Supplementary Information

Direct Catalytic Co-conversion of Cellulose and Methane to Renewable Petrochemicals

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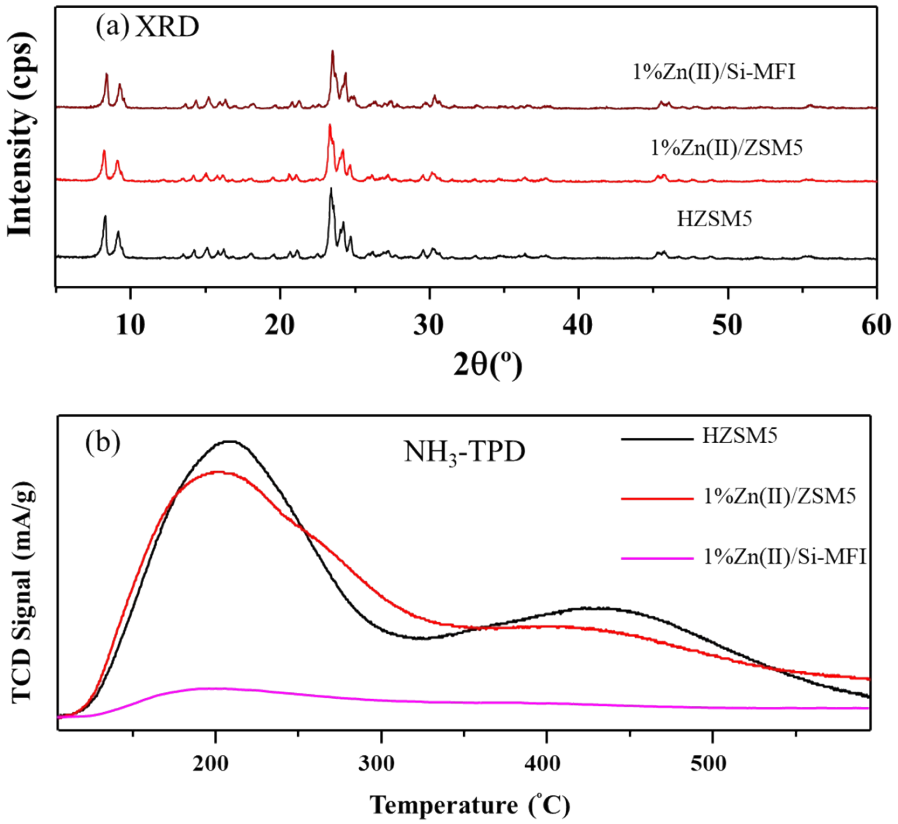

Figure S1. XRD (a) patterns and NH_3-TPD (b) profile of the catalysts HZSM5, 1%Zn(Ⅱ)/ZSM5 and 1%Zn(Ⅱ)/Si-MFI.

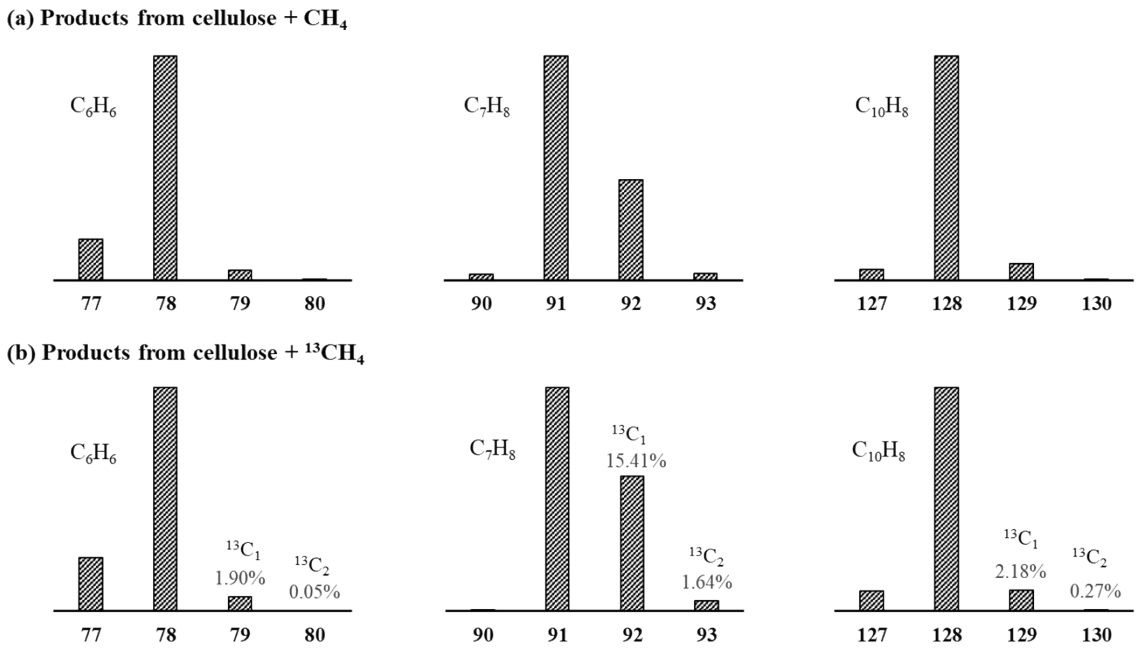

Figure S2. Mass spectra of major products (C_6H_6, C_7H_8, and $C_{10}H_8$): (a) with the natural abundance of ^{13}C and (b) formed form $^{13}CH_4$ and cellulose over 3%Zn-Zn/ZSM5 with the estimated isotopic composition (mol%)

Table S1. ^{13}C liquid NMR peak area ratio with respect to $CDCl_3$ of the products from cellulose conversion under $^{13}CH_4$ and CH_4 environments

Chemical shift/ppm	Peaks assigned	$^{13}CH_4$	CH_4	Increased by / %
129.05	Ortho positions of the alkyl substituted phenyl ring	0.107	0.067	60.3
128.34	Benzene ring /meta positions of the alkyl substituted phenyl ring	0.205	0.192	6.4
125.42	Para positions of the alkyl substituted phenyl ring	0.037	0.021	74.3
21.72	Benzylic carbon	0.060	0.046	30.7

Table S2. ^{1}H liquids NMR peak area ratio with respect to $CDCl_3$ of the products from the reactions between cellulose and CH_4/CD_4

The type of proton	Chemical Shifts /ppm	cellulose+CH_4	cellulose+ CD_4
aromatic	7.0-7.8	3.98	1.25
benzylic	2.0-2.8	0.99	0.30
Alkyl	0.6-1.4	4.53	4.51

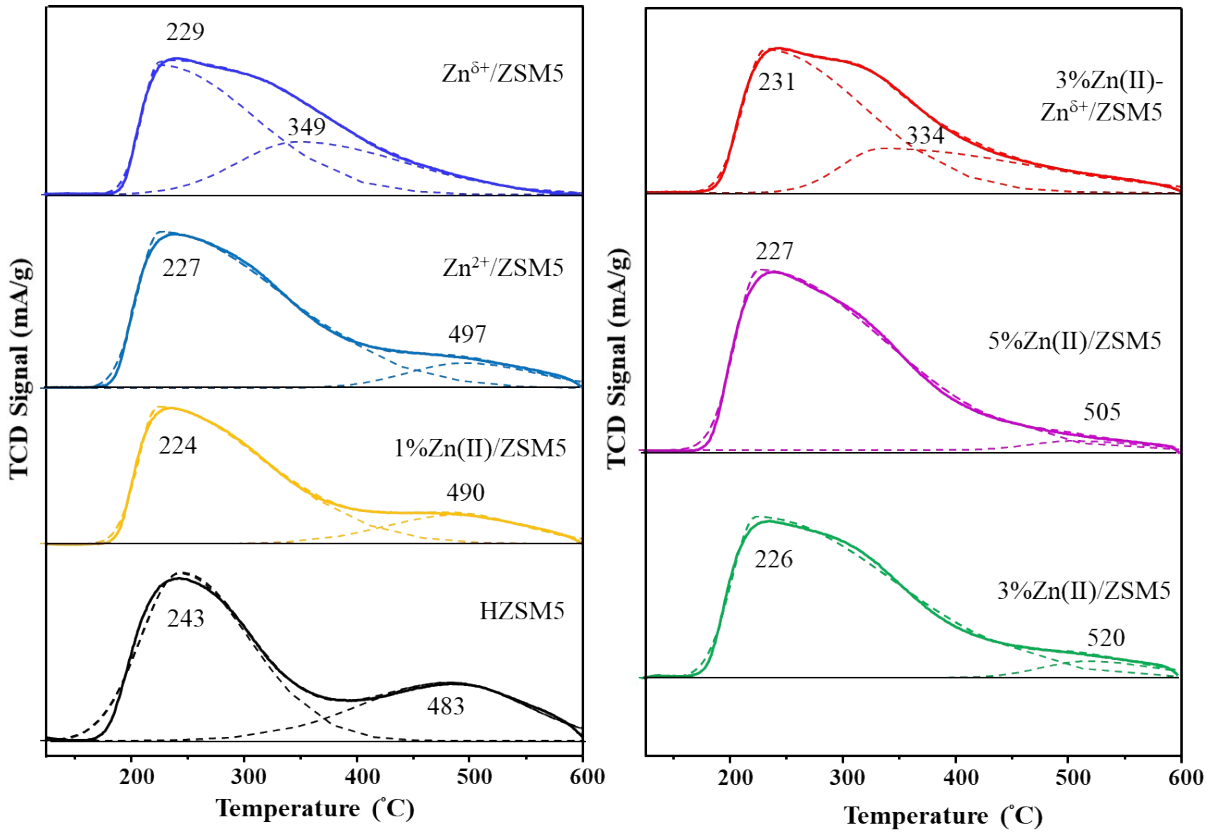

Figure S3. NH_3-TPD profiles and Bigaussian deconvoluted peaks of various fresh catalysts.

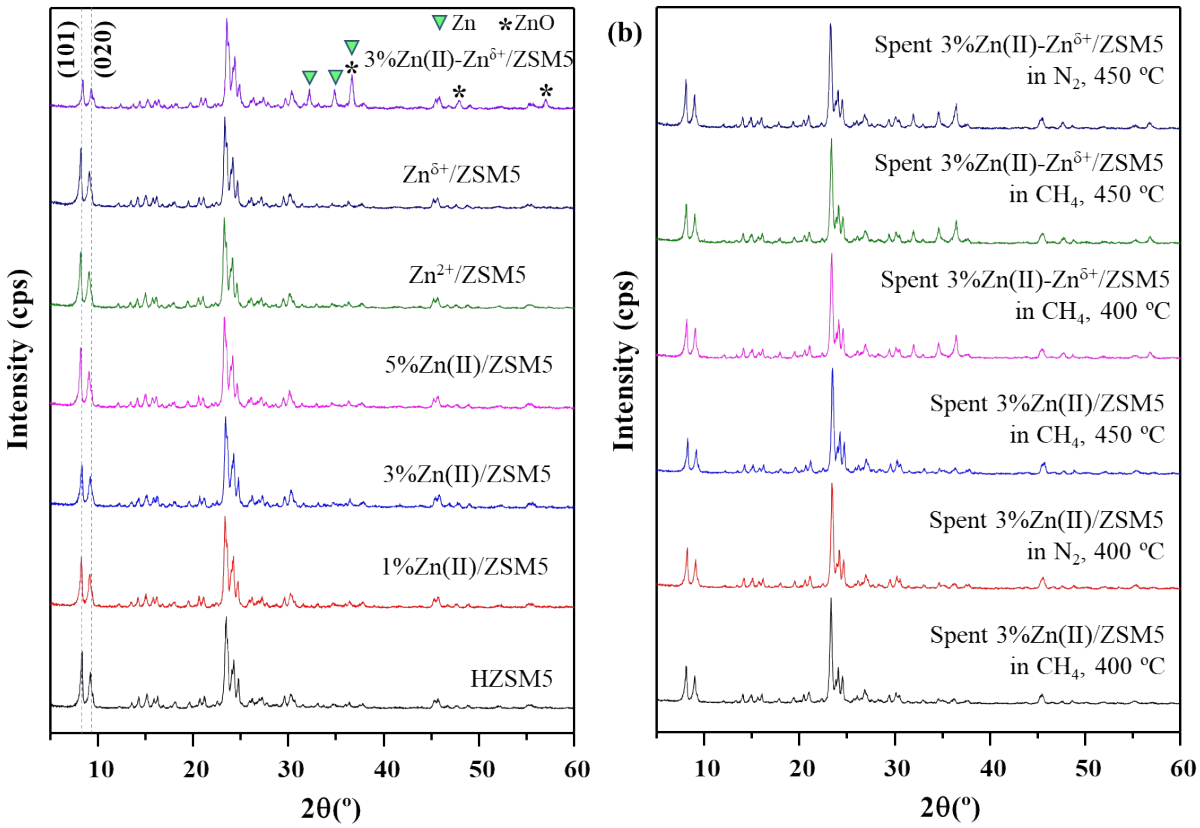

Figure S4. Powder XRD patterns of (a) various fresh catalysts, and (b) spent 3%Zn(Ⅱ)/ZSM5 and 3%Zn(Ⅱ)-Zn$^{\delta+}$/ZSM5 catalysts under different environments

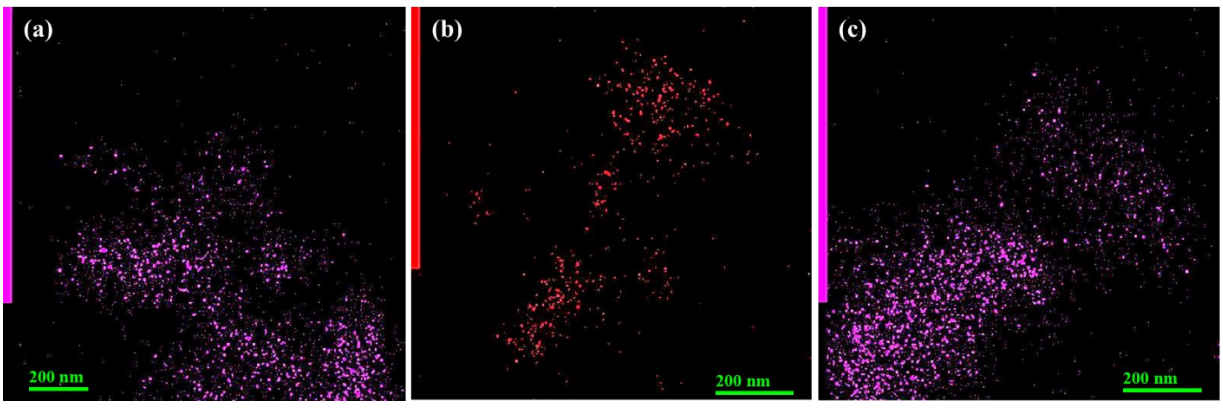

Figure S5. TEM-EDS mapping analysis of Zn species on the fresh 3%Zn(Ⅱ)-Zn$^{\delta+}$/ZSM5 catalyst (a), spent 3%Zn(Ⅱ)-Zn$^{\delta+}$/ZSM5 catalysts collected under environments of CH_4 (b) and N_2 (c).