Electronic Supplementary Information

Facile sonochemical assisted synthesis of a hybrid red-black phosphorus/sulfonated porous carbon composite for high-performance supercapacitors

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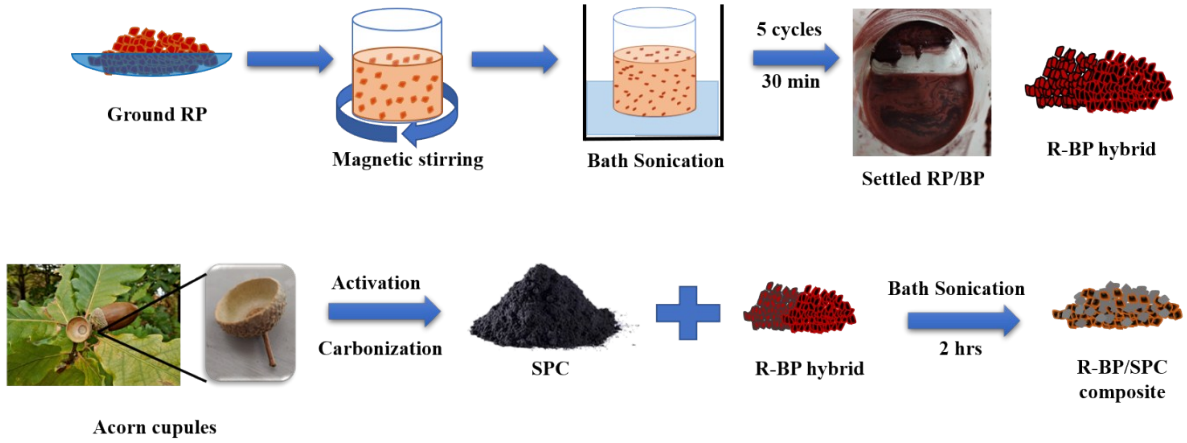
Synthesis of R-BP/carbon composite:

The R-BP/carbon composites were synthesized by the direct mixture of R-BP with sulfonated porous carbon under sonication. The porous carbon was synthesized from acorn cupule by carbonization and activation method. The acorn cupule collected from local gardens were cleaned with DI water and ethanol and were subjected to hydrothermal pre-carbonization in diluted sulfuric acid solution. The obtained pre-carbonized material was then activated with KOH (1:3 ratio) and carbonized at 700°C for 1 hr under nitrogen atmosphere. The as obtained product was washed with 30% HCl and DI water simultaneously until the pH reached neutral and dried in oven completely. The obtained sulfur doped or sulfonated porous carbon (SPC) was sonicated with hybrid R-BP (1:1 ratio) with ethanol as solvent under bath sonication for 2 hrs. The mixture was dried in oven to yield hybrid R-BP/SPC composite.



Scheme S1: Synthesis process of hybrid R-BP and hybrid R-BP/SPC composite

Calculations:

The specific capacitance, energy density and power density were calculated as follows:

Three-electrode cell : $$C = \frac{I}{m\left(dV/dt\right)}$$ F g^{-1} …… (1)

Two-electrode cell : $$C_{cell} = \frac{2I}{m\left(dV/dt\right)}$$ F g^{-1} …… (2)

where I is the current, m is the mass of carbon material loaded, and dV/dt is the slope of the discharge profile. The energy density (E) and power density (P) were calculated for a two-electrode cell with *dt* as the discharge time (s):

$$E = \frac{1}{2 * \frac{3600}{1000}} C_{cell}\, dV^2$$ Wh Kg^{-1} …… (3)

$$P = \frac{E}{dt} \times 3600$$ W Kg^{-1} …… (4)

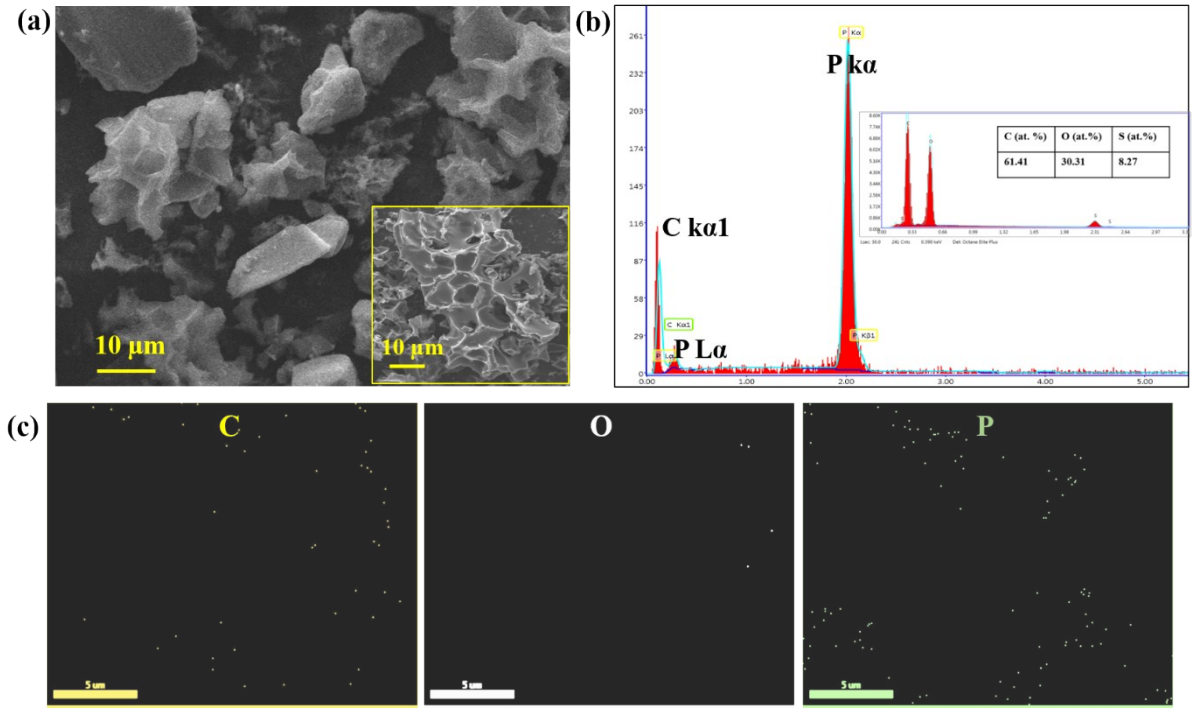


Figure S1: (a) SEM image of R-BP/SPC with inset: Sem image of SPC; (b) EDS spectrum of RBP/SPC with inset: SPC; (c) elemental mapping.

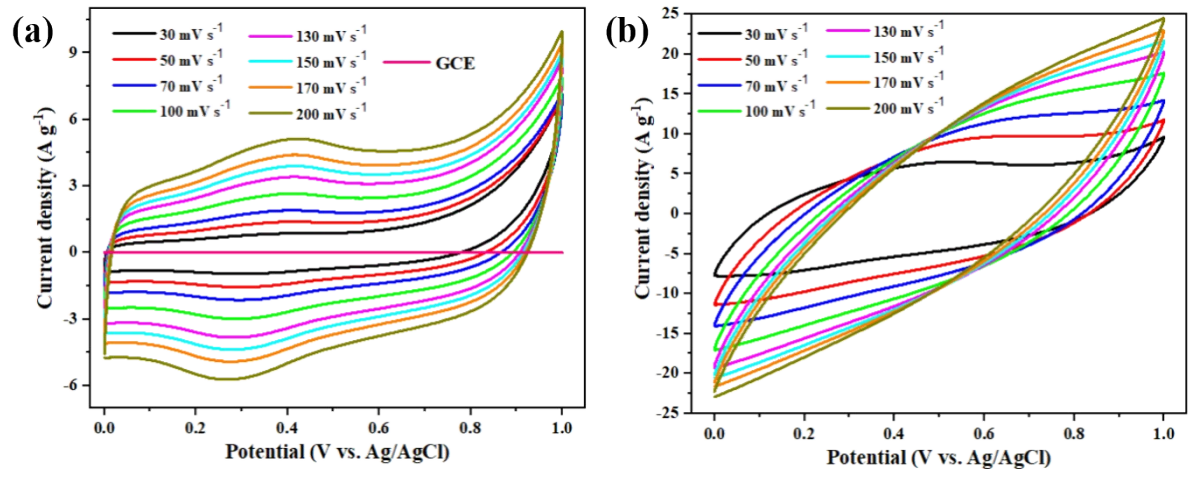


Figure S2: CV curves of (a) R-BP and (b) R-BP/SPC composite.

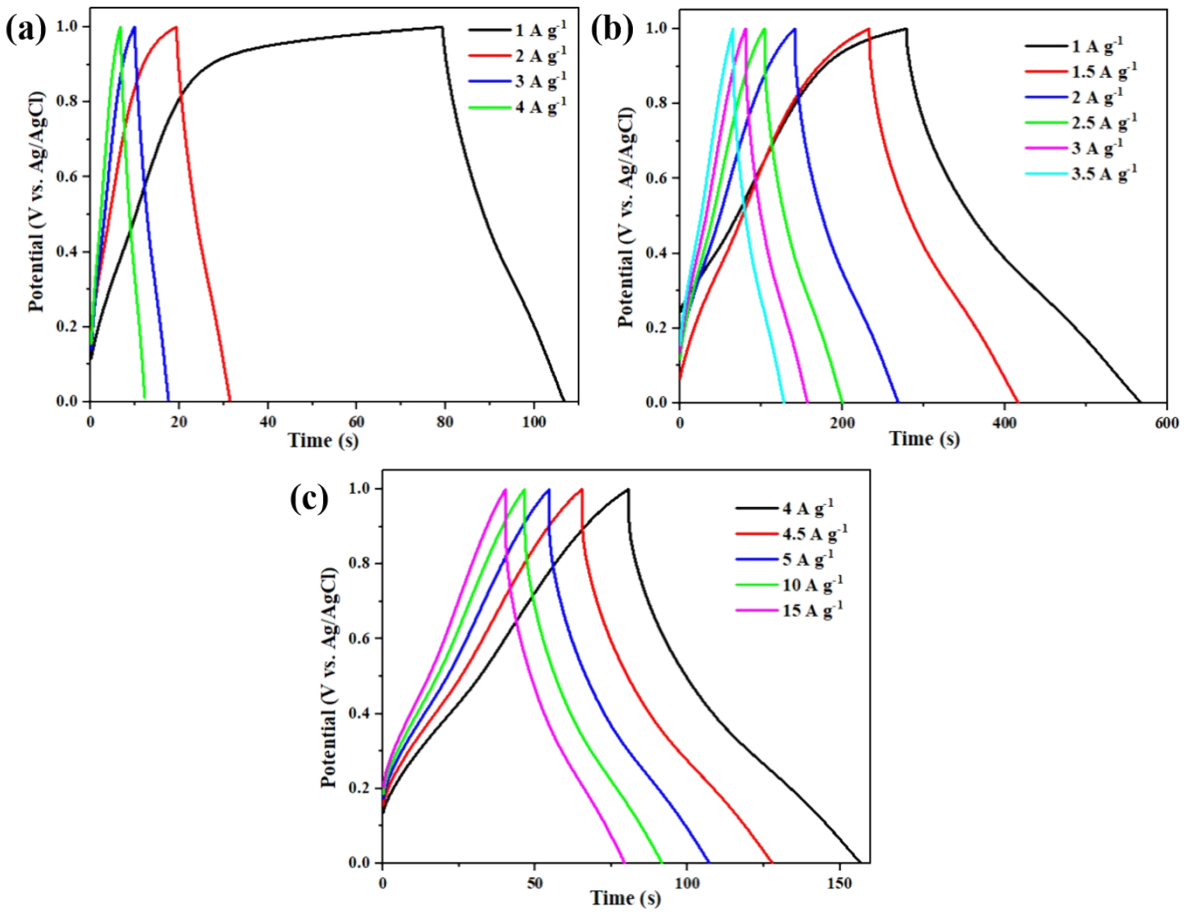


Figure S3: GCD profiles of (a) R-BP; (b-c) R-BP/SPC composite at lower at higher current densities.

The electrochemical impedance spectroscopy was performed to explore the electrode kinetics of R-BP, R-BP/SC and SC. The Nyquist plots of all three electrodes in Fig. S4(a) displays an inclined line in the low frequency region and a depressed semi-circle in the high frequency region indicating its capacitive behaviour and charge transfer resistance (R_{ct}), respectively. The R-BP/SC electrode displays low R_{ct} and steeper tail compared to other electrodes, attributing to its faster kinetics and better capacitive behaviour. Fig. S4(b) gives the Nyquist plot of R-BP/SC electrode before and after 10000 charge/discharge cycles. It shows that there is no

change in capacitive behaviour (vertical line) whereas the R_{ct} did not show large difference indicating that charge transfer kinetics was retained.

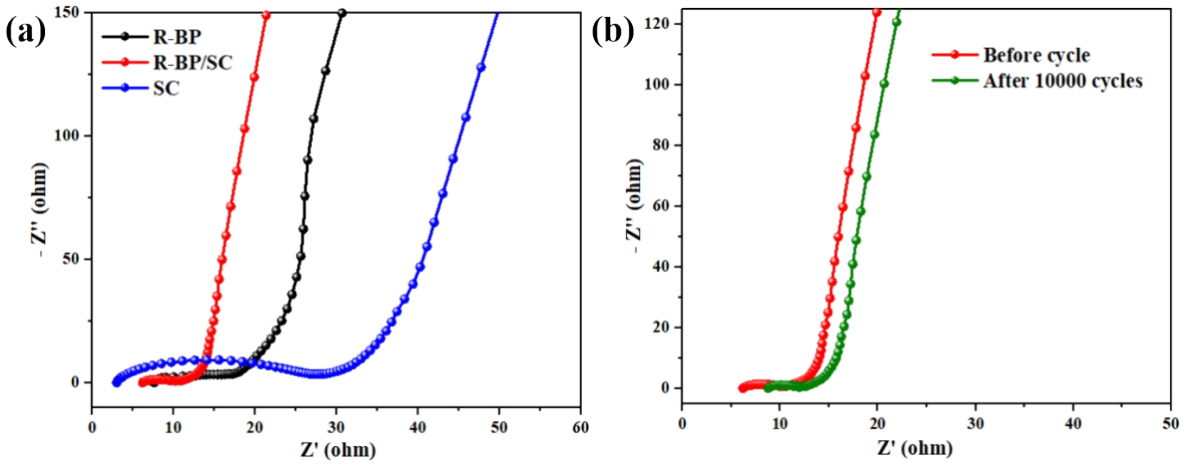


Figure S4: Nyquist plot of (a) R-BP, R-BP/SC and SC; (b) R-BP/SC before and after10000 charge/discharge cycles.

Table S1: Comparison of electrochemical performance of BP based electrodes with R-BP/SPC composite for supercapacitors.

Electrode material	**BP Precursor**	**Synthesis method**	**Electrolyte**	**Specific Capacitance Cs (F g^{-1})**	**Capacitance retention (%) No. of cycles**	**Ref.**
BP	Bulk BP	LPE	6M KOH	45.8 (10 mV s^{-1})	84.5% 10000 cycles	[9]
BP/RP	RP	Sonication	0.1M KOH	60.1 (0.1 A g^{-1})	83.3% 2000 cycles	[11]

BP/PANI	RP	Shear force milling	1M H_2SO_4	354 (0.3 A g^{-1})	96% 175 cycles	[26]
BP/PPy	Bulk BP	Sonication	H_3PO_4-PVA	452 (0.5 A g^{-1})	65% 10000 cycles	[27]
R-BP/SPC	**RP**	**Sonication**	**1M H_2SO_4**	**364.5 (0.5 A g^{-1})**	**89% 10000 cycles**	**This work**

LPE-Liquid phase exfoliation; H_3PO_4-PVA- phosphoric acid-polyvinyl alcohol; PPy- Polypyrrole.