

Supporting information

Catalyst free silica templated porous carbon nanoparticles from bio-waste materials

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The trunks, empty fruit bunches, fronds and leaves are the estimated 30 million tons of lignocellulosic biomass in Malaysian oil-palm industry.[1s] The ineffective utilization; open burning and land felling of oil-palm residues, can cause pollution. Therefore, finding uses for oil-palm biomasses would be profitable from both an environmental and economic point of views.

Experimental Section

Materials: The dry oil palm fronds were collected from local oil palm estate in Malaysia, the leaves was separated from the fronds and dry in oven at 60 °C for two days to remove all the moisture. The dry OPL was crushed into small size, than grind at speed 12000 rpm using grinder (Retsch, ZM 200, Germany) and further the grind OPL was sieved to the particle size 62 µm.

Pyrolysis: The OPL was pyrolyzed in tube furnace (Nabertherm, EW-33334-36) at 500 °C and 600 °C for 2h under the continuous flow of N₂ (150 ml cm⁻³) at a heating rate of 5 °C m⁻¹ and simultaneously cool down to room temperature in the N₂ atmosphere to get pyrolyzed product. The aqueous NaOH, 2.5 M was employed to remove the silica from pyrolyzed product and generate the PCNs.

Characterizations: The OPL and PCNs was characterized using FTIR (Perkin, Elmer Spectrum 100), FESEM-EDX (JEOL, JSM-7800F), XRD (Rigaku Mineflex II) and TEM (JEOL, JSM 1230). The BET surface area and pore width of PCNs was evaluated using Micromeritics ASAP 2020 under low pressure dose, the PCNs samples was degased for 12 h at 200 °C. The Raman spectra of PCNs were taken using HORIBA Scientific Raman spectroscopy.

REFERENCES

[1s] S. Sumathi, S. P. Chai, R. Mohamed. *J. Renew. Sust. Energy Rev.* 2008, **12**, 2404.

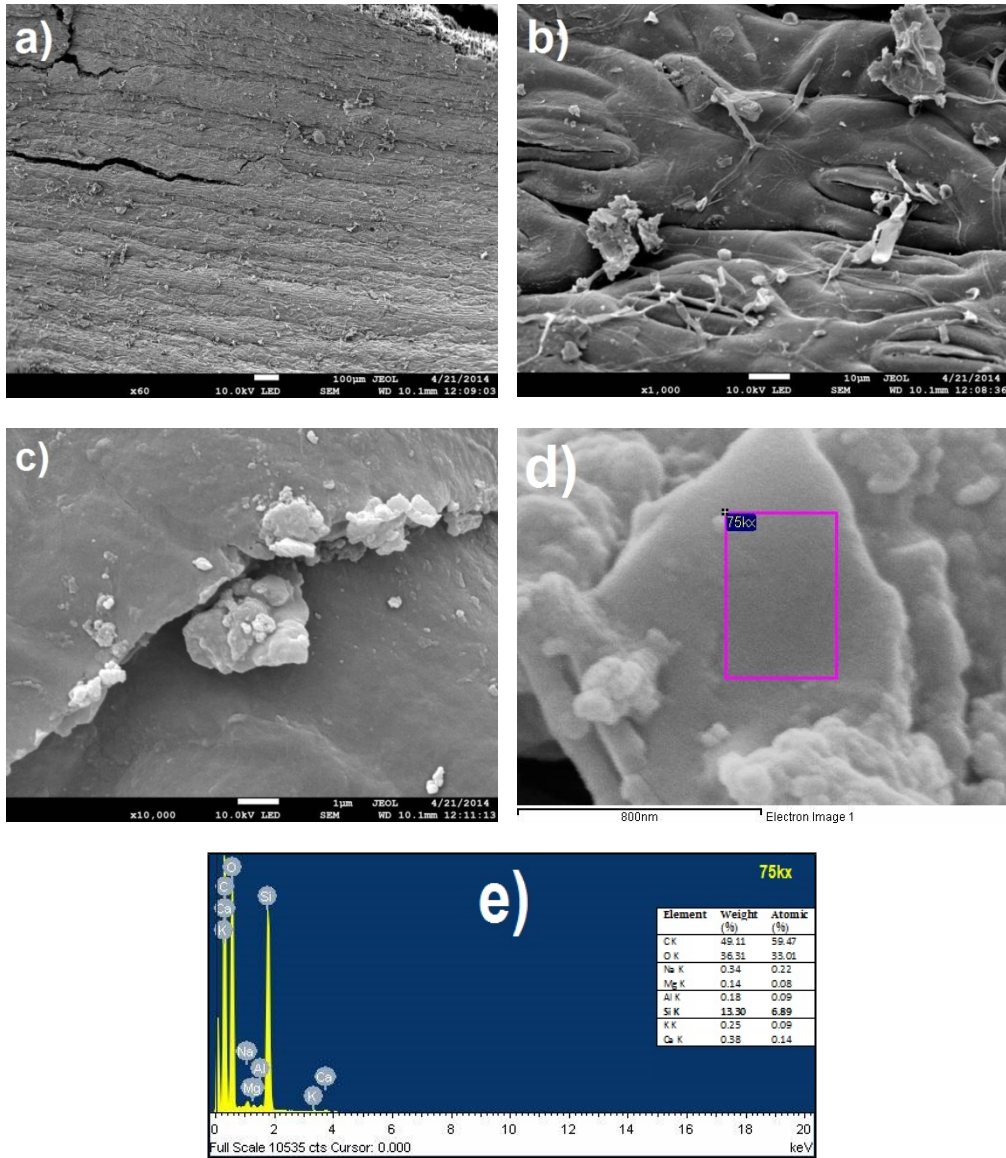


Figure S1. Microscopic (FESEM) images of OPL (a) surface structure of OPL at 100 μm scale, (b) OPL cell wall at 10 100 μm scale, (c) secondary wall layer of OPL at 1 100 μm scale, (d) cell wall at 800 nm scale and (e) energy dispersive X-ray (EDX) analysis of different elements present in cell wall of OPL.

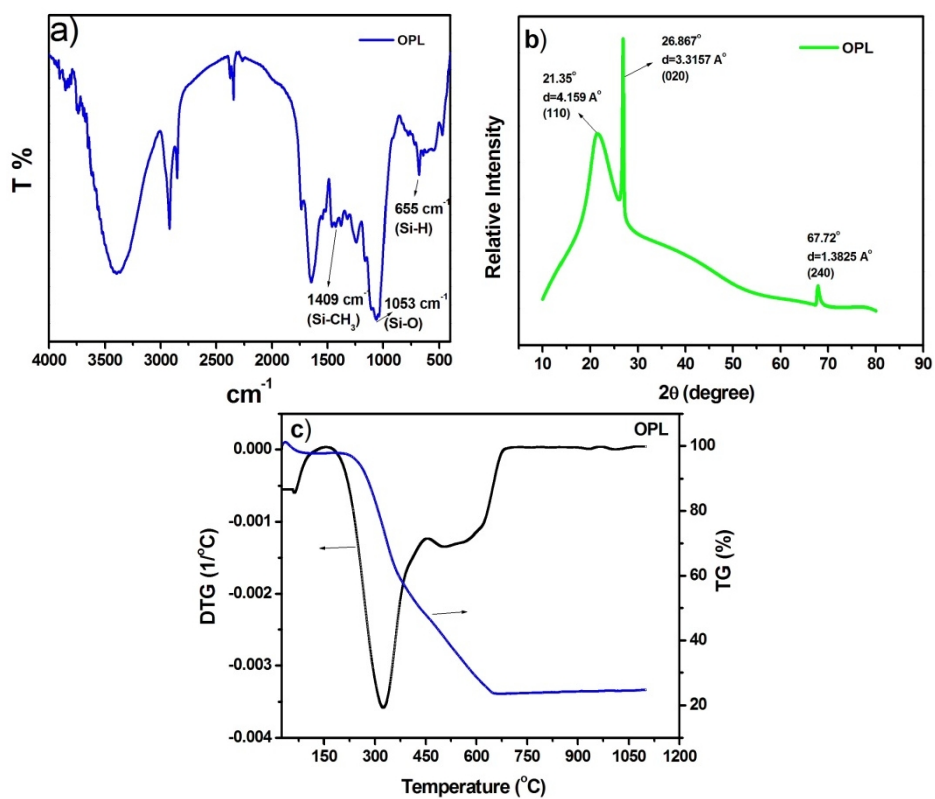


Figure S2. Characterization of OPL (a) FTIR spectrum, (b) X-Ray diffraction peaks, and (c) thermo gravimetric analysis.

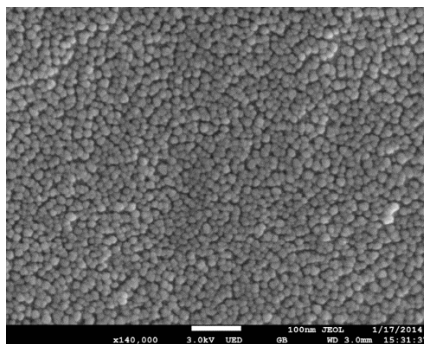


Figure S3. FESEM images of PCNs 600 $^{\circ}\text{C}$ pyrolysis temperature.

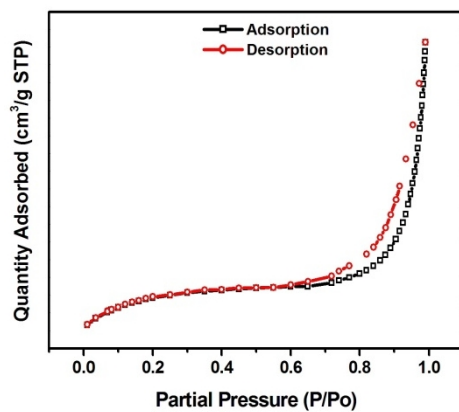


Figure S4. Nitrogen adsorption and desorption curve of PCNs prepared at 600 °C pyrolysis temperature.

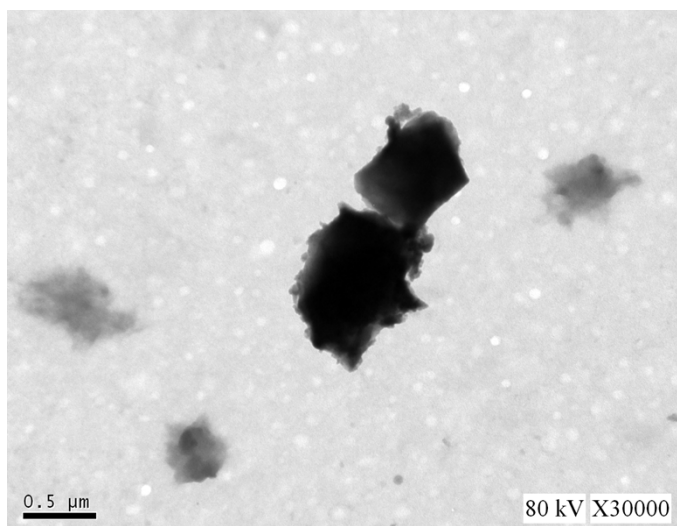


Figure S5. The TEM image of PCNs at 700 °C pyrolysis temperature.

Table S1: Elemental analysis results of porous carbon nanoparticles after silica removal.

Sample	C (%)	H (%)	O (%)	N (%)
500 °C	78.223	8.370	9.463	4.04
600 °C	86.340	5.154	7.742	1.764