Synthesis and investigation of a Pt-containing micro-mesoporous catalyst for xylene isomerization

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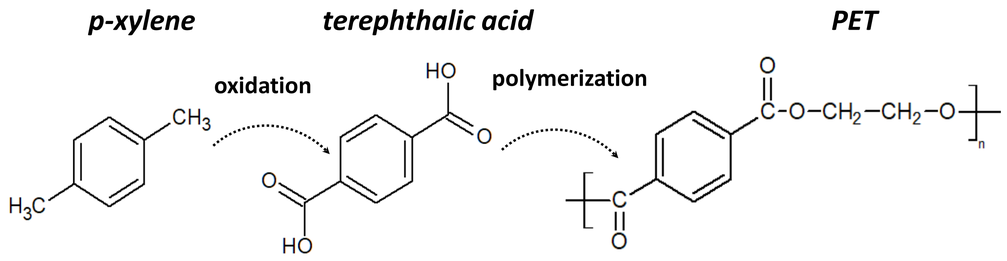
BACKGROUND

The naphtha fraction from reforming units is rich in aromatic compounds of C_8H_{10} composition (*p*-, *o*-, *m*-xylenes and ethylbenzene), which are widely used in petrochemical industry for producing synthetic resins, fibers, and plasticizers.

For instance, oxidation of the most demanded isomer, *p*-xylene, yields terephthalic acid, which is used in production of textile fibers.



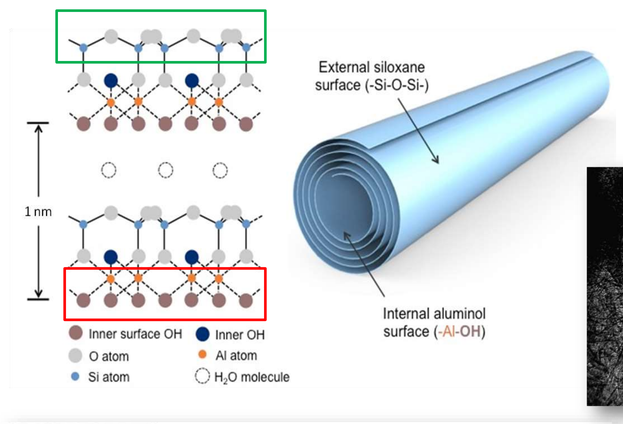
OBJECTIVES

- ✓ Synthesis of functional micro-mesoporous aluminosilicates ZSM-5 types armed with natural halloysite nanotubes
- ✓ Synthesis of Pt-containing catalysts based on micro-mesoporous supports
- ✓ Catalytic testing in C8-aromatics isomerization comparing with industrial catalyst

MATERIALS AND METHODS

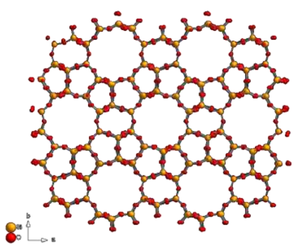
Halloysite nanotubes (HNT) are natural mesoporous materials with the structure of rolled kaolinite layers.

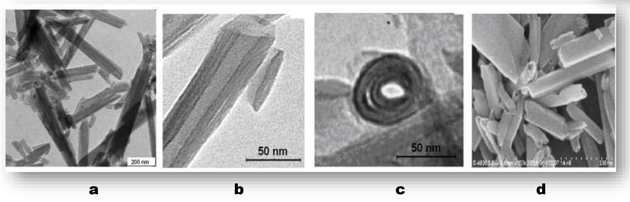
Chemical formula of **$Al_2Si_2O_5(OH)_4 \times 2H_2O$**



ZSM-5

Pore diameter, Å	6
Wall thickness, Å	2
Surface area, m^2/g	380
Pore volume, cm^3/g	0.28

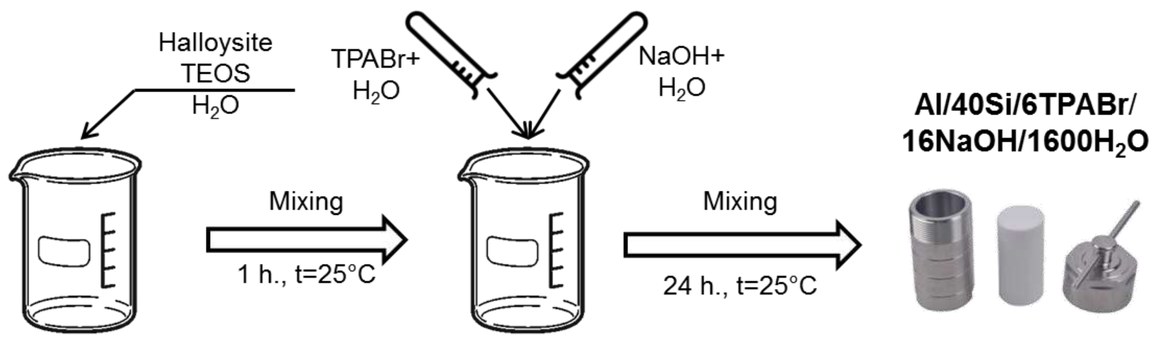




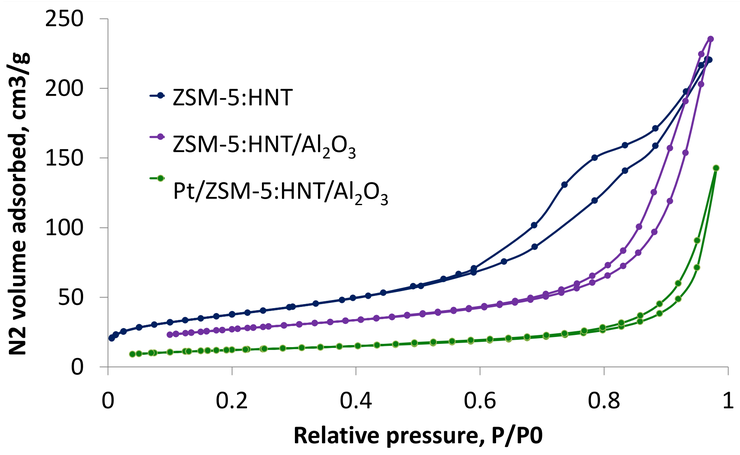
Transmission (a, b, c: tube cross-section) and scanning (d) electron microscopy images of halloysite nanotubes

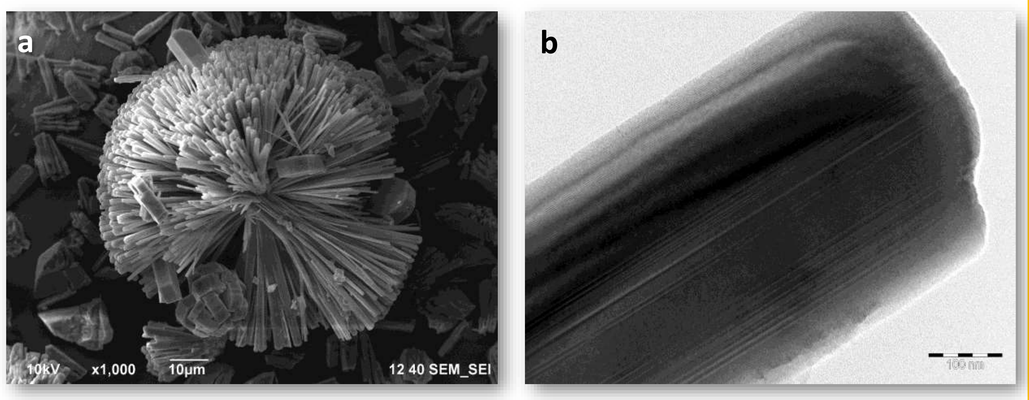
All resulting materials and catalysts were investigated by **XRD, TEM, SEM, N_2 adsorption/desorption and ammonia temperature programmed desorption (NH_3-TPD).**

ZSM-5:HNT SYNTHESIS

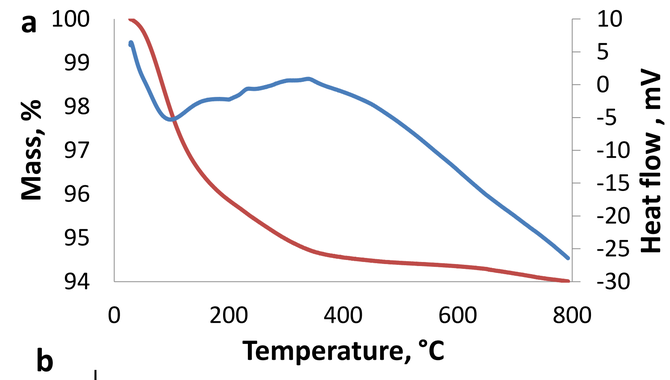


Sample	Acidity (µmol NH_3/g)			Strong/ weak	BET surface area, m^2/g	Microporous surface area, m^2/g	Pore volume, cm^3/g		Average pore diameter, Å	
	Weak (<300°C)	Strong (>300°C)	Total				meso-	micro-	meso-	micro-
HNT	110	80	190	0.72	34	-	0.17	-	164	-
HNT/Al_2O_3	137	56	193	0.40	118	-	0.35	-	90	-
Pt/HNT/Al_2O_3	140	126	266	0.9	114	-	0.34	-	87	-
ZSM-5:HNT	196	340	536	1.73	58	130	0.34	0.06	160	9
ZSM-5:HNT/Al_2O_3	246	299	545	1.22	233	84	0.37	0.04	98	17
Pt/ZSM-5:HNT/Al_2O_3	231	284	515	1.23	95	35	0.14	0.03	39	14
Industrial catalyst	259	1318	1577	5.09	313	54	0.60	0.03	65	7



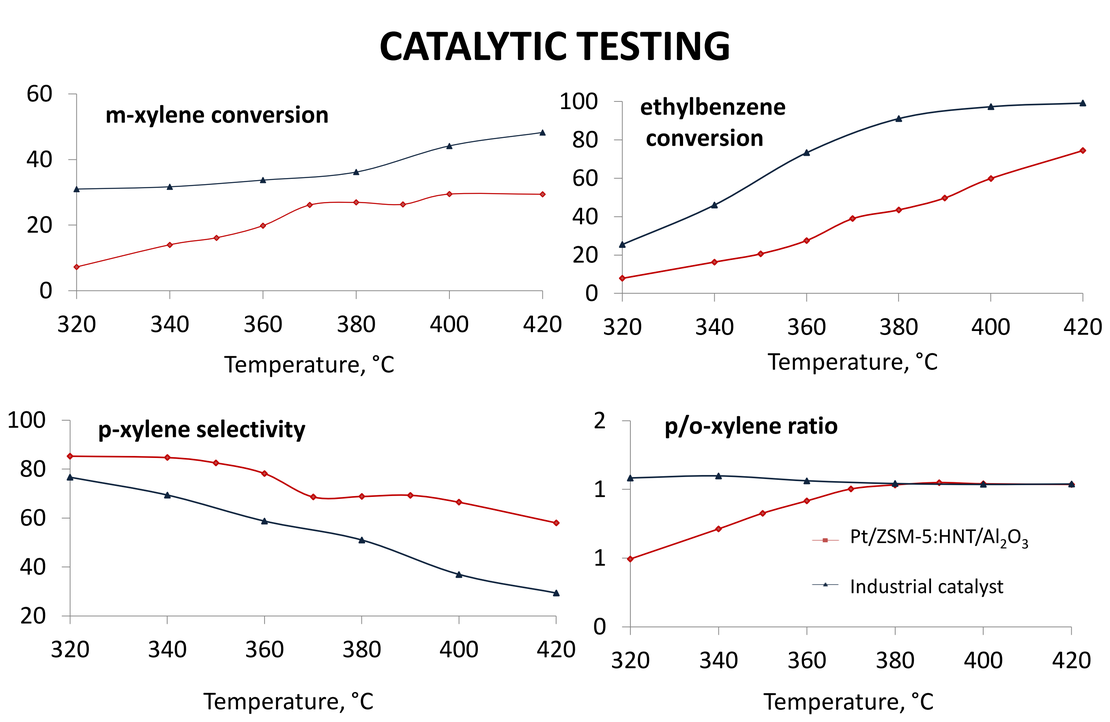


(a) ZSM-5:HNT SEM image and (b) ZSM-5:HNT TEM image



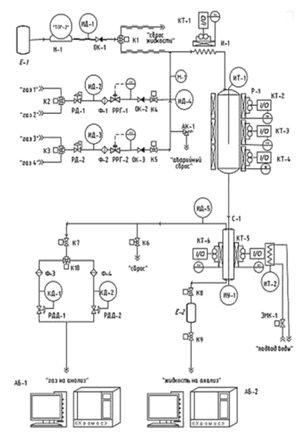
(a) TGA-DSC profile for ZSM-5:HNT and (b) ZSM-5:HNT XRD pattern

CATALYTIC TESTING



EXPERIMENTAL

The catalytic activity of the prepared materials was investigated in isomerization of C_8 aromatic fraction supplied from catalytic reforming unit. The catalytic experiments were performed in a flow-type reactor with a fixed-bed catalyst (5 µL) under hydrogen pressure 1.0 MPa in a temperature range from 320 to 40°C, volume hourly space velocity (LHSV) 1 h^{-1}, H_2:feed volume ratio of 1200.



Feedstock composition

Component	Content, wt. %
Toluene	0.38
Ethylbenzene	10.00
p-Xylene	3.04
m-Xylene	66.12
Isopropylbenzene	0.03
o-Xylene	16.04
Other	4.39

CONCLUSION

- ✓ New functional micro-mesoporous materials were synthesized, characterized and tested as components of catalysts for isomerization of aromatic compounds.
- ✓ The operating characteristics of the developed catalysts exceeded the same of the industrial analog.
- ✓ The obtained catalysts based on cheap and environmentally friendly materials can be easily scaled up for industrial applications.

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