

**ETHYLATION OF BENZENE WITH ETHANOL TO ETHYLBENZENE
USING SYNTHESIZED HZSM-5 CATALYSTS:
EFFECTS OF TEXTURAL PROPERTIES AND ACIDITY**



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A Thesis Submitted in Partial Fulfilment of the Requirements
for the Degree of Master of Science
The Petroleum and Petrochemical College, Chulalongkorn University
in Academic Partnership with
The University of Michigan, The University of Oklahoma,
Case Western Reserve University, and Institut Français du Pétrole
2012


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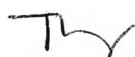
Thesis Title: Ethylation of Benzene with Ethanol to Ethylbenzene Using Synthesized HZSM-5 Catalysts: Effects of Textural Properties and Acidity
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Program: Petrochemical Technology
Thesis Advisors: Assoc. Prof. Thirasak Rirksomboon
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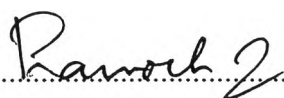
Accepted by The Petroleum and Petrochemical College, Chulalongkorn University, in partial fulfilment of the requirements for the Degree of Master of Science.

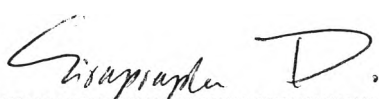

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ABSTRACT

5371026063: Petrochemical Technology Program

Tanakrit Rugwong: Ethylation of Benzene with Ethanol to Ethylbenzene Using Synthesized HZSM-5 Catalysts: Effects of Textural Properties and Acidity

Thesis Advisors: Assoc. Prof. Thirasak Rirksomboon and Asst. Prof. Siriporn Jongpatiwut 98 pp.

Keywords: Alkylation/ Benzene/ Ethanol/ Ethylbenzene/ HZSM-5

Ethylbenzene (EB), which is a key intermediate in the manufacture of styrene in the petrochemical industry is usually produced via alkylation of benzene with ethylene. The direct use of ethanol as an alkylating agent has also become a suitable substitute for ethylene. Ethanol has gained more attention because it provided a longer catalyst life and higher production efficiency when it was used for the ethylation of benzene accompanied by a HZSM-5 catalyst. In this work, HZSM-5 catalysts were synthesized at a desired $\text{SiO}_2/\text{Al}_2\text{O}_3$ molar ratio of ca.195 with different textural properties and Brönsted acid sites via hydrothermal synthesis. The catalytic activity of the catalysts was tested using a fixed-bed continuous down-flow reactor under various conditions: reaction temperature (300-600 °C), weight hourly space velocity (10-20 h^{-1}), and benzene to ethanol ratio (1:1, 2:1, and 4:1). The results showed that textural properties and acidity of the synthesized HZSM-5 catalysts significantly affected the catalytic activity.

บทคัดย่อ

ธนกฤต รักษ์วงศ์ : ปฏิริยาเอธิลเลชันของเบนซีนกับเอทานอลเพื่อผลิตเอธิลเบนซีน โดยใช้ตัวเร่งปฏิริยา HZSM-5 ที่สังเคราะห์ได้เอง : ผลกระทบของลักษณะทางสัณฐานและความเป็นกรด (Ethylation of Benzene with Ethanol to Ethylbenzene Using Synthesized HZSM-5 Catalysts: Effects of Textural Properties and Acidity) อ.ที่ปรึกษา: รศ.ดร. ธีรศักดิ์ ฤกษ์สมบูรณ์, ผศ.ดร. ศิริพร จงผาคิวดี 98 หน้า

เอธิลเบนซีนเป็นสารที่สำคัญในอุตสาหกรรมปิโตรเคมี เพราะเป็นหนึ่งในตัวกลางที่ใช้ในการผลิตสไตรีน โดยปกติแล้วเอธิลเบนซีนจะผลิตผ่านปฏิริยาแอลคิลิชั่นของเบนซีนและเอทีลิน เนื่องด้วยการนำเอทานอลมาใช้ในปฏิริยาแอลคิลิชั่นโดยตรง กลายเป็นสิ่งที่ได้รับความสนใจมากกว่าการใช้เอทีลิน เนื่องจากเอทานอลสามารถยืดอายุของตัวเร่งในกระบวนการผลิตและให้ประสิทธิภาพในการผลิตที่สูงกว่าเมื่อผลิตผ่านปฏิริยาแอลคิลิชั่นของเบนซีน ควบคู่ไปกับการใช้ HZSM-5 เป็นตัวเร่ง ในงานวิจัยนี้ HZSM-5 ซึ่งเป็นตัวเร่งได้ถูกสังเคราะห์ที่อัตราส่วนของซิลิกาต่ออะลูมินาให้ใกล้เคียงกับ 195 และใช้วิธีการสังเคราะห์แบบไฮโดรธอมอลเพื่อจะให้ลักษณะทางสัณฐานและความเป็นกรดที่ต่างกัน อัตราการเกิดปฏิริยาผ่านตัวเร่งได้ถูกทดสอบโดยใช้ปฏิริกรณแบบ Fixed-bed ภายใต้การศึกษาผลกระทบจากตัวแปรต่าง ๆ ได้แก่ อุณหภูมิในการทำปฏิริยา (300-600 องศาเซลเซียส) Weight Hourly Space Velocity (10-20 ต่อชั่วโมง) และอัตราส่วนของเบนซีนต่อเอทานอล (1:1, 2:1 และ 4:1) ผลของปฏิริยาแสดงให้เห็นว่า ลักษณะทางสัณฐานและความเป็นกรดของตัวเร่งปฏิริยา ส่งผลต่ออัตราการเกิดปฏิริยา

ACKNOWLEDGEMENTS

This work has been memorable, interesting, and important experience. This work would not have been possible, if the following people were not present.

First of all, I would like to express my gratefully thanks my advisor Assoc. Prof. Thirasak Rirksomboon, for suggestion, encouragement, discussions and problem solving throughout of the course of my reresearch work.

I am pleased to Asst. Prof. Siriporn Jongpatiwut, who provides me encouragment and suggestion during doing this thesis work.

I deeply appreciate and thank Dr. Siraprapha Dokjampa and Assoc. Prof. Pramoch Rangsunvigit for their valuable comments and suggestions and being my thesis committee.

I am grateful for the scholarship and funding of the thesis work provided by the Petroleum and Petrochemical College; and Center of Excellence on Petrochemical and Materials Technology (PETRO-MAT).

I sincerely extent my appreciation to all my friends and all PPC's staff for their help and creative suggestions.

Finally, I would like to extend the most sincere thank to my lovely family for providing me their love, endless encouragement and forever love during my two year study at the college.

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ABBREVIATIONS

a	Synthesis temperature (°C)
b	Synthesis time (h)
$\text{Al}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$	Aluminium nitrate
B/E	Benzene to ethanol feed molar ratio
B/L ratio	Brönsted acid site to the Lewis acid site ratio
DEBs	Diethylbenzenes
EB	Ethylbenzene
HT	Hydrothermal
Mi/T	Micropore to total pore volume
T	Reaction temperature
TA	Theoretical Acidity
TA/(B/L)	Theoretical Acidity per Brönsted acid site to the Lewis acid site ratio
TOS	Time on stream
TPD-IPA	Temperature Programmed Desorption (TPD) Technique of Isopropylamine
w	Molar ratio of the water to silica in the initial gel
WHSV	Weight hourly space velocity