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Assessing the reliability of solid acid as catalyst in methylation of toluene to produce p-Xylene

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Abstract – *Solid acid used in many industrial chemical processes. At* present, *about 180 industrial processes using* solid catalyst. *It is used as a support material for catalyst. A model is constructed to evaluate how the reliability of solid through the reaction methylation of toluene to produce p-Xylene.*

Key Words: **Reliability, Solid acid catalyst, Para-xylene, ZSM-5, Methylation**

1. INTRODUCTION

Solid acid hidden among the tiny galleries pores and cavities. It is used in most of the manufacturing industry due to its undissolved property in the reaction. It offer the potential for superior efficacy and environmental integrity. Acid catalzed reaction is initiated through acid base interaction in which catalyst act as acid and the reactant act as a base On the completion of reaction, acids are further regenerated. This reaction may be homogeneous or heterogeneous. In heterogeneous reaction surface solid act as acid toward reactant molecule called solid acid catalyst. p- xylene production through toluene methylation over zeolite based catalysts and toluene disproportionation. Which is important raw aromatic feedstock for the industrial production of terephthalic acid and dimethyl terephthalate In spite of the fact that toluene disproportionation has delivered noteworthy xylene yield with wonderful p-xylene selectivity also, has been connected modernly in forms like the MSTDP2 also, GT-STDP,3 the arrangement of benzene as a coproduct is thought to be a noteworthy disservice. Toluene alkylation with methanol, then again, produces an insignificant measure of benzene and further makes utilization of a less expensive bolster stock, methanol. Consequently, toluene methylation is viewed as a fascinating option to both naphtha changing and toluene disproportion. However, in spite of the large volume of work done on toluene methylation regarding catalyst.in this paper we did work on Assessing the reliability solid acid catalyst in methylation of toluene to produce p-xylene.

Most of p -xylene comes from catalytic re-forming of naphtha. x ylene isomers, along with toluene, are produced from catalytic re-forming of naphtha. P-xylene is separated by crystallization or adsorption. Due to the very close boiling points of the different xylene isomers (Table 1)

Table -1: Boiling and Freezing point of xylene isomer

Isomer	Normal Boiling point (°C)	Freezing point (°C)
p-xylene	138.3	13.3
m-xylene	139.1	-47.85
o-xylene	144.4	-25.16

1.1 Chemical Reaction

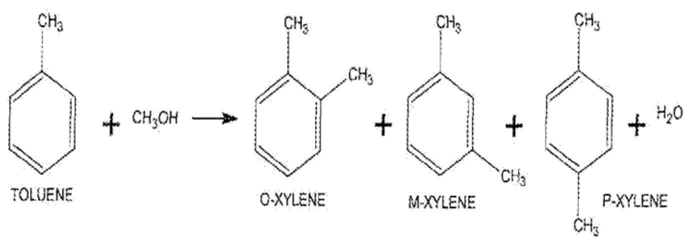

Fig -2: Molecular structure of toluene and xylene isomer

The conventional para-xylene process converts toluene to para-xylene (and its isomers) in the presence of methanol over a heated catalyst bed of ZSM-5 zeolite. In this reaction 23% para-, 51% meta-, and 26% ortho- xylene is produced. An oxide-modified ZSM-5 catalyst is commonly used to improve the selectivity towards paraxylene The process follows the following highly exothermic reaction:

$$C_7H_8 + CH_3OH \xrightarrow[\text{T- 450°C}]{\text{Zsm-5}} C_8H_{10} + H_2O \text{------------- (1)}$$

Toluene Methylation

T+M →p-xylene +W……………..….(2)

Methynol Dehydration

2M → GH+2W……………..………(3)

Toluene Disproportion

T→ ½B + ½ p-xylene…………..……..(4)

Para-xylene is a flammable, colorless aromatic hydrocarbon that exists as a liquid at ambient pressure and temperature. As seen in Figure 2, xylenes are the ortho-, meta-, and para isomers of dimethyl benzene, where the ortho-, meta-, and para- prefixes refer to which carbon atoms on the benzene ring the two methyl groups are attached.

In the above chemical reaction ZSM-5 catalyst is used for the production of p-xylene Table2 shows the types of solid acid catalyst.

Table -2: Types of Solid acid catalyst

Physico-chemical properties of catalysts			
Catalyst	Types of catalyst	Surface Area(m^2/g)	Acid Amount(mmol/gm)
H-USY (Si/Al=15)	Micro	873	0.55
H-ZSM-5 (Si/Al=11.5)	Micro	423	0.97
H-BEA (Si/Al=19)	Micro	761	0.91
H-MOR (Si/Al=10)	Micro	528	1.18

Zeolite, H-USY (Si/Al=15), H-ZSM-5 (Si/Al=11.5), Hβ (Si/Al=19) and H-MOR (Si/Al=10), were obtained from Zeolyst International. Prior to use, zeolites were calcined at 550◦C for 16 h in air flow.

2. Material and Method

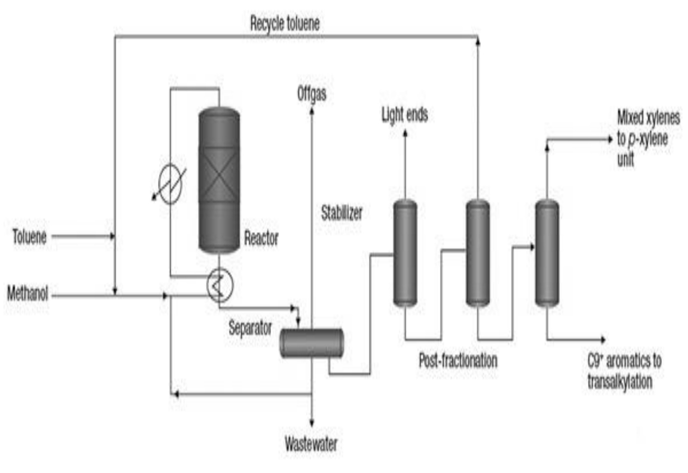

Fig -1: Flow process diagram of p-xylene production from toluene methylation

A new low-pressure xylenes-production process combines toluene with methanol to yield a xylenes product. The new process requires no hydrogen addition and produces only water as a byproduct.. In the process (flowsheet), toluene and methanol are pre-mixed before entering a set of low-pressure, fixed-bed reactors where the aromatic ring of toluene is methylated over a zeolite-based catalyst. Products contain very low ethylbenzene levels, an impurity for xylenes. Bridgeman says the process is heat-integrated, so the overall energy input is modest.

The xylenes product proceeds to a recovery and purification stage in which unreacted toluene is recycled back to the beginning of the process. Subsequently, p-xylene is purified .

Table -3: Equilibrium data of toluene methylation over solid acid catalyst

Temp	Time	Toluene (% Yield)	Methanol (% Yield)	P-xylene (% Yield)
	5	69.46	18.44	3.61
450	10	66.05	15.13	5.77
	15	61.69	13.38	6.96
	5	70.38	18.54	3.25
400	10	69.04	16.29	4.33
	15	66.82	12.61	6.10

3. Reliability of equilibrium conversion over solid acid catalyst

Fig 2. Shows the catalyst reliability (% yield versus time) when the temp is 450°C.

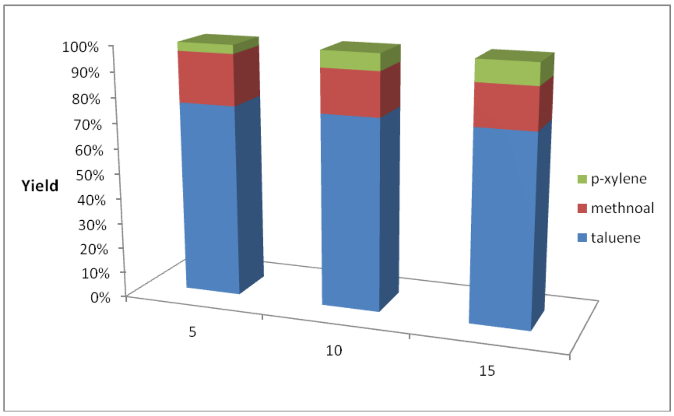

Fig -2: Reliability assessment of ZSM-5 catalyst at temperature 450°C.

Fig 3. Shows the catalyst reliability (% yield versus time) when the temp is 400°C.

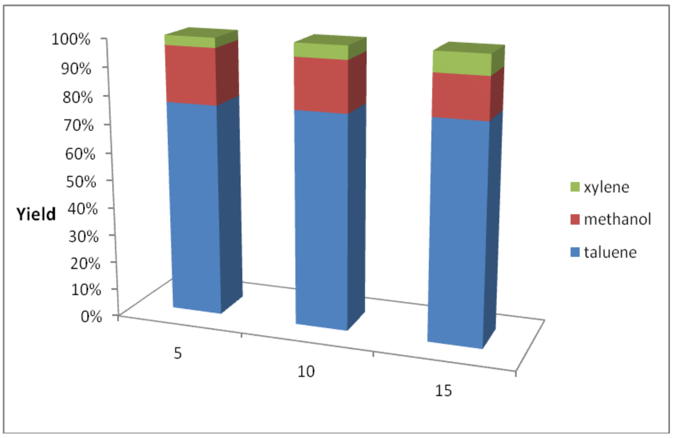

Fig -2: Reliability assessment of ZSM-5 catalyst at temperature 400°C.

4. Result & Conclusion

Toluene methylation has been examined over new ZSM-5 based impetus in a vapure equilibrium test system. The examination done convey out the process the temperature scope of 400 - 450 °C. The accompanying abridges our significant discoveries:

Regardless of the short response times utilized (5-15 s), critical toluene transformation and xylene yield were accomplished. Both toluene transformation and xylene yield were seen to increment with response temperature and time. Greatest toluene change furthermore, xylene yield of 14.09% , 33.25% and 18.76% individually, were gotten at 450 °C and response time of 15 s. This relates to xylene selectivity of 92%.

Further investigations using pure H-USY zeolites, H-BEA and H-MOR with and without defects, have to be performed to understand the role of the solid acid catalyst groups and acid sites on the mechanism of the reaction.

Nomenclature used

Component:

B = benzene

GH = light gaseous hydrocarbons

M = methanol

p-X= P xylene

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