Supplementary Material (ESI) for Chemical Communications

Supplementary information

Mesoporous Carbon/silica Nanocomposite Particles through Aerosol-assisted Multi-component Assembly

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Experimental Section

Material synthesis

The synthesis of oligomeric resol was performed according to published procedures [2]. Briefly, 6.5 mmol phenol, 13 mmol formaldehyde and 0.65 mmol sodium hydroxide were reacted at 70 ^{o}C for 1 hour and then neutralized using HCl. The organic precursor sol was prepared by mixing the obtained resol, 1 g block copolymer F127 and 20 mL ethanol. The silicate precursor sol was prepared by reacting tetraethoxysilane (TEOS) in acid water/ethanol solvent at room temperature under sonication for 30 minutes. The molar ratio of the reactants was maintained at TEOS:ethanol: HCl:H_2O:F127 =1:50:0.01:5:0.01. Desired amount of silicate sol was added into the organic precursor sol and sent to the aerosol atomizer (TSI model 3076) to produce aerosol droplets using 40 Psi N_2 as carrier gas. [1] The surfactant was removed by calcination at 350 °C under N_2 for 4 hours. The obtained brown samples with a resol/silica weight ratio of 1:0.75, 1:0.5 and 1:0.25 are labeled as polymer-Si-1, polymer-Si-2 and polymer-Si-3 respectively. These samples were carbonized at 900 ^{o}C under N_2 for 4 hours to produce carbon/silica nanocomposites C-Si-1, C-Si-2 and C-Si-3, respectively. The silica component can be removed by stirring the sample in 20% HF for 48 hours to produce pure carbon C-1, C-2 and C-3, respectively.

Catalyst deposition

Pt was deposited on the porous carbon/silica or Vulcan XC72 using an aqueous solution of diamineplatinum nitrite as a precursor. The mixture of sample and the aqueous catalyst precursor solution was maintained at 90^{o}C and pH=3 with diffused passage of carbon monoxide gas through the reaction medium. Hydrazine hydrate was used for the reduction of platinum.

Characterization

Nitrogen adsorption/desorption isotherms were obtained using a Micrometitics ASAP 2010. The BET surface area and pore size distribution were calculated from the isotherms using the ASAP 2010 v.5 software. TEM micrographs were obtained using a JEOL 2010 microscope operated at 200 KV. XRD measurements were performed on a Philips Xpert X-ray diffractometer using Cu K radiation.

The electrical conductivity were measured using four point method on a Modal LR-700 AC Resistance Bridge made by Linear Research Inc.

Oxidation test was conducted through accelerated thermal sintering experiments on a Micromeritics 2910 Automated Catalyst Characterization System that was modified to allow external gas inputs through the vapor accessory valve. Fresh 60 mg electrode sample was carried out at 250 ^{o}C in humidified He gas streams under certain O_2 concentration. The total gas flow during each sintering test was held constant at 50 sccm. The initial and final sample weight was recorded to determine the percent weight loss.

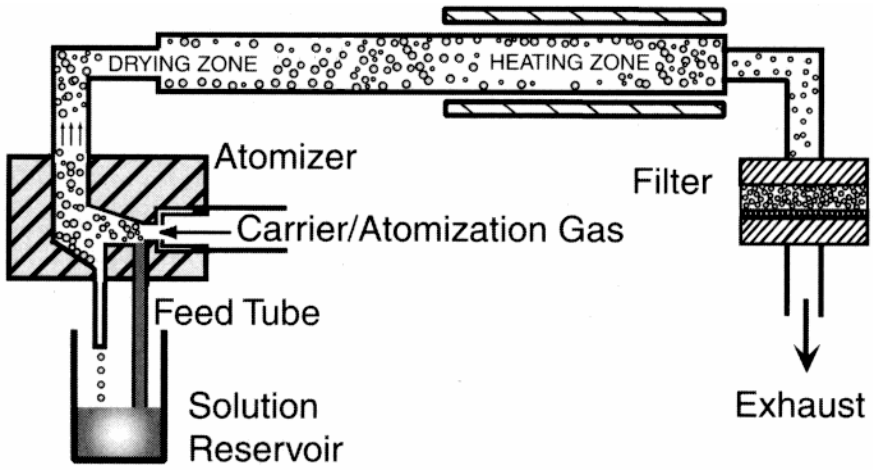


Figure S1. Schematic of the aerosol apparatus used for the aerosol process

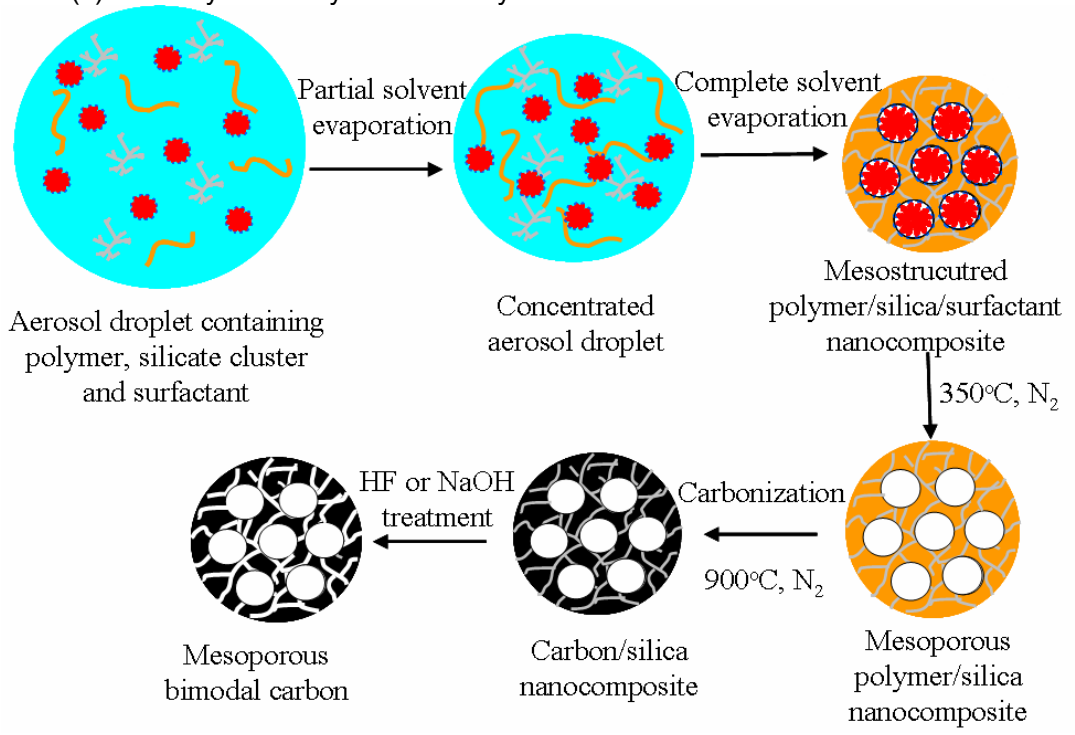


Figure S2. Proposed formation of ordered mesoporous polymer/silica, carbon/silica nanocomposites and bimodal carbon particles through aerosol-assisted multi-component assembly.

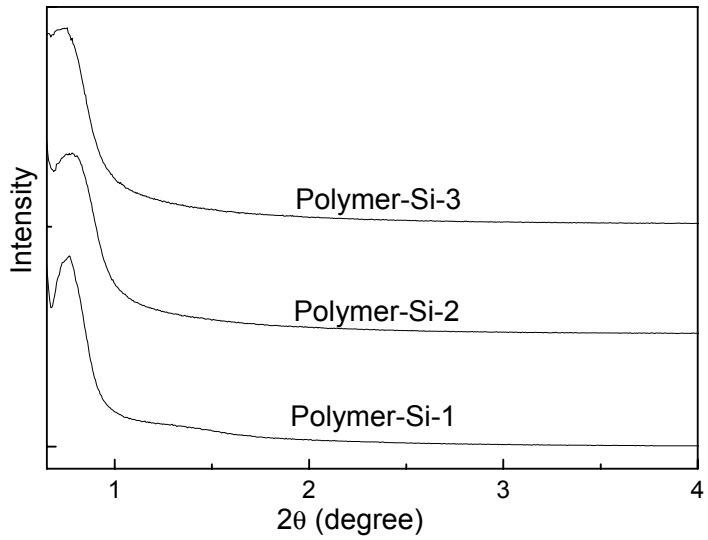


Figure S3. Low angle XRD patterns of mesoporous polymer/silica nanocomposites with oligomer:silica weight ratio of 1:0.75, 1:0.5, and1:0.25 respectively.

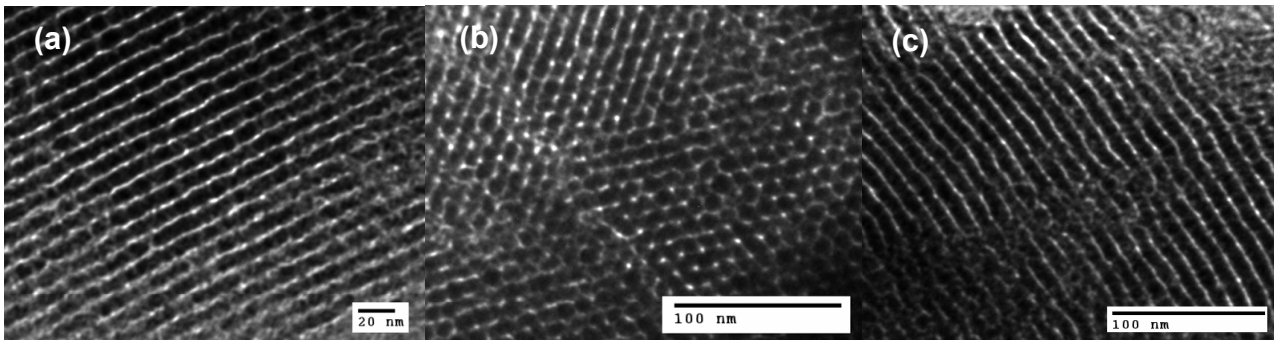
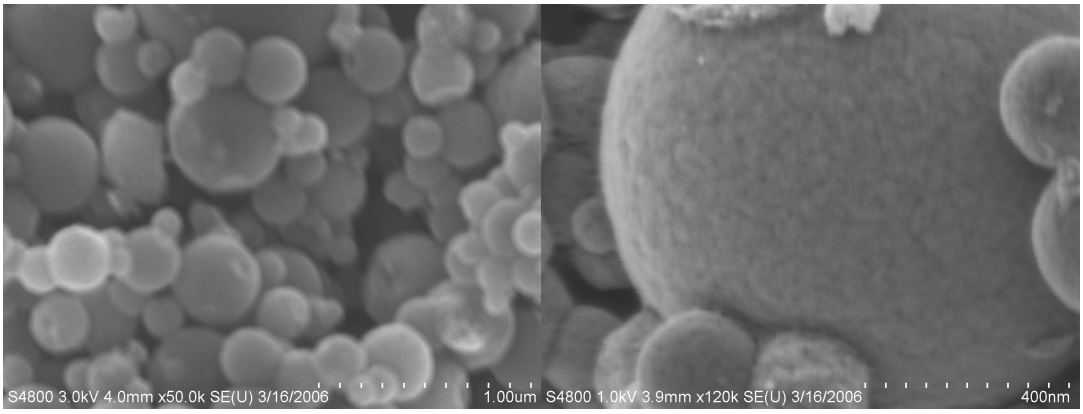


Figure S4. TEM images of mesoporous polymer/silica (a), carbon/silica (b) and pure carbon (c) prepared by casting process from precursors containing oligomer: silica weight ratio of 1:0.5



（a） (b)

Figure S5. Representative SEM images of mesoporous carbon/silica nanocomposites C-Si-1

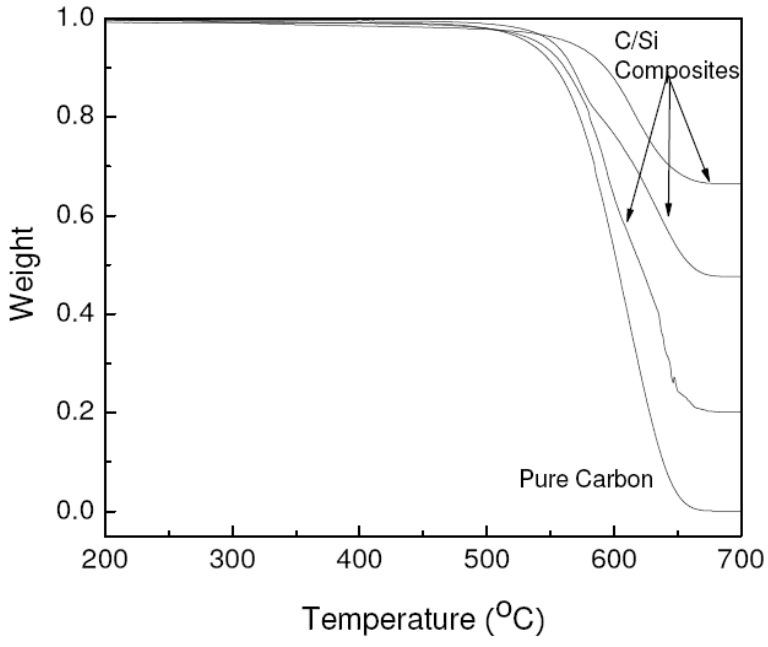


Figure S6 TGA curves of mesoporous carbon/silica nanocomposites and pure carbon under air

Table S1. Porosity properties for Polymer-Si-X, Si-C-X and C-X samples

Samples	Oligomer:Silica (weight ratio)	Surface area (m^2/g)	Micropore Surface area (m^2/g)	Peak pore diameter (nm)	Pore volume (cm^3/g)	Micropore volume (cm^3/g)
Polymer-Si-1	1:0.75 Fig 1a, 1c, 1e	526	121	7.0	0.61	0.050
C-Si-1		566	147	5.7	0.64	0.065
C-1		2344	375	2.0, 5.9	2.02	0.21
Polymer-Si-2	1:0.5 Fig 1b, 1d, 1f	465	15.5	7.5	0.69	~0
C-Si-2		577	167	6.0	0.71	0.075
C-2		2109	411	2.0, 6.0	1.92	0.23
Polymer-Si-3	1:0.25	468	113	10.0	0.65	0.048
C-Si-3		691	253	8.5	0.76	0.11
C-3		1685	327	2.0, 6.3	1.73	0.14