

# TECHNOLOGICAL APPROACHES TO THE PRODUCTION OF C<sub>9</sub> MONONUCLEAR ARENES FROM HYDROCARBON PYROLYSIS

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## Abstract

This article discusses modern technologies for producing C<sub>9</sub> 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<sub>9</sub> 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.

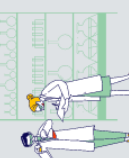
**Keywords:** Pyrolysis, mononuclear arenes, C<sub>9</sub> fraction, trimethylbenzene, propylbenzene, pyrolysis gasoline, aromatic hydrocarbons, hydrotreating, sulfolane, selective extraction.

## 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<sub>9</sub> mononuclear arenes[2]. These C<sub>9</sub> 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<sub>9</sub> fractions from pyrolysis gasoline. These



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<sub>9</sub> fraction.

However, the separation and purification of C<sub>9</sub> 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<sub>9</sub> 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 <sub>1</sub> –C <sub>4</sub>	Methane, ethylene, propylene
Light gasoline	C <sub>5</sub> –C <sub>6</sub>	Paraffins, olefins
Heavy gasoline	C <sub>7</sub> –C <sub>9</sub>	Aromatics (benzene, toluene, xylenes, C <sub>9</sub> arenes)
Tar and coke	C <sub>10</sub> +	Polycyclic aromatics, carbonaceous residues

The yield of olefins depends strongly on the feedstock:

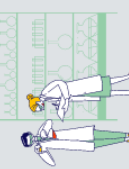
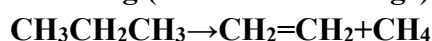
- **Ethane pyrolysis** → highest ethylene yield
- **Heavier fractions** → more aromatics and lower olefin yield

Reaction Mechanisms in Pyrolysis

Pyrolysis involves both primary and secondary reactions:

Primary reactions

**Cracking (C–C bond cleavage):**



**Dehydrogenation:****Processing of Pyrolysis Gasoline**

Pyrolysis gasoline is the main source for recovering aromatic hydrocarbons, including C<sub>9</sub> 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<sub>6</sub>–C<sub>8</sub> (BTX) and C<sub>9</sub> fractions
- Further purification of individual compounds

**Key C<sub>9</sub> Aromatic Compounds**

Compound	Chemical Formula	Structure Type	Main Applications
Mesitylene (1,3,5-trimethylbenzene)	C <sub>6</sub> H <sub>3</sub> (CH <sub>3</sub> ) <sub>3</sub>	Symmetrical aromatic	Dyes, surfactants, antioxidants
Pseudocumene (1,2,4-trimethylbenzene)	C <sub>6</sub> H <sub>3</sub> (CH <sub>3</sub> ) <sub>3</sub>	Asymmetrical aromatic	Resins, solvents
n-Propylbenzene	C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub> CH <sub>2</sub> CH <sub>3</sub>	Linear alkylbenzene	Intermediate for cumene synthesis
Cumene (isopropylbenzene)	C <sub>6</sub> H <sub>5</sub> CH(CH <sub>3</sub> ) <sub>2</sub>	Branched alkylbenzene	Phenol and acetone production

**Methods for Producing Trimethylbenzenes and Propylbenzenes****Trimethylbenzenes:**

- Obtained via:
  - Fractionation of C<sub>9</sub> 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<sub>9</sub> 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.

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