of functionalization were synthesized via the modified Hummers method and thermally reduced at 300, 700, and 1000 °C to obtain rGO-300, rGO-700, and rGO-1000, respectively [2]. Before electrode assembly, the rGOs were saturated with a concentrated IC solution. Despite notable differences in specific surface area (S_{BET}) and oxygenated functional group content (**Fig. 1a**), all three materials exhibited similar IC adsorption capacities ranging from 0.55 to 0.66 mmol g^{-1}. The SCs were assembled using H_2SO_4 1 mol L^{-1} as the electrolyte and carbon felt as the counter electrode. Voltammetric curves (**Fig. 1b**) reveal that removing functional groups enhances the reversibility of the adsorbed IC species reaction—signals centered at +0.05 V vs. Ag/AgCl/3.5 mol L^{-1}—likely due to increased conductivity in the more reduced rGOs. In contrast, rGO-300 shows enhanced charge accumulation via electric double layer due to improved wetting of the more functionalized interface. Finally, the electrodes' charge accumulation capacity was evaluated via galvanostatic measurements at various current densities (**Fig. 1c**). With a higher content of oxygenated groups, rGO-300 emerges as the electrode with the highest capacity, accumulating 245 and 42 C g^{-1} at 1 and 20 A g^{-1}, respectively.

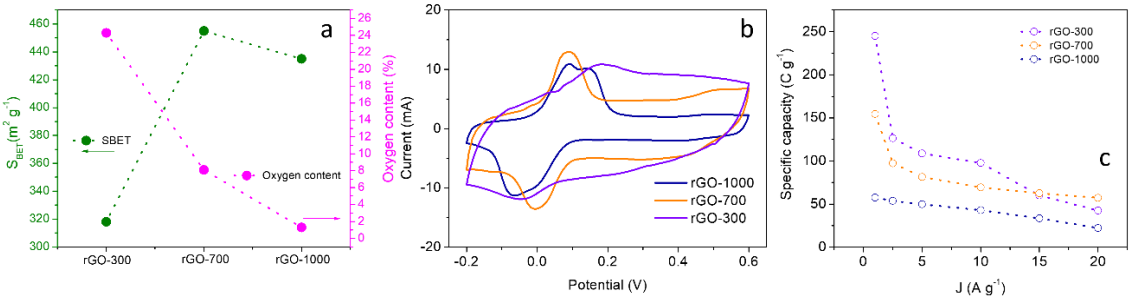

Figure 1. (a) Specific surface area and oxygen content obtained via elemental analysis of rGOs; (b) Voltammetric curves obtained at 25 mV s^{-1}; and (c) Specific capacity values as a function of current density for the rGO electrodes.

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References

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