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Oxidative Dehydrogenation of Isobutane on Mesoporous Silica-Based Catalysts

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Highlights

- Ca. 7% yield of isobutene on FSM-16 and MCM-41 doped with chromium.
- Ca. 6% yield of isobutene on MCM-41 undoped with chromium but treated with acid.
- Ca. 15% yield of isobutene on SBA-15 doped with chromium.

1. Introduction

In our laboratory, the oxidative dehydrogenation (ODH) of isobutane to isobutene has been focused since isobutene is one of the attractive precursors for the production of methyl methacrylate. During our initial stage, various complex oxide catalysts that had been reported as active catalysts for the general ODH have been used for the ODH of isobutane, resulting in the lower yield of isobutene less than 2%. In the present study, the enhanced nature due to various mesoporous silicas will be described.

2. Methods

Doping of chromium into FSM-16 and MCM-41 was via a template ion exchange method [1] while a direct synthesis method was employed for the doping of chromium into SBA-15 [2]. The catalytic activity tests were carried out in a fixed-bed continuous flow reactor at atmospheric pressure and 723 K using reactant gas (15 mL/min) consisting of P(He) = 74.6 kPa, P(i-C_4H_{10}) = 14.4 kPa, and P(O_2) = 12.3 kPa on various catalysts (0.25 g). Under the present reaction conditions, homogeneous reaction was not observed.

3. Results and discussion

The yields of isobutene on 2.9wt.%Cr-FSM-16 and 1.8wt.%Cr-MCM-41 were 6.6 and 6.8%, respectively. NH_3-TPD revealed that new and stronger acidic sites were produced from the doping. It should be noted that the yield of isobutene was further enhanced on FSM-16 doped with chromium, which was prepared from the mixture of $Cr(NO_3)_3$ and surfactant, cetyl trimethyl ammonium bromide (CTABr), in the preparation step. The present catalyst also showed the stronger acidic sites. In contrast, 1.8wt.%Cr-SBA-15 did not show the stronger acidic site while the yield of isobutene achieved up to 15%. The greater specific surface area of 1.8wt.%Cr-SBA-15 (1,610 m^2/g) may contribute to the dramatic improvement of the yield.

4. Conclusions

It was revealed that acidic sites newly formed or great specific surface area due to various mesoporous silicas directly contributed to the extensive improvement of the yield of isobutene from the ODH of isobutane.

References

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Keywords
Mesoporous silica; Oxidative dehydrogenation; Isobutane; Isobutene.