EXTRACTION OF BENZENE FROM GASOLINE AND ITS APPLICATION AREAS

Yusupova Gozal Khusan qizi
Associate Professor at TDTU Almalyk Branch named after Islam Karimov

Khatamov Khayrullo Shukrullo ogli
Student at TDTU Almalyk Branch named after Islam Karimov
xayrullohatamov@gmail.com
+998500531769

Annotation:
This article provides detailed information about the methods of obtaining aromatic hydrocarbons from gasoline and their areas of application. Due to the high concentration of toluene in gasoline, the reaction was carried out in the presence of hydrogen, and the catalytic properties of selected catalysts (platinum chloride or rhenium chloride) were studied. Information is also provided on the properties and synthesis methods of aromatic hydrocarbons such as benzene, phenol, toluene, and others.

Keywords: Benzene, phenol, biphenyl, aniline, toluene, aromatic hydrocarbon, biphenyl.

In Uzbekistan, benzene is also used as an important raw material in industry. This substance is mainly obtained through the processing of oil and gas. The Bukhara and Fergana oil refineries, as well as the Shurtan Gas Chemical Complex, are the leading enterprises in benzene production. In these plants, benzene is extracted through the pyrolysis of oil fractions using modern technologies. In Uzbekistan, benzene is widely used in the chemical, pharmaceutical, paint, and plastics industries. It is also used in laboratory works in research institutes and higher educational institutions. However, due to its possible negative effects on human health and the environment, strict compliance with environmental safety and occupational protection requirements is ensured during its use. Environmental protection organizations of the Republic of Uzbekistan exercise strict control in this regard.

Globally, benzene is primarily considered an important raw material in the chemical industry. Through it, many intermediate and final products such as phenol, aniline, ethylbenzene, styrene, and cyclohexane are synthesized. These products are widely used in the production of plastics, synthetic fibers, paints, polymers, pharmaceuticals, and other chemical products. Today, countries with large industries such as China, the USA, South Korea, and Germany are the main producers and consumers of benzene. Especially China leads in this field globally. The economic significance of benzene is also immense. As a product of the oil and gas chemical industry, it is traded on international markets, and its price often fluctuates depending on oil prices. However, due to its toxic properties and environmental hazards, its use is regulated by strict standards in many countries. The World Health Organization includes it in the list of carcinogenic substances, and industrial workers handling benzene must take special protective measures [1-2].

Benzene is a colorless liquid with a sharp odor, with a boiling point of 80.1°C and a melting point of 5.5°C. It is a light compound with a density of 0.876 g/cm^3, poorly soluble in water (1.8 g/L at 25°C), but well soluble in organic solvents (e.g., ethanol, acetone). Benzene's high vapor pressure indicates its volatility. Its chemical properties are defined by its aromatic structure. It mainly undergoes electrophilic substitution reactions because its π-electron cloud is an attractive center for electrophiles. The following main reactions illustrate the characteristic properties of benzene [3]. Until the 1920s, it was frequently used as an industrial solvent, especially for degreasing metals. After its toxicity was recognized, benzene was replaced by other solvents. Before World War II, benzene was mainly obtained as a byproduct of coke production in the steel industry. However, in the 1950s, increasing demand, especially in the growing plastics industry, required its production from oil. Today, most benzene comes from the petrochemical industry, with a small portion from coal.

Many important chemical compounds are derived from benzene in which one or more hydrogen atoms are replaced with functional groups. Common benzene derivatives include phenol (C_6H_5OH), toluene ($C_6H_5CH_3$), and aniline ($C_6H_5NH_2$).

Linking two aromatic rings forms biphenyl (C_6H_5–C_6H_5). Connecting two or more aromatic rings (where one ring is attached to another) forms fused aromatic hydrocarbons, such as naphthalene (two fused rings) and anthracene (three fused rings) [4]. Some aromatic compounds are also considered heterocyclic. In such cases, one or more carbon atoms in the benzene ring are replaced with other elements. Examples of heterocyclic compounds include pyridine (C_5H_5N) and pyrimidine ($C_4H_4N_2$). (Other heterocyclic compounds, pyridazine and pyrazine, have the same chemical formula as pyrimidine, but the relative positions of the two nitrogen atoms in each ring are different.) Initially obtained from coal tar, it was once discarded as a waste of coke and gas industries, but now serves as a source for extracting various organic compounds. It is fractionally distilled to yield several fractions: arenes and their derivatives (benzene, toluene, etc.). Coke gas contains benzene, toluene, xylenes, phenol, ammonia, hydrogen sulfide, and other substances. After separating ammonia and hydrogen sulfide from coke gas, valuable substances such as benzene are obtained [5].

Nitration: Benzene reacts with a mixture of nitric and sulfuric acid to form nitrobenzene ($C_6H_5NO_2$):

$C_6H_6 + HNO_3 \rightarrow [H_2SO_4] \rightarrow C_6H_5NO_2 + H_2O$

Sulfonation: Benzene reacts with concentrated sulfuric acid or sulfur trioxide to form benzenesulfonic acid ($C_6H_5SO_3H$):

$\mathbf{C_6H_6 + H_2SO_4 \rightarrow C_6H_5SO_3H + H_2O}$

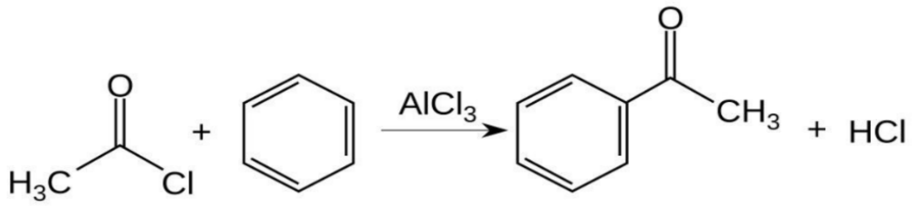
Halogenation: Benzene reacts with halogens (Cl_2 or Br_2) in the presence of a catalyst ($FeCl_3$ or $AlCl_3$) to form chlorobenzene or bromobenzene:

$\mathbf{C_6H_6 + Cl_2 \rightarrow [FeCl_3] \rightarrow C_6H_5Cl + HCl}$

Benzene rarely undergoes addition reactions, as it would lose its aromaticity. However, under high pressure and in the presence of catalysts, it can be hydrogenated to form cyclohexane (C_6H_{12}) [6].

Halogenoalkanes: Interaction with halogenoalkanes (Friedel-Crafts alkylation) forms alkylbenzenes.

In the Friedel-Crafts acylation reaction, benzene reacts with anhydrides or acyl halides to produce aromatic and fatty-aromatic ketones.



Combustion of benzene represents its complete oxidation. Benzene ignites easily and burns with a sooty flame in air (the molecule contains up to 92% carbon):

$$2C_6H_6 + 15O_2 \rightarrow 12CO_2\uparrow + 6H_2O$$

Industrially, benzene is primarily obtained from petroleum products. The following are its main synthesis methods:

Catalytic reforming: Conversion of hydrocarbons to benzene during oil refining, using platinum catalyst.

Toluene dealkylation: Toluene ($C_6H_5CH_3$) is converted to benzene using hydrogen or other reagents:

$$C_6H_5CH_3 + H_2 \rightarrow C_6H_6 + CH_4$$

Trimerization of acetylene: In laboratories, benzene is synthesized from acetylene (C_2H_2) with a nickel catalyst:

$$3C_2H_2 \rightarrow [Ni] \rightarrow C_6H_6$$

Most of the benzene obtained is used for synthesizing other products:

~50% converted to ethylbenzene (alkylation with ethylene)

~25% converted to cumene (alkylation with propylene)

~10–15% hydrogenated to cyclohexane

~10% used to produce nitrobenzene

2–3% converted to linear alkylbenzenes

~1% used to synthesize chlorobenzene [6].

Literature Review and Results:

A mixture of hydrocarbons with a boiling point of 60–200°C was mixed with hydrogen gas, and the reaction was carried out at 500–525°C under 50 atmospheres using a catalyst (e.g., platinum chloride or rhenium chloride). Under such conditions, aliphatic hydrocarbons form rings and convert to aromatic hydrocarbons. Almost all aromatic hydrocarbons are separated by distillation, for example, using diethylene glycol or sulfolane, and benzene is separated from other aromatics by distillation.

Toluene is mixed with hydrogen and passed through a catalyst (chromium, molybdenum, or platinum oxide) at 500–600°C and 40–60 atm. Sometimes high temperatures are used instead of a catalyst. The reaction equation is as follows:

$C_6H_5CH_3 + H_2 \rightarrow C_6H_6 + CH_4$

The yield of the reaction exceeds 95%. Sometimes xylene or heavier aromatic hydrocarbons can be used instead of toluene, as their effectiveness is similar.

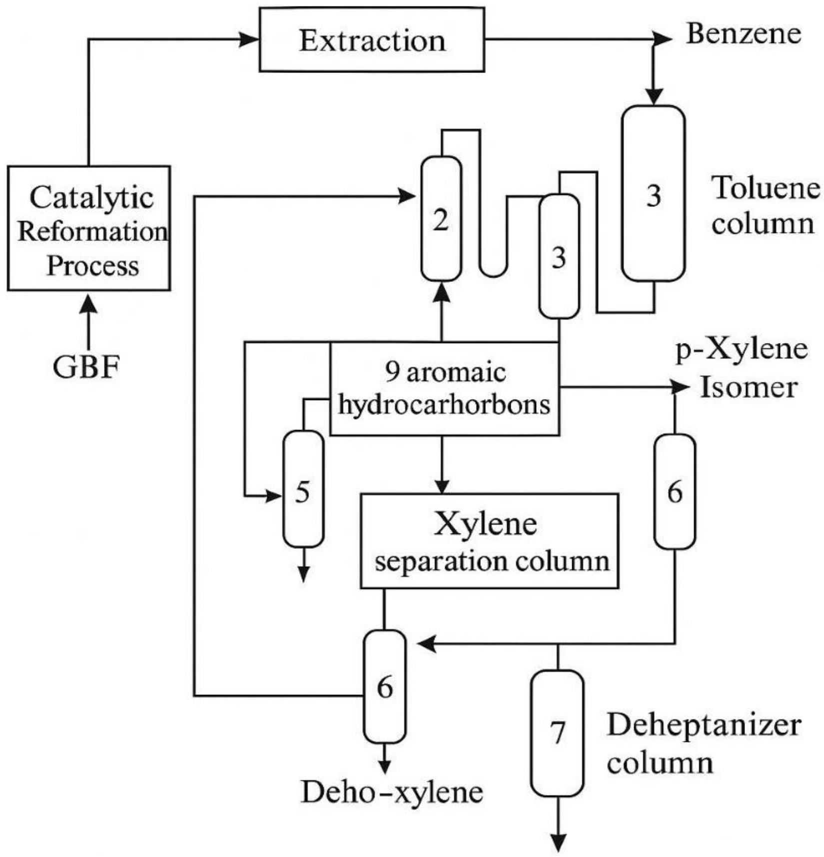


Figure 1. Complex UOP for aromatic hydrocarbon production

1 – Column for reformate separation 2 – Benzene column 3 – Toluene column 4 – C9 aromatic hydrocarbons column 5 – Xylene separation column 6 – Ortho-xylene column 7 – Deheptanizer column

In some cases, acetylation or sulfonation reactions are used to extract benzene from gasoline. Through these reactions, benzene is chemically altered and then recovered in pure form. Additionally, benzene is also extracted on an industrial scale via fractional distillation. In this method, gasoline is fractionated at specific temperatures, and the component boiling around 80°C — benzene — is separated.

Conclusion

Gasoline is a complex mixture that contains benzene in small quantities. To extract this component, physical-chemical methods are used in modern industrial plants. Extraction and distillation are among them. Especially, extraction with sulfolane stands out for its selectivity, efficiency, and economic value. In the first stage, gasoline reacts with sulfolane, transferring benzene to the sulfolane. As a result, extracting benzene from gasoline is not a simple lab reaction but a complex, multi-step technological process conducted under strict control on an industrial scale. This technology not only provides economic benefits but also plays a significant role in strengthening the chemical industry and developing import-substituting products. In Uzbekistan, ongoing developments, existing plants, and technological advancements in this direction create a foundation for future expansion in this field.

References

1. Yusupova G.X., Bekturdiyev G.M., Mamatqulov N.N. Preparation of carriers for huro-cleaning catalysts based on palygorsk clay// International journal of advanced research in science, engineering and technology. India,-Vol. 6, Issue 12, oktober 2019. -Pp. 12294-12298.
2. Юсупова Г.Х., Бектурдиев Г.М. Природные минеральные глины-сырьё, для получения катализаторов гидроочистки// Международная конфиренция Инновационное развитие наука и оброзования Россия сентябрь 2020, 40-43 с.

3.Юсупова Г.Х., Бектурдиев Ғ.М. Природные минеральные глины в качестве сырья для получения катализаторов гидроочистки// Горный вестник Узбекистана 2020. № 3 (82) –С. 100-104.

4.Юнусов М.П., Саидов У.Х., Насуллаев Х.А., Гуломов Ш.Т. Новые подходы к синтезу катализаторов и адсорбентов для переработки жидкого и газообразного углеводородного сырья. // III Российский конгресс по катализу «Роскатализ» 22-26 мая. 2017. Г. Нижний Новгород сб. тезисов «Новосибирск-2017» с. 157-158.

5.Юсупова Г.Х. Изучение каталитических свойств синтезированных носителей катализатора гидроочистки// Международная конференция Инновационное развитие наука и оброзования Казахстан ноябрь 2020, 8-9 с.

6.Суербаев Х.А., Жубанов К.А., Шалмагамбетов К.М. Каталитические процессы в нефтеперерабатывающей промышленности. Учебное пособие. – Алматы: Казак университети, 2002, - 129 с