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Supporting Information

for

Synthesis of MnO_2–CuO–Fe_2O_3/CNTs catalysts: low-temperature SCR activity and formation mechanism

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Additional experimental data

Table S1: BET surface area and pore volume for the pristine CNTs, acid-treated CNTs and as-prepared catalysts

sample	S_{BET} ($m^2 \cdot g^{-1}$)	pore volume ($cm^3 \cdot g^{-1}$)
pristine CNTs	63.11	0.1457
acid-treated CNTs	71.11	0.1585
1% Mn–CuO–Fe_2O_3/CNTs	61.29	0.1319
2% Mn–CuO–Fe_2O_3/CNTs	86.40	0.1660
4% Mn–CuO–Fe_2O_3/CNTs	95.66	0.1841
6%Mn–CuO–Fe_2O_3/CNTs	130.54	0.2447
Mn–Cu–FeO_x/CNTs-IWIM	111.05	0.1673

Table S2: Relative oxygen content of the as-prepared catalysts.

sample	O(%)	
	O_L	O_S
4% MnO_2–CuO–Fe_2O_3 /CNTs	33.3	66.7
Mn–Cu–FeO_x/CNTs-IWIM	63.2	36.8

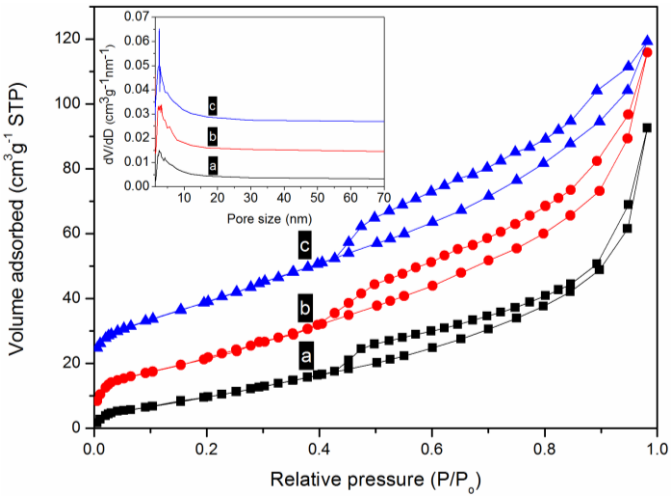

Figure S1: N_2 adsorption–desorption isotherm and pore size distribution (inset) of (a) acid-treated CNTs, (b) 4% MnO_2–CuO–Fe_2O_3/CNTs, and (c) Mn–Cu–FeO_x/CNTs-IWIM.

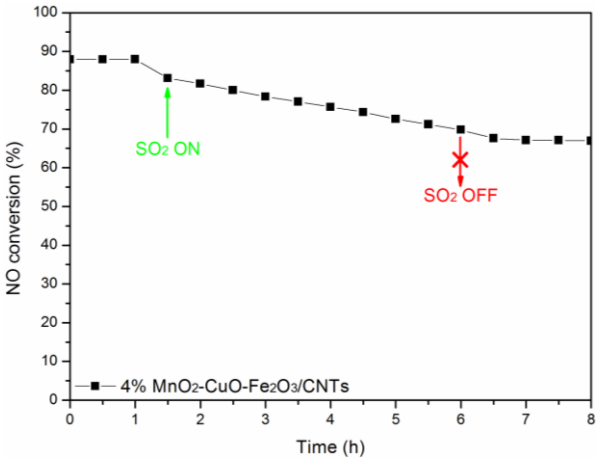

Figure S2: SO_2 tolerance of 4% MnO_2–CuO–Fe_2O_3/CNTs catalyst. Reaction conditions: [NO] = [NH_3] = 400 ppm, [SO_2] = 50 ppm (when used), [O_2] = 5%, N_2 as balance gas, WHSV=280 $L \cdot g_{cat}^{-1} \cdot h^{-1}$, 0.15 g catalyst.

BET surface area data

The results of BET surface area measurements (Table S1) show that the surface area of the pristine CNTs was 63.11 $m^2 \cdot g^{-1}$, whereas it became larger after being loaded with catalyst, indicating the even distribution of metal-oxide catalysts on the CNTs. It should be noted that although the 4% MnO_2–CuO–Fe_2O_3/CNTs catalyst showed the best catalytic activity among all samples, it possessed a smaller surface area (95.66 $m^2 \cdot g^{-1}$) than Mn–Cu–FeO_x/CNTs-IWIM (111.05 $m^2 \cdot g^{-1}$), revealing that the surface area is not the only important factor in SCR activity [1].

N_2 adsorption-desorption curves

Figure S1 shows the N_2 adsorption–desorption isotherm and the pore size distribution of the acid-treated CNTs and the as-synthesized catalysts. All samples present a typical type-IV isotherm along with a type-H4 loop, verifying the mesoporous structure [2,3]. The pore sizes of the samples were between 2.5 and 5.0 nm.

SO_2 tolerance

SO_2, a common component of flue gas, can inhibit the catalytic activity. Therefore, the catalysts need to be resistant against SO_2. In Figure S2, it is shown that the denitration efficiency of 4% MnO_2–CuO–Fe_2O_3/CNTs catalyst is ca. 87.9% in the absence of SO_2. When 50 ppm SO_2 is added to the gas flow for 5 h, there is a decline in catalytic efficiency to ca. 67.6%. Afterwards, the catalytic activity remains stable at around 67.1%. Hence, the 4% MnO_2–CuO–Fe_2O_3/CNTs exhibits SO_2 tolerance, which is favorable for its practical application.

References

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