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Study on the influence of small molecular gases on toluene reforming in molten salt

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ABSTRACT

The upgrading of tar is a key issue for the sufficient application of biowaste pyrolysis technology. Molten salt, with high migration and diffusion of ions to prevent the deactivation of coke deposition of tar reforming functional metals, is considered as a feasible catalytic reaction medium and heat carrier for the upgrading of tar. The present study investigated the interactions between small molecular pyrolysis gases (including H_2, CO, CH_4) and main tar model compound in ternary carbonate eutectics (Li_2CO_3–Na_2CO_3–K_2CO_3). The results demonstrated that H_2 could be decomposed to produce H radicals, promoting the conversion of toluene into gaseous products. CO_3^{2-} could consume H radicals required by toluene cracking, making the process toluene polymerized to polycyclic aromatic hydrocarbons be strengthened. On the other hand, CO would react with OH radicals to produce H radicals and could enhance gas-generating process. In addition, toluene could react with CO to form benzaldehyde and phenylacetaldehyde. With the addition of CH_4, more H radicals were supposed to be consumed, and toluene cracking process was further inhibited. Finally, the effect sequence of small molecular gases (H_2 > CH_4 > CO) on toluene reforming reaction was authenticated by investigating the impacts of introducing any two gases in toluene reforming.

1. Introduction

Biowaste is a potential renewable energy source to combat the energy crisis. Among biowaste utilization technologies, pyrolysis is considered to be the most promising way to convert biowaste into value-added products for expanding its utilization [1–3]. During pyrolysis process, biowaste can be flexibly converted into tar, char or gas, which provides multiple further application possibilities, such as syngas or biofuel [4,5]. However, tar is a complex mixture of hydrocarbons, of which high oxygen content limits its sufficient utilization [6,7]. Hence, the upgrading and homogenization of tar is a key issue for the efficient application of tar.

For tar upgrading, solid catalysts are widely reported in converting complex tar into value-added products through the stimulation of tar decomposition/cracking [8–10]. Nevertheless, catalysts are easy to be deactivated by coke deposition and agglomeration [6]. Efforts have been made to slow down catalyst deactivation by dispersing and introducing anti-deposition skeleton [11]. Similarly, molten salts, as a special reaction medium, contained various catalytic compounds in eutectic stage, which have been applied for the direct catalytic pyrolysis of coal and biomass [12]. By using the molten salts, the effective contact area increased and the process of coke deposition slowed down, thus reducing catalyst deactivation [13]. Meanwhile, the sulfide and chloride contents, such as H_2S and HCl, produced during the thermochemical process can be in situ captured in the salt [14]. The impact on environment and cost of gas clean equipment will be reduced consequently. On the other hand, molten salt, with large specific heat and thermal conductivity coefficient, could be used as heat storage medium for solar energy electricity generation [15].

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