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Supporting Information:

Improved Low Temperature NH_3-SCR Performance of FeMnTiO*x* Mixed Oxide with CTAB-assisted Synthesis

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Catalysts preparation

FMT: FMT mixed oxide was prepared by inverse co-precipitation method. $Fe(NO_3)_3\cdot 9H_2O$, $Mn(AC)_2\cdot 4H_2O$, $Ti(SO_4)_2$ (mole ratio = 0.1:0.1:1.0) with suitable amount were dissolved in distilled water with subsequent mixing for 10 min. Then the mixture was added dropwise to an ammonia solution (25 wt. %) and the pH value of the final solution is maintained at 11. During the reaction, the system was continuously stirred at 300 rpm. 3 h later, the particles were then separated by filtrate and washed with distilled water for 3 times at least. Then the particles were collected and dried in an oven at 110 ºC for 12 h. Then the samples were calcined in muffle furnace in air condition at 500 ºC for 6 h and the heating rate was kept at 2 $^{\circ}C\cdot min^{-1}$. The calcined samples were crushed and sieved to 40-60 mesh for activity test.

FMT(S): FMT(S) mixed oxide catalyst was prepared by inverse co-precipitation method. Suitable CTAB (30 mmol/L) were added to distilled water, and then the solution was heated to 30 ºC to ensure that the CTAB dissolved. $Fe(NO_3)_3\cdot 9H_2O$, $Mn(AC)_2\cdot 4H_2O$, $Ti(SO_4)_2$ with suitable amount (mole ratio = 0.1:0.1:1.0) were dissolved in CTAB solution with subsequent mixing for 30 min. Then the mixture was added dropwise to an ammonia solution (25 wt.%) and the pH value of the final solution is maintained at 11, and other steps just the same as FMT mixed oxide catalyst.

Characterization

XRD: X-ray diffraction (XRD) patterns were recorded on a Philips X'pert Pro diffractometer using Ni-filtered Cu Kα radiation (λ = 0.15418nm). The X-ray tube was operated at 40 kV and 40 mA. The intensity data were collected over a 2θ range of 10-80°. The scan speed was set at 10°min^{-1} with a step size of 0.02°.

TPR: H_2-temperature programmed reduction (H_2-TPR) experiments were performed in a quartz U-type reactor connected to a thermal conductivity detector (TCD) with Ar-H_2 mixture (7.0% of H_2 by volume, 70 mL·min^{-1}) as a reductant. Prior to the reduction, the sample (50 mg) was pretreated in a high purified N_2 stream at 300 ºC for 40 min and then cooled to room temperature. After that, the TPR started from 50 ºC to target temperature at a rate of 10 ºC·min^{-1}.

BET and BJH: Textural characteristics of these catalysts were measured by N_2-physisorption at −196 ºC on a Micromeritics ASAP-2020 analyzer, using the Brunauer-Emmet-Teller (BET) method to determine their specific surface area. The pore size distributions were calculated from the desorption branch of the isotherm using the Barrett-Joyner-Halenda (BJH) algorithm. The sample was degassed under vacuum at 90 ºC for 1 h and 300 ºC for 4 h before each analysis.

XPS: X-ray photoelectron spectroscopy (XPS) analysis was performed on a PHI 5000 Versa Probe system, using monochromatic Al Kα radiation (1486.6 eV) operating at an accelerating power of 15 kW. Before the measurement, the sample was outgassed at room temperature in a UHV chamber ($<5\times10^{-7}$ Pa). The sample charging effects were compensated by calibrating all binding energies (BE) with the adventitious C1s peak at 284.6 eV. This reference gave BE values with accuracy at ±0.1 eV.

***In situ* DRIFTS:** *In situ* diffuse reflectance infrared Fourier transform spectra (*in situ* DRIFTS) were collected from 650 to 4000 cm^{-1} at a spectral resolution of 4 cm^{-1} (number of scans, 32) on a Nicolet 5700 FT-IR spectrometer equipped with a high-sensitive MCT detector cooled by liquid N_2. The DRIFTS cell (Harrick) was fitted with a ZnSe window and a heating cartridge that allowed sample be heated to 300 ºC. The same amount of fine catalyst powder was placed in a sample holder every time, and flattened to enhance IR reflection. The sample was pretreated with a high purified N_2 stream at 300 ºC for 60 min to eliminate the physical adsorbed water and other impurities. The sample background of each target temperature was collected during the cooling process. At ambient temperature, the sample was exposed to a controlled stream of 1% NH_3 (by volume, N_2 balance, hereinafter the same) or 1% NH_3 +1% NO +5% O_2 at a rate of 50 mL·min^{-1} for 1 h to be saturated. And then, the gaseous and weakly adsorbed NH_3 molecules were purged by a high purified N_2 stream (50 mL·min^{-1}) for 1 h. Desorption/reaction studies were performed by heating the adsorbed species and the spectra were recorded at various target temperatures at a rate of 10 ºC·min^{-1} from room temperature to 300 ºC by subtraction of the corresponding background reference.

TPD: NH_3-temperature programmed desorption (NH_3-TPD) experiments were carried out on a multifunction chemisorption analyzer with a quartz U-tube reactor, detected by a thermal conductivity detector (TCD). About 100 mg of the sample was pretreated by passage of high purified N_2 (40 mL·min^{-1}) at 400 ºC for 1 h. After pretreatment, the sample was saturated with NH_3-N_2 (1% of NH_3, 10 mL·min^{-1}) at room temperature for 1 h, and then flushed with the flowing high purified N_2 (40 mL·min^{-1}) at 100 ºC for 1 h to remove gaseous and weakly adsorbed NH_3. Subsequently the sample was heated to 600 ºC at a rate of 10 ºC·min^{-1} with the flowing high purified

N_2 (40 mL·min^{-1}).

Catalytic performance measurements

The catalytic performances of FMT(S) and FMT for NH_3-SCR in the presence of excess oxygen were measured under the following conditions: 500 ppm NO, 500 ppm NH_3, 5% O_2, 3.5% H_2O (when used), and N_2 balance. firstly, the sample (200 mg) was fitted in a quartz tube and pretreated in a high purified N_2 stream at 300 ºC for 1 h; secondly, the sample was cooled down to room temperature; the third, feed gas (O_2, NO and NH_3) were introduced, and the catalyst adsorbed feed gases until the sample got saturated; next, increasing to the aimed temperature at the rate of 10 ºC·min^{-1} and holding the temperature for 15 minutes to get the steady state; then, collecting data at aimed temperature, and so on. Sampling and recording a data point per 25 ºC until 375 ºC. The whole process is stepwise. The reactions were carried out with a space velocity of 30,000 mL·g^{-1}·h^{-1}. The concentrations of NO, NH_3, NO_2, and N_2O were measured at 150 ºC by a Thermofisher IS10 FTIR spectrometer equipped with 250 mL volume gas cell. The gas path from the reactor to FTIR spectrometer was kept a fixed temperature of 150 ºC to avoid the deposition of nitrite/nitrate and the dissolution of NH_3 in liquid H_2O. The NO conversion and N_2 selectivity were calculated from the following equations:

$$NO\ conversion\ (\%) = \frac{[NO]in\ -\ [NO]out}{[NO]in} \times 100.$$

$$N_2\ \text{selectivity}\ (\%) = \frac{[NO]in\ -\ [NO]out\ +\ [NH_3]in\ -\ [NH_3]out\ -\ [NO_2]out\ -\ 2[N_2O]out}{[NO]in\ -\ [NO]out\ +\ [NH_3]in\ -\ [NH_3]out} \times 100$$

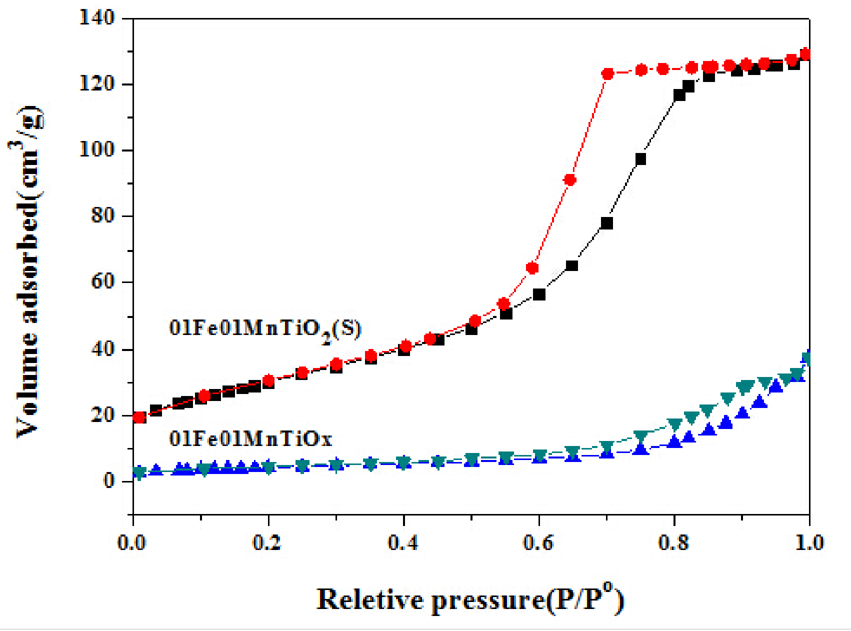

Fig. S1. The N_2 adsorption-desorption isotherms curves of FMT(S) and FMT.

Table S1 Textural properties of FMT(S) and FMT.

Samples	BET surface area (m^2·g^{-1})	Average pore diameter (nm)
FMT(S)	109	6
FMT	15	16

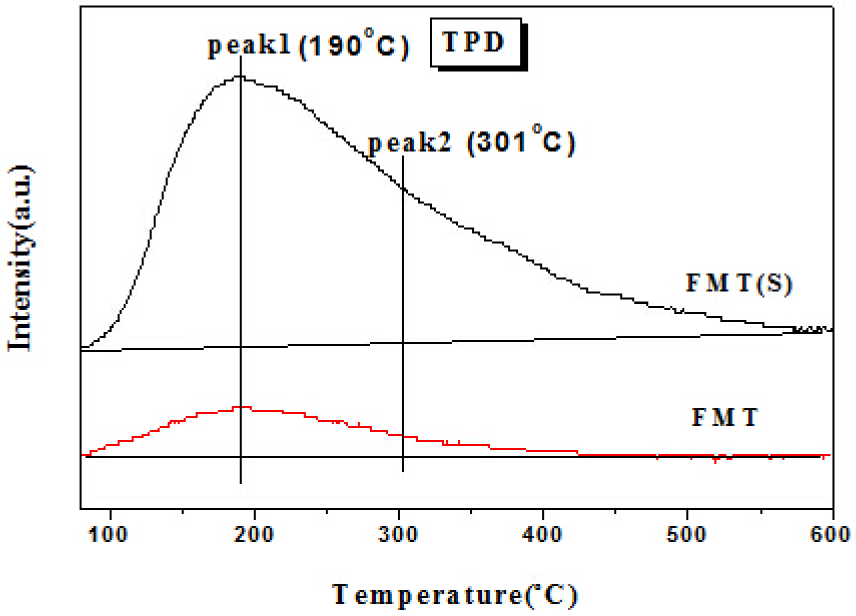

Fig. S2. NH_3-TPD profiles over FMT(S) and FMT.

Table S2 The quantitative analysis data of NH_3-TPD over the obtained samples.

	Information of peaks				
catalysts	Peak 1		Peak 2		Area 2/(Area 1 + Area 2)
	Area 1	Center (°C)	Area 2	Center (°C)	
FMT(S)	3943	190	6735	301	0.63
FMT	1062	190	368	302	0.26

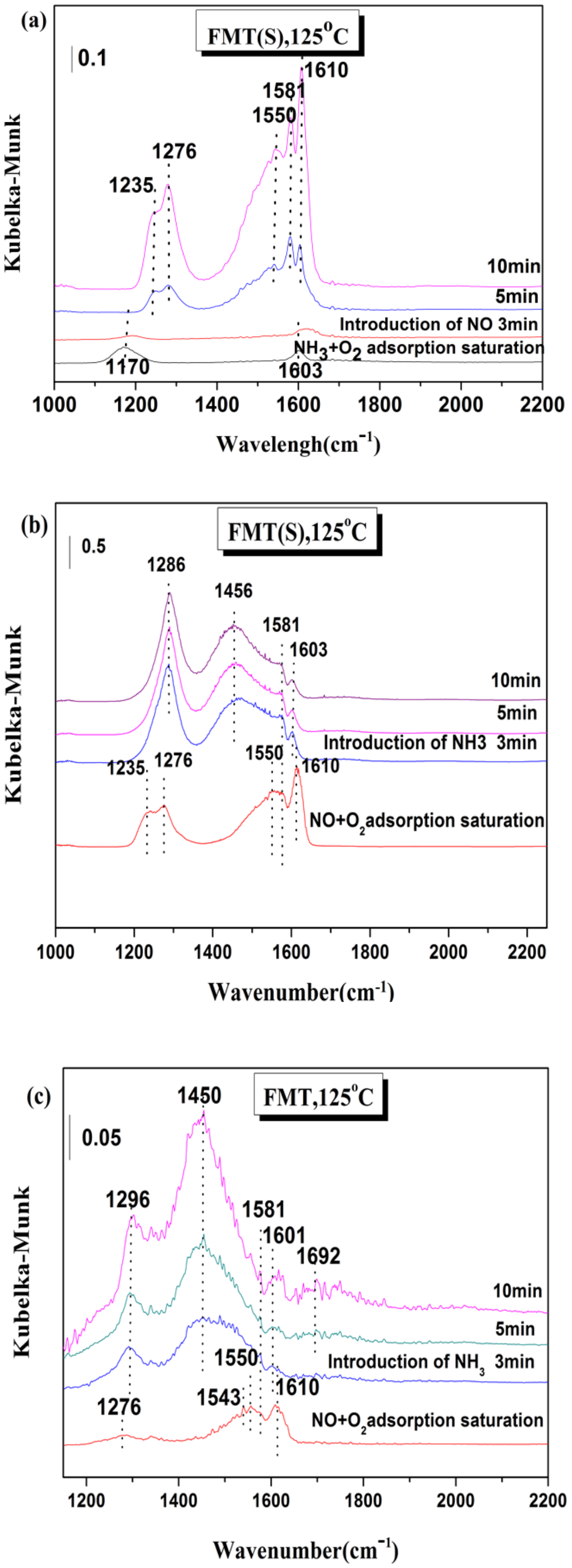

Fig. S3. *In situ* DRIFTS of (a) NO was introduced into IR sample cell after the NH_3+O_2 adsorption saturation on FMT(S) sample at 125 ºC, (b) NH_3 was introduced into IR sample cell after the $NO+O_2$ adsorption saturation at 125 ºC on FMT(S) and NH_3 was introduced into IR sample cell after the $NO+O_2$ adsorption saturation at 125 ºC on (c) FMT sample.

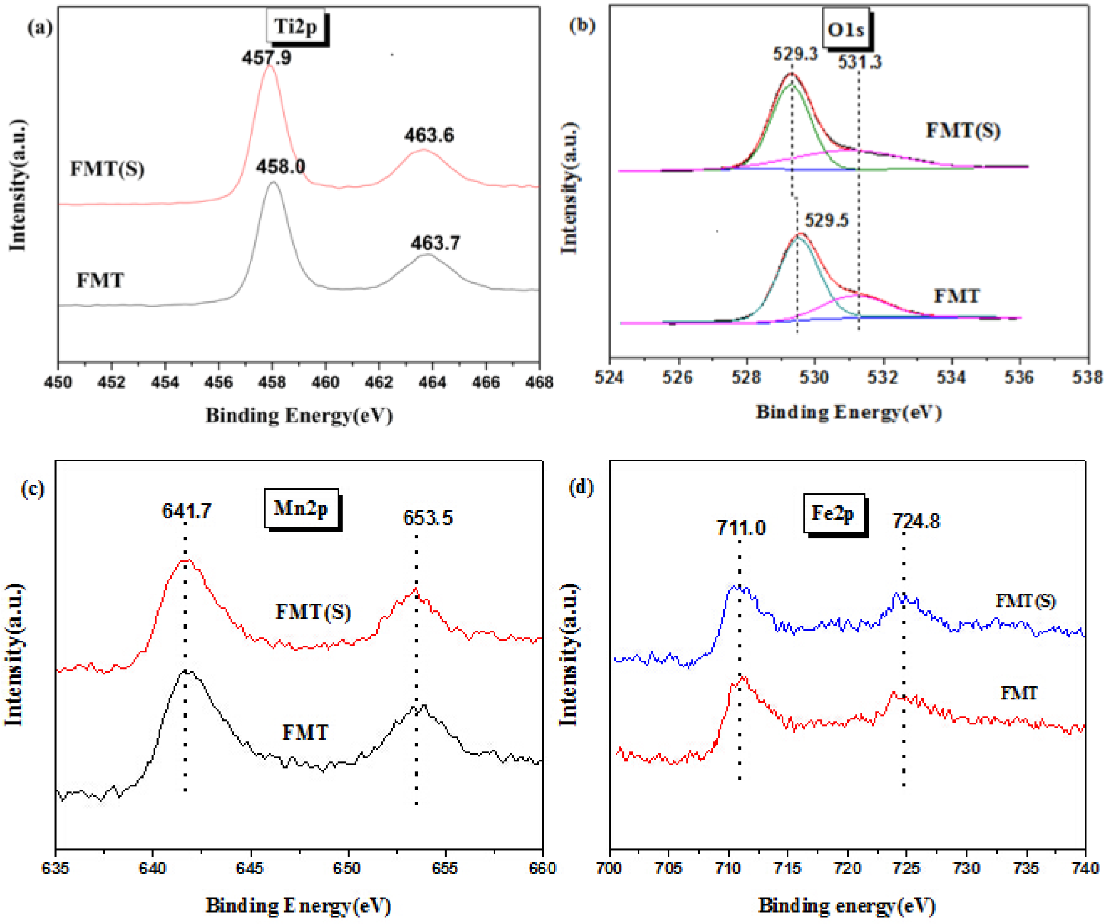

Fig. S4. XPS spectra of (a) Ti 2p, (b) O 1s, (c) Mn 2p and (d) Fe 2p for obtained samples.

Table S4 XPS elementary surface concentration of these catalysts.

	Amount of oxygen species				
catalysts	Lattice oxygen (O_{α})		Adsorbed oxygen (O_{β})		
	BE (eV)	AO_{α} (a.u.)	BE (eV)	AO_{β} (a.u.)	$AO_{\beta}/(AO_{\alpha} + AO_{\beta})$ (%)
FMT(S)	529.3	14630	531.0	9127	38.4
FMT	529.5	15707	531.0	6341	28.8

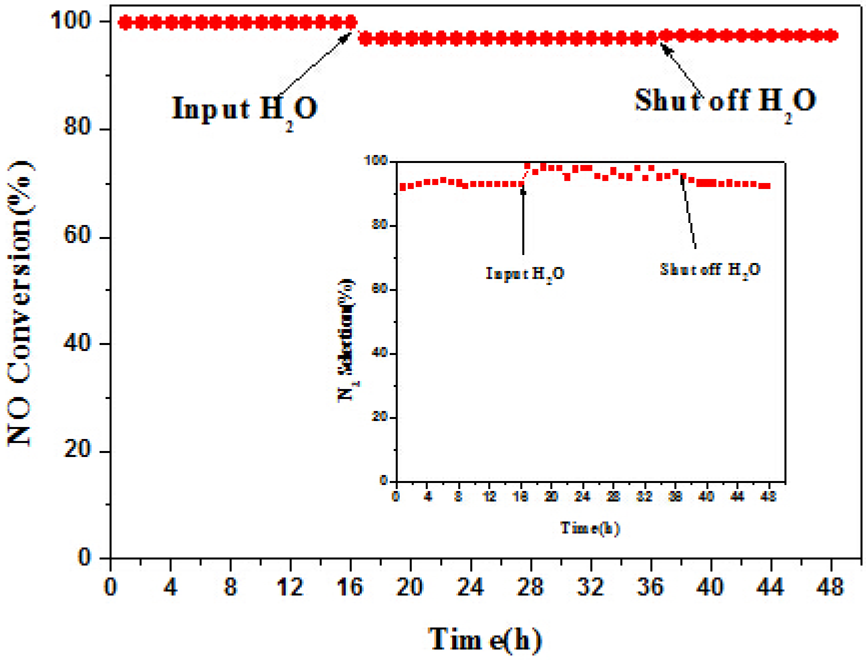

Fig. S5. NO conversion and N_2 selectivity (inserted) in NH_3-SCR reaction over FMT(S). Reaction conditions: [NO] = [NH_3] = 500 ppm, [O_2] = 5%, N_2 balance, catalyst mass = 200 mg, total flow rate = 100 mL·min^{-1}, [H_2O] = 3.5%, GHSV = 30000 mL·min^{-1}·h^{-1} and T = 150 ºC.