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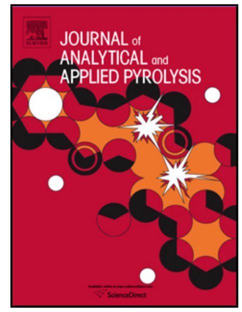

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Effect of Infrared Laser Radiation on Gas-Phase Pyrolysis of Ethane

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Highlights

- The ethane pyrolysis was carried out using CO_2-laser radiation
- Introduction of the laser radiation decreases the temperature of pyrolysis
- The conversion rate could be increased with the increase of the laser power density

Abstract
Pyrolysis of hydrocarbons is widely used for the production of light olefins. The pyrolytic processes are energy-consuming, proceeding at high wall reactor temperature and producing large amounts of undesired carbonaceous side-products. There is a demand for the search of lower temperature regimes together with the reduction of side products at high conversion efficiencies. The objective of our research is to decrease the temperature of walls of the pyrolytic reactor for the ethane thermal decomposition by CO_2-laser radiation. Gas-phase laser induced pyrolysis of ethane was studied in a continuous flow tubular reactor. Introduction of infrared laser radiation into the pyrolysis reactor results in significant reduction of the reaction temperature threshold and noticeable increase of the ethane conversion at temperatures 870-970 K. At low-temperature range, 760-920 K, significant increase of ethane conversion was observed in the presence of ethylene comprising 5 to 10 % vol. of the initial gas mixture. Similar shift of temperature threshold was also observed with the increase of radiation power density. Analysis of volatile products demonstrated minor differences in the product content for both conventional and laser-induced pyrolysis, thus confirming the laser radiation function as an additional energy source without significant interference in the gas phase reactions. From practical point of view the laser induced pyrolysis opens the possibility to save energy on the account of reduced temperature. The low-temperature pyrolysis could additionally be promoted by the introduction of unsaturated hydrocarbons.

Keywords: Ethane, ethylene, pyrolysis, hydrocarbons, thermal dehydrogenation, CO_2-laser

1. Introduction

The pyrolysis of hydrocarbons is the bulky industrial process for the light olefins (C_2-C_4) production. The world demand for ethylene in 2016 was estimated at the level of more than 150 million tonnes per year with the growth rate of around 3.5% per year [1]. Due to the demand and economic importance of ethylene, the pyrolysis of ethane has been the subject of intensive studies for the past few decades.

Thermal pyrolysis proceeds at temperatures around 1000-1200 K and atmospheric pressure. Unfortunately, this process yields some unwelcome by-products including soot and coke, compounds of high-molecular weight (polyaromatics, resins) and gaseous CO and CO_2. This requires the separation of pyrolysis products and the regular cleaning of equipment surfaces. Nowadays, the pyrolytic furnaces, mostly operating near the major oil refineries, are optimized for the production with capacity exceeding 100 thousand tons of feed stocks per year. There are numerous sources of raw materials, such as oil shale and associated petroleum gases, which require the pyrolytic treatment in significantly smaller amounts. Thus, there is a demand for the search