

Supporting Information

Origin of enhanced reversible Na ion storage in hard carbon anode through p-type molecular doping

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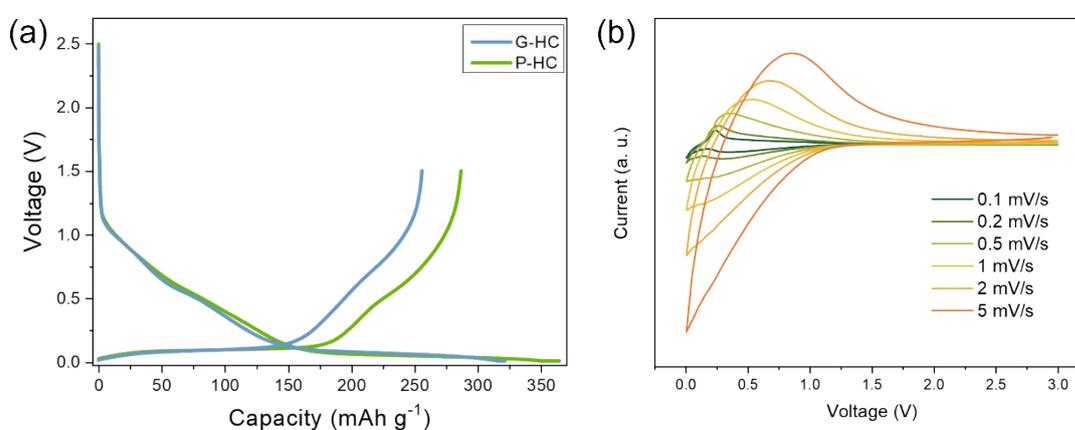


Figure S1. (a) Capacity comparison between G-HC (without PA) and P-HC (with PA). Capacity was enhanced through the doping of PA. (b) Cyclic voltammetry results of G-HC with various scan rates.

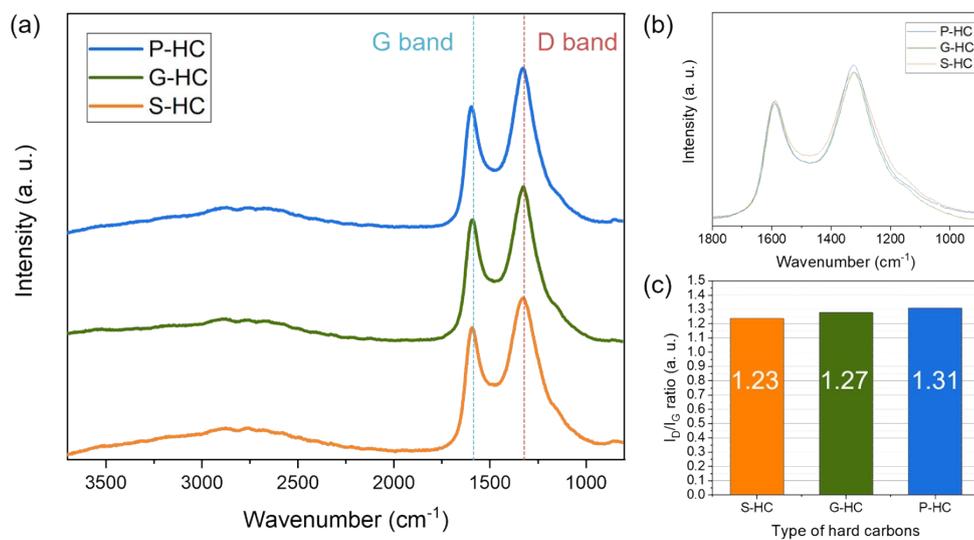


Figure S2. (a) Raman spectra of hard carbons with different precursor configurations. (b) Normalized and magnified spectra around G and D bands. (c) Ratios between the intensity of G and D bands.

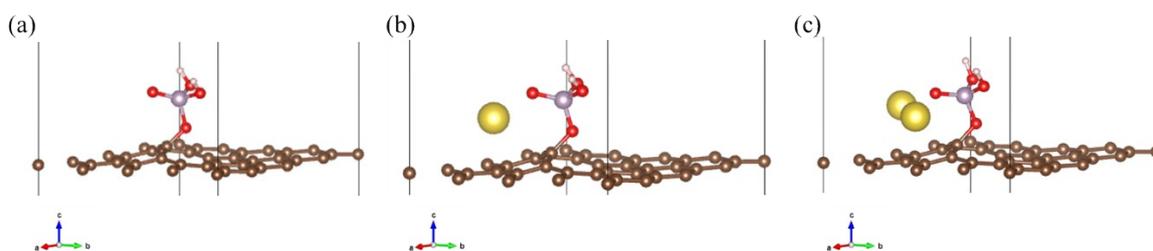


Figure S3. Atomic structures of Na_xP-HC as contents of (a) $x = 0$, (b) $x = 1$ and (c) $x = 2$

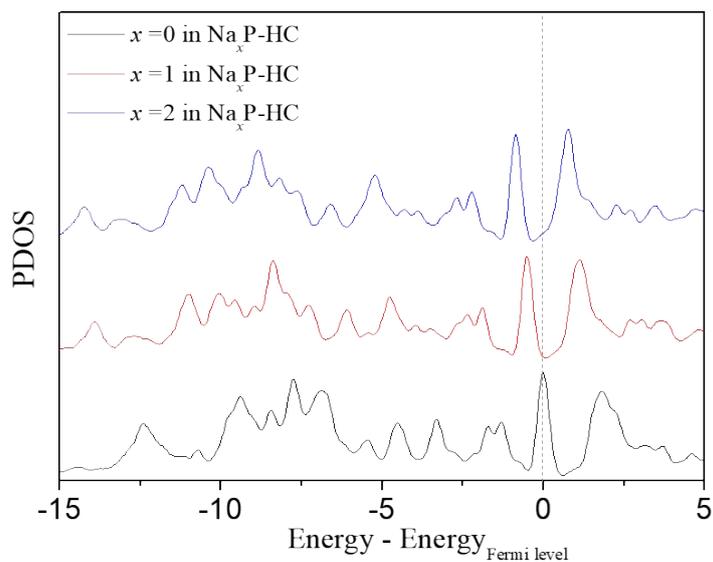


Figure S4. PDOS of carbon(C2) bonding with O in P-HC as Na contents

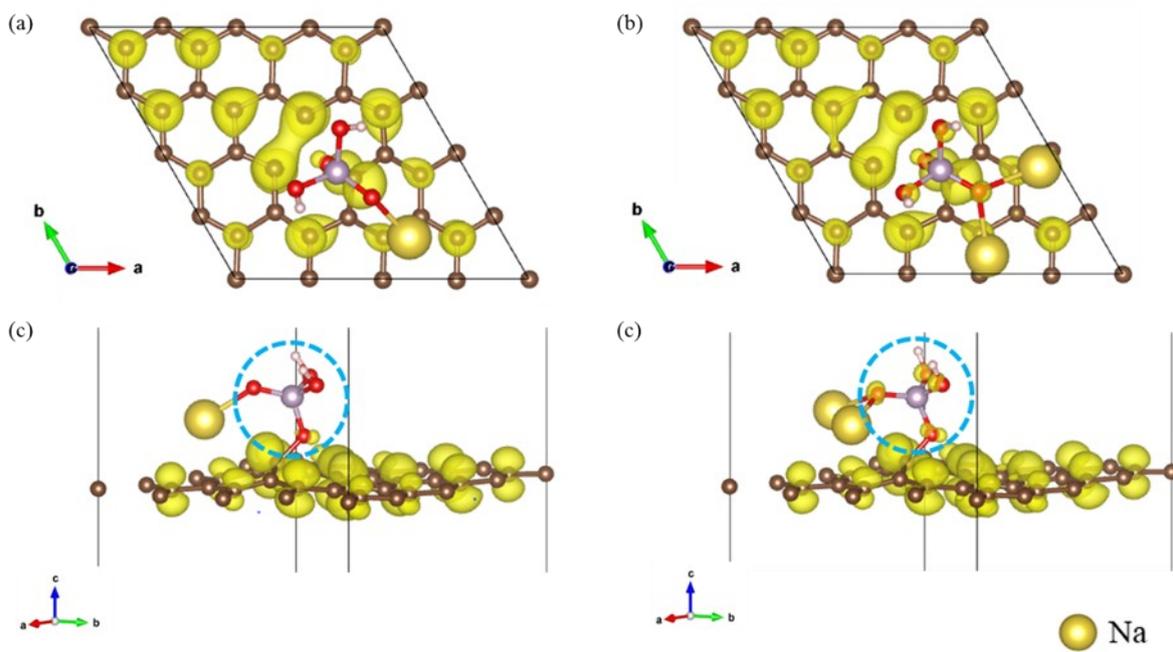


Figure S5. Spatial electron distribution of the occupied states from fermi level from -1 eV to 0eV as Na contents variation of (a, c) $x = 1$ and (b, d) $x = 2$ in $\text{Na}_x\text{P-HC}$.

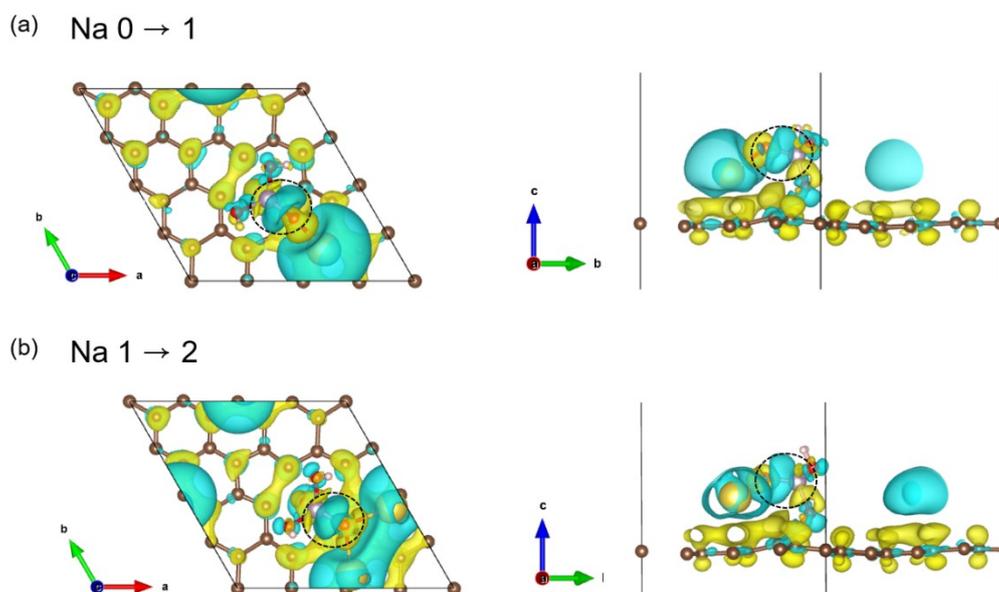


Figure S6. Spatial charge density variation of P-GL during the sodiation process. (yellow profiles are reduced states, while blue profiles are oxidized states)

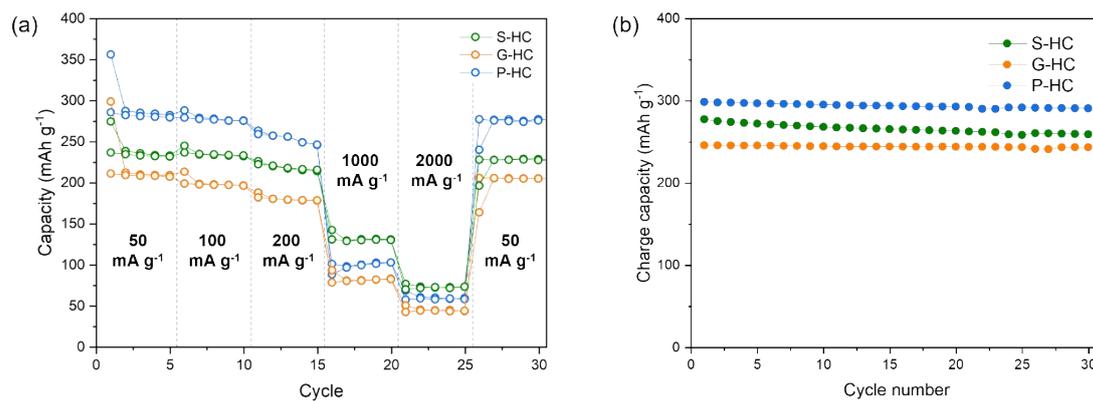


Figure S7. (a) Rate capabilities and (b) cyclabilities of hard carbons. The current density of the cyclability test is 20 mA g⁻¹

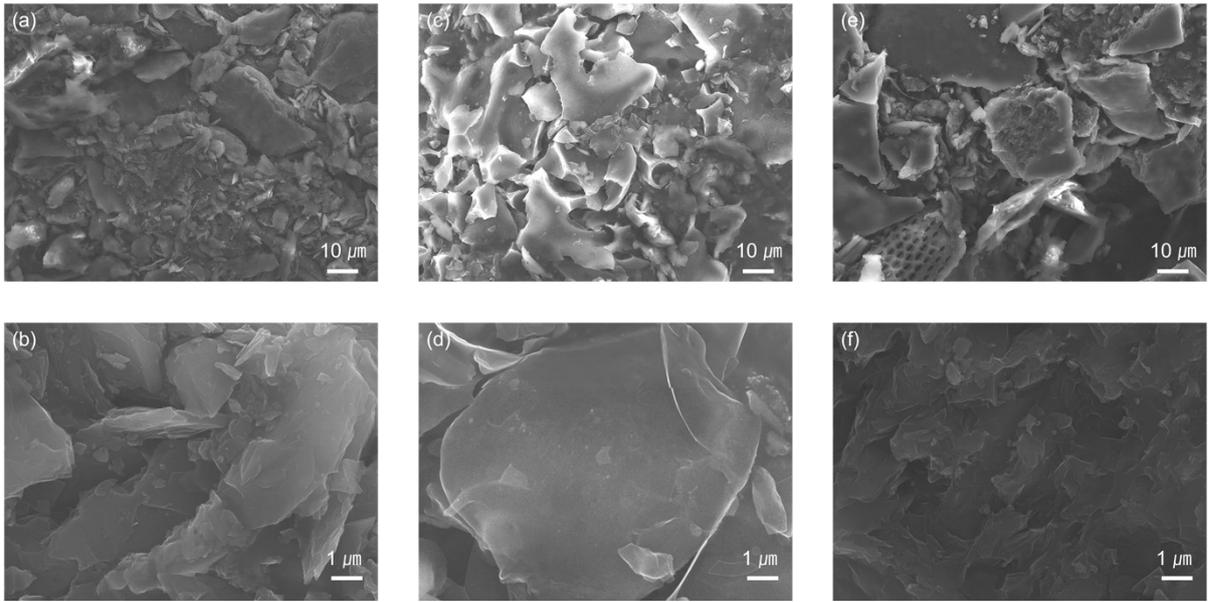


Figure S8. SEM images of hard carbons. (a, b) S-HC (c, d) G-HC (e, f) P-HC.

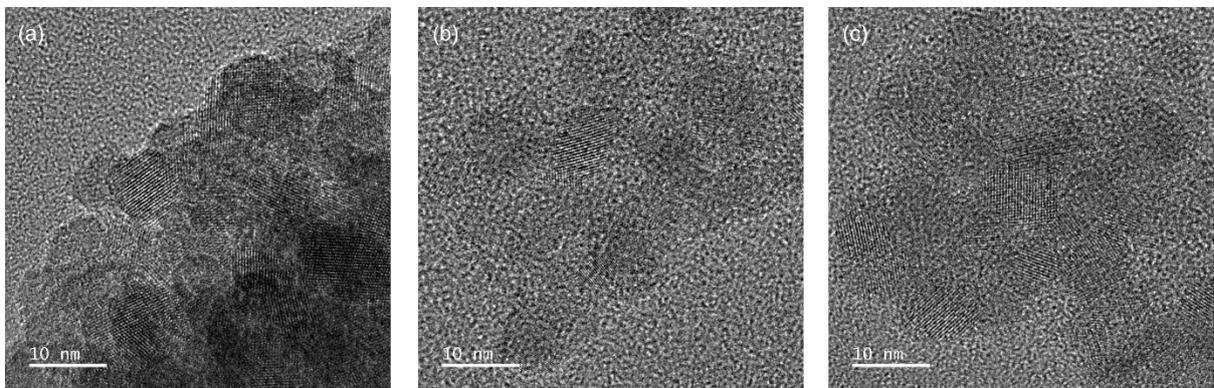


Figure S9. TEM images of hard carbons (a) S-HC (b) G-HC (c) P-HC

Table S1. The electric conductivities of hard carbons.

	Load [kgf]	Conductivity [S cm ⁻¹]	Density [g cc ⁻¹]
S-HC	2000.00	23.980	1.090
R-HC	1999.00	35.075	1.097
P-HC	2000.00	39.759	1.084

Table S2. P=O bond lengths depending on the sodiation degree (x) in Na_xP-HC

x	P=O bond length [Å]
0	1.474
1	1.495
2	1.511