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Extended activity of zeolite catalysts with CO_2 as reaction medium

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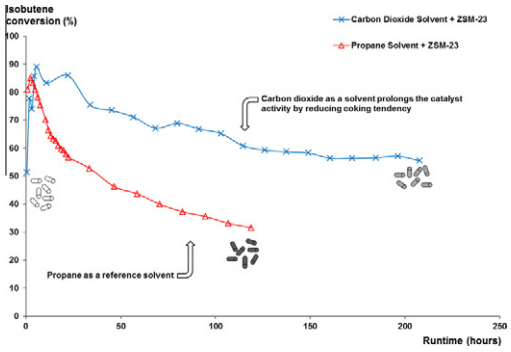
HIGHLIGHTS

- CO_2 is a potential solvent option for industrial applications.
- The catalyst activity maintained on a higher level with CO_2 solvent.
- Lower carbon dioxide emissions are expected due to the steadier catalyst activity.
- CO_2 results differ in selectivity compared to propane solvent.
- Standard engineering simulation tools give valuable information of phases.

GRAPHICAL ABSTRACT



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ABSTRACT

Isooctane is a typically used vehicle fuel component. However, the synthesis of isooctane is limited due to the coking phenomenon when using zeolite catalysts. In this paper the suitability of CO_2 as a solvent for zeolite based acid catalytic reactions was studied in general and isobutene dimerization in particular. The special focus of this study was to clarify whether using CO_2 as a solvent reduces coking compared to propane, which was used as a reference solvent in this case. The reaction was carried out in a 50 cm^3 continuous stirred tank reactor with two solid acid catalysts, ZSM-5 and ZSM-23 zeolites. Besides the desired dimerization reaction, the oligomerization reaction was also considered. The study also includes determination and discussion on phase conditions. Calculations based on thermodynamic methods show that the reaction phase may change during the experiment from a single phase (liquid, gas or supercritical) to a two phase domain (coexistence of vapor and liquid). Experiments with the ZSM-23 catalyst gave initial isobutene conversion of above 80%. The conversion with CO_2 was approx. 56% after ~200 h whereas with propane it was approx. 32% after about 120 h. These results were similar also over the ZSM-5 catalyst. The reduced coking tendency results in lower carbon dioxide emissions as the need for burning off the coke in catalyst regeneration is decreased. The results show that carbon dioxide is a potential solvent for industrial purposes as it prolongs the catalyst activity due to a reduced coking tendency.

1. Introduction

Isooctane (2,4,4-trimethylpentane) can be used as a gasoline component because it provides the necessary high octane number boost for gasoline to avoid coking phenomena inside an internal combustion engine. Isooctane has also low vapor pressure, but

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