Supporting information

Influence of phosphorus activation and carbonization temperature on the electrochemical performance of hard carbon made from olive pomace as an anode for sodium-ion batteries

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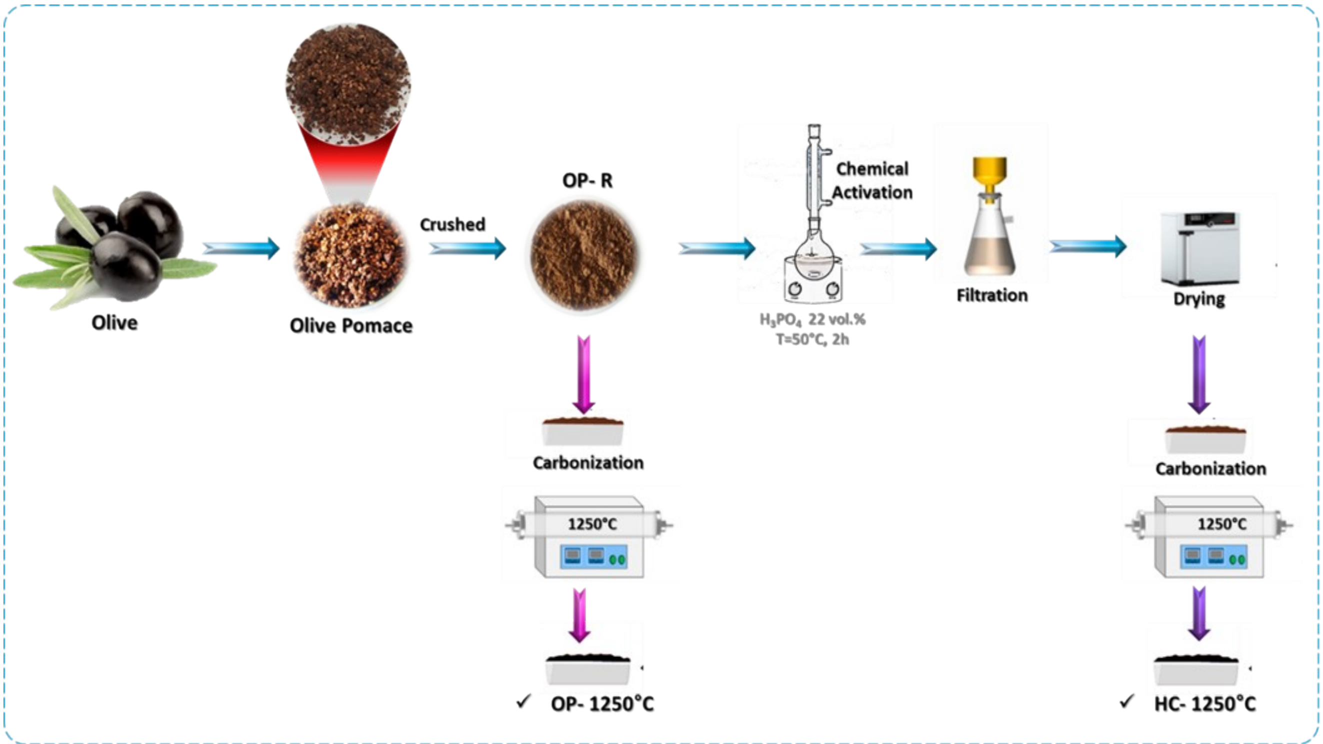

Fig. S1. Hard carbon preparing process from olive pomace.

The thermogram (Fig. S2) shows three different stages of weight loss. First, from room temperature to 105°C, there is a weight loss of about 4-6% due to the physical evaporation of water molecules, accompanied by a weak DTG peak. Second, the decomposition of hemicellulose and volatile matter, which is characterized by a weight loss of half the mass [1-2]. Usually, the degradation of hemicelluloses occurs in a temperature range of 240°C to 300°C. Afterward, the breakdown of the cellulose bonding and its decomposition between 250°C and 380°C. The DTG curve provides a clearer representation of this thermal decomposition, displaying a strong asymmetrical peak that highlights the degradation of hemicelluloses and cellulose [3-4]. During the third stage, between 400°C and 600°C, lignin is decomposed, which begins to degrade later and has better thermal stability than other components of olive pomace [3]. The DTG curve also shows an intense peak at temperatures between 400 and 600°C, followed by stabilizing the mass loss and decomposition of olive pomace.

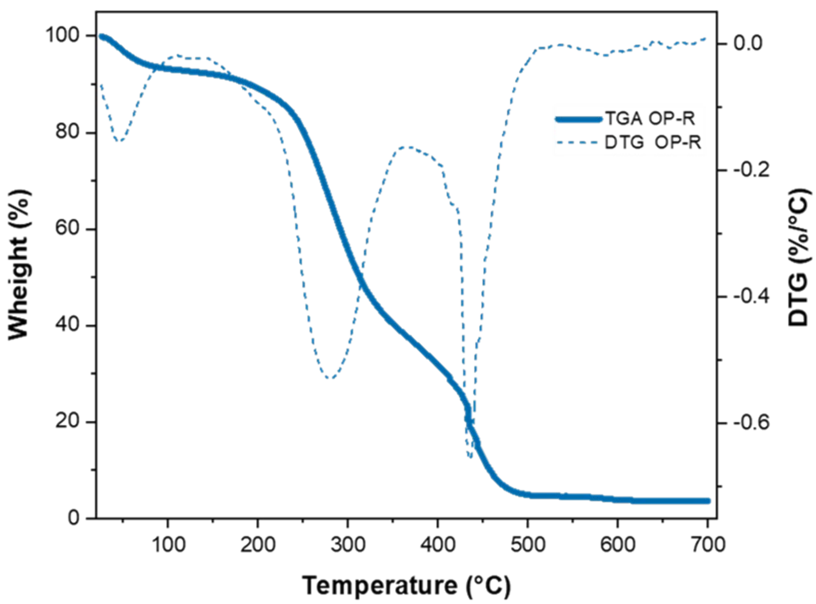

Fig. S2. TG and DTG curves of the OP-R

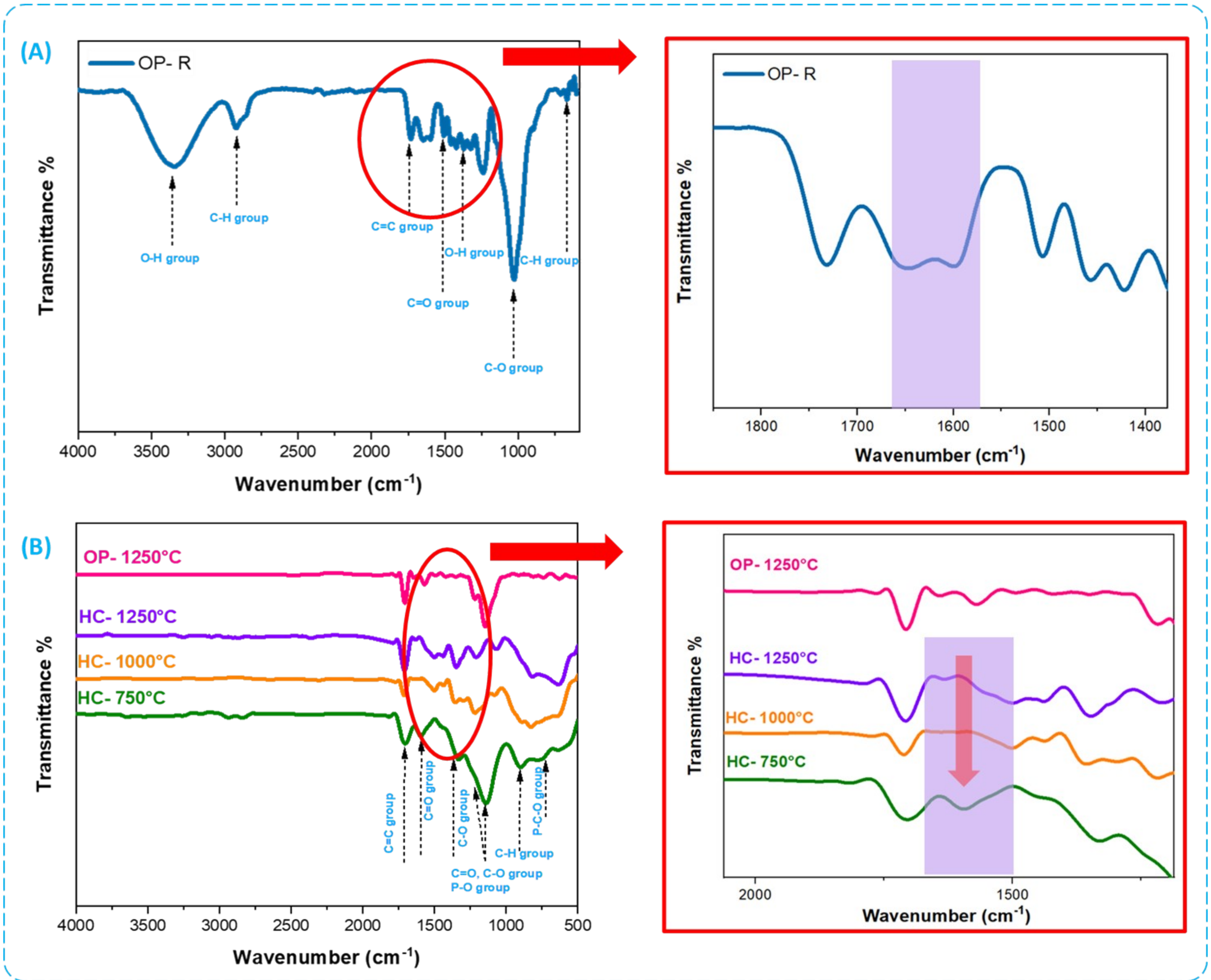

Fig. S3. (A) FT-IR spectra of OP-R, (B) of HCs obtained for different temperatures.

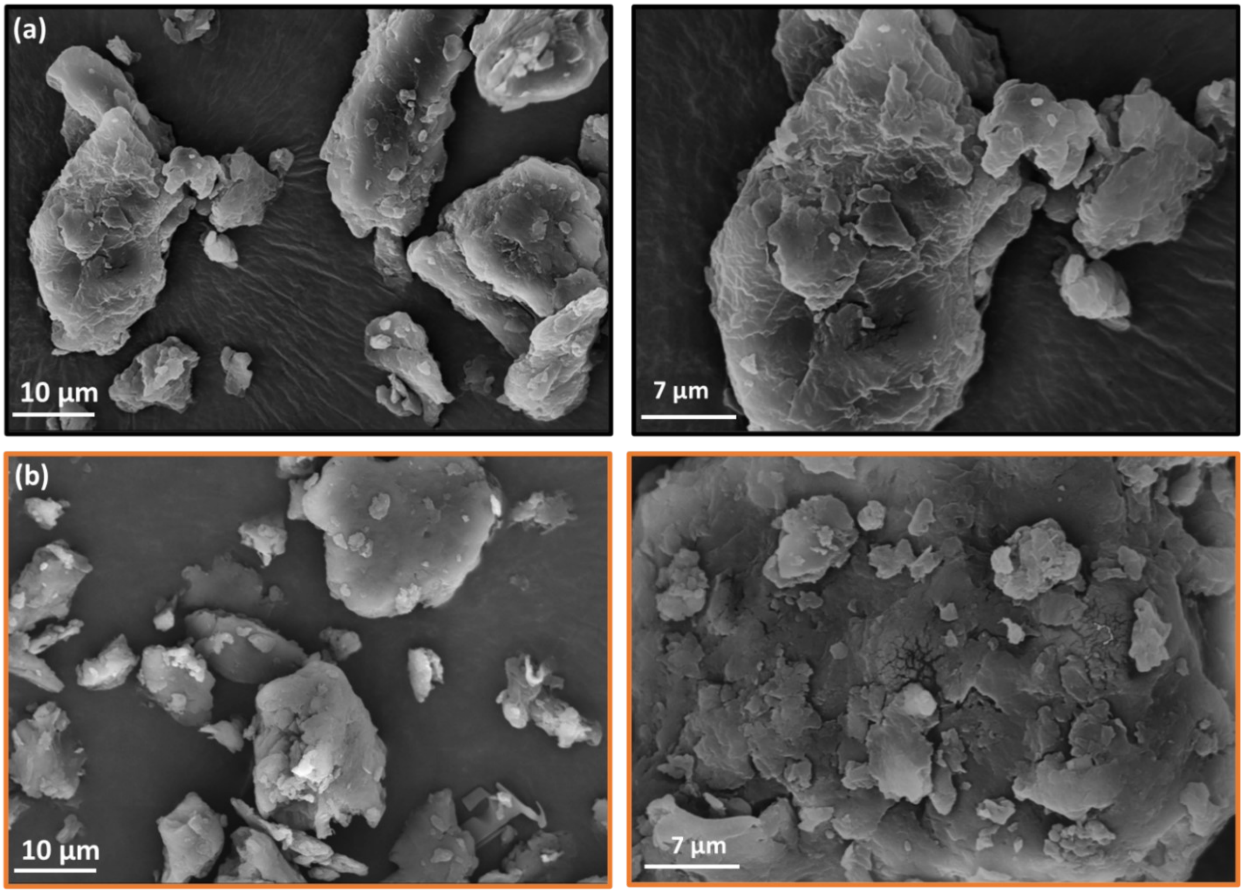

Fig.S4. SEM images and magnification of (a) Raw olive pomace OP-R, and (b) chemically activated OP-A.

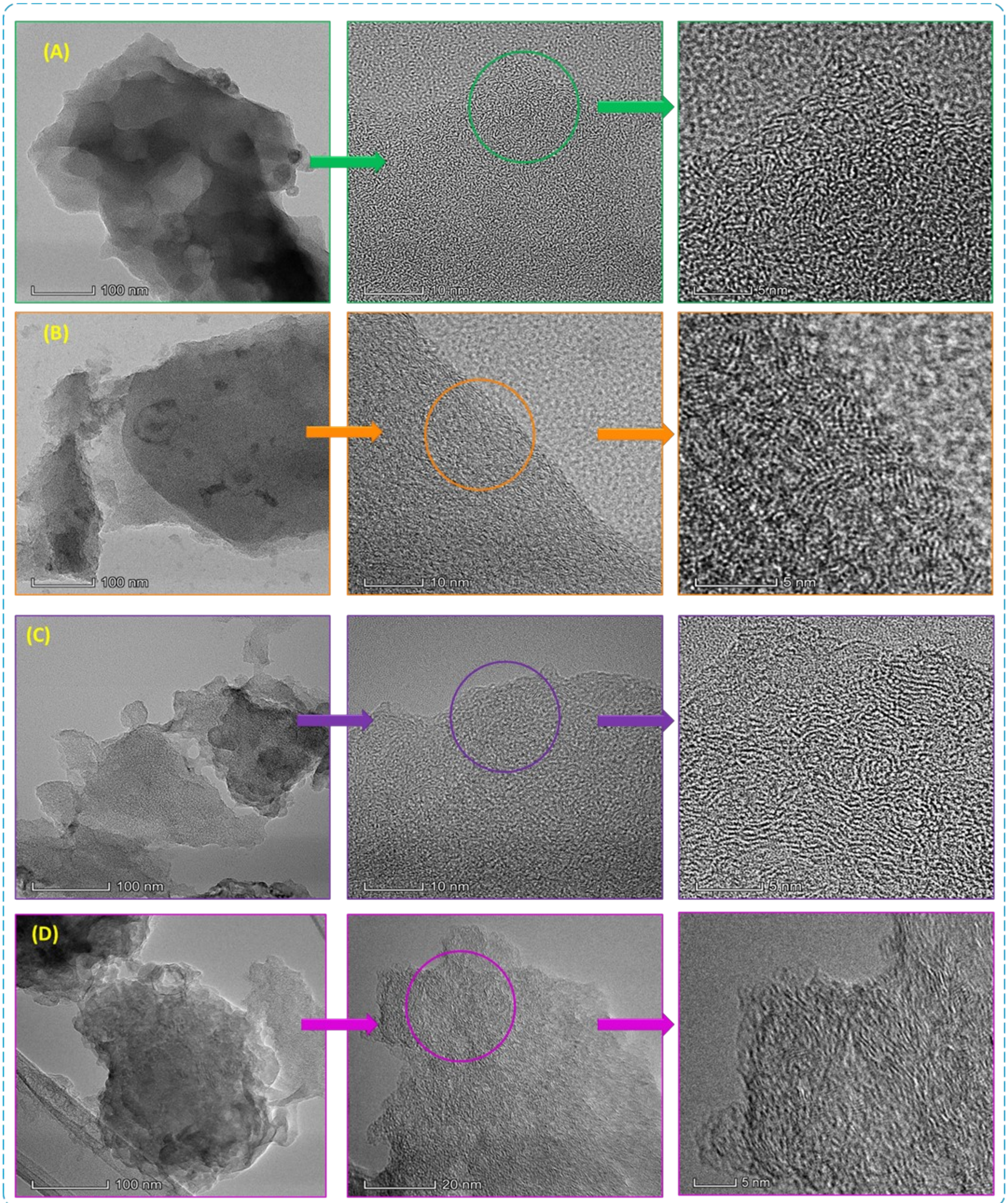

Fig. S5. HR-TEM images of HC samples synthesized at various temperatures. (A) HC-750°C, (B) HC-1000°C, (C) HC-1250°C, and (D) OP-1250°C.

Table S1. Results of EDX (SEM) and XRF analysis for activated carbons derived from olive pomace.

Sample	***EDS (wt %)***					***XRF (%)***					
	C%	O%	Ca%	K%	P%	SiO_2	Al_2O_3	Fe_2O_3	CaO	K_2O	P_2O_5
OP- R	82.50	15.40	0.93	0.63	**0.05**	0.46	-	0.13	1.97	2.05	**0.19**
OP-A	67.38	31.49	-	-	**0.33**	0.51	-	0.03	0.06	0.02	**5.45**

Table S2. Results of EDX (HRTEM) of HCs derived from olive pomace.

Sample	***EDS (wt %)***									
	C%	O%	Mg%	Si%	Ca%	K%	S%	Cu%	Cl%	Fe%	P%
HC-750 °C	69.87	20.93	2.13	0.44	2.18	-	-	-	-	-	**4.46**
HC-1000°C	93.33	4.95	-	0.22	0.13	-	0.10	-	0.17	-	**1.10**
HC-1250°C	89.39	6.19	-	0.26	0.31	-	0.33	2.99	-	-	**0.53**
OP-1250°C	77.06	10.47	-	0.33	1.95	1.60	0.10	7.73	-	0.29	**0.21**

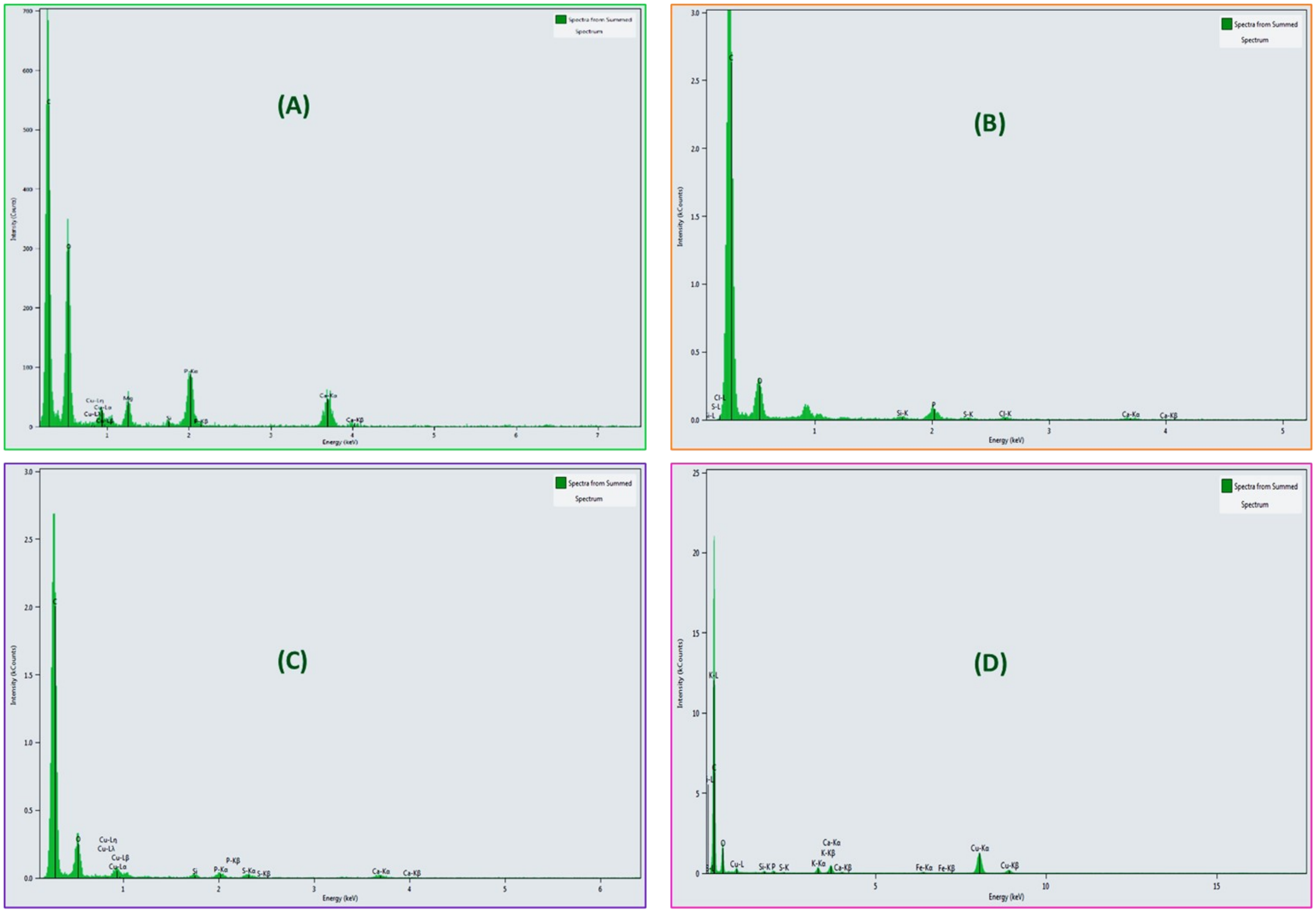

Fig. S6. (A-D) EDX-HRTEM spectra of HC-750, HC-1000, HC-1250 and OP-1250°C respectively.

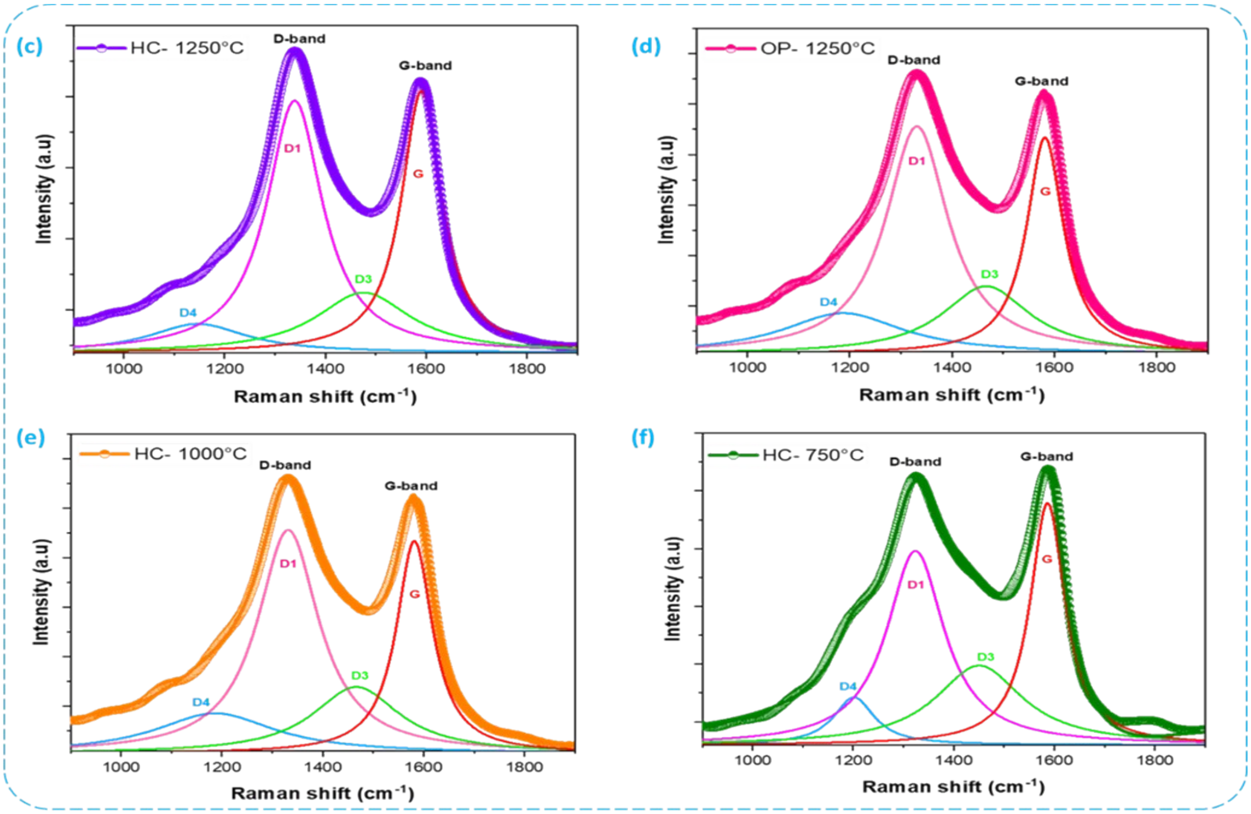

Fig. S7. (C-E) Fitted Raman spectra of HC-1250, OP-1250, HC-1000 and HC-750°C respectively.

REFERENCES

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