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Unveiling the effects of nickel loading on methane dry reforming: Perspectives from ni/fibrous Zeolite-Y catalysts

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A R T I C L E I N F O

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A B S T R A C T

The development of new technologies that employ greenhouse gases, such as CO_2 and CH_4, is becoming more important in the fight against global warming. Catalytic methane dry reforming (MDR) is one straightforward way to reduce CO_2 and CH_4. In this study, the influence of nickel (Ni) loading on the catalytic performance of fibrous zeolite-Y catalysts (Ni/FHY) for MDR was explored. The study involved the synthesis and testing of Ni/FHY with varying Ni loadings (1 wt% to 10 wt%). The results demonstrate that the metal loading significantly affects the catalysts' performance through metal-support interaction. The catalytic activity showed that the performance of FHY increased with optimum metal loading of 5 wt% where the CO_2 conversion increased to 90.3% from 82.2%, and CH_4 conversion to 94.2% from 79.6%. The findings suggest that the 5 wt% optimal Ni loading showed the critical role of the metal-support interaction in shaping catalytic properties. Hence, this work provides insights into catalyst optimization for sustainable industrial processes, highlights the importance of the synergistic metal-support interaction, and provides insights into the relationship between Ni content and catalytic behavior. Thus, it offers a basis for optimizing catalysts in MDR and contributes to the advancement of sustainable industrial processes.

1. Introduction

Nowadays, there has been much attention on cutting back on fossil fuel, owing to its adverse impacts on the environment and contribution to greenhouse gas (GHG) emissions. Humans have been purposely altering the composition of GHGs at an increasing frequency, primarily by excessive use of fossil fuels [1,2]. In general, three-quarters of the total GHG component is made up of methane (CH_4) and carbon dioxide (CO_2) [3]. Thus, significant efforts are being made to convert GHG into laudable products like high-purity syngas. Syngas, which is a combination of hydrogen (H_2) and carbon monoxide (CO), is a possible clean energy alternative to fossil fuels that can be used as a natural resource for a variety of processes, including the manufacturing of oxygenated compounds and Fishcer-Tropsch synthesis [3,4]. They produced sustainable aviation fuel (SAF) and other clean fuels with lower carbon footprint and can reduce GHG emissions compared to conventional jet fuel.

Methane reforming processes are essential for syngas production, including steam reforming ($CH_4 + H_2O \rightarrow 3H_2 + CO$) [5,6], partial oxidation ($CH_4 + 0.50_2 \rightarrow 2H_2 + CO$) [7], and CH_4 auto thermal reforming ($CH_4 + 0.25O_2 + 0.5H_2O \rightarrow CO$) [8]. Nevertheless, there are several drawbacks to such synthesis processes, including the extra expense from the generation of steam and the need for clean oxygen. Up till now, methane dry reforming (MDR) (Equation (1)), which produces syngas, has drawn increasing attention because it provides a mechanism to efficiently use both CO_2 and the unfavorable greenhouse gas, CH_4 [9].

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