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APPENDICES

APPENDIX A

SAMPLE OF CALCULATIONS

A-1 Calculations for beta zeolite preparation

The calculation for beta zeolite preparation with molar ratio is $\text{SiO}_2: 0.01\text{Al}_2\text{O}_3: 0.1\text{Na}_2\text{O}: 0.37\text{TEAOH}$ are shown as follows:

Reagents:

- Cataloid [SiO_2 30% wt in water] for SiO_2 source

$$\text{Molecular Weight} = 60.0843$$

- Aluminium sulfate [$\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$] for Al_2O_3 source

$$\text{Molecular Weight} = 666.45$$

- Sodium hydroxide [NaOH] for Na_2O source

$$\text{Molecular Weight} = 40$$

- Tetraethylammonium hydroxide [TEAOH, 40% wt in water] for TEAOH source

$$\text{Molecular Weight} = 147$$

The calculation of amount of Cataloid, $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$, NaOH , TEAOH as following:

$$\begin{aligned} 1. \text{ Amount of Cataloid} &= (1 \times 60.0843 \times 100) / 30 \\ &= 200.281 \quad \text{g} \end{aligned}$$

$$\begin{aligned} 2. \text{ Amount of } \text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O} &= 0.01 \times 666.45 \\ &= 6.6645 \quad \text{g} \end{aligned}$$

(1 mole of Al_2O_3 is equivalent to 1 mole of $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$)

$$\begin{aligned} 3. \text{ Amount of NaOH} &= 0.1 \times 40 \times 2 \\ &= 8 \quad \text{g} \end{aligned}$$

(1 mole of Na_2O is equivalent to 2 mole of NaOH)

$$4. \text{ Amount of TEAOH} = (0.5 \times 147 \times 100) / 40$$

$$= 183.75 \text{ g}$$

Note, for preparation of beta zeolite in this experimental, the amount of used reagents are divided by 10

A-2 Calculation of percent relative crystallinity

$$\% \text{ Relative crystallinity} = \frac{\text{Area under XRD pattern } (2\theta=22.4) \text{ of sample} \times 100}{\text{Area under XRD pattern } (2\theta=22.4) \text{ of reference}}$$

Reference is beta zeolite with $\text{SiO}_2/\text{Al}_2\text{O}_3$ of 100.

A-3 Calculation of the specific surface area

From Brunauer-Emmett-Teller (BET) equation

$$\frac{p}{n(1-p)} = \frac{1}{n_m C} + \frac{(C-1)p}{n_m C} \quad (\text{A-5-1})$$

Where, p = Relative partial pressure of adsorbed gas, P/P_0

P_0 = Saturated vapor pressure of adsorbed gas in the condensed state at the experimental temperature, atm

P = Equilibrium vapor pressure of adsorbed gas, atm

n = Gas adsorbed at pressure P , ml. At the NTP/g of sample

n_m = Gas adsorbed at monolayer, ml. At the NTP/g of sample

$$C = \exp \left[\frac{(H_c - H_1)}{RT} \right]$$

H_c = Heat of condensation of adsorbed gas on all other layers

H_1 = Heat of adsorption into the first layer

Assume $C \rightarrow \infty$, then

$$\frac{p}{n(1-p)} = \frac{p}{n_m} \quad (\text{A-5-2})$$

$$n_m = n(1-p)$$

The surface area, S , of the catalyst is given by

$$S = S_b \times n_m \quad (\text{A-5-3})$$

From the gas law

$$\frac{P_b V}{T_b} = \frac{P_t V}{T_t} \quad (\text{A-5-4})$$

Where, P_b = Pressure at 0 °C

P_t = Pressure at t °C

T_b = Temperature at 0 °C = 273.15 K

T_t = Temperature at t °C = 273.15 + t K

V = Constant volume

Then, $P_b = (273.15/T_t) P_t = 1 \text{ atm}$

Partial pressure

$$P = \frac{[\text{Flow of (He + N}_2) - \text{Flow of He}]}{\text{Flow of (He + N}_2)}$$

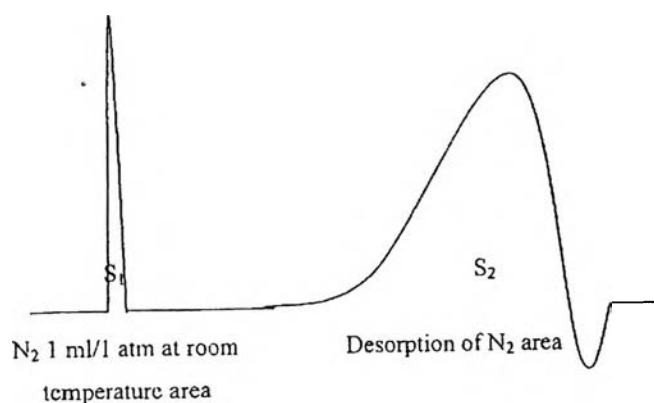
$$= 0.3 \text{ atm}$$

For nitrogen gas, the saturated vapor pressure equals to

$$P_o = 1.1 \text{ atm}$$

Then, $p = P/P_o = 0.3 / 1.1 = 0.2727$

To measure the volume of nitrogen adsorbed, n



$$n = \frac{S_2}{S_1} \times \frac{1}{W} \times \frac{273.15}{T} \text{ ml. / g of catalyst} \quad (\text{A-5-5})$$

Where, S_1 = N_2 1 ml/ 1 atm at room temperature area

S_2 = Desorption of N_2 area

W = Sample weight, g

T = Room temperature, K

Therefore,

$$n_m = \frac{S_2}{S_1} \times \frac{1}{W} \times \frac{273.15}{T} \times (1 - p)$$

$$n_m = \frac{S_2}{S_1} \times \frac{1}{W} \times \frac{273.15}{T} \times 0.7273 \quad (\text{A-5-6})$$

Whereas, the surface area of nitrogen gas from literature equal to

$$S_b = 4.373 \text{ m}^2 / \text{ml of nitrogen gas}$$

Then,

$$S = n_m = \frac{S_2}{S_1} \times \frac{1}{W} \times \frac{273.15}{T} \times 0.7273 \times 4.343$$

$$S = n_m = \frac{S_2}{S_1} \times \frac{1}{W} \times \frac{273.15}{T} \times 3.1582 \text{ m}^2 / \text{g} \quad (\text{A-5-7})$$

A-4 Calculation of reaction flow rate

The used catalyst = 0.1000 g

Pack catalyst into quartz reactor (inside diameter = 0.6 cm).

Determine the average high of catalyst bed = H cm, so that,

$$\text{Volume of bed} = \pi (0.3)^2 \times H \text{ ml-cat.}$$

Use Gas Hourly Space Velocity (GHSV) = 4000 h⁻¹

$$\text{GHSV} = \frac{\text{Volumetric flow rate}^1}{\text{Volume of bed}}$$

$$\text{Volumetric flow rate}^1 = 4000 \times \text{Volume of bed ml/h}$$

$$= \frac{4000 \times \pi (0.3)^2 \times H}{60} \text{ ml/min}$$

At STP condition:

$$\text{Volumetric flow rate} = \text{Volumetric flow rate}^1 \times \frac{(273.15+T)}{273.15}$$

Where T = room temperature

A-5 Calculation of conversion and hydrocarbon distribution of methanol conversion reaction

Methanol conversion activity was evaluated in term of conversion of methanol into other hydrocarbons

For example: Synthesized beta zeolite of SiO₂/ Al₂O₃ of 100

Reaction condition: reaction temperature 450°C,
 GHSV = 4000 h⁻¹,
 Feed 20 %methanol N₂ balance,
 Time on steam = 15 mintute

$$\text{Methanol conversion (\%)} = \frac{(\text{methanol}_{\text{in}} - \text{methanol}_{\text{out}}) \times 100}{\text{methanol}_{\text{in}}}$$

From data of Shimadzu GC 8A (Porapack-Q column)

$$\begin{aligned} \text{Methanol conversion (\%)} &= \frac{(297925 - 20627) \times 100}{297925} \\ &= 93.08 \% \end{aligned}$$

From data of Shimadzu GC 14B (VZ-10 column)

Area of C ₁	=	65264
Area of C ₂	=	16868
Area of C ₂ ⁼	=	602282
Area of C ₃	=	223752
Area of C ₃ ⁼	=	599251
Area of C ₄	=	85736
Area of i-C ₄	=	1053663
Area of C ₄ ⁼	=	135013
Area of i-C ₄ ⁼	=	31689
Area of C ₅ ⁺	=	0
Area of C ₁ -C ₅ ⁺	=	summation of area C ₁ to area C ₅ ⁺
	=	2813653

From data of Shimadzu GC 14A (OV-1 column)

The first part of data area is $C_1-C_5^+$.

$$\text{Area of } C_1-C_5^+ = 69710$$

$$\text{Total area} = 74081$$

So that: compared area from Shimadzu GC 14B (VZ-10 column) and Shimadzu GC 14A (OV-1 column)

$$\begin{aligned} \text{Area of } C_1(\text{OV-1}) &= \frac{\text{Area of } C_1(\text{VZ-10}) \times \text{Area of } C_1-C_5^+(\text{OV-1})}{\text{Area of } C_1-C_5^+(\text{VZ-10})} \\ &= \frac{65264 \times 69710}{2813518} \\ &= 1563.68 \end{aligned}$$

The other were calculated as the same way

$$\text{Area of } C_1(\text{OV-1}) = 1563.68$$

$$\text{Area of } C_2(\text{OV-1}) = 404.146$$

$$\text{Area of } C_2^-(\text{OV-1}) = 14430.3$$

$$\text{Area of } C_3(\text{OV-1}) = 5360.95$$

$$\text{Area of } C_3^-(\text{OV-1}) = 14357.7$$

$$\text{Area of } C_4(\text{OV-1}) = 2054.18$$

$$\text{Area of } i-C_4(\text{OV-1}) = 25245.1$$

$$\text{Area of } C_4^-(\text{OV-1}) = 3234.82$$

$$\text{Area of } i-C_4^-(\text{OV-1}) = 759.247$$

$$\text{Area of } C_5^+(\text{OV-1}) = 67410$$

Hence: Product distribution (C-wt%)

$$C_1 = 2.11 \%$$

$$C_2 = 0.54 \%$$

$$C_2^- = 19.38 \%$$

$$C_3 = 7.23 \%$$

$$C_3^- = 19.38 \%$$

$$C_4 = 2.77 \%$$

i-C ₄	=	34.07	%
C ₄ ⁼	=	4.366	%
i-C ₄ ⁼	=	1.02	%
C ₅ ⁺	=	0	%
Other	=	9	%

VITA

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