TECHNOLOGICAL APPROACHES TO THE PRODUCTION OF C_9 MONONUCLEAR ARENES FROM HYDROCARBON PYROLYSIS

Abbos Nurimbetov
Master's Student, Tashkent State
Technical University, Uzbekistan

Maxkamova Latofat
PhD Tashkent State Technical University, Uzbekistan

Abstract

This article discusses modern technologies for producing C_9 mononuclear arenes from hydrocarbon pyrolysis products. A process scheme for extracting aromatic compounds from pyrolysis gasoline is presented, including hydrotreating, selective extraction, and fractional distillation. Special attention is given to methods for obtaining trimethylbenzenes and propylbenzenes as key representatives of the C_9 fraction. Their industrial applications in petrochemical synthesis, solvents, and polymer production are also described. Additionally, recent advances in process optimization and environmental considerations are highlighted.

Keywords: Pyrolysis, mononuclear arenes, C_9 fraction, trimethylbenzene, propylbenzene, pyrolysis gasoline, aromatic hydrocarbons, hydrotreating, sulfolane, selective extraction.

Introduction

Pyrolysis of hydrocarbons is one of the fundamental processes in modern petrochemical industry, playing a key role in the conversion of various feedstocks into valuable chemical products. This process involves the thermal decomposition of hydrocarbons at high temperatures (typically 700–900°C) in the absence of oxygen, leading to the formation of a wide range of gaseous, liquid, and solid products[1]. The primary objective of industrial pyrolysis is the production of light olefins such as ethylene and propylene, which serve as essential building blocks for polymers and other chemical materials.

Alongside gaseous products, pyrolysis generates a significant amount of liquid by-products, commonly referred to as pyrolysis gasoline (pygas). This fraction is particularly rich in aromatic hydrocarbons, including benzene, toluene, xylenes, and heavier compounds such as C_9 mononuclear arenes[2]. These C_9 aromatic hydrocarbons, which include trimethylbenzenes and propylbenzenes, represent an important yet often underutilized resource in petrochemical processing.

In recent years, increasing demand for high-value aromatic compounds has intensified interest in the efficient recovery and utilization of C_9 fractions from pyrolysis gasoline. These

Web of Scientists and Scholars: Journal of Multidisciplinary Research

compounds are widely applied in the production of synthetic resins, plasticizers, solvents, antioxidants, and specialty chemicals. Furthermore, certain derivatives, such as cumene, play a crucial role as intermediates in the large-scale production of phenol and acetone[3-5].

The composition and yield of pyrolysis products strongly depend on the type of feedstock used. Light hydrocarbons such as ethane tend to produce higher yields of ethylene, whereas heavier feedstocks, including naphtha and gas oils, generate larger quantities of liquid products rich in aromatic compounds. As a result, pyrolysis gasoline obtained from heavier feedstocks becomes a key raw material for the extraction of valuable aromatics, including the C_9 fraction.

However, the separation and purification of C_9 mononuclear arenes present significant technical challenges due to the complexity of pyrolysis gasoline composition. It contains a mixture of paraffins, olefins, diolefins, and aromatics with close boiling points. Therefore, advanced processing techniques—such as hydrotreating to remove impurities, selective solvent extraction (commonly using sulfolane), and precise fractional distillation—are required to achieve efficient separation.

Modern research is focused not only on improving the efficiency and selectivity of these processes but also on reducing energy consumption and environmental impact. The development of more sustainable extraction methods, alternative solvents, and catalytic upgrading technologies is becoming increasingly important in the context of green chemistry and industrial sustainability.

Thus, the study of methods for obtaining C_9 mononuclear arenes from pyrolysis products remains highly relevant, both from an industrial and scientific perspective, as it contributes to the more efficient utilization of hydrocarbon resources and the expansion of the raw material base for the chemical industry.

Composition of Pyrolysis Products

Pyrolysis results in a complex mixture of products, including:

Fraction Type	**Carbon Range**	**Main Components**
Gases	C_1–C_4	Methane, ethylene, propylene
Light gasoline	C_5–C_6	Paraffins, olefins
Heavy gasoline	C_7–C_9	Aromatics (benzene, toluene, xylenes, C_9 arenes)
Tar and coke	C_{10}+	Polycyclic aromatics, carbonaceous residues

The yield of olefins depends strongly on the feedstock:

- **Ethane pyrolysis** → highest ethylene yield
- **Heavier fractions** → more aromatics and lower olefin yield

Reaction Mechanisms in Pyrolysis

Pyrolysis involves both primary and secondary reactions:

Primary reactions

Cracking (C–C bond cleavage):

$$CH_3CH_2CH_3 \rightarrow CH_2{=}CH_2 + CH_4$$

Dehydrogenation:

$$CH_3CH_2CH_3 \rightarrow CH_3CH{=}CH_2 + H_2$$

Processing of Pyrolysis Gasoline

Pyrolysis gasoline is the main source for recovering aromatic hydrocarbons, including C_9 arenes.

Technological scheme:

1. **Hydrotreating**
   - Removes sulfur, nitrogen, and unsaturated compounds
   - Stabilizes the feedstock
2. **Selective extraction**
   - Typically uses **sulfolane solvent**
   - Separates aromatics from non-aromatics
3. **Distillation (fractionation)**
   - Separates C_6–C_8 (BTX) and C_9 fractions
   - Further purification of individual compounds

Key C_9 Aromatic Compounds

Compound	Chemical Formula	Structure Type	Main Applications
Mesitylene (1,3,5-trimethylbenzene)	$C_6H_3(CH_3)_3$	Symmetrical aromatic	Dyes, surfactants, antioxidants
Pseudocumene (1,2,4-trimethylbenzene)	$C_6H_3(CH_3)_3$	Asymmetrical aromatic	Resins, solvents
n-Propylbenzene	$C_6H_5CH_2CH_2CH_3$	Linear alkylbenzene	Intermediate for cumene synthesis
Cumene (isopropylbenzene)	$C_6H_5CH(CH_3)_2$	Branched alkylbenzene	Phenol and acetone production

Methods for Producing Trimethylbenzenes and Propylbenzenes

Trimethylbenzenes:

- Obtained via:
  - Fractionation of C_9 aromatics
  - Catalytic reforming and alkylation
- Isomer separation achieved through:
  - Distillation
  - Adsorption processes

Propylbenzenes:

- Produced by:
  - Alkylation of benzene with propylene
- Cumene process is especially important for:
  - Phenol and acetone production

C_9 mononuclear arenes represent a valuable class of aromatic hydrocarbons derived from pyrolysis gasoline. Advances in hydrotreating, extraction, and separation technologies enable efficient recovery and utilization of these compounds. Future developments will focus on improving process sustainability and meeting the growing demand for high-value petrochemical products.

References

1. Ermakov V.A., Sorokin A.M. Pyrolysis of Hydrocarbons and Processing of Pyrolysis Products. Moscow: Khimiya, 2009.
2. Smirnov A.A., Kuznetsov V.N. Technology of Aromatic Hydrocarbons. St. Petersburg: Profession, 2014.
3. Ozhegov S.I., Andreev E.L. Hydrotreating and extraction of pyrolysis gasoline. Petrochemistry, 2020, No. 3, pp. 45–52.
4. Tarasov I.P. C_9 Aromatic Hydrocarbons: Properties and Applications. Kazan: Khimprom, 2017.
5. Chemical Encyclopedia, Vol. 1–5. Moscow: Soviet Encyclopedia, 1992.