Electronic Supplementary Material (ESI) for RSC Advances.

Improvement of cycling performance of a pitch-based carbon/nano-silicon matrix anode for Li-ion batteries

Angel Manuel Escamilla-Pérez[a,*], Aude Roland[a], Sophie Giraud[a], Céline Guiraud[a], Héloïse Virieux[b], Kévin Demoulin[b], Yohan Oudart[b*], Nicolas Louvain[a,c], Laure Monconduit[a,c]

[a]Institut Charles Gerhardt Montpellier, CNRS UMR 5253, Univ. Montpellier, 34095 Montpellier, France

[b]Nanomakers, 1 rue de Clairefontaine, 78120 Rambouillet, France

[c]Réseau sur le Stockage Electrochimique de l'Energie (RS2E), CNRS FR3459, 33 Rue Saint Leu, 80039 Amiens, Cedex, France

*Corresponding authors

e-mail addresses: youdart@nanomakers.fr; laure.monconduit@umontpellier.fr

Supplementary Information

TEM of the Si nano-particles with and without carbon coating

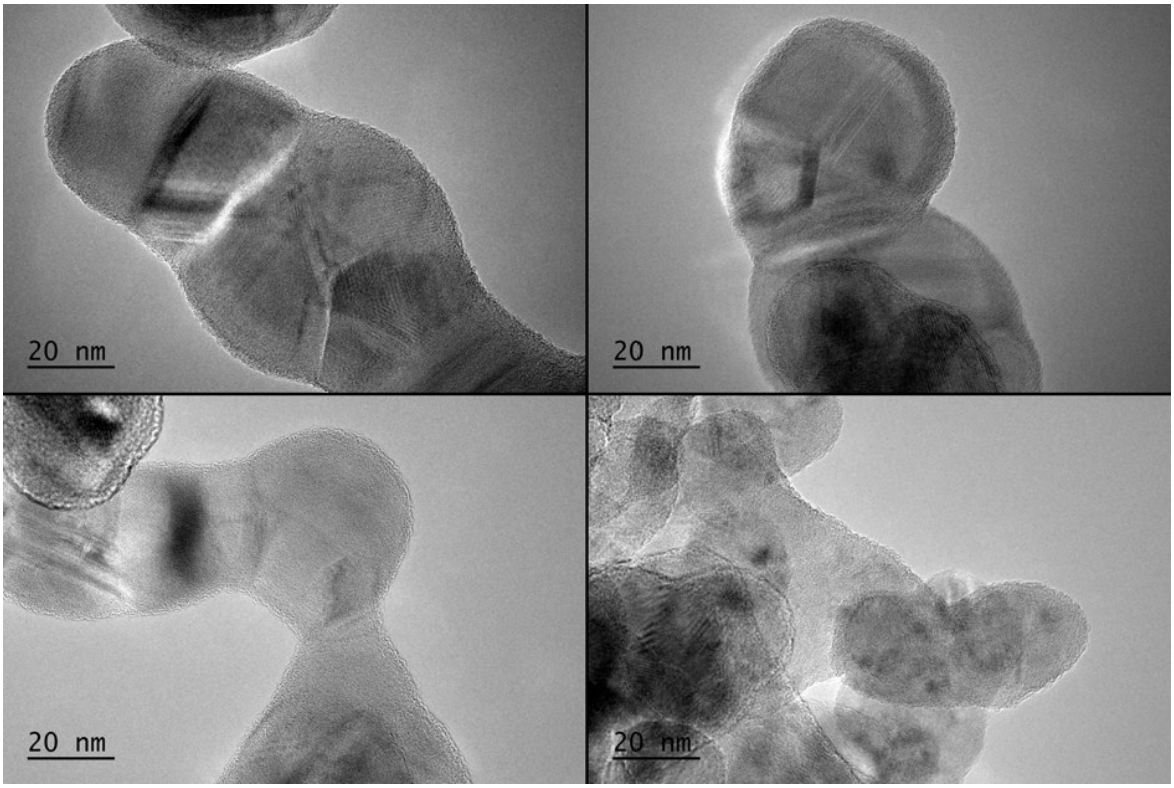


Fig. S1-a TEM images of Si_40C carbon coated particles

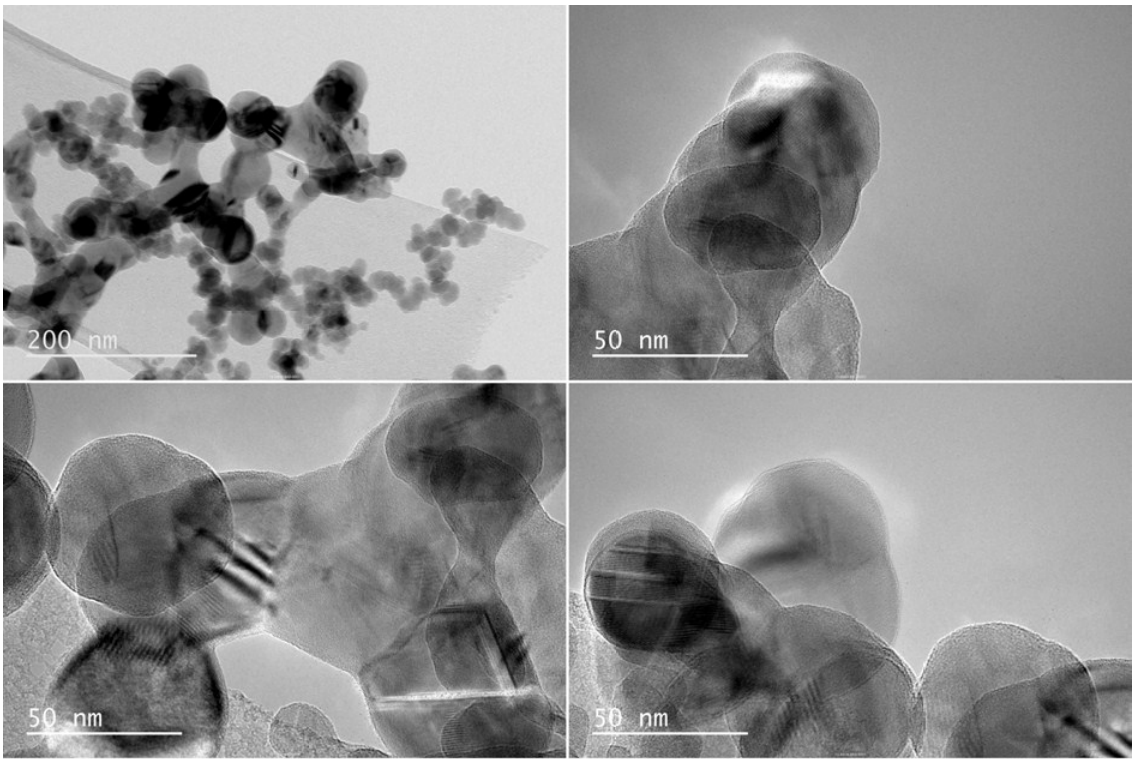


Fig. S1-b TEM images of Si_40 uncoated particles

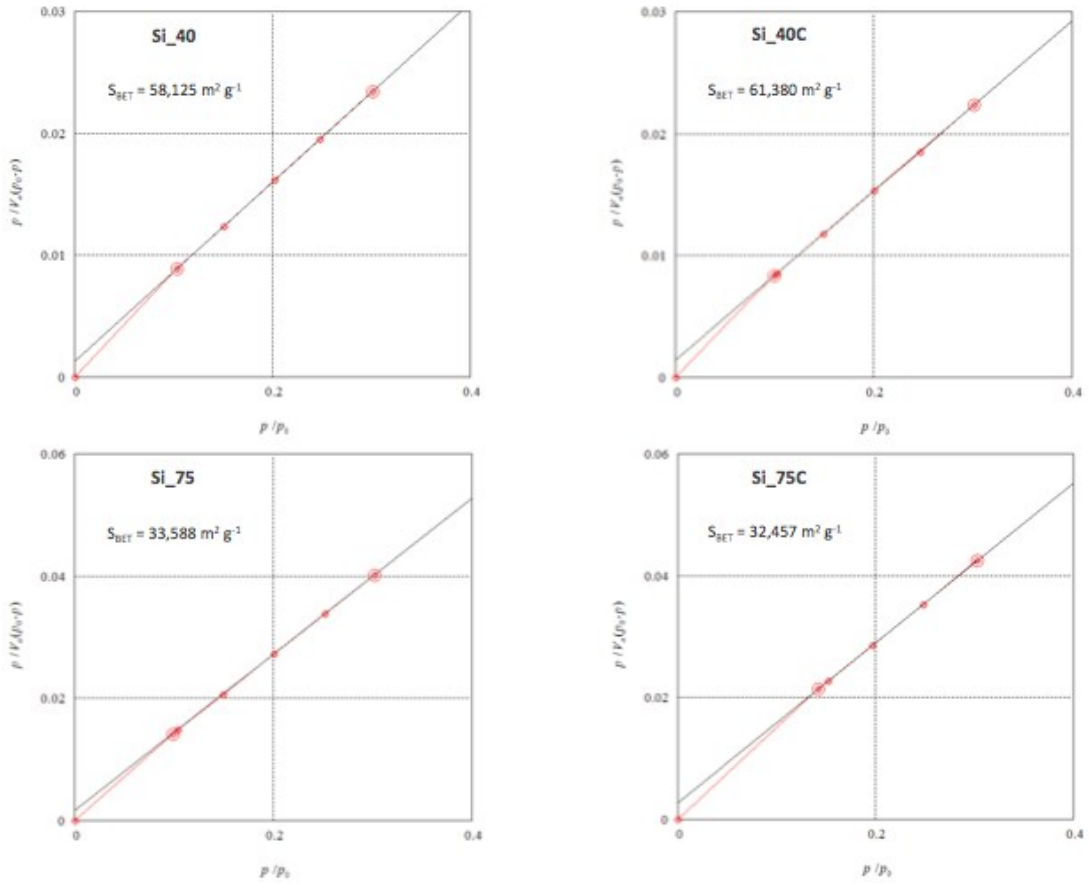


Fig. S2: BET plots of the different types of Si particles (adsorptive N_2, adsorption temperature at 77K)

The particle size was deduced form those BET measurements using the following formula:

d (nm) = 6000 / S_{BET} (m^2 g^{-1}) * ρ (g cm^{-3}) with ρ = 2,30 g cm^{-3} for these silicon nanoparticles

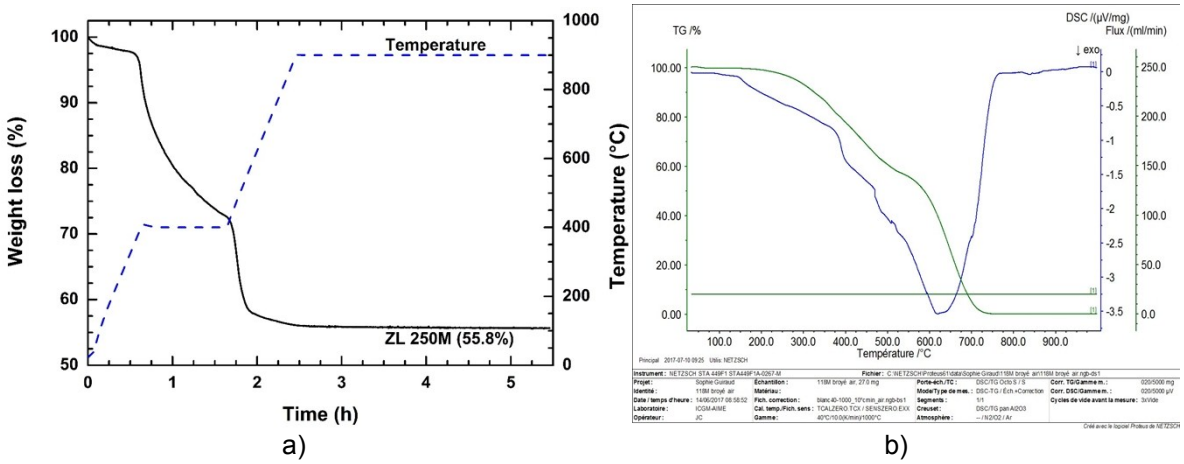


Fig. S3 TGA of a) ZL 250M under N_2 (heating rate 10 °C min^{-1}) and b) of 118M under air (heating rate 10 °C min^{-1})

Calculations:
For a composite prepared with 100mg of Si and 1.285g of ZL250M, due to the weight loss of ZL250M at 900°C (44.2%), the stoichiometry in Si can be estimated to be 0.1/(0.1+ 0.558 x1.285)= 12.2% wt.

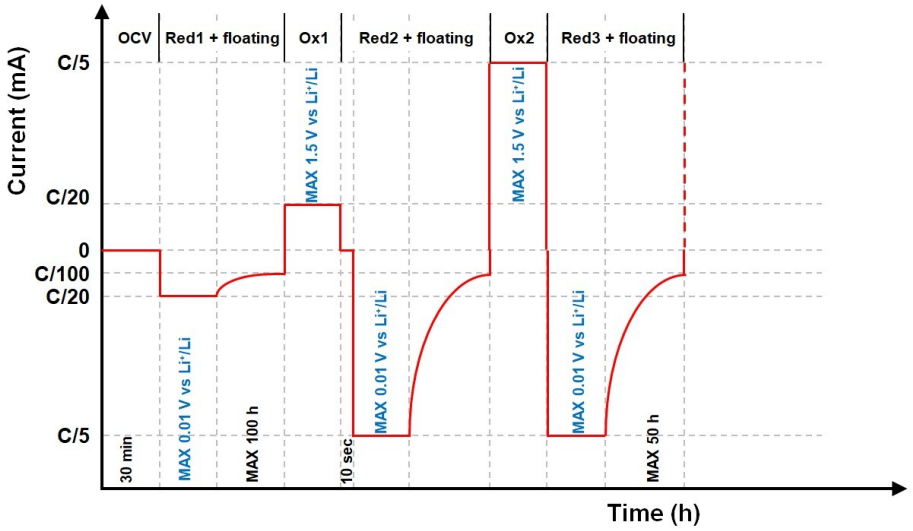


Fig. S4 Cycling conditions for electrochemical galvanostatic measurements

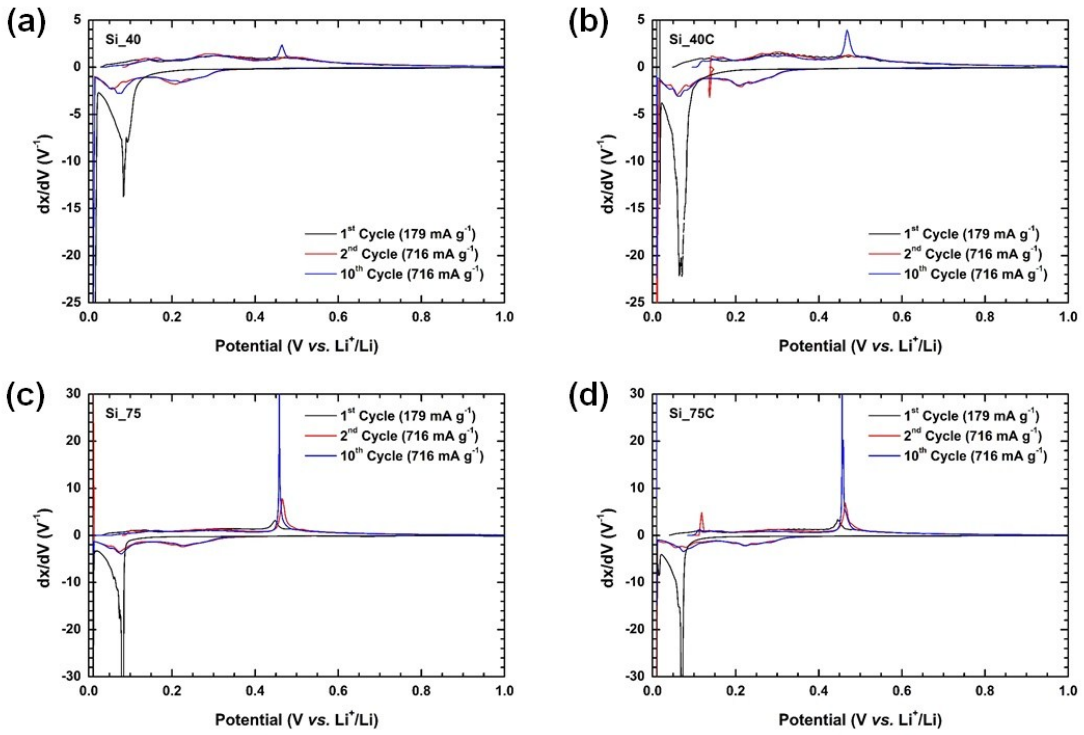


Fig. S5 First derivative of the charge/discharge profiles of the silicon nanoparticles at a current rate of 179 mA.g^{-1} (1st cycle) and at a current rate of 716 mA.g^{-1} (2nd and 10th cycles) for a voltage window of 0.01-1.5 V *vs.* Li$^+$/Li; Si_40 (a), Si_40C (b), Si_75 (c) and Si_75C (d)

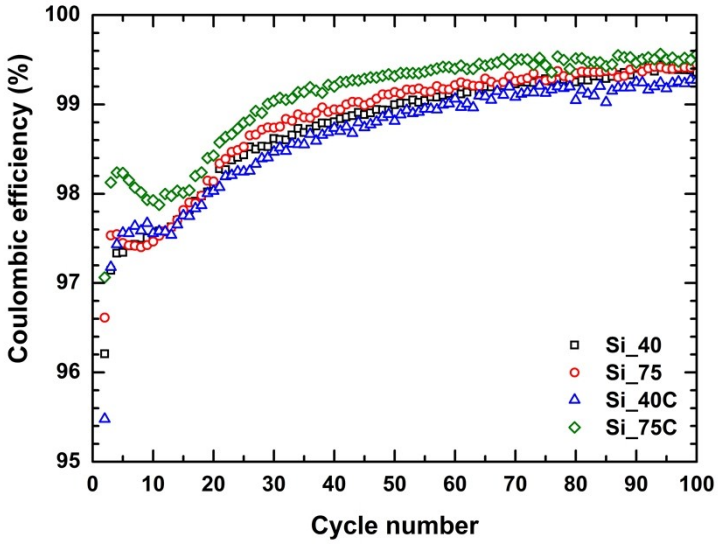


Fig. S6 Coulombic efficiency of carbon-coated and uncoated silicon nanoparticles at a current density of 716 mA.g^{-1} (179 mA.g^{-1} for the 1st cycle). Voltage window of 0.01-1.5 V *vs.* Li$^+$/Li.

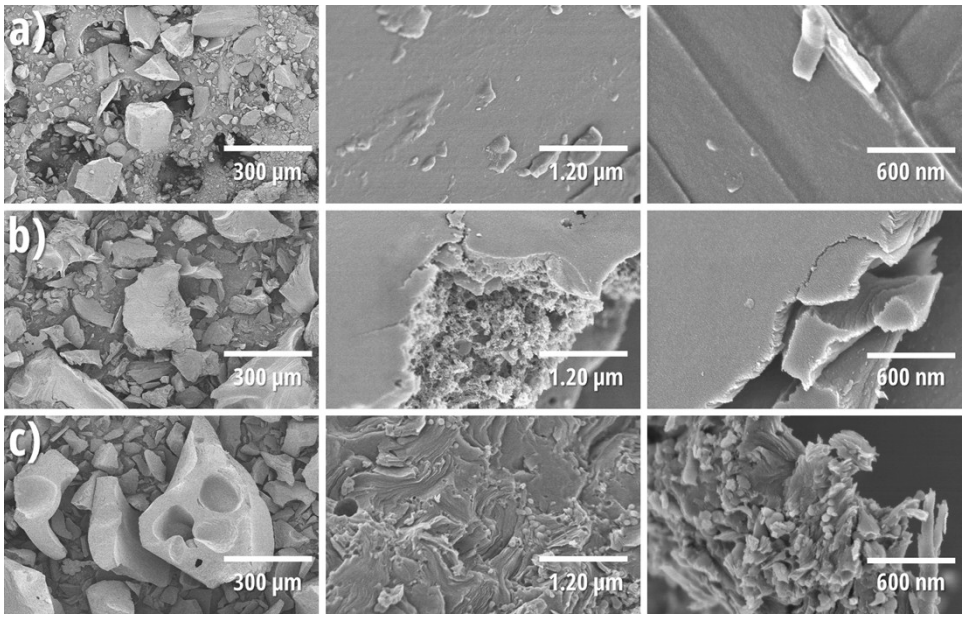


Fig. S7 Scanning electron micrographs of ZL 118M (a), _118M (b) and Si_75C_118M (c) at different magnifications

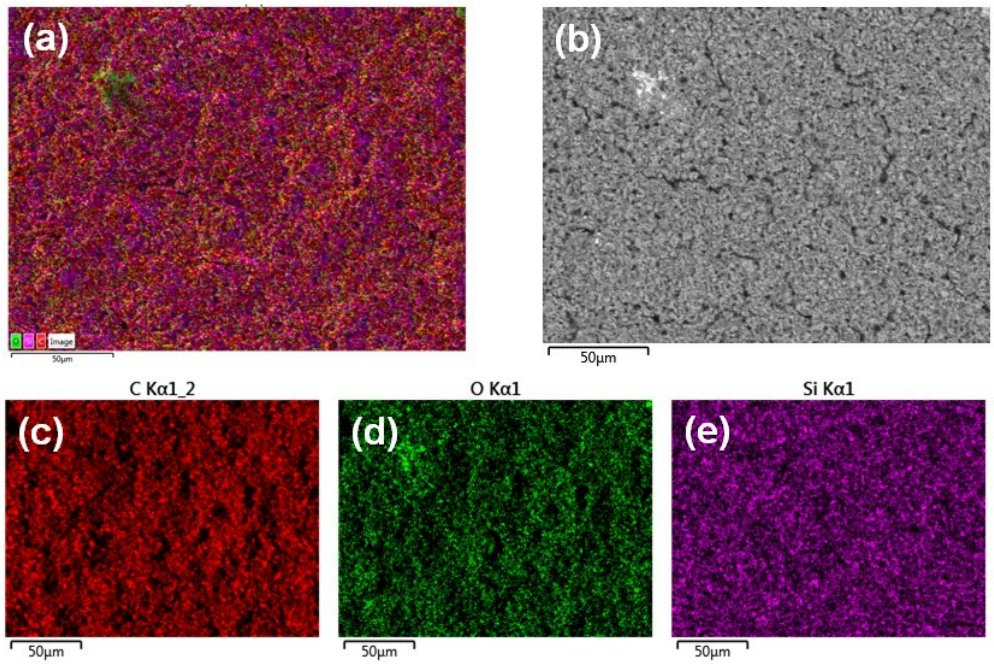


Fig. S8 SEM-EDX mapping micrographs of the Si_75C_118M electrodes; superposed micrograph (a), secondary electron micrograph (b), carbon mapping (c), oxygen mapping (d) and silicon mapping (e)

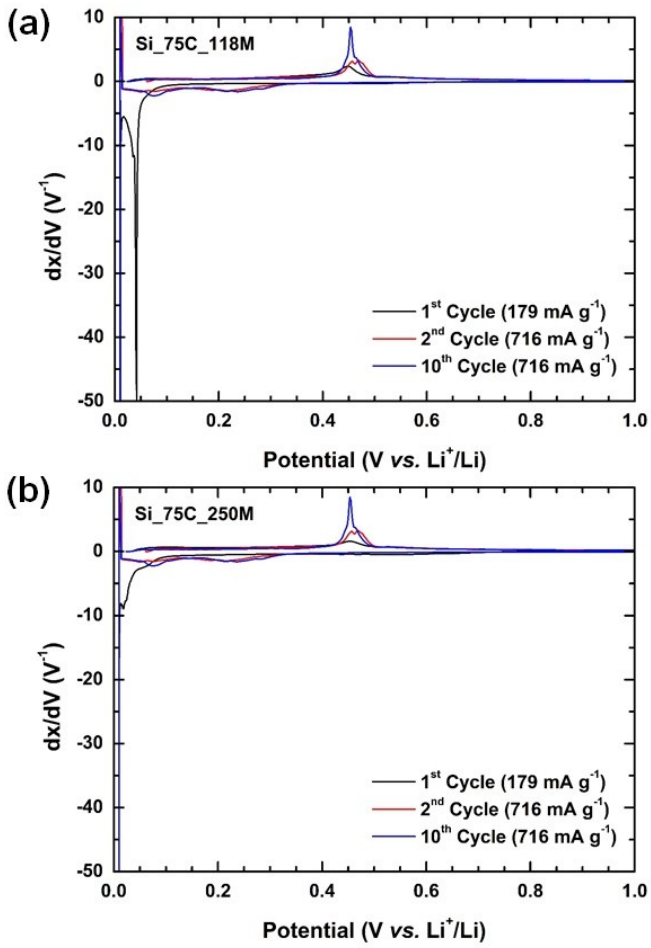


Fig. S9 First derivative of the charge/discharge profiles of the Si_75C-based composites using the two types of pitches; Si_75C_118M (a) and Si_75C_250M (b) at a current rate of 716 mA.g^{-1} (179 mA.g^{-1} for the 1st cycle). Voltage window of 0.01-1.5 V *vs.* Li$^+$/Li

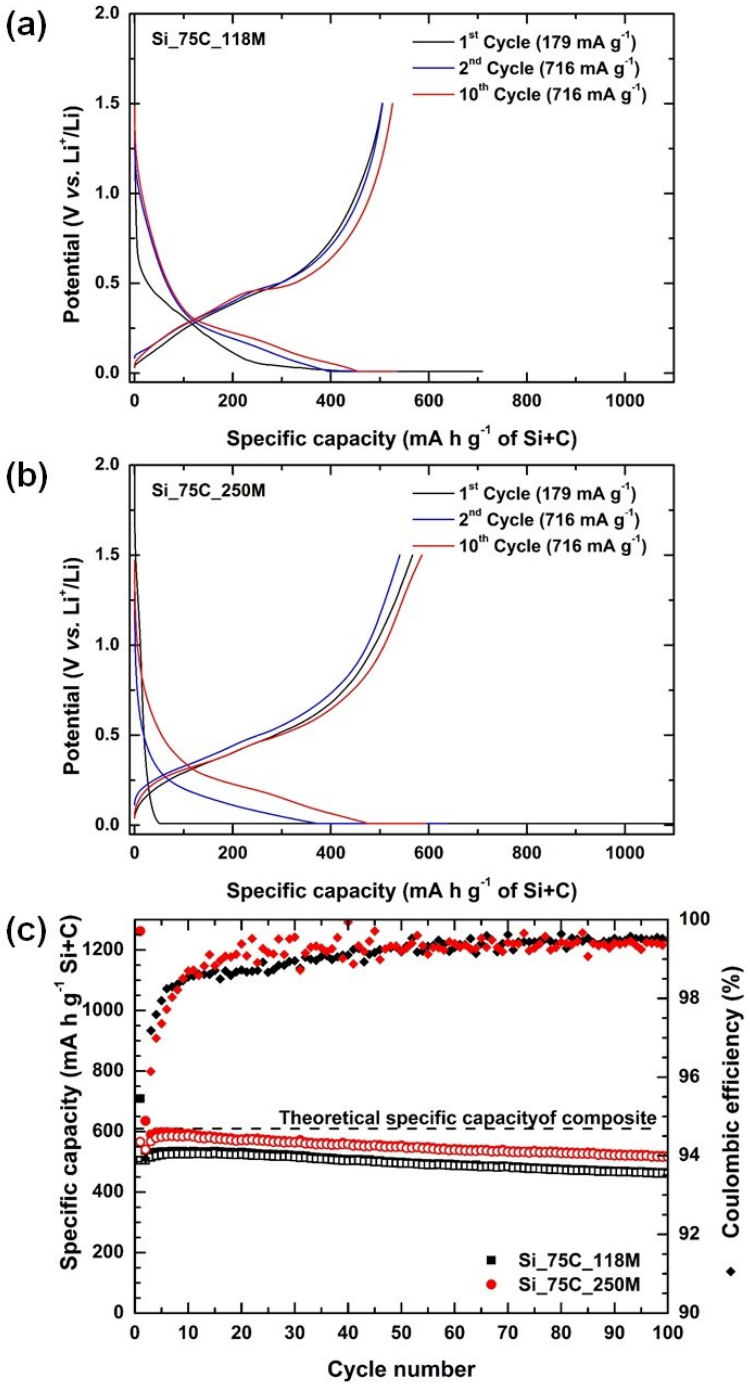


Fig. S10 Charge/discharge profiles of the Si_75C-based composites ball-milled for 1h for electrode formulation using the two types of pitches; Si_75C_118M (a) and Si_75C_250M (b); and their cycling performances and coulombic efficiency (c) at a current rate of 716 mA.g^{-1} (179 mA.g^{-1} for the 1st cycle). Voltage window of 0.01-1.5 V *vs.* Li$^+$/Li. Filled and open symbols refer to reduction (discharge) and oxidation (charge), respectively

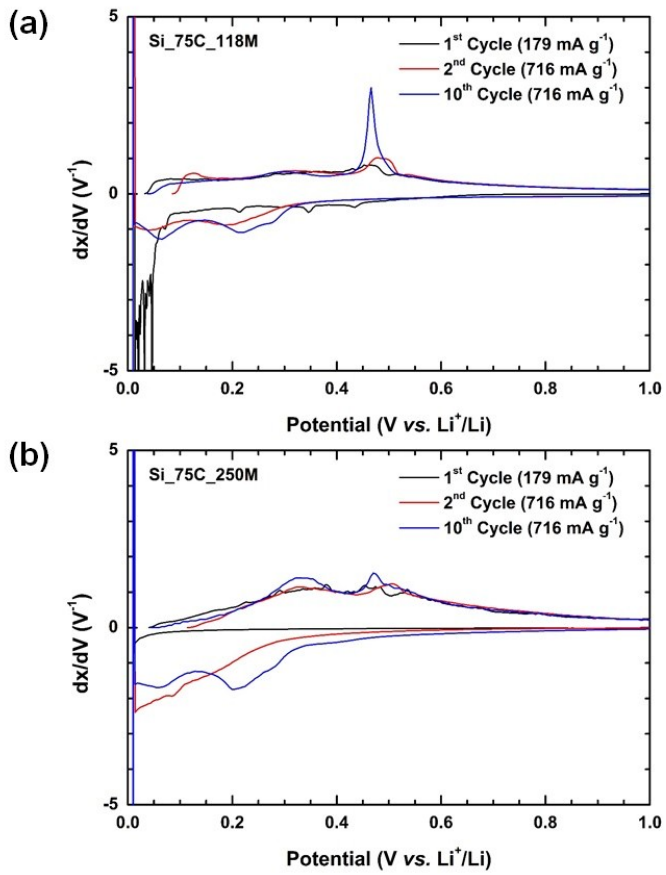
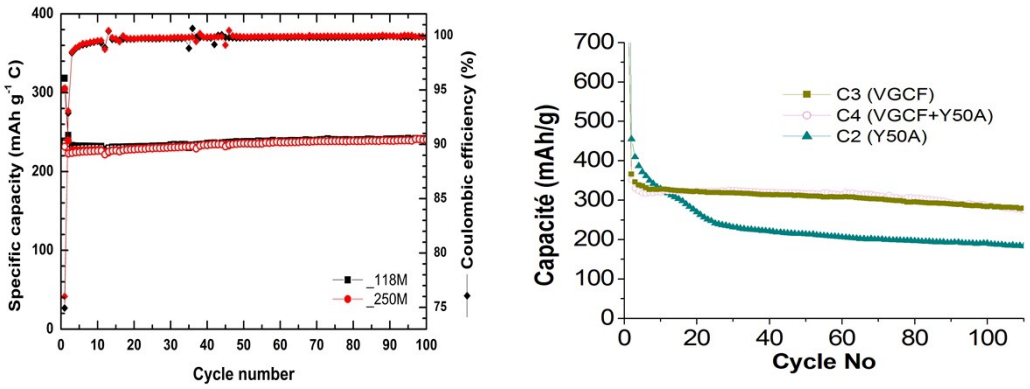


Fig. S11 First derivative of the charge/discharge profiles of the Si_75C-based composites ball-milled for 1h for electrode formulation using the two types of pitches; Si_75C_118M (a) and Si_75C_250M (b) at a current rate of 716 mA.g^{-1} (179 mA.g^{-1} for the 1st cycle). Voltage window of 0.01-1.5 V *vs.* Li$^+$/Li



a) b)

Fig. S12 Cycling performances of a) the 2 pyrolyzed pitches (electrodes without silicon) and their coulombic efficiency at a current density of 716 mA.g^{-1} (179 mA.g^{-1} for the 1st cycle). Voltage window of 0.01-1.5 V *vs.* Li$^+$/Li. Filled and open symbols refer to reduction (discharge) and oxidation (charge), respectively; b) Cycling performances of a) VGCF, CB and VGCF/CB electrodes (without silicon).