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PRODUCTION OF LINEAR PARAFFINS FROM CYCLIC HYDROCARBONS BY CATALYTIC RING-OPENING

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Abstract

The conversion of cyclic hydrocarbons into linear paraffins represents an important industrial process in modern petrochemical technology. Linear paraffins are widely used as raw materials for detergents, lubricants, fuels, and petrochemical intermediates. This article reviews the fundamental principles, reaction mechanisms, and technological approaches for producing paraffins from cyclic hydrocarbons through catalytic hydrogenation and ring-opening reactions. Special attention is given to reaction conditions, catalysts, and product selectivity. The study highlights the efficiency and industrial relevance of these processes in meeting the growing demand for high-purity paraffins.

Keywords: Cyclic hydrocarbons, paraffins, catalytic hydrogenation, ring-opening reactions, petrochemical processes.

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Introduction

Cyclic hydrocarbons such as cycloalkanes and cycloalkenes constitute a significant fraction of petroleum and naphtha streams. Although these compounds possess valuable chemical properties, linear paraffins are often preferred in industrial applications due to their higher chemical stability and predictable physical behavior. Consequently, the transformation of cyclic hydrocarbons into paraffins has gained increasing attention in petrochemical research and industry.

The production of paraffins from cyclic hydrocarbons typically involves catalytic hydrogenation followed by ring-opening reactions. These processes enable the conversion of saturated or unsaturated cyclic molecules into linear or branched alkanes under controlled conditions. This article aims to analyze the main reaction pathways, catalysts, and operating parameters involved in paraffin synthesis from cyclic hydrocarbons.

The primary feedstocks used in this process include:

- Cyclohexane
- Cyclopentane
- Cyclohexene
- Alkyl-substituted cycloalkanes

Hydrogen gas (H_2) is used as a reducing agent, while metal-based catalysts facilitate hydrogenation and ring cleavage.

Common catalysts applied in these reactions include:

- Platinum (Pt/Al_2O_3)
- Palladium (Pd/C)
- Nickel-based catalysts
- Zeolite-supported metal catalysts

Typical reaction parameters are:

- Temperature: 300–450 °C
- Pressure: 2–6 MPa
- Hydrogen-to-hydrocarbon ratio: 3:1 to 6:1

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Hydrogenation of Cyclic Hydrocarbons

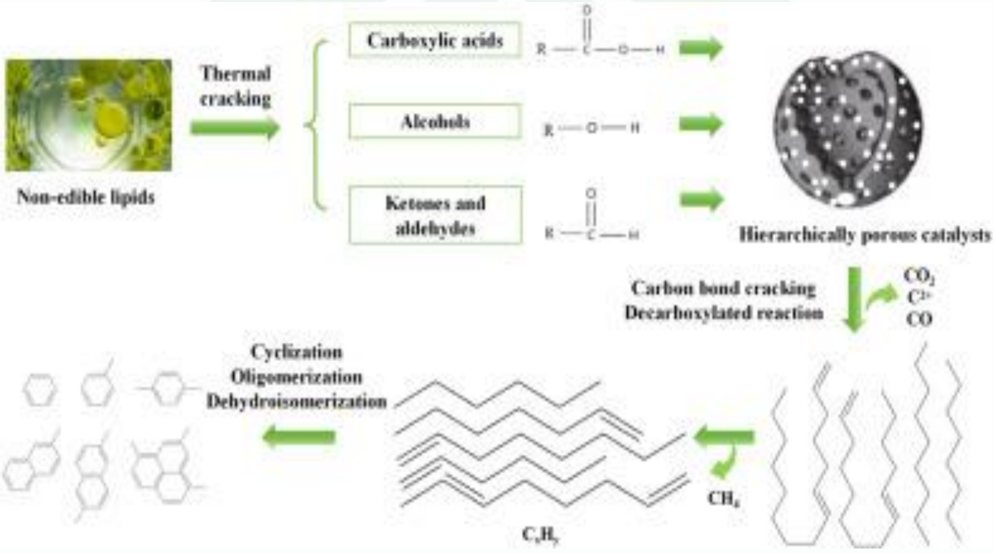
$$C_6H_{10}+H_2 \rightarrow C_6H_{12}$$

Ring-Opening Reaction

$$C_6H_{12}+H_2 \rightarrow C_6H_{14}$$

Cyclohexane is converted into n-hexane via catalytic ring opening.

Experimental and industrial data demonstrate that high conversion rates (up to 95%) can be achieved using noble metal catalysts. The selectivity toward linear paraffins increases with optimized temperature and hydrogen pressure. Zeolite-supported catalysts showed improved control over molecular structure, minimizing by-product formation.



The hydrogenation step ensures saturation of unsaturated bonds, while the subsequent ring-opening step determines the structure of the resulting paraffin. The combination of these reactions results in high yields of linear alkanes suitable for industrial applications.

The synthesis of paraffins from cyclic hydrocarbons offers several advantages, including efficient utilization of petroleum fractions and production of high-value

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chemicals. Catalyst selection plays a crucial role in determining product selectivity and process efficiency. While noble metal catalysts provide high activity, their cost necessitates ongoing research into alternative catalyst systems. Environmental considerations also favor these processes, as modern catalytic systems reduce coke formation and energy consumption. Further advancements in catalyst design and reactor technology are expected to enhance the sustainability and economic viability of paraffin production.

The conversion of cyclic hydrocarbons into linear paraffins through catalytic hydrogenation and ring-opening reactions is a vital petrochemical process. Proper selection of catalysts and reaction conditions allows for high conversion efficiency and selectivity. Continued research in this field will contribute to improved industrial processes and expanded applications of paraffins.

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