

Application of modified CNTs with $\text{Ti}(\text{SO}_4)_2$ in selective oxidation of dimethyl ether

Qingde Zhang,^a Wenfeng Wang,^{a,b} Zhenzhou Zhang,^{a,b} Junfeng Zhang,^a Yunxing Bai,^{a,b} Noritatsu Tsubaki,^{a,c} Yizhuo Han^{a*} and Yisheng Tan^{a*}

FT-IR spectra

FT-IR spectra were measured on a Bruker Tensor 27 instrument with MCT detector.

Thermal gravimetric analysis (TGA)

TGA was conducted on a Setaram Setsys Evolution. Weight loss was measured during a heat treatment up to 800°C with a rate of 5°C /min under air.

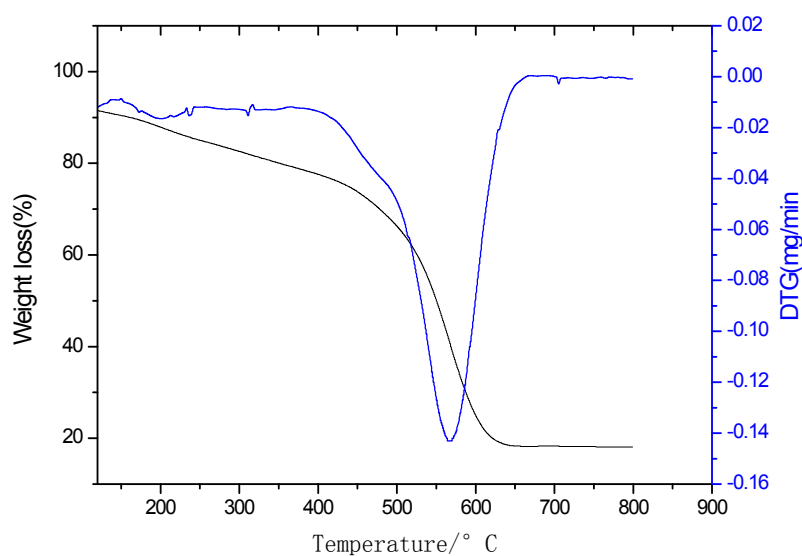


Fig. ESI-1 TG profiles of the 40% SO_4^{2-} /CNTs calcined at 120°C.

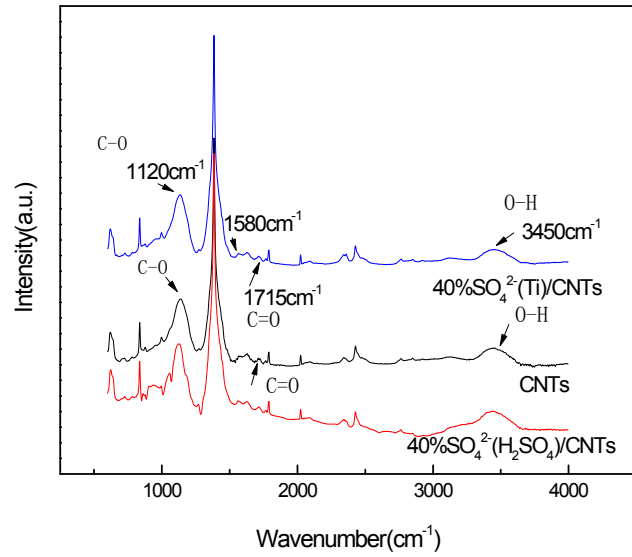


Fig. ESI-2 FT-IR of CNTs.

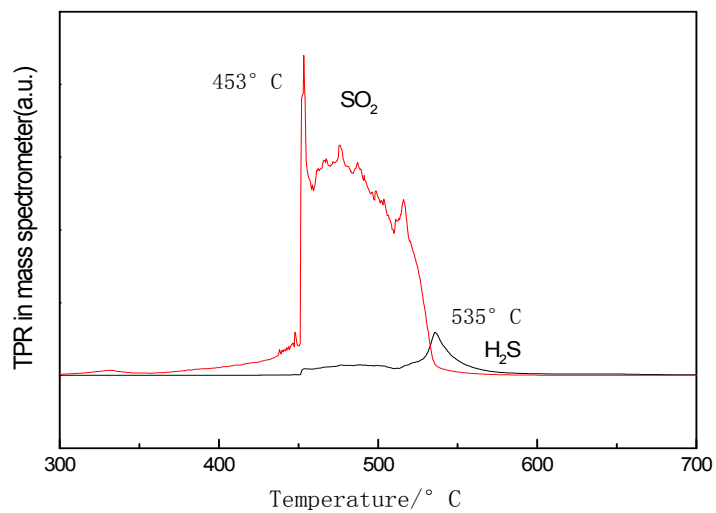


Fig. ESI-3 H₂-TPR-MS of 40%SO₄²⁻/CNTs calcined at 240 $^{\circ}\text{C}$.

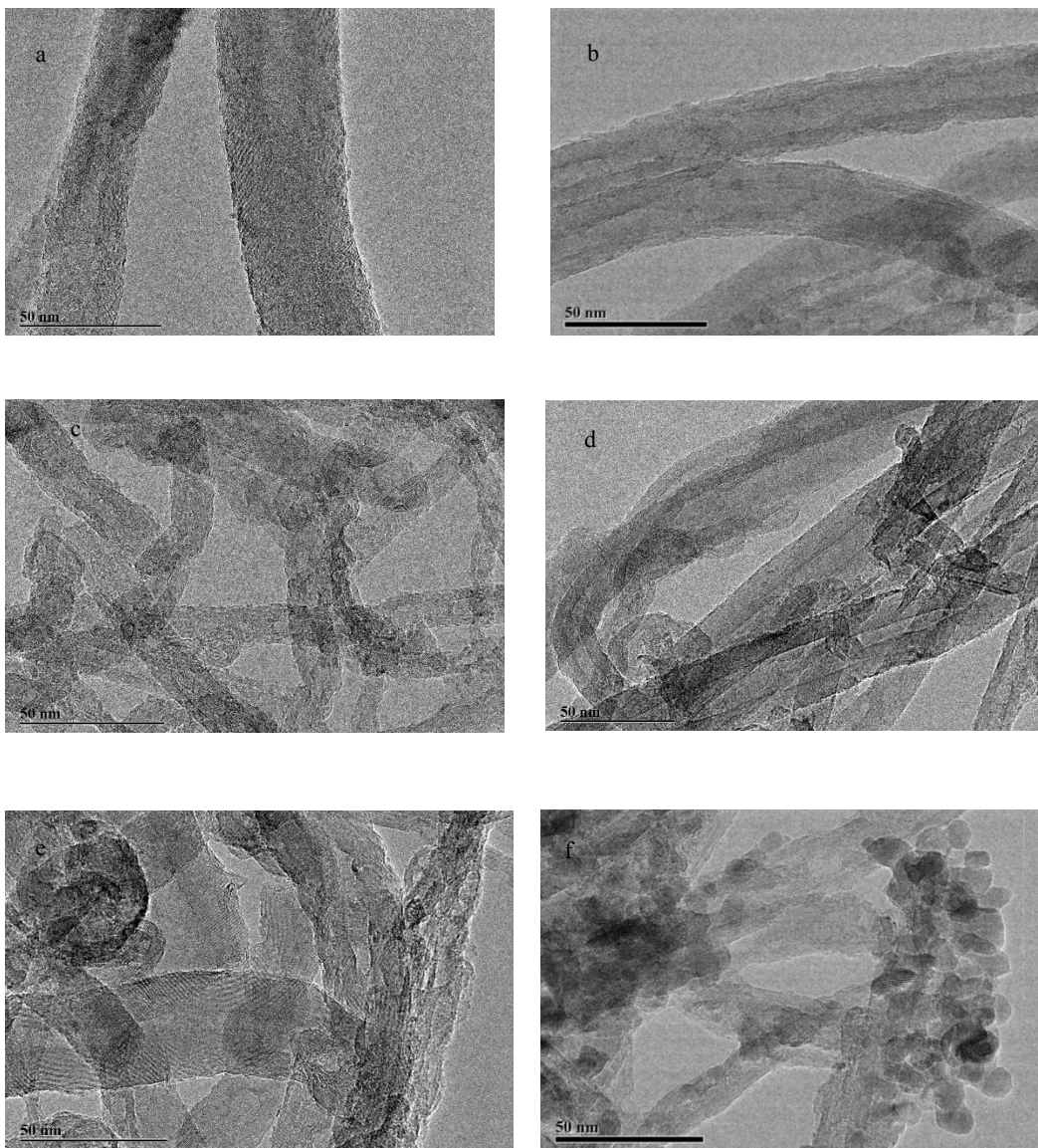


Fig. ESI-4 TEM images of the 40%SO₄²⁻/CNTs calcined at 200 °C (a), 240 °C (b), 300 °C (c), 400 °C (d), 450 °C (e) and 500 °C (f).

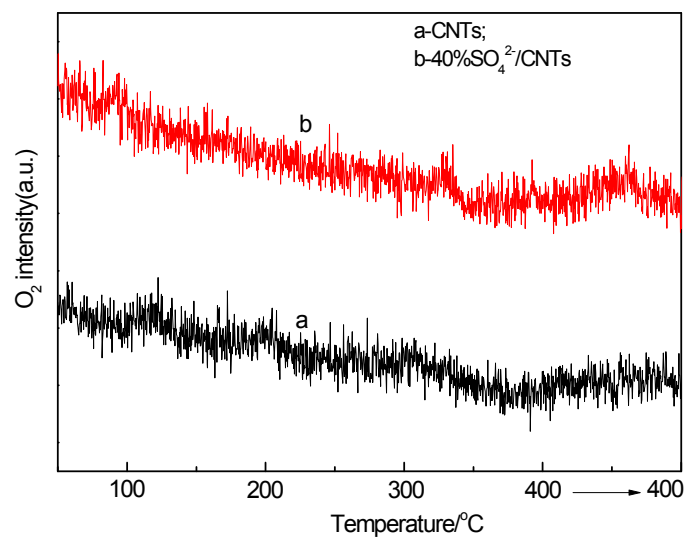


Fig. ESI-5 O₂-TPD-MS of CNTs and 40%SO₄²⁻(Ti)/CNTs calcined at 400°C

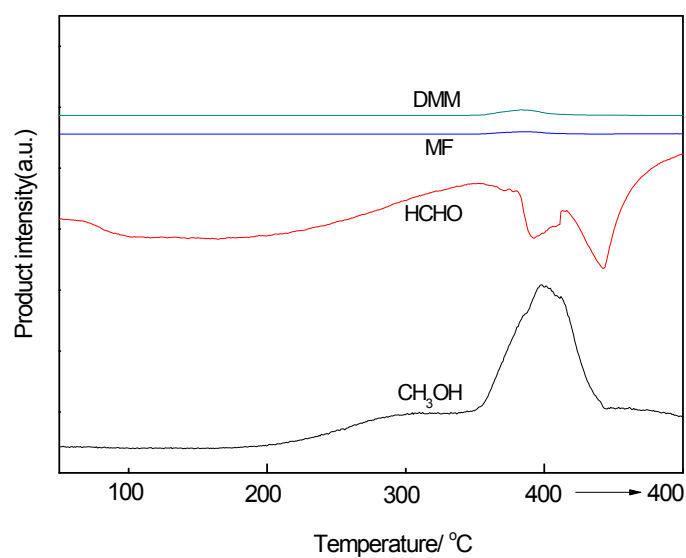


Fig. ESI-6 DME-TPSR-MS of 40%SO₄²⁻(Ti)/CNTs calcined at 400°C

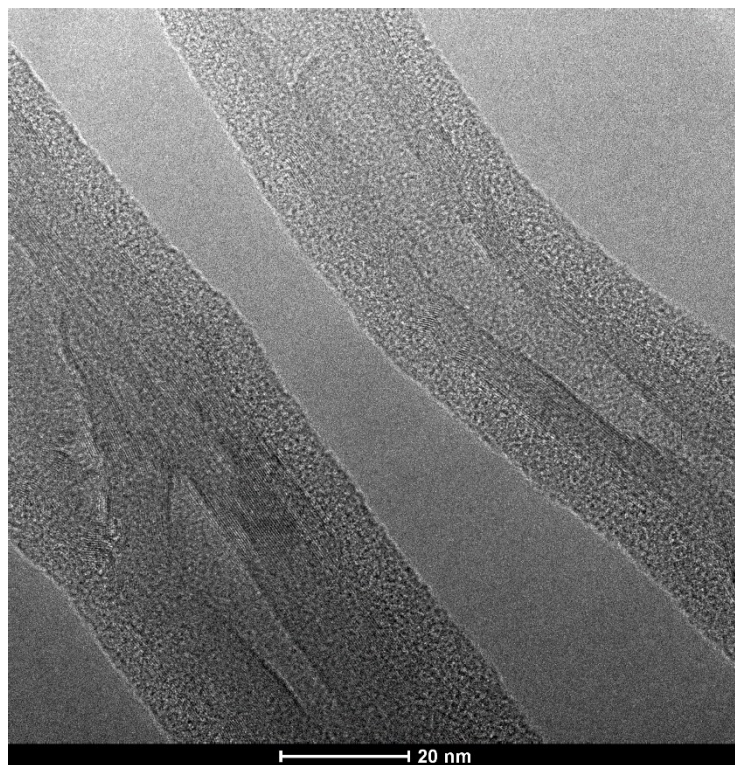


Fig. ESI-7 TEM images of the 40%SO₄(H₂SO₄)/CNTs calcined at 240°C.

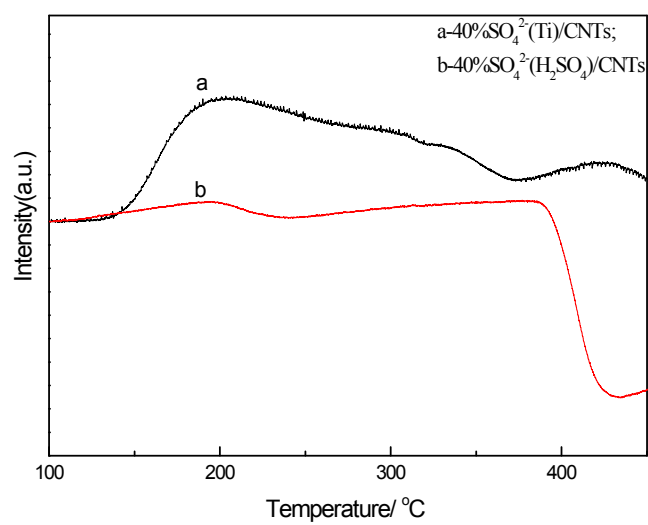


Fig. ESI-8 NH₃-TPD profiles of 40%SO₄²⁻(H₂SO₄)/CNTs and 40%SO₄²⁻(Ti)/CNTs calcined at 240 °C.

Table ESI-1 Results of NH₃-TPD integration

Catalyst	Weak acid (mmol NH ₃ /g)
CNTs	0.029
10% SO ₄ ²⁻ /CNTs	0.125
30% SO ₄ ²⁻ /CNTs	0.161
40% SO ₄ ²⁻ /CNTs	0.174
50% SO ₄ ²⁻ /CNTs	0.126

Table ESI-2 Results of NH₃-TPD integration for 40%SO₄²⁻/CNTs

Calcination temperature (°C)	Weak acid (mmol NH ₃ /g)
200	0.537
240	0.354
300	0.201
400	0.174
450	0.153
500	0.143

Table ESI-3 Surface composition results of 40%SO₄²⁻/CNTs at different calcination temperature from XPS

Calcination temperature (°C)	S ⁶⁺ (mol%)	Ti ⁴⁺ (mol%)	O (mol%)
200	4.15	1.00	28.2
240	3.55	0.94	25.3
300	2.53	0.97	19.6
400	2.06	1.15	15.2
450	1.81	1.06	13.4
500	0.60	3.14	16.9