Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A

Kroll-carbons based on silica and alumina templates as high-rate electrode material in electrochemical double-layer capacitors

M. Oschatz,[a] S. Boukhalfa,[b] W. Nickel,[a] J. T. Lee,[b] S. Klosz,[c] L. Borchardt,[d] A. Eychmüller,[c] G. Yushin[b] and S. Kaskel[a]

[a] *Inorganic Chemistry, Dresden University of Technology, Bergstrasse 66, D-01062 Dresden, Germany*

[b] *Department of Materials Science and Engineering, Georgia Institute of Technology, Atlanta, GA, USA*

[c] *Physical Chemistry, Dresden University of Technology, Bergstrasse 66b, D-01062 Dresden, Germany*

[d] *Institute for Chemical and Bioengineering, ETH Zürich, Wolfgang-Pauli-Strasse 10, CH-8093 Zurich, Switzerland*

Electronic Supplementary Information (ESI†)

Supplementary Figures

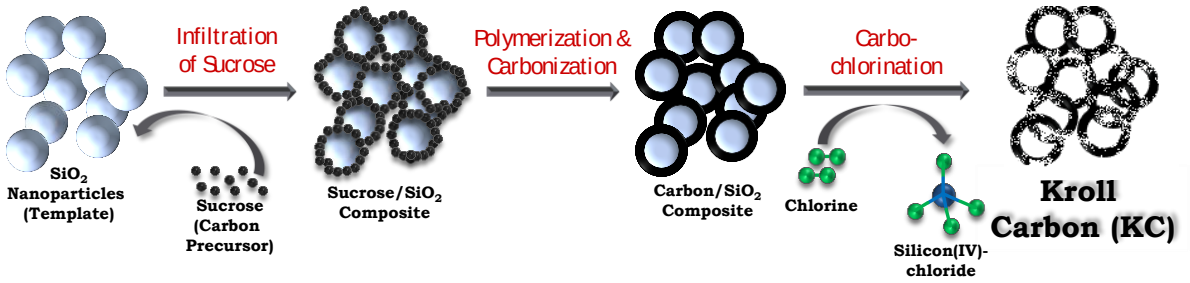

Fig. S1. Schematic of the KC synthesis starting from fumed silica template particles. Infiltration of the SiO_2 nanoparticles is followed by carbonization under inert atmosphere and template removal by the reductive carbochlorination reaction.

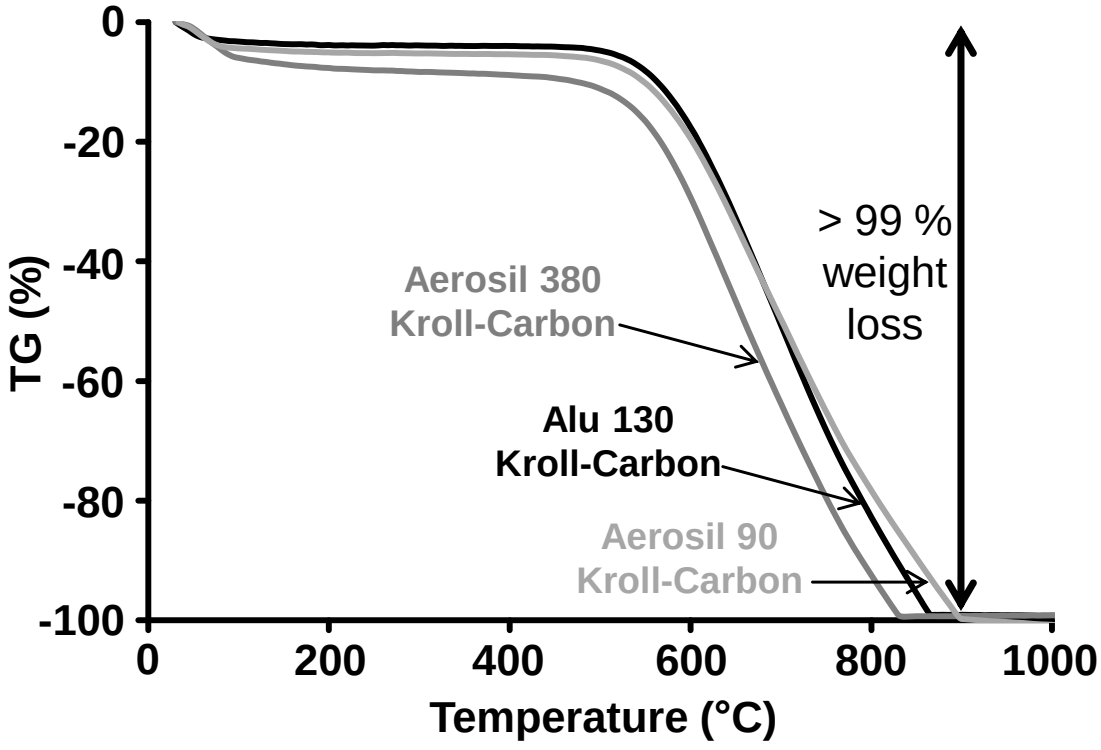

Fig. S2. Thermogravimetric analyses of the KCs under oxidative conditions (air atmosphere).

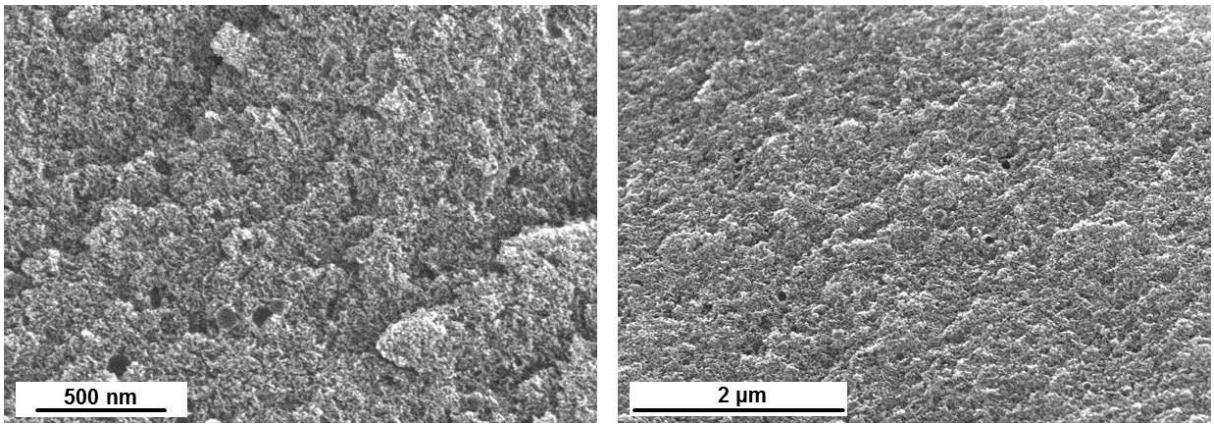

Fig. S3. SEM images of the KCs obtained from Alu 130 templates.

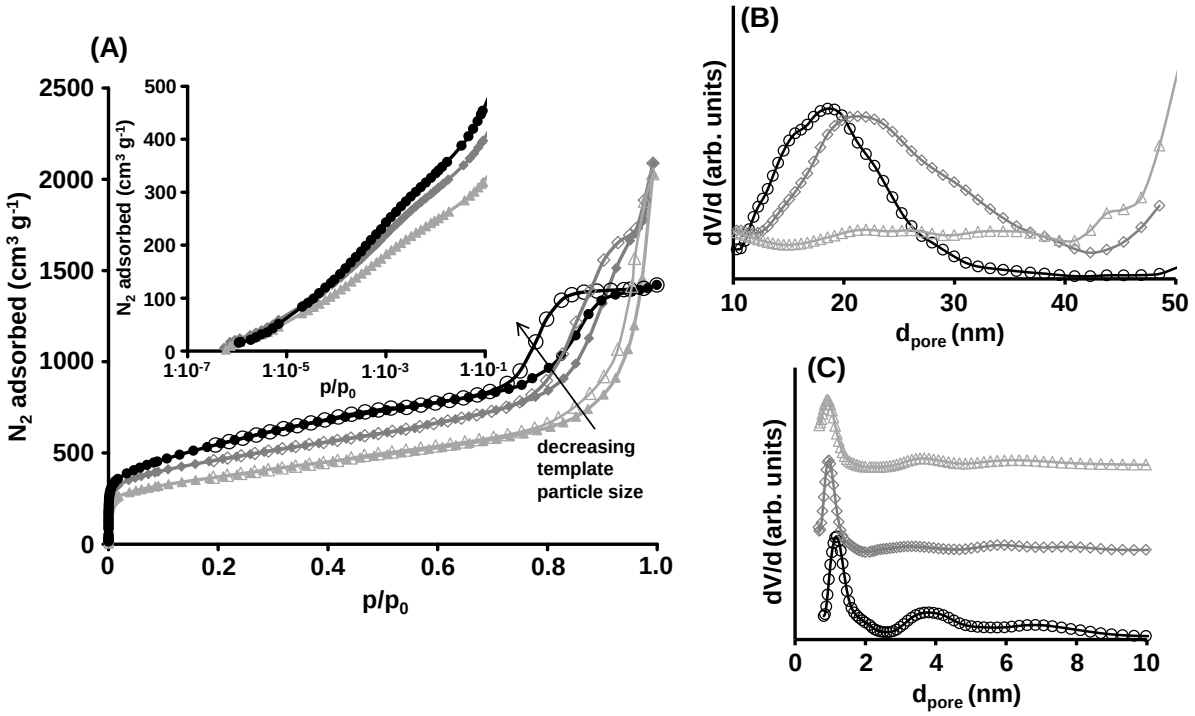

Fig. S4. Nitrogen adsorption/desorption (filled symbols/empty symbols) isotherms (-196°C) of the KCs prepared from Aerosil 90 (light grey triangles), Aerosil 380 (dark grey diamonds), and Alu 130 (black circles) templates at 1000°C. The semi-logarithmic plot in the inset shows the adsorption in the low pressure region (A). The corresponding QSDFT PSDs are shown in (B) and (C).

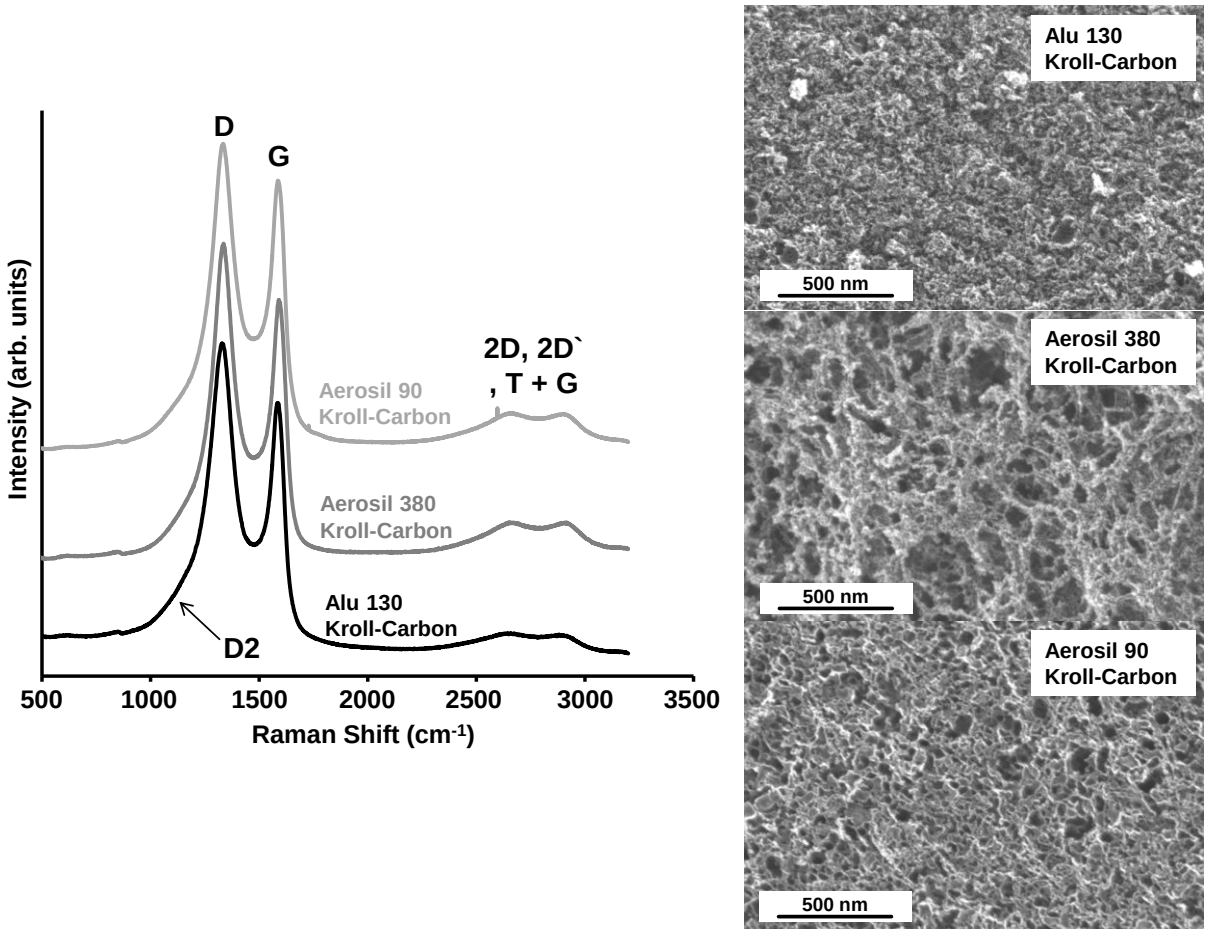

Fig. S5. Raman spectra and SEM images of the KCs prepared at 1000°C.

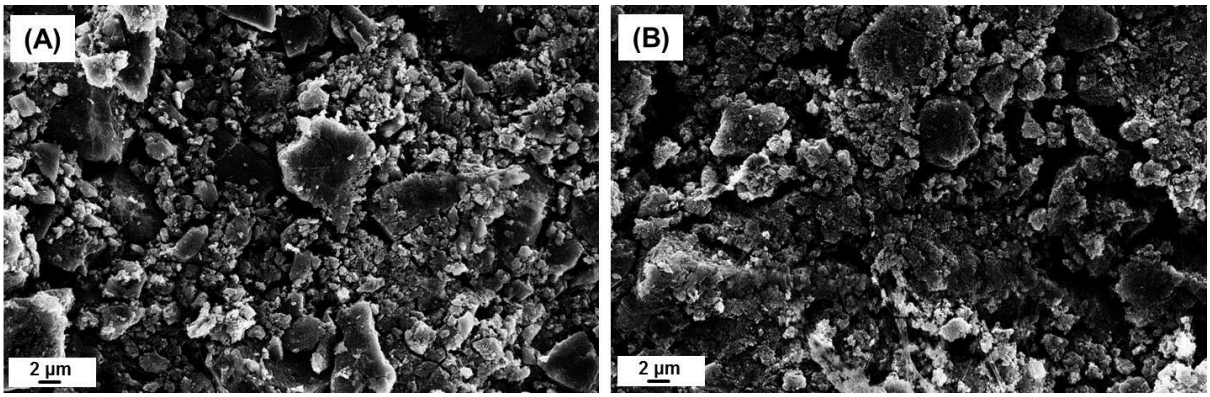

Fig. S6. SEM images of the EDLC electrodes based on KC from Alu 130 (A) and Aerosil 90 (B) templates.

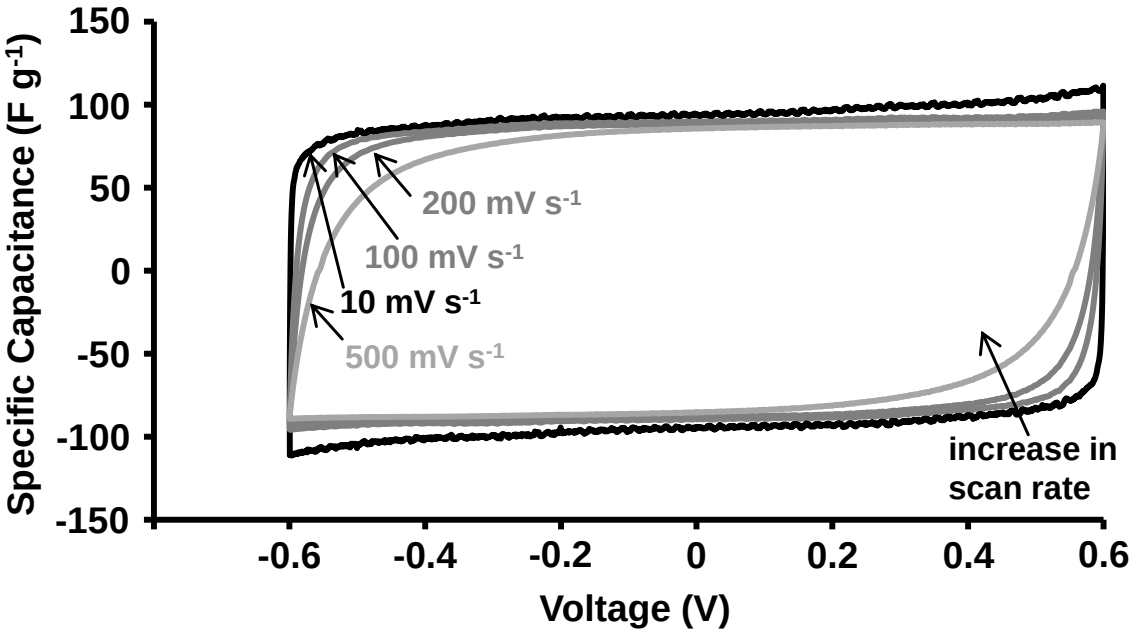

Fig. S7. Cyclic voltammograms of the KC obtained from Aerosil 90 template particles in 1 M H_2SO_4 electrolyte at different CV scan rates.

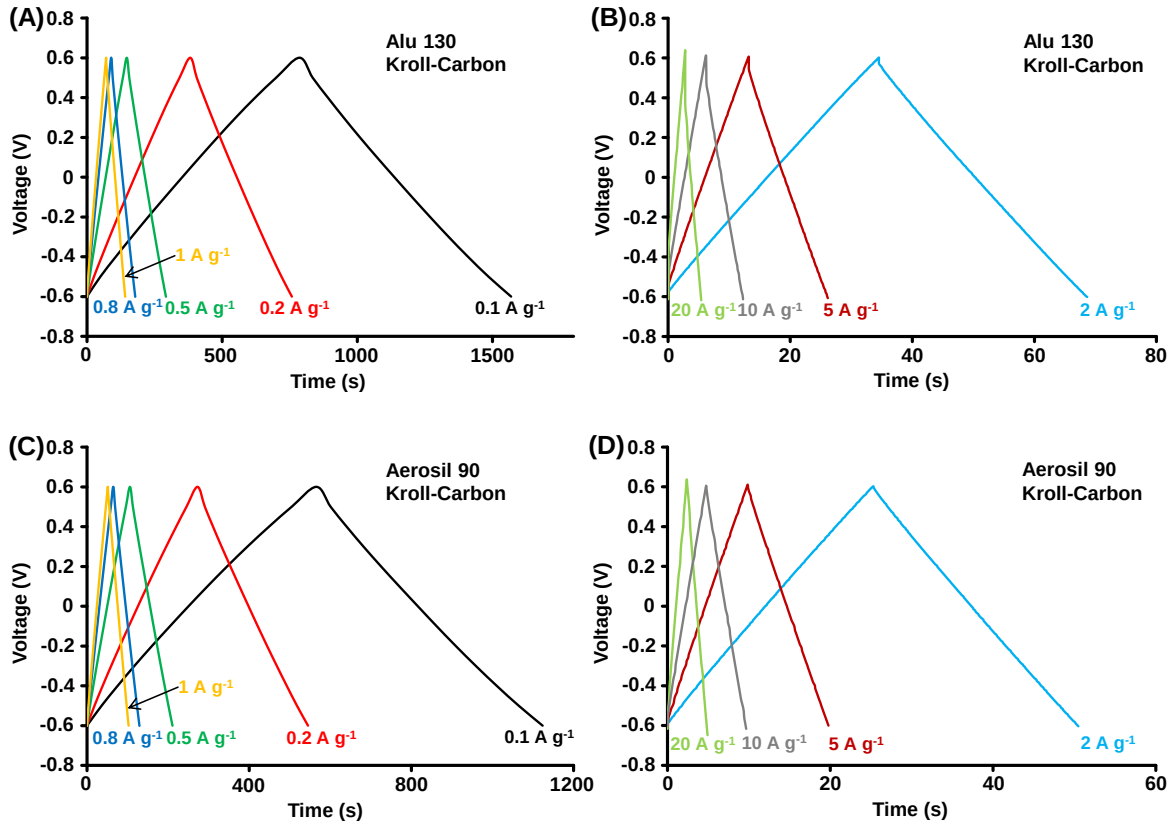

Fig. S8. Charge-Discharge profiles of the the KCs obtained from Alu 130 (A and B) and Aerosil 90 (C and D) template particles in 1 M H_2SO_4 electrolyte.

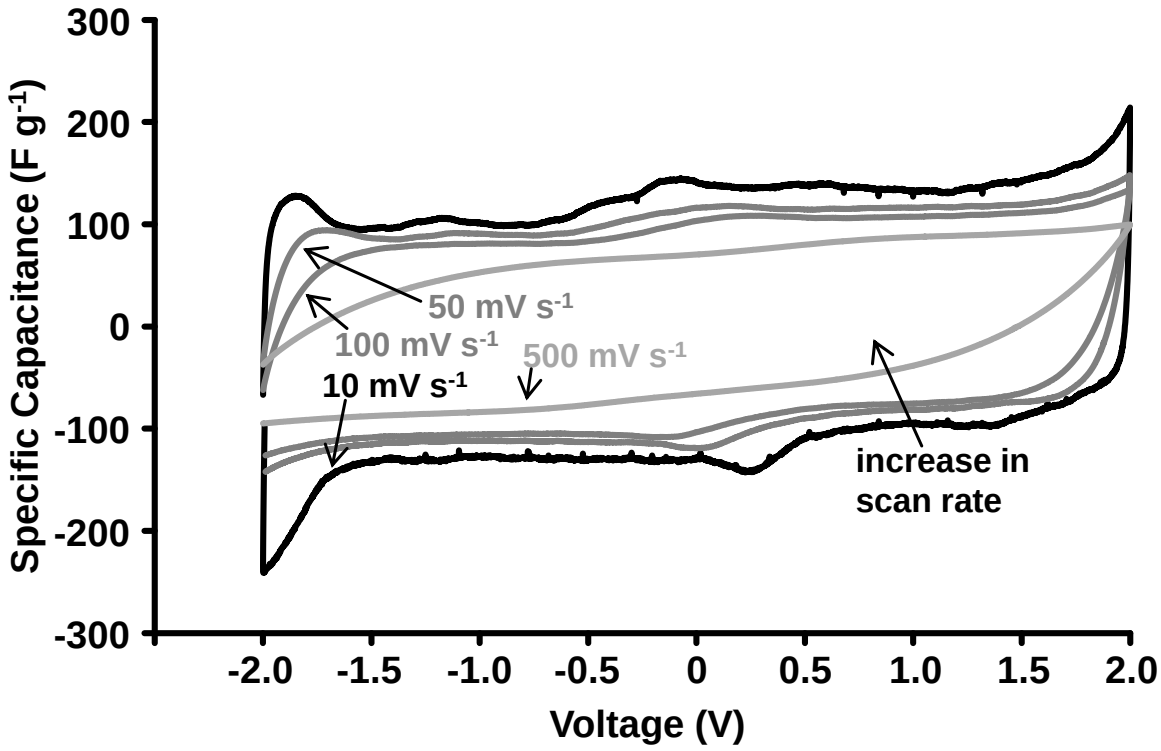

Fig. S9. Cyclic voltammograms of the KC obtained from Aerosil 90 template particles in $EMIBF_4$ ionic liquid electrolyte electrolyte at different CV scan rates.

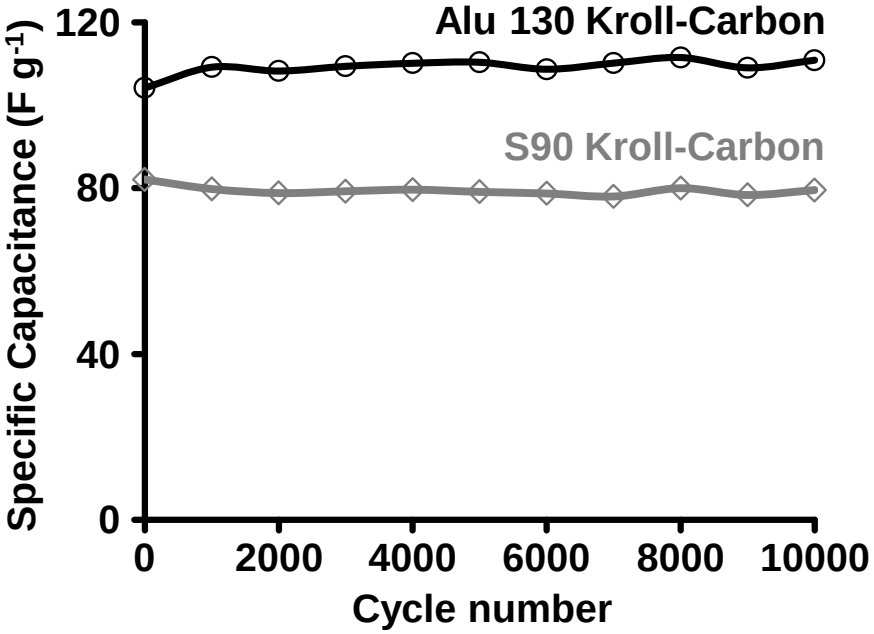

Fig. S10. Cycling stability of the KCs. Galvanostatic charge/discharge cycling (-2.0 V – +2.0 V) in $EMIBF_4$ ionic liquid electrolyte.

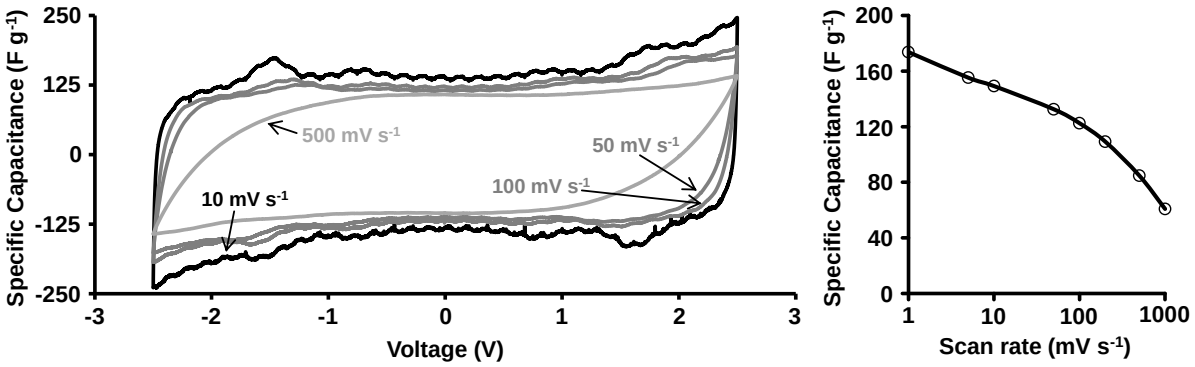

Fig. S11. Cyclic voltammograms of the KC obtained from Alu 130 template particles and corresponding specific capacitances in $EMBF_4$ ionic liquid electrolyte and a CV voltage range from -2.5 V – +2.5 V.

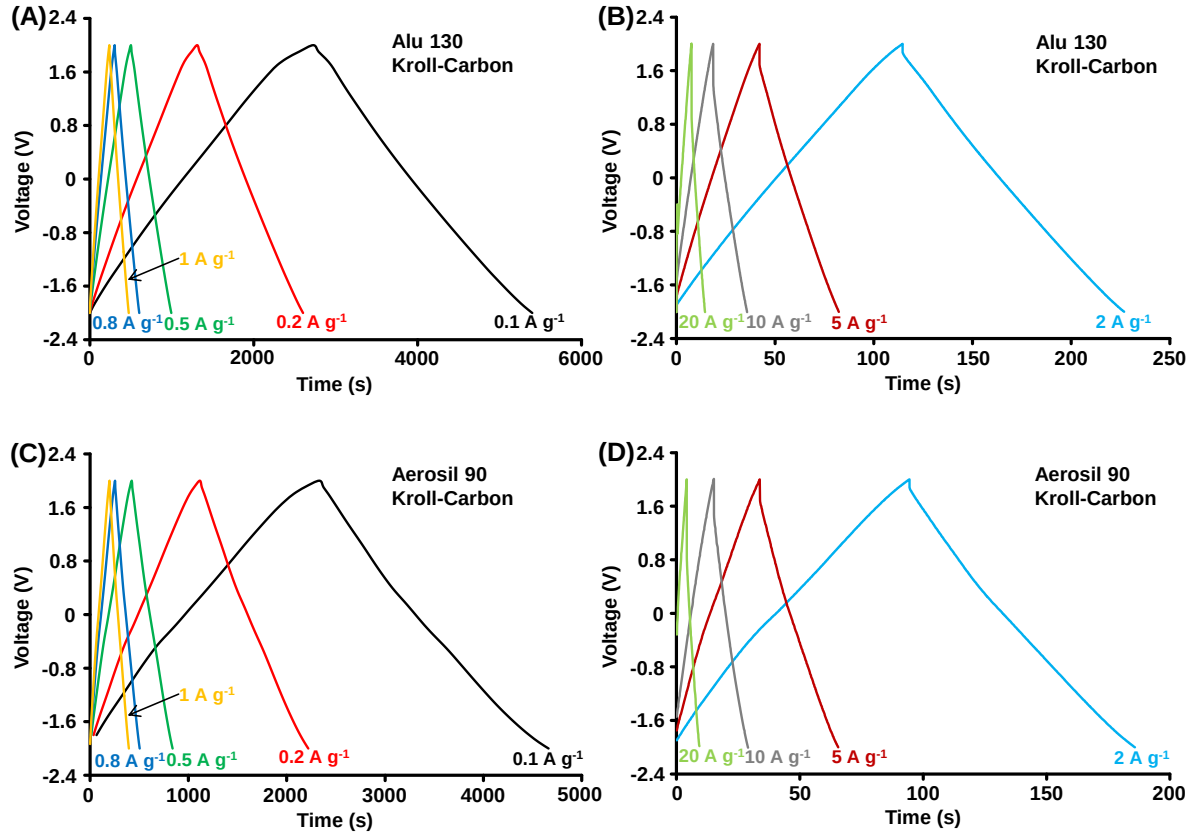

Fig. S12. Charge-Discharge profiles of the KCs obtained from Alu 130 (A and B) and Aerosil 90 (C and D) template particles in $EMIBF_4$ ionic liquid electrolyte at 20°C.

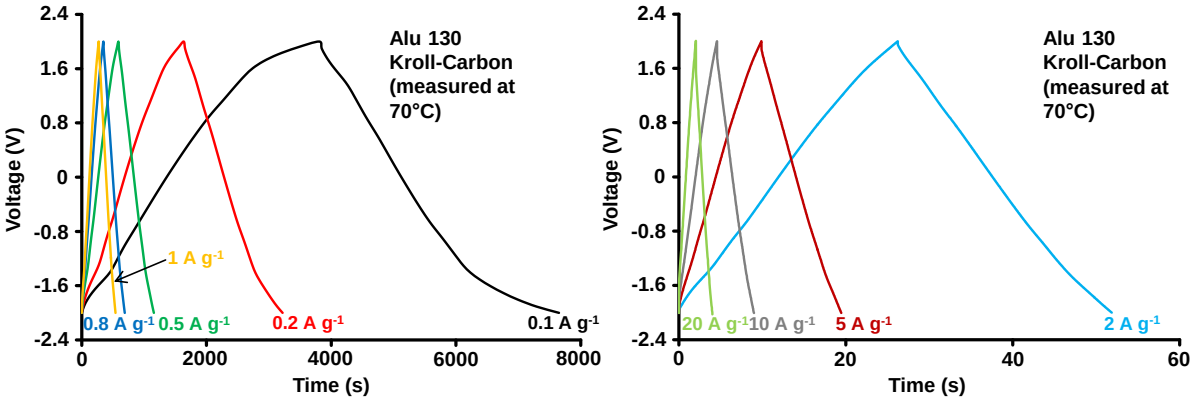

Fig. S13. Charge-Discharge profiles of the KCs obtained from Alu 130 template particles in $EMIBF_4$ ionic liquid electrolyte measured at 70°C.

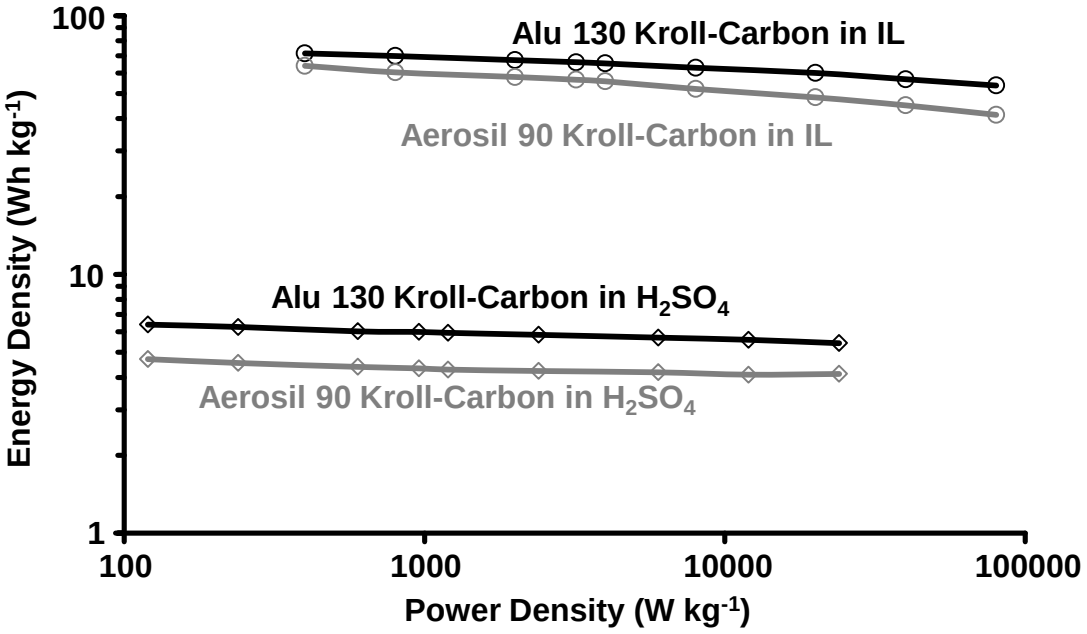

Fig. S14. Ragone plots of the KCs obtained from Alu 130 (black) and Aerosil 90 (grey) template particles in 1 M H_2SO_4 (diamonds) and $EMIBF_4$ ionic liquid (circles) electrolyte.

Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A

Supplementary Tables

Table S1. Raman and EDX spectroscopy analyses as well as porosity data summary of the KCs prepared at 1000°C.

Template	I_D/I_G	Carbon [atom%]	SSA_{BET} (SSA_{DFT}) [$m^2\ g^{-1}$]	PV_{Total} (PV_{DFT}) [$cm^3\ g^{-1}$]	PV_{Micro} ($PV_{t\text{-}plot}$) [$cm^3\ g^{-1}$]
Alu 130	1.43	99.1	1982 (1699)	2.20 (2.06)	0.36 (0.27)
Aerosil 380	1.44	99.8	1643 (1562)	3.23 (2.55)	0.33 (0.26)
Aerosil 90	1.33	99.3	1304 (1242)	3.14 (1.84)	0.28 (0.20)

Table S2. EDLC data summary of the KCs determined from the CV measurements at a scan rate of 1 mV s^{-1}.

Template/ Electrolyte	Capacitance per KC weight [$F\ g^{-1}$]	Capacitance per Electrode Volume [$F\ cm^{-3}$]	Capacitance per KC Specific Surface Area [$F\ cm^{-2}$]
Alu 130/1 M H_2SO_4	135	31.1	7.2
Aerosil 90/1 M H_2SO_4	100	21.1	6.6
Alu 130/$EMIBF_4$	141	31.3	7.6
Aerosil 90/ $EMIBF_4$	124	26.5	8.1