applied sciences

MDPI

CVD Synthesis of Solid, Hollow, and Nitrogen-Doped Hollow Carbon Spheres from Polypropylene Waste Materials

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Experimental procedure

The procedure described in ref 1 was used here. The only difference related to the use of a quartz reactor instead of a steel reactor. After the PP had been loaded into the quartz reactor the system was flushed with argon for 10 min. The second stage oven was heated at 10 °C per minute under 100 sccm argon gas until the required reaction temperature had been reached (900, 1000 and 1100 °C). Once this has been achieved the first reactor stage was heated at 10 °C per minute from room temperature to 500 °C. At this temperature the plastic waste converted to propylene which was used as the hydrocarbon source to make carbon materials in the second stage of the reactor. The reaction was maintained at the required temperature for 1–2 hours and after natural cooling of the CVD furnace, the black soot was recovered by scraping the black powder from the tube. The procedure used to make the carbon materials is summarized in Figure S1.

1. Tripathi PK, Durbach S, Coville NJ. Synthesis of Multi-Walled Carbon Nanotubes from Plastic Waste Using a Stainless-Steel CVD Reactor as Catalyst. Nanomaterials. 2017; 7(10):284.

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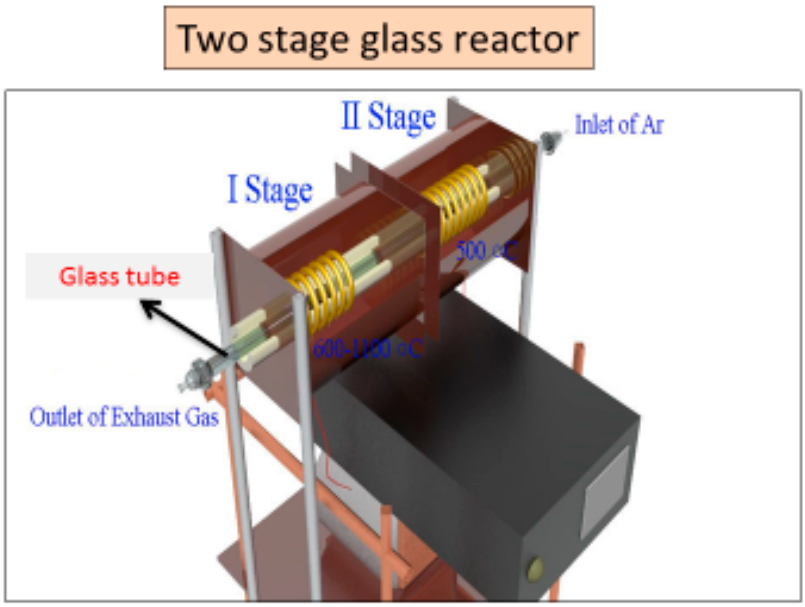
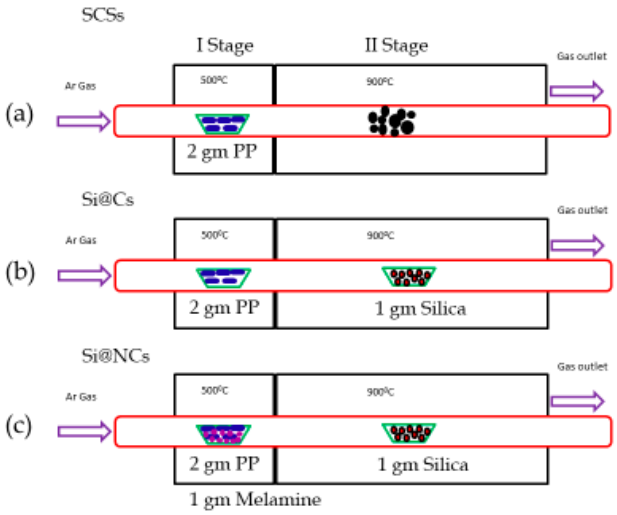


(**A**)



(**B**)

Figure S1. (A) Schematic of the apparatus (modified form from ref. [26]), **(B)** Schematic view of the two stage based CVD furnace used for the synthesis of CSs from polypropylene (a) SCSs, (b) Si@CSs and (c) Si@NCSs.

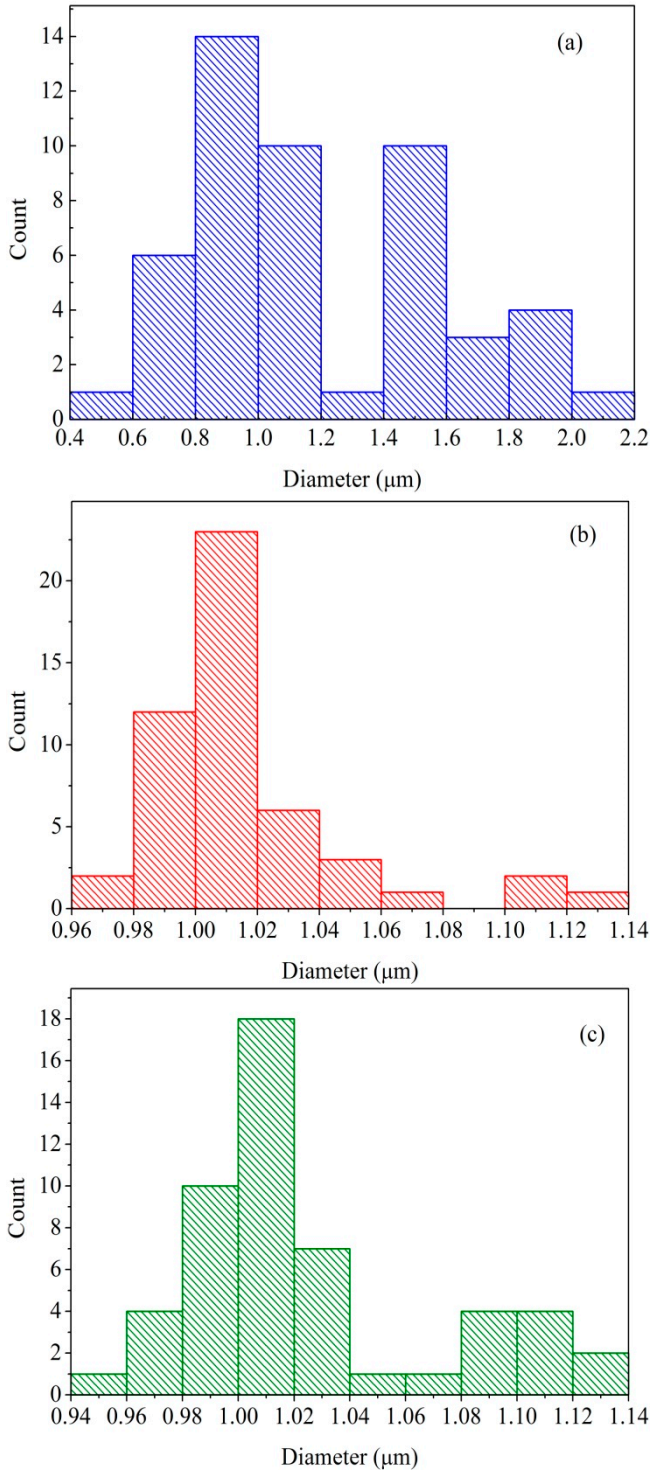


Figure S2. Diameter distribution of (**a**) SCSs, (**b**) HCSs and (**c**) and NHCSs.

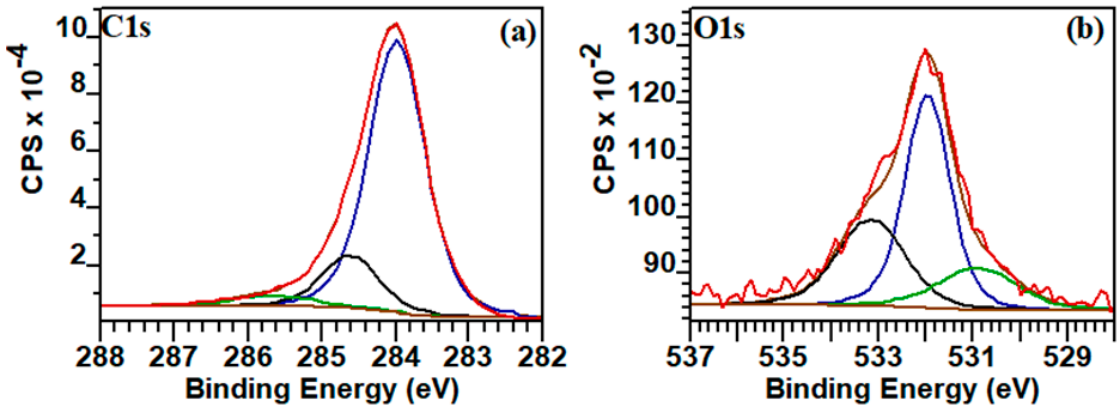


Figure S3 High resolution XPS data for (**a**) C1s and (**b**) O1s XPS spectra of HCS sample.

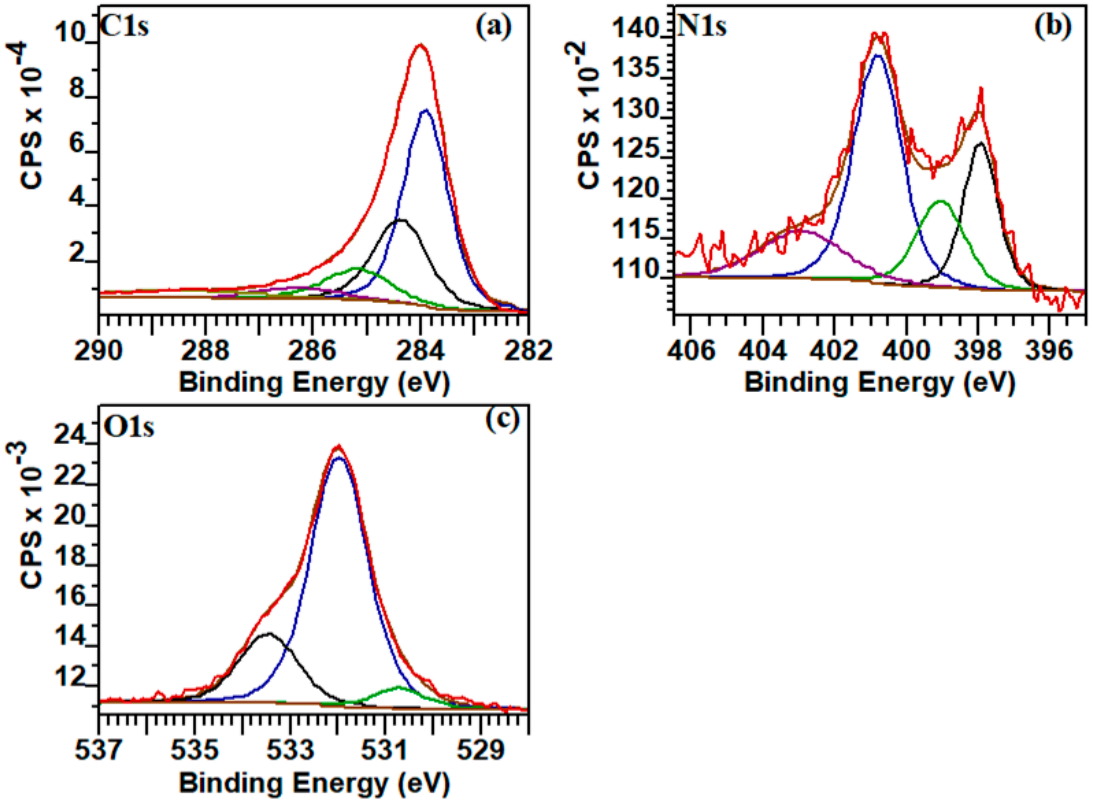


Figure S4 High resolution XPS data for (a) C1s, (b) N1s and (c) O1s XPS spectra of NHCS sample.

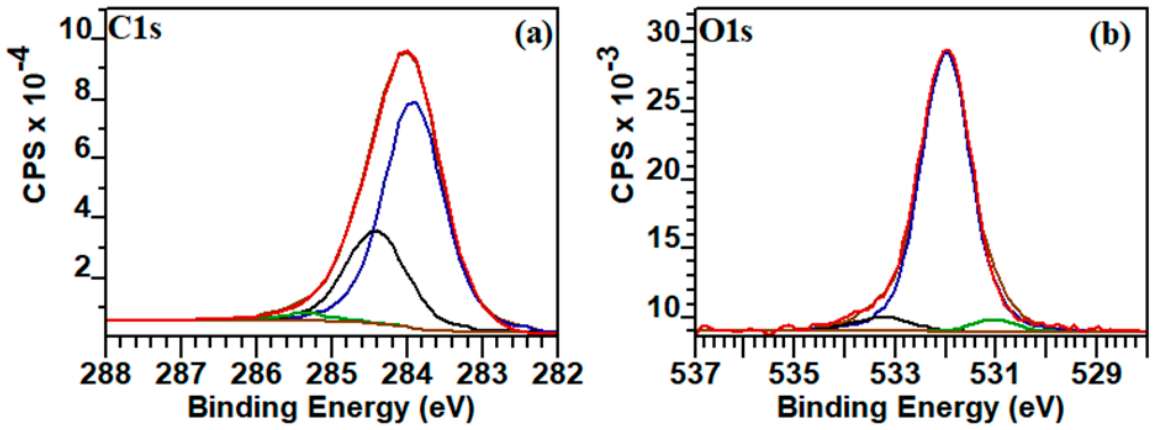


Figure S5 High resolution XPS data for (a) C1s and (b) O1s XPS spectra of SCS sample.

Table S1. Summary of XPS data.

Element / Samples	C (at %)	N (at %)	O (at %)	N/C (at %)	O/C (%)
HCS	97.73	-	2.27	-	2.32
SCS	92.86	-	7.14	-	7.69
NHCS	91.76	3.48	4.77	3.79	5.20

Table S2. XPS component peak positions.

Peaks / Samples	C-C (eV)	N-sp²-C (eV)	N-sp³-C/ sp³-C (eV)	C-O (eV)	N-C=O/O-C=O (eV)	Pyridinic-N (eV)	Pyrrolic-N (eV)	Graphitic-N (eV)	N-O (eV)	O-C-O	O-C=O	C-O-C
HCS	283.97	-	284.60	285.64	-	-	-	-	-	530.90	533.16	531.96
SCS	283.89	-	284.43	285.36	-	-	-	-	-	531.02	533.26	531.99
NHCS	283.91	284.38	285.18	286.26	288.52	397.93	399.04	400.81	402.94	530.70	533.45	531.96

Table S3. Summary of % concentration of all bonds in the samples.

	% Concentration of C-bonds					% Concentration of N-bonds				% Concentration of O-bonds		
Peaks / Samples	**C-C (eV)**	**N-sp²-C (eV)**	**N-sp³-C/ sp³-C (eV)**	**C-O (eV)**	**N-C=O/O-C=O (eV)**	**Pyridinic-N (eV)**	**Pyrrolic-N (eV)**	**Graphitic-N (eV)**	**N-O (eV)**	**O-C-O**	**O-C=O**	**C-O-C**
HCS	79.96	-	15.66	4.88	-	-	-	-	-	17.75	30.78	51.47
SCS	69.28	-	28.48	2.24	-	-	-	-	-	3.52	5.03	91.45
NHCS	51.22	26.21	11.88	4.88	5.82	20.87	17.37	45.20	16.56	5.43	21.03	73.54