Zeolite domination in coordination between metal and acid sites on an industrial catalyst for tetralin hydrocracking

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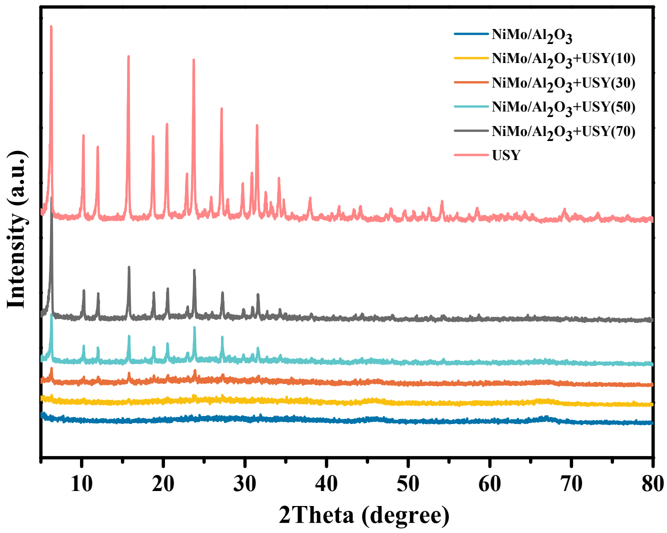


Fig. S1. XRD patterns of $NiMo/Al_2O_3$, USY and catalysts

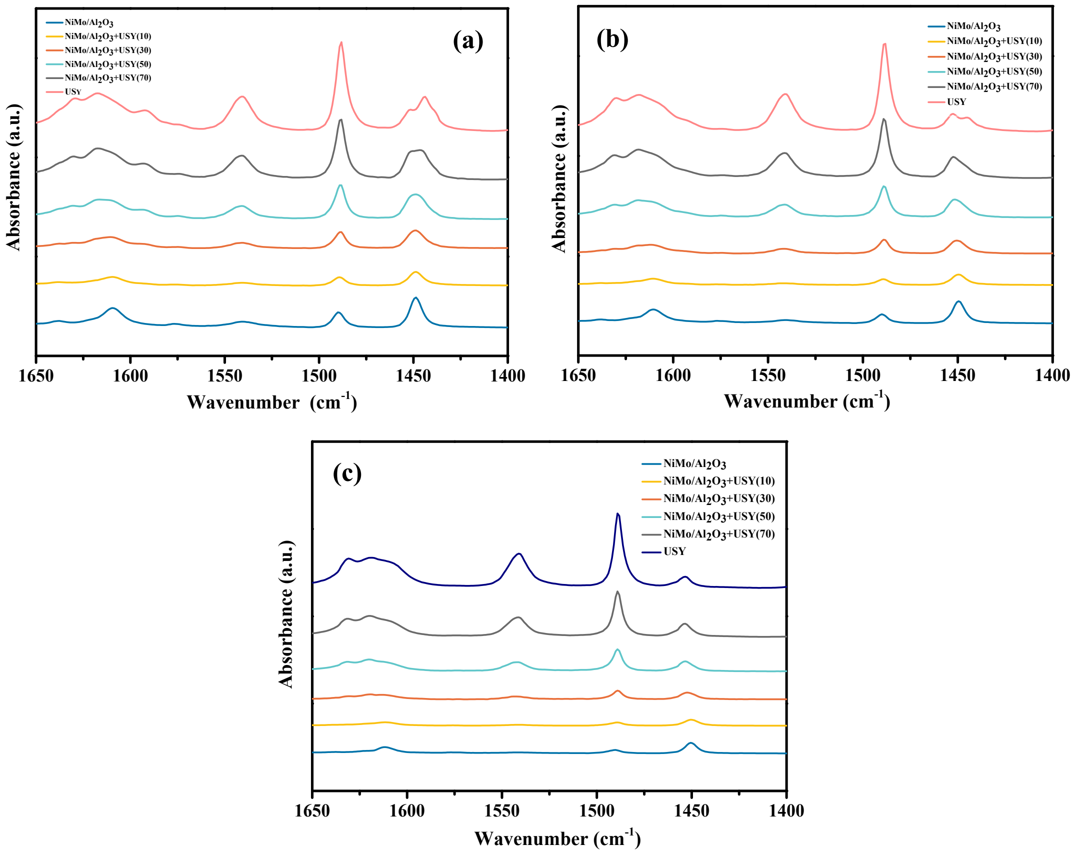


Fig. S2. Py-FTIR spectra of $NiMo/Al_2O_3$, USY and catalysts after desorption of pyridine at 150 ℃, 250 ℃, 350 ℃.

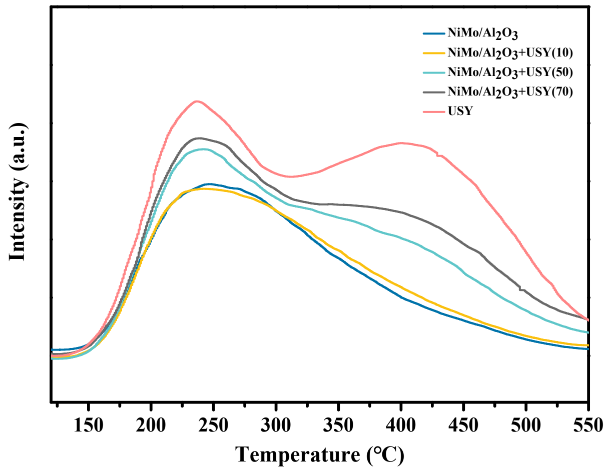


Fig. S3. NH_3-TPD profiles of NiMo/Al_2O_3, USY and their composite catalysts

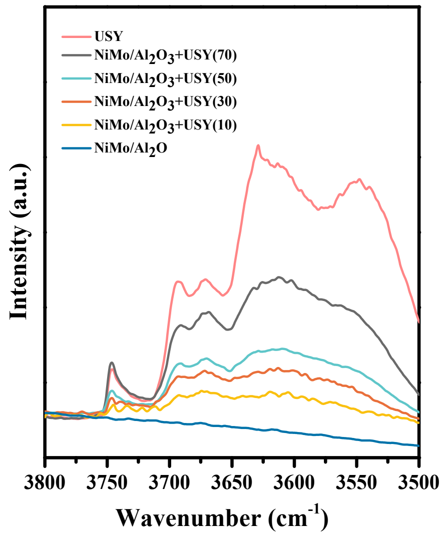


Fig. S4. The FTIR spectra in the OH stretching vibration of different catalysts.

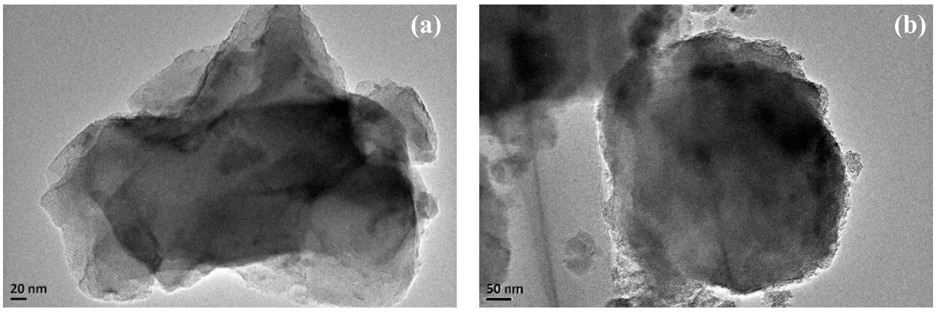
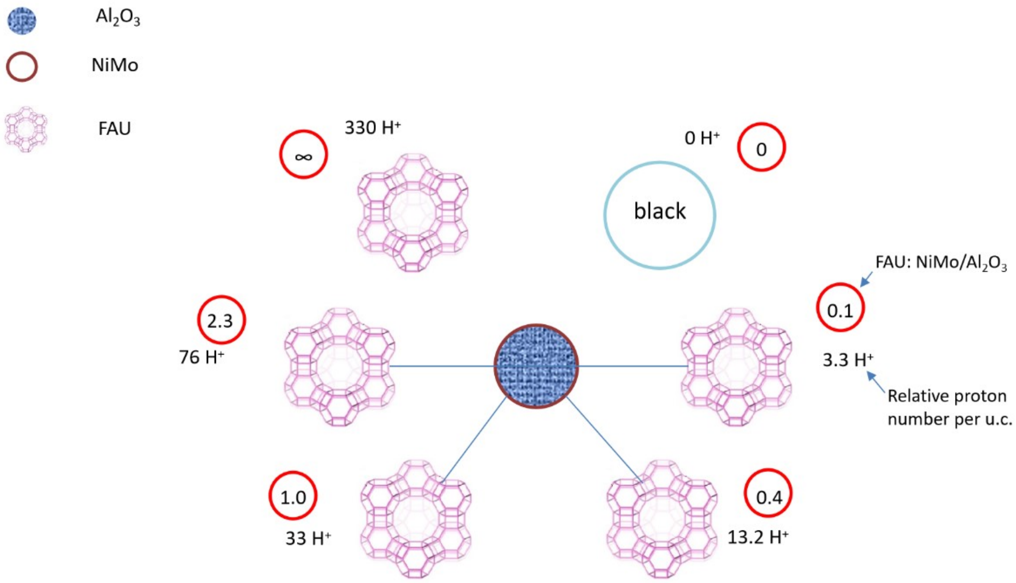


Fig. S5. TEM image of (a) USY (b) NiMo/Al_2O_3+Y(70) catalysts



Scheme S1 Compatibility of zeolite and NiMo/Al_2O_3 in the catalysts (FAU zeolite Si/Al = 4.8, nAl/u.c= 33)

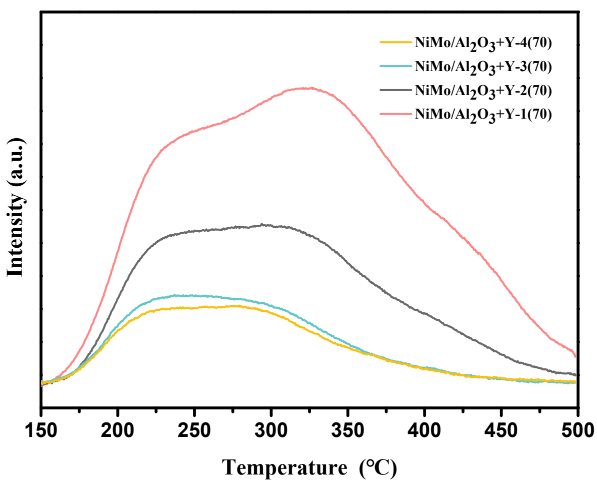


Fig. S6. NH_3-TPD profiles of the NiMo/Al_2O_3+Y(70) catalysts.

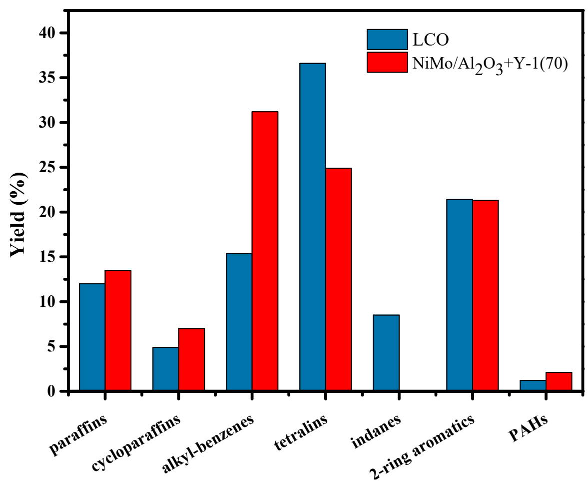


Fig. S7. Hydrocracking of LCO using NiMo/Al_2O_3+USY-1(70) catalyst; Temp-380 °C, Pressure-4 mpa, WHSV-2.3 h^{-1}, TOS-22 h

Table S1 The detailed product distribution of different catalysts s at 9 h.

Sample	$NiMo/Al_2O_3$	$NiMo/Al_2O_3$ +USY(10)	$NiMo/Al_2O_3$ +USY(30)	$NiMo/Al_2O_3$ +USY(50)	$NiMo/Al_2O_3$ +USY(70)	USY
Conversion (%)	27.3	29.3	38.7	48.6	56.9	49.3
Product Distribution(wt%)						
$C10^-$ Naphtha	0	0.3	0.6	1.3	1.8	0.6
Benzene	0.1	0.8	2.2	4.1	5.6	3.5
Toluene	0.0	0.4	0.8	1.8	2.4	2.2
Xylene	0.1	0.3	0.3	0.2	0.6	0.6
Ethylbenzene	0.0	0.1	0.2	0.3	0.6	0.4
C9 Aromatics	0.1	0.3	0.6	0.9	1.4	0.4
Indane	0.0	0.3	0.7	1.0	1.3	0.8
Methylindane	0.5	3.8	8.8	14.6	17.1	11.6
C10 Aromatics	0.1	1.3	2.5	5.2	7.1	3.5
Decalin	13.9	4.9	3.2	3.1	3.1	1.2
Tetralin	72.7	70.7	61.3	51.4	43.1	50.7
Naphthalene	12.5	14.4	14.2	11.6	10.8	19.5
$C10^+$	0.1	2.2	4.6	4.5	5.1	4.9

Subtotal	100	100	100	100.0	100.0	100.0
BTX yield (wt%)	0.2	1.5	3.3	6.0	8.7	6.3
Cracking Yield (wt%)	0.3	2.5	5.4	9.5	13.7	8.5

Table S2 Effect of the reaction pressure for USY zeolite on the tetralin hydrocracking

Pressure (MPa)	3	4	5
Conversion (%)	51.5	49.3	47.3
Product Distribution(wt%)			
$C10^-$ Naphtha	0.3	0.6	0.8
Benzene	3.7	3.5	2
Toluene	3.4	2.2	1.5
Xylene	0.6	0.6	0.7
Ethylbenzene	0.4	0.4	0.4
C9 Aromatics	0.6	0.4	0.5
Indane	0.8	0.8	0.9
Methylindane	10.2	10.6	11.5
C10 Aromatics	3.7	3.5	4
Decalin	1	1.2	1.3
Tetralin	48.5	50.7	52.7
Naphthalene	21.8	19.5	19.4
$C10^+$	5	4.9	4.3
Subtotal	100	100	100

Table S3 Textural parameters of catalysts with different Si/Al ratios of USY zeolite.

Sample	Si/Al	S_{BET} (m^2/g)	S_{mic} (m^2/g)	S_{ext} (m^2/g)	V_{mic} (cm^3/g)	V_{meso} (cm^3/g)	V_{total} (cm^3/g)
NiMo/Al_2O_3+USY-1(70)	18.8	609.7	485.5	124.2	0.19	0.23	0.41
NiMo/Al_2O_3+USY-2(70)	25.7	645.8	511.0	134.8	0.20	0.20	0.40
NiMo/Al_2O_3+USY-3(70)	35.1	639.0	501.5	137.5	0.20	0.21	0.41
NiMo/Al_2O_3+USY-4(70)	63.0	631.1	488.2	142.9	0.20	0.21	0.41

Table S4 Acid properties of catalysts with different Si/Al ratios of USY zeolite determined by Py-FT-IR.

Sample	Acid amount (150 °C) (μmol/g)				Acid amount (250 °C) (μmol/g)				Acid amount (350 °C) (μmol/g)			
	B	L	B+L	B/L	B	L	B+L	B/L	B	L	B+L	B/L
NiMo/Al_2O_3+USY-1(70)	160.7	108.7	269.4	1.5	153.1	79.6	232.7	1.9	134.9	56.9	191.8	2.4
NiMo/Al_2O_3+USY-2(70)	61.1	68.4	129.5	0.9	50.5	48.6	99.0	1.0	38.4	34.2	72.6	1.1
NiMo/Al_2O_3+USY-3(70)	33.0	59.5	92.5	0.6	25.7	40.8	66.5	0.6	16.2	27.1	43.3	0.6
NiMo/Al_2O_3+USY-4(70)	30.5	83.1	113.6	0.4	27.7	63.2	91.2	0.4	18.5	46.7	65.2	0.4

Table S5 Analysis of Light Cycle Oil.

Property	Value
Density, g/cm^3	0.916
Nitrogen, ppm	39
Distillation range, °C	
IBP-T10	186–218
T30-T50	242–260
T70-T90	281–309
T95-FBP	323–334
Hydrocarbon distribution, wt%	
Alkanes	12.0
Cycloalkanes	4.9
Aromatics	83.1
Monoaromatics	60.5
Diaromatics	21.4
Tri-aromatics	1.2