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Effect of the mixing ratio of methylcyclohexane and *n*-dodecane on the product composition and coke formation in the catalytic decomposition reaction of blended fuels

Tae Ho Lee^a, Sungyong Mun^{b,*}, Sung Hyun Kim^{a,*}, Ki Bong Lee^{a,*}^a Department of Chemical and Biological Engineering, Korea University, 145 Anam-ro, Seongbuk-gu, Seoul 02841, Republic of Korea^b Department of Chemical Engineering, Hanyang University, Haengdang-dong, Seongdong-gu, Seoul 04763, Republic of Korea

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ABSTRACT

Analyzing the products obtained from the catalytic reaction of jet fuels is challenging because the fuels consist of several components. It is crucial to select suitable model compounds as representatives of the fuel to study its catalytic reaction, and methylcyclohexane (MCH) and *n*-dodecane were selected consequently. Further, the change in the products obtained from the reaction (catalyzed by commercial HZSM-5 in a flow reactor under a supercritical condition (550 °C and 5 MPa)) was investigated by varying the ratios of MCH and *n*-dodecane in the blended fuels. Although the fuel conversion and gas yield were proportional to the *n*-dodecane fraction in the fuel, the yield of aromatic compounds at each time, which was relative to the yield at the initial time, did not indicate any relation with it. The relative yields of the aromatic hydrocarbons obtained from the blended fuel reduced much slower than those obtained from the pure fuels. Particularly, the fuel containing an *n*-dodecane mass fraction of 0.2 exhibited the lowest reduction rate regarding the relative yields of aromatic hydrocarbons. The change in the relative yields of the products regarding the fuels was not crucial to coke formation.

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Introduction

The temperature of a hypersonic aircraft increases rapidly because of fuel combustion and friction with the air. This sudden rise in temperature can cause engine failure or structural deformation within the aircraft. Consequently, engine cooling technologies are desired for hypersonic aircrafts. Thus, liquid hydrocarbons are employed as endothermic fuels [1,2]. Endothermic fuels can cool the engines of an aircraft via a decomposition process after absorbing heat from the surroundings at high temperatures and pressures.

It is challenging to analyze the products obtained from the decomposition reaction of endothermic fuels containing various compounds because of the complexity in their composition. Therefore, the selection of representative substances with less complexity among the components of endothermic fuels as model compounds is necessary for an efficient analysis of their reaction [3,4]. Some jet fuels that are utilized as endothermic fuels include

Jet A-1, JP-5, JP-7, JP-8, JP-9, and JP-10. Apart from JP-10, the others are kerosene-type fuel mixtures with various components [5,6]. The compositions of the *n*- and iso-alkanes in most jet fuels are 40%–50% and that of cycloalkanes is 20%–40% [5,6,7]. Thus, many studies have been conducted on endothermic fuels employing *n*- or cyclo-alkanes as representative substances.

Methylcyclohexane (MCH) is the simplest alkylated cyclohexane and a representative of the cycloalkanes in JP-9 and kerosene-type fuels [8,9]. Kim et al. selected MCH as a representative substance of kerosene-type fuels, and the products from the pyrolysis reaction performed in a batch reactor were analyzed to investigate the mechanism of coke formation [10]. Bounaceur et al. also selected MCH and constructed a thermodynamic model for pyrolysis based on experimental data over a wide temperature range (450–920 °C) at atmospheric pressure. They reported that aromatic hydrocarbons were formed mainly by the dehydrogenation and dealkylation of cyclohexene or alkylcyclohexene regardless of temperature [11]. *n*-dodecane, which is a good representative of *n*-alkanes [12–15], is also a major component of several jet fuels, including NORPAR-12, JP-7, and JP-8 [16,17]. Herbinet et al. studied the pyrolysis of *n*-dodecane in a jet-stirred reactor in the 500–800 °C temperature range employing the EXGAS software. They obtained a detailed kinetic model for the thermal

* Corresponding authors.

E-mail addresses: munsy@hanyang.ac.kr (S. Mun), kimsh@korea.ac.kr (S.H. Kim), kibonglee@korea.ac.kr (K.B. Lee).