Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.

Supporting Information

Development of high power and energy density microsphere silicon carbide/nanoneedle MnO_2 and thermally oxidized activated carbon asymmetric electrochemical supercapacitors

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Figure S1.

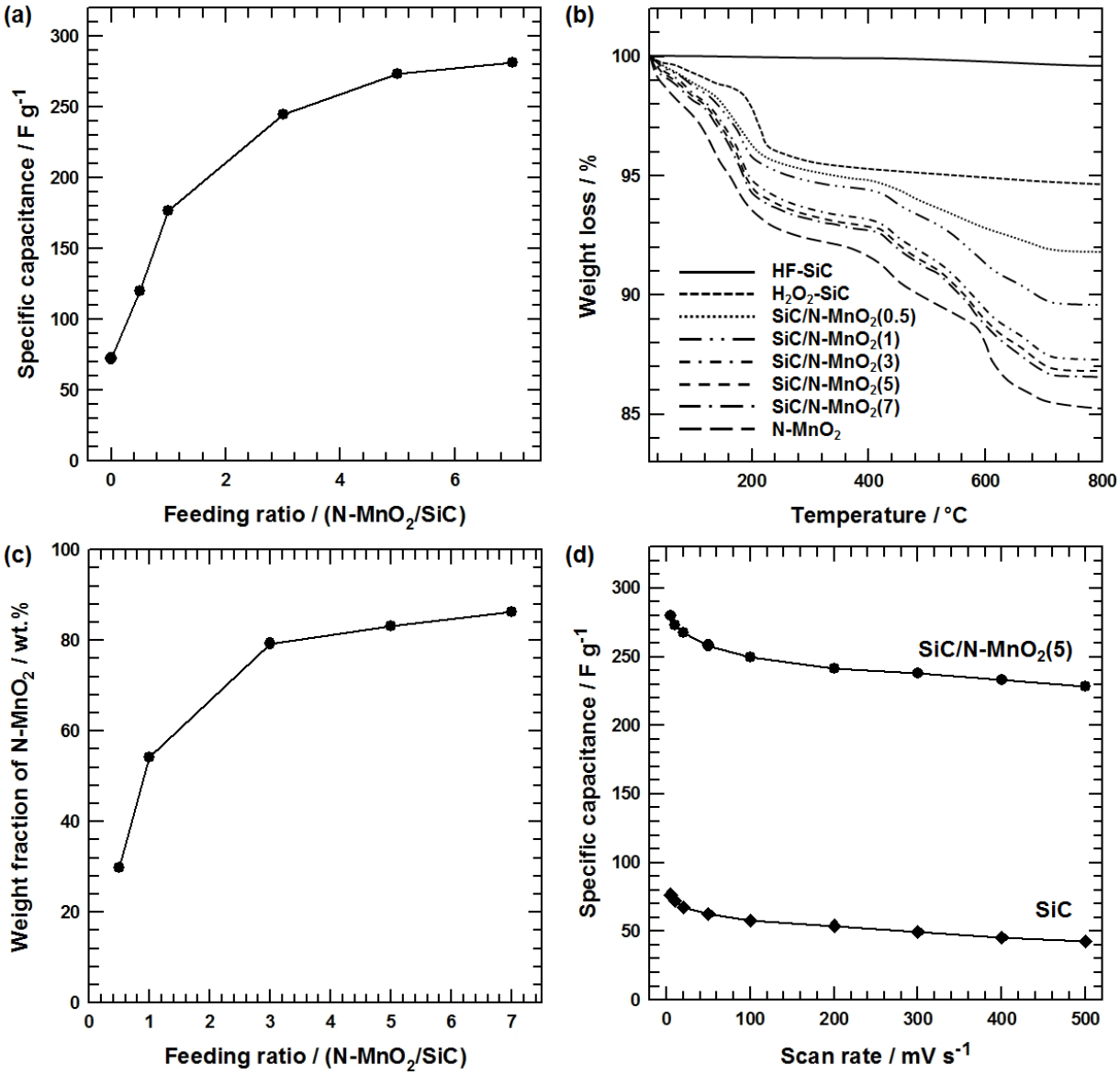

Figure S1. (a) Variation of the specific capacitance of SiC/N-MnO_2 electrode as a function of N-MnO_2/SiC feeding ratio at a scan rate of 10 mV s^{-1}. (b) TGA curves of HF-SiC, H_2O_2-SiC, SiC/N-MnO_2(0.5), SiC/N-MnO_2(1), SiC/N-MnO_2(3), SiC/N-MnO_2(5), SiC/N-MnO_2(7) and N-MnO_2. (c) Weight fractions of N-MnO_2 in SiC/N-MnO_2 composite as a function of N-MnO_2/SiC feeding ratio. (d) Specific capacitance of SiC and SiC/N-MnO_2(5) electrodes at different scan rates.

Figure S1(a) represents the specific capacitance as a function of the different feeding ratios of SiC/N-MnO_2 composites (1/0.5, 1/1, 1/3, 1/5, and 1/7) and the samples are denoted as SiC/N-

MnO_2(1), SiC/N-MnO_2(3), SiC/N-MnO_2(5) and SiC/N-MnO_2(7) for the feeding ratios 1/0.5, 1/1, 1/3, 1/5 and 1/7, respectively. The specific capacitances of the SiC/N-MnO_2 electrodes gradually increased as the ratio of nanoneedle MnO_2/SiC increased from 0.5 to 5. Nevertheless, no obvious difference can be found when the ratio is higher than 5, indicating that they have nearly the same specific capacitance. The reason is that the density of the oxygen-containing functional groups on the SiC surface is limited to provide reactive sites between the SiC and nanoneedle MnO_2, and this was confirmed by the TGA analysis. Figure S1(b) provides representative TGA curves for HF-SiC, H_2O_2-SiC, SiC/N-MnO_2(0.5), SiC/N-MnO_2(1), SiC/N-MnO_2(3), SiC/N-MnO_2(5), SiC/N-MnO_2(7) and N-MnO_2. The experiments were performed at temperatures up to 800 °C under air flow at a heating rate of 10 °C min^{-1}. Under these conditions, HF-SiC exhibits only 0.4 % weight loss, whereas H_2O_2-SiC starts to lose mass upon heating below 100 °C due to the adsorbed water and shows a significant decrease in mass around 215 °C because of the evolution of CO and CO_2 from H_2O_2-SiC caused by the destruction of oxygenated functional groups.[1] Moreover, nanoneedle MnO_2 was converted into Mn_2O_3 and exhibited 14.7 % weight loss.[2] The weight losses of HF-SiC, H_2O_2-SiC, SiC/N-MnO_2(0.5), SiC/N-MnO_2(1), SiC/N-MnO_2(3), SiC/N-MnO_2(5), SiC/N-MnO_2(7) and N-MnO_2 were 0.4%, 5.3%, 8.11%, 10.39%, 12.75%, 13.12%, 13.41% and 14.7%, respectively. Accordingly, the weight fraction of N-MnO_2 in SiC/N-MnO_2 composite for SiC/N-MnO_2(0.5), SiC/N-MnO_2(1), SiC/N-MnO_2(3), SiC/N-MnO_2(5) and SiC/N-MnO_2(7) were derived as 29.8%, 54.1%, 79.3%, 83.2% and 86.2%, respectively. Figure S1(c) shows the weight fractions of N-MnO_2 in SiC/N-MnO_2 composite and their behavior as a function of the different N-MnO_2/SiC feeding ratio. Interestingly, the weight fractions of N-MnO_2 gradually increase as the ratio of N-MnO_2/SiC increases from 0.5 to 5. Nevertheless, no obvious difference can be found when the weight fractions of N-MnO_2 is higher than 5, as in the case of SiC/N-MnO_2(5) and SiC/N-MnO_2(7) composites, indicating that they have nearly the similar weight fractions of N-MnO_2, which is in accordance with their specific capacitance behavior. Moreover, the rate capability is an important factor for the use of supercapacitors in power applications. A good electrochemical energy storage device is required to provide its high energy density at a high charge/discharge rate. Figure S1(d) shows the specific capacitance of SiC and

SiC/N-MnO_2(5) electrodes at various scan rates. SiC/N-MnO_2(5) electrode not only exhibits high specific capacitance values from 279.8 to 228.2 F g^{-1} as the scan rates increase from 5 to 500 mV s^{-1}, but also maintain 81.5 % of specific capacitance retention. As a results, the excellent rate capability in the SiC/N-MnO_2(5) electrode can be attributed to the reduced short diffusion path of ions, high activated surface and increased electrical conductivity.

Figure S2.

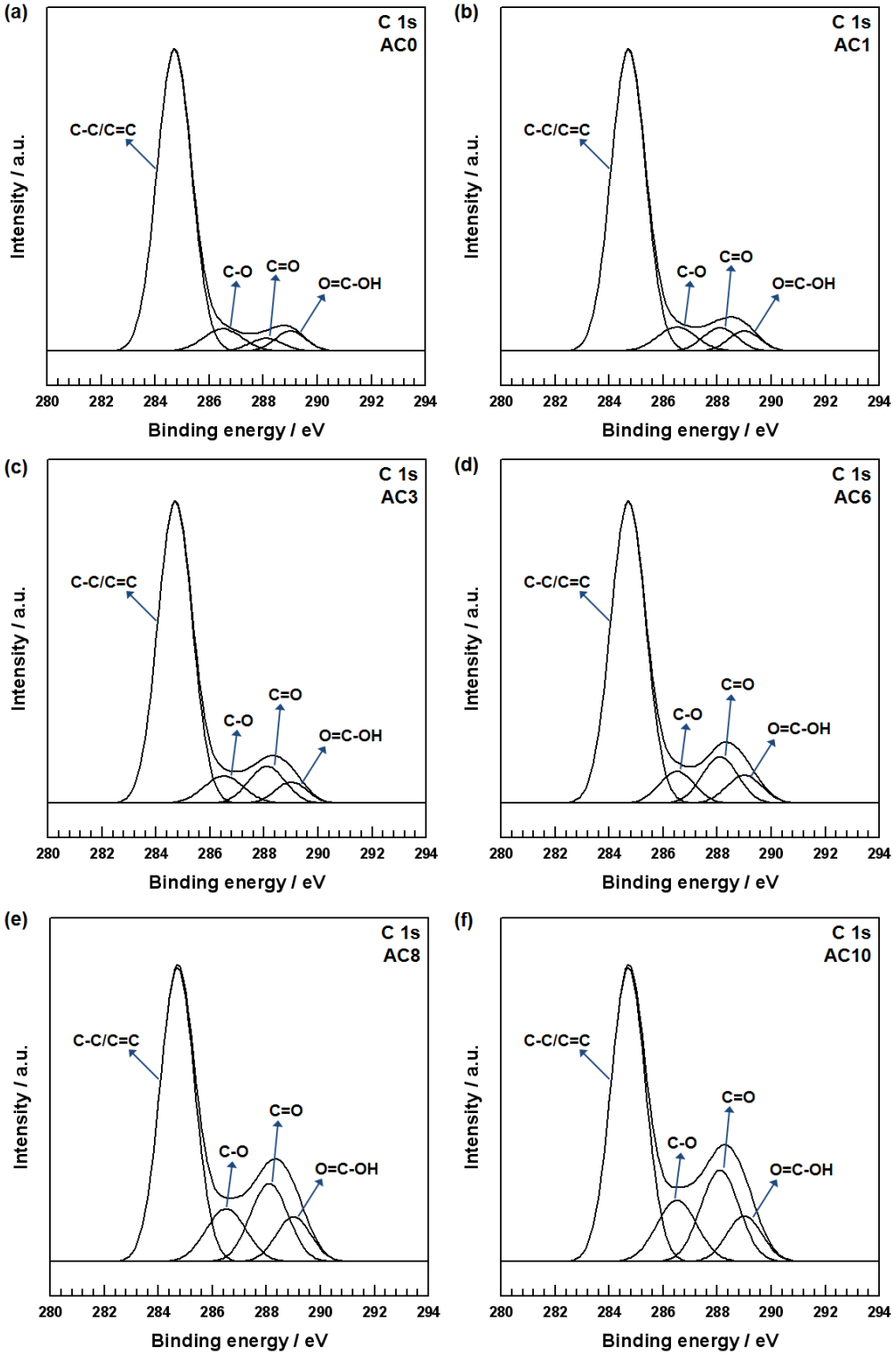

Figure S2. (a) XPS deconvoluted C 1s spectrum of AC0. (b) XPS deconvoluted C 1s spectrum of AC1. (c) XPS deconvoluted C 1s spectrum of AC3. (d) XPS deconvoluted C 1s spectrum of AC6. (e) XPS deconvoluted C 1s spectrum of AC8. (f) XPS deconvoluted C 1s spectrum of AC10.

Table S1. The C 1s peak position and the relative atomic percentages of various functional groups in AC0, AC1, AC3, AC6, AC8 and AC10.

	Fitting of the C 1s peak Binding energy [eV] (relative atomic percentage [%])			
	C-C/C=C	C-O	C=O	O=C-OH
AC0	284.7 (84.2)	286.5 (7.2)	288.1 (3.5)	289 (5.1)
AC1	284.7 (81.2)	286.5 (7.4)	288.1 (6.2)	289 (5.2)
AC3	284.7 (76.9)	286.5 (8.1)	288.1 (9.8)	289 (5.2)
AC6	284.7 (73.5)	286.5 (7.9)	288.1 (11.7)	289 (6.9)
AC8	284.7 (60.4)	286.5 (12.7)	287.8 (17.5)	289 (9.4)
AC10	284.7 (57.1)	286.4 (13.9)	287.9 (19.1)	289.1 (9.1)

References

1 C. Xu, X. Wang, J. Zhu, X. Yang and L. Lu, J. Mater. Chem., 2008, **18**, 5625.

2 L. Mao, K. Zhang, H. Chan and J. Wu, J. Mater. Chem., 2012, **22**, 1845