Comparative Study of a Variety of Surfactant-Modified Micro-Mesoporous ZSM-5 Catalysts for Enhanced Cracking Ability.

Muhammad R. Usman[1]*, Abdullah Ramzan[1]

1 Institute of Chemical Engineering and Technology, University of the Punjab, Lahore 54590, Pakistan

**Corresponding author: mrusman.icet@pu.edu.pk*

Highlights

- Micro-mesoporous catalysts have been developed by recrystallizing zeolite ZSM-5.
- Catalysts were well characterized and tested by cracking n-hexadecane.
- Cracking experiments were performed in a stirred batch reactor.
- A catalyst prepared with 50%F127-50%P123 was found the most suitable catalyst.

1. Introduction

Catalytic cracking is an important industrial reaction used to upgrade heavy oil fractions, waste polymers, and residua from biomasses and crude oils. The search for a cracking catalyst that provides high conversion and desired selectivity for valuable cracked products, at a lower reaction temperature, is thus a crucial research topic. Zeolites are most often used for cracking and hydrocracking reactions [1]. However, owing to their microporous nature they hinder the movement of large reactant molecules and produce smaller product molecules. A micro-mesoporous zeolitic catalyst on the other hand shows improved activity, selectivity, and stability and effectively handles large reactant molecules and produces a liquid range product [2, 3]. The present research is about synthesizing, characterizing, and evaluating micro-mesoporous ZSM-5 catalysts for their cracking activity and desired selectivity.

2. Methods

As received, the ZSM-5 catalyst was recrystallized using multiple surfactants. Non-ionic, Pluronic P-123 and F-127, cationic template, cetyltrimethylammonium bromide (CTAB), and sodium dodecyl sulfate (SDS) were utilized to induce mesopores alongside micropores in a ZSM-5 catalyst. The cracking ability of the developed catalysts was tested by doing experimentation with n-hexadecane. A high pressure stirred batch reactor was employed to test the cracking ability of the catalysts. An initial cold pressure of 1 bar was used and three reaction temperatures, 325°C, 350°C, and 375°C, were studied. The cracked liquid product and the gaseous product were quantitatively analyzed by a gas chromatograph fitted with a flame ionization detector (FID).

3. Results and discussion

The results of hexadecane cracking over the catalysts employed in the present study at one temperature (350°C) are shown in Table 1. It is revealed that generally the recrystallized micro-mesoporous catalysts show much better cracking characteristics than the parent ZSM-5 catalyst.

Table 1 Results of hexadecane cracking over micro-mesoporous ZSM-5 catalysts at 350°C

Catalyst	Surfactant (Wt%)	N_2-BET S_g (m^2/g)	Conversion (wt%)	C8-C10 (wt%)
CAT-1	0%	425.0	63.0	23.3
CAT-2	100% F127	323.6	71.6	29.5
CAT-3	75% F127-25% P123	167.0	73.0	28.1
CAT-4	50% F127-50% P123	450.9	79.0	32.2
CAT-5	25% F127-75% P123	385.1	77.0	29.0
CAT-6	100% P123	-	77.0	30.9
CAT-7	100% SDS	-	35.0	9.28
CAT-8	100% CTAB	449.9	70.0	27.8

N.B. Hexadecane weight: 12 g, Catalyst weight: 0.6 g, Initial pressure: 1 atm, Residence time: 60 min.

4. Conclusions

Following the synthesis, X-ray diffraction (XRD) displayed that all the catalysts retained their ZSM-5 structure. Out of the three reaction temperatures studied, 350°C proved to be the most appropriate reaction temperature with respect to activity as well as selectivity towards the C8−C10 fraction. Among the various surfactants applied in recrystallization, the catalyst developed using 50%F127-50%P127 was recognized as the most appropriate, giving the highest conversion and the best C8−C10 yield.

References

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Keywords
Waste plastics; catalytic cracking; micro-mesoporous catalysts; upgradation of heavy oils; hexadecane cracking.