

Supporting information

Effect of Potassium Promoter on the Performance of Nickel-Based Catalysts Supported on MnO_x in Steam Reforming of Ethanol

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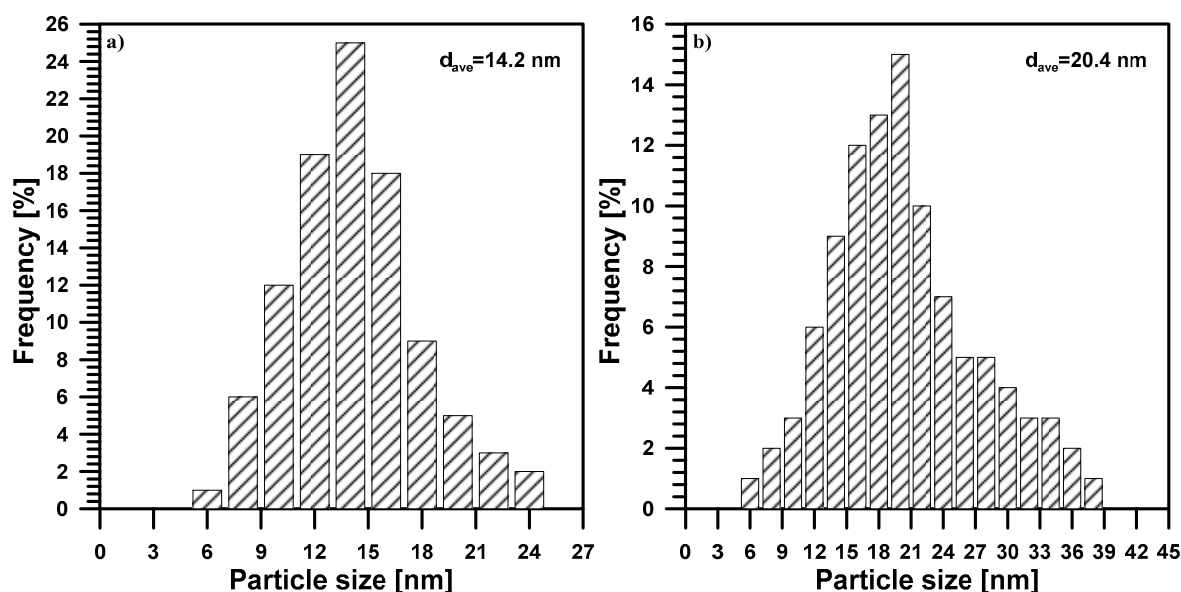


Figure S1. Particle size distribution histograms for (a) Ni/MnO_x and (b) KNi/MnO_x catalysts reduced at 500 °C. Size distribution of particles determined from measurement of at least 200 particles from representative HRTEM images.

The XRD patterns of the as-prepared and reduced with hydrogen at 500 °C MnO_x support are shown in Fig. S2. For as-prepared MnO_x support, the diffraction peaks at 2 θ exhibited a mixed phase structure of Mn₂O₃ and Mn₃O₄. The diffraction peaks of Mn₂O₃ are centered around 22.9°, 33.2°, 49.3°, 55.5° and 65.7°, and the diffraction peaks of Mn₃O₄ are centered at 2 θ angles of around 28.9°, 31.0°, 32.2°, 35.8°, 38.2°, 44.5°, 50.7°, 54.3°, 56.2°, 58.8°, 60.2°, 64.7° and 74.5°. After reduction of the sample with hydrogen at 500 °C, the XRD pattern indicates

only crystalline peaks for cubic structure of MnO. Sharp diffraction peaks, indicating high crystallinity, are at 2θ angles of 34.8° , 40.3° , 58.3° , 69.5° , 73.0° , 87.3° and 97.7° [37-41].

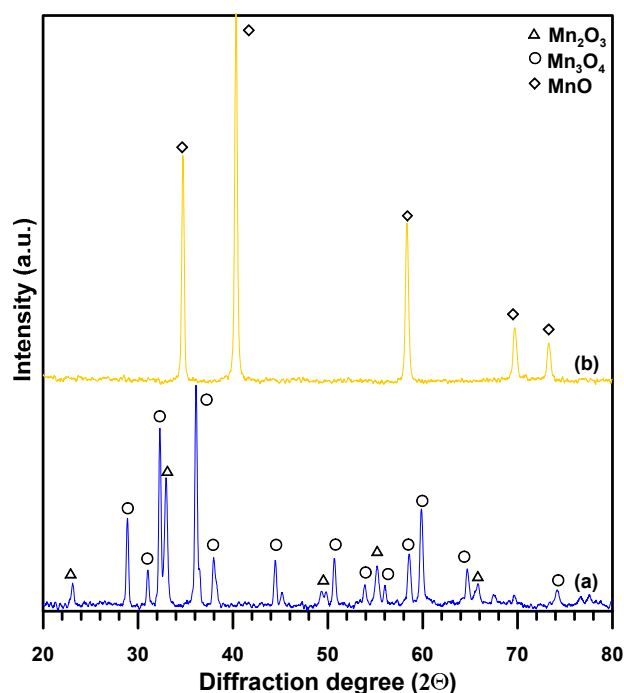


Figure S2. XRD patterns of (a) calcined and (b) reduced at 500°C of MnO_x support.

Table S1. XRD details with 2θ , and hkl values of the obtained crystalline phases for as-prepared and reduced with hydrogen at 500°C of Ni/MnO_x and KNi/MnO_x catalysts [37–42].

Phase	2θ ($^\circ$)	[hkl]
as-prepared samples		
NiO	43.2	200
Mn_2O_3	23.1	211
	33.0	222
	38.2	400
	49.3	431
	55.1	440
	65.7	622
Mn_3O_4	29.0	112
	36.2	211
	45.1	220
reduced samples		
Ni^0	44.3	111
	51.2	200
MnO	34.4	111
	40.3	200
	58.5	220
	70.0	311
	73.0	222

Table S2. Hydrogen consumption from H₂-TPR results.

	MnO _x	Ni/MnO _x	KNi/MnO _x
H ₂ consumption (mmol/g)	5.13	6.55	8.13

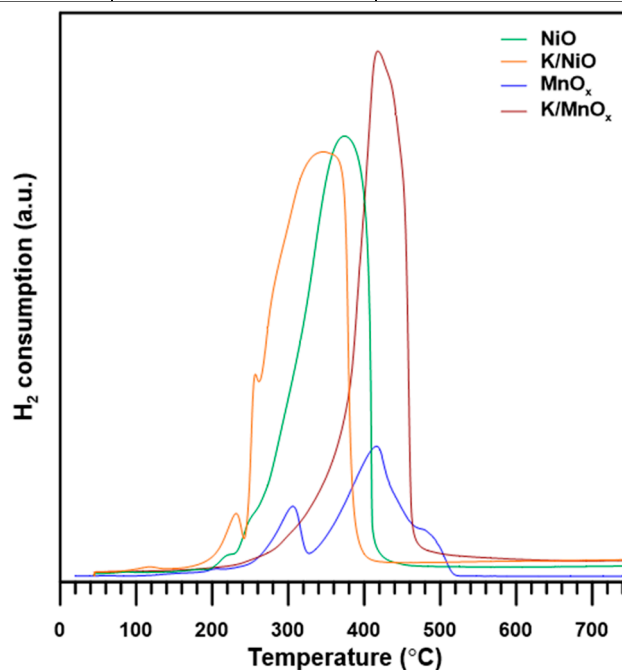


Figure S3. H₂-TPR profiles of NiO and K/NiO samples.

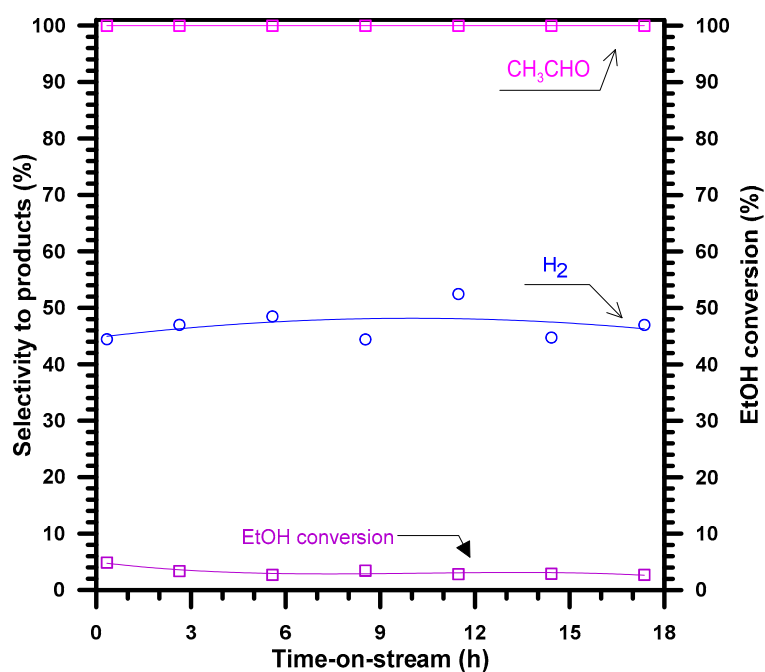
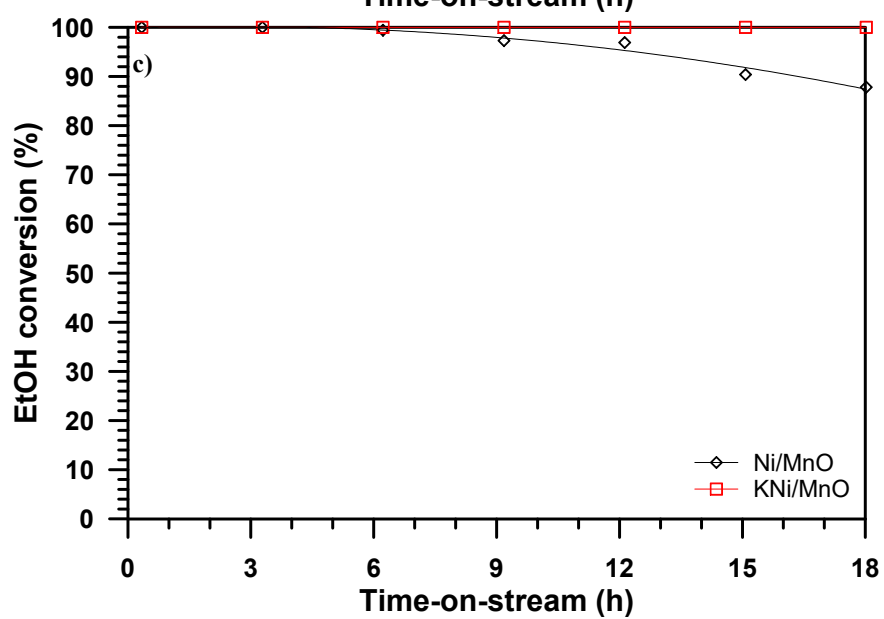
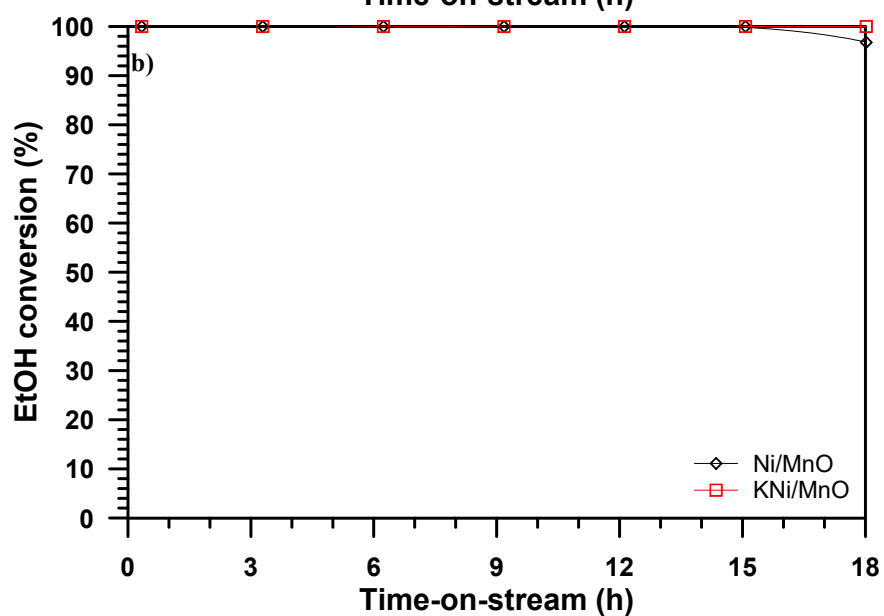
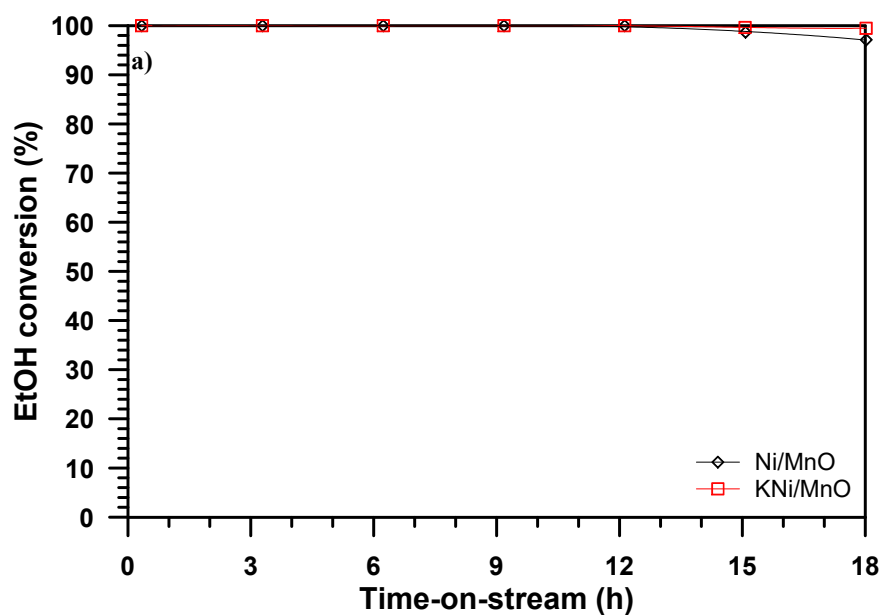


Figure S4. Ethanol conversion and selectivity to products over MnO_x support in SRE process at 420 °C. (H₂O/EtOH=12/1).



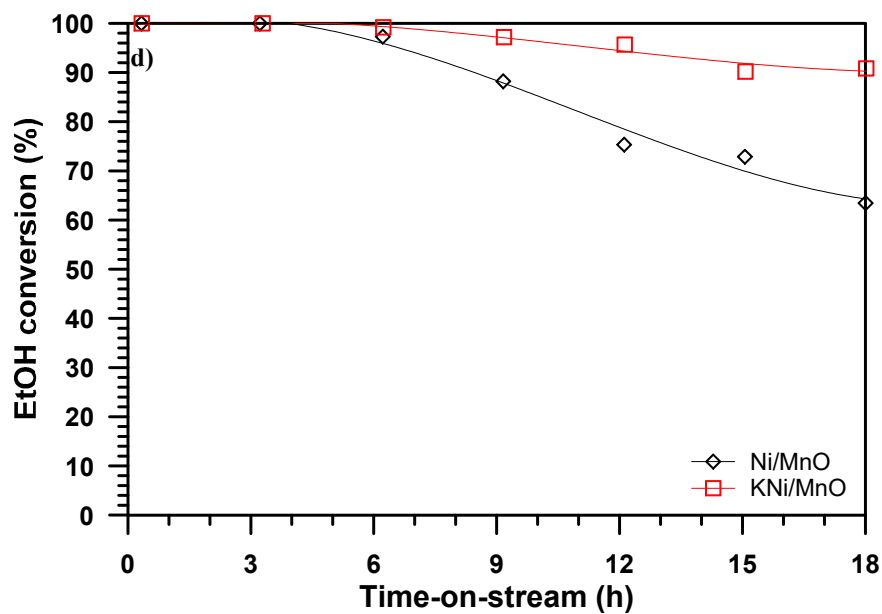


Figure S5. Stability tests of Ni/MnO_x and KNi/MnO_x catalysts at temperature of 420 °C under SRE conditions for H₂O/EtOH molar ratio of (a) 12/1 (b) 9/1, (c) 6/1 and (d) 4/1.

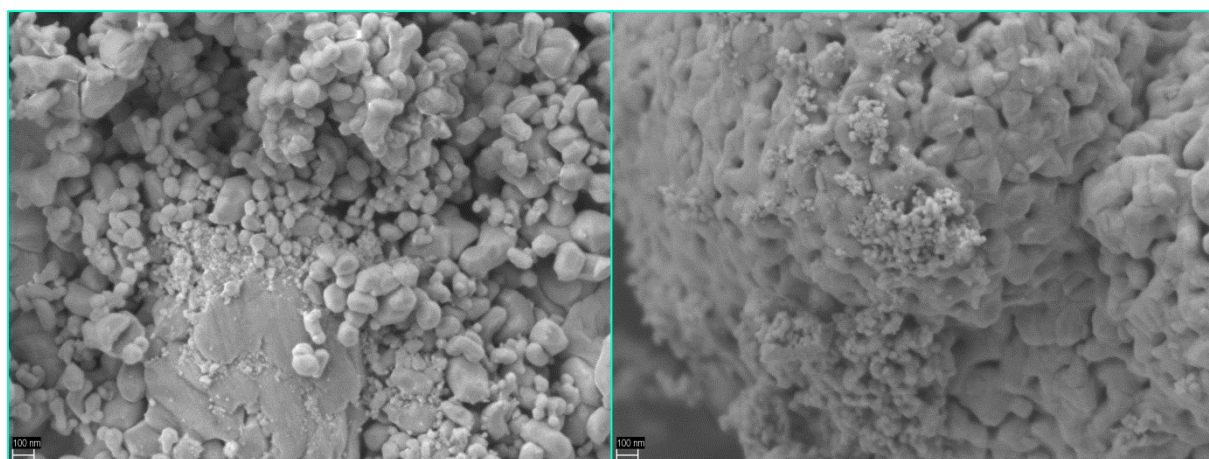


Figure S6. SEM images of MnO_x support (a) in the fresh state and (b) after 18 hours of SRE reaction at 420 °C (H₂O/EtOH molar ratio=12/1).

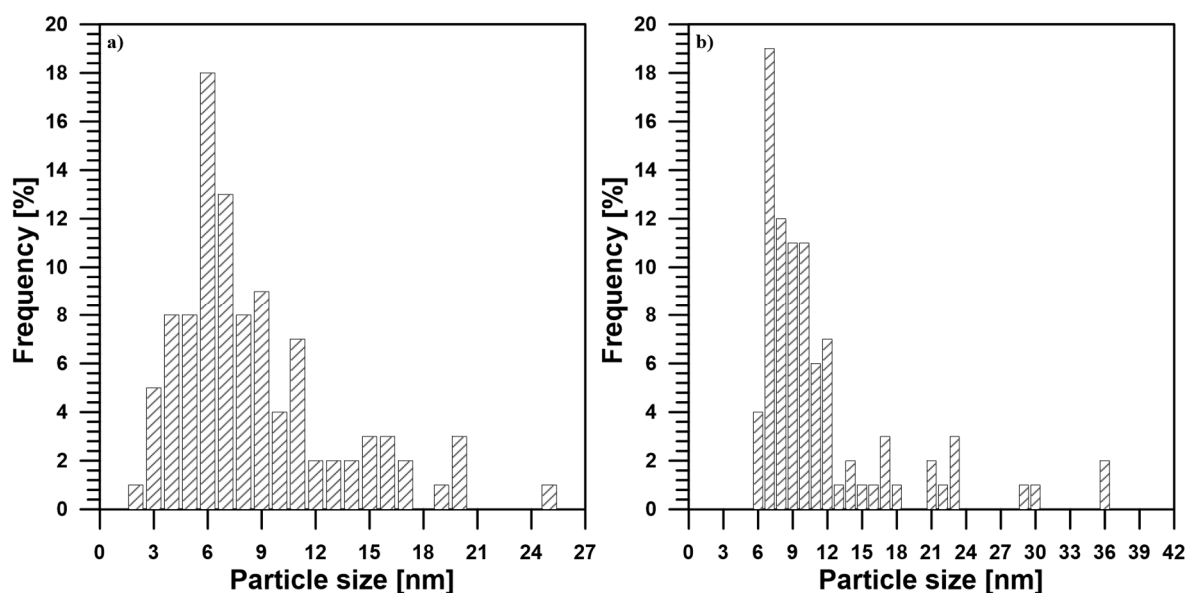


Figure S7. Particle size distribution histograms for (a) Ni/MnO_x and (b) KNi/MnO_x catalysts after SRE reaction at temperature of 420 °C under SRE conditions for H₂O/EtOH molar ratio of 12/1. Size distribution of particles determined from measurement of at least 200 particles from representative HRTEM images.

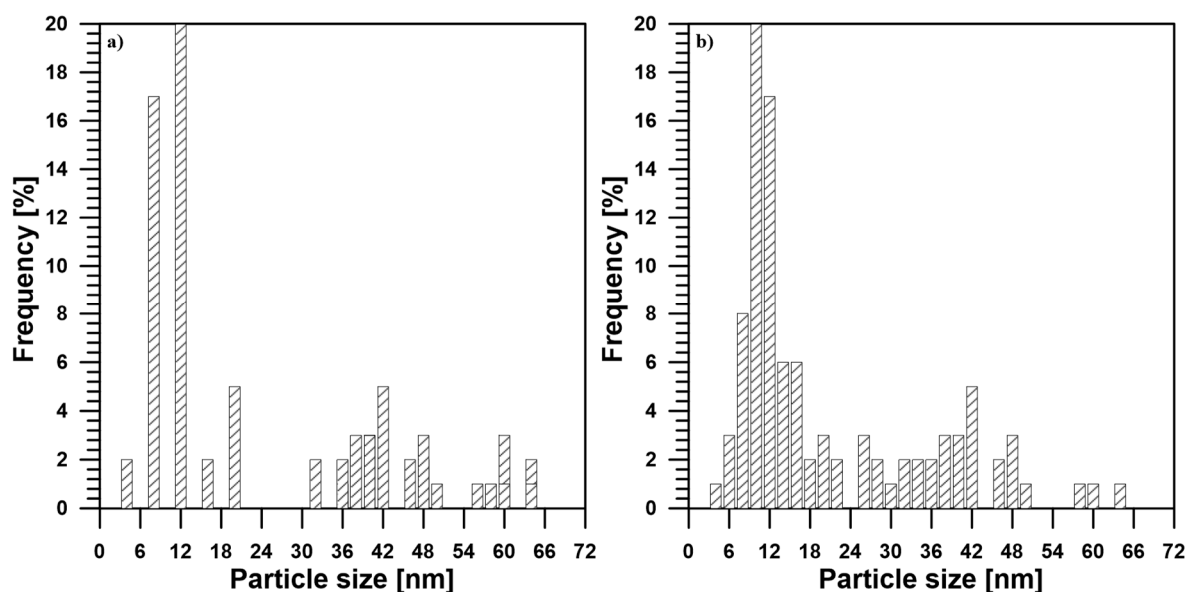


Figure S8. Particle size distribution histograms for (a) Ni/MnO_x and (b) KNi/MnO_x catalysts after SRE reaction at temperature of 420 °C under SRE conditions for H₂O/EtOH molar ratio of 4/1. Size distribution of particles determined from measurement of at least 200 particles from representative HRTEM images.