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# A Study on the Production of Hydrocarbons from Used Thermoplastics in the Republic of Congo

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## Abstract

End-of-life plastics represent a major hazardous waste stream worldwide, with an estimated 353 million tons of plastic waste generated in 2019 (Global Plastics Outlook, 2019). Their non-biodegradable nature causes significant environmental and health problems, including landscape degradation, proliferation of harmful insects, and fire hazards, with toxic smoke posing serious risks to human health. In the context of high demand for raw materials and the depletion of petroleum resources, the management of these wastes has become a critical environmental challenge, making recycling and energy recovery from plastics an essential component of sustainable development strategies. The aim of this study is to convert these wastes into fuels, thereby providing both economic and ecological benefits. Among the possible processes, pyrolysis is preferred because it decomposes plastics at lower temperatures than incineration or gasification, reducing the risk of metal evaporation and the release of other toxic substances. Therefore, pyrolysis emerges as an effective solution to reduce the volume of used plastics while producing reusable hydrocarbons.


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**Keywords:** Thermoplastics; Plastic Waste; Pyrolysis; Pyrolytic Oil; Fuels; Energy Recovery

## INTRODUCTION

The growing production of plastics, particularly thermoplastics, has led to a significant accumulation of non-biodegradable waste, which pollutes the environment and poses health risks in the city of Brazzaville, Republic of Congo. Traditional waste management methods, such as landfilling or incineration, have shown their limitations, while the gradual depletion of fossil resources emphasizes the need for alternative solutions. In this context, the conversion of thermoplastics into hydrocarbons through pyrolysis appears as a promising approach, simultaneously reducing the volume of plastic waste and producing useful fuels and gases. This strategy aligns with the transition toward a circular economy and represents a major challenge for sustainable resource management and energy security. The analyses of the produced oil focus on density, specific gravity, pH, viscosity, and color.

## MATERIALS AND METHODS

### Materials

To carry out this study, several materials were used, the most important of which are listed below:

#### 1. Precision balance

This was used to weigh the masses of the raw materials and the obtained product.




**Fig. 1 :** Précision balance

**2. Heating tank**

This equipment was used to heat the inner tubes in the absence of oxygen. It is the most essential equipment in our work, serving as the reactor.

**3. pH paper**

pH paper is a simple and effective measurement tool used to determine the acidity or alkalinity of a solution. It indicates the level of acidity or alkalinity on a scale from 0 to 14.




**Fig. 2:** pH paper

**4. Graduated cylinder**

This is a measuring instrument mainly used in the laboratory to determine the volume of liquids. The markings on the cylinder indicate the volume in milliliters (mL) or liters (L).

**5. Stopwatch**

It is used to measure accurately the time it takes for the ball to reach the bottom of the cylinder, which is crucial for obtaining reliable results.




**Fig. 3:** Stopwatch (wikhow, 2025)

**6. Aluminum ball**

The ball is used to measure the fall time in the oil from a given height.

### 7. Heating tank

This equipment is used to heat the materials in the absence of oxygen. It serves as the reactor and is essential for the pyrolysis process.



**Fig. 4: Heating tank**

### 8. Heating stove

A wood-fired stove was used to heat the tank (reactor). This stove served as the energy source for the process.



**Fig. 5:** Heating stove

## Methodology

### 1. Raw materials

The process used in this work is endothermic. The raw materials used are as follows:

- Used plastic bottles collected from various streets of Mikalou;
- A mixture of silicone and sand to ensure the sealing of the reactor;
- Firewood.

## 2. Méthodologie

### *Matières premières*

Le procédé utilisé dans ce travail est endothermique. Les matières premières utilisées sont les suivants:

- Bouteilles en plastiques usagés des différentes rues de Mikalou;
- Mélange de la silicone et du sable pour assurer l'étanchéité de notre réacteur;
- Le bois de chauffage.




**Fig. 6:** The different raw materials

### Steps for the production of pyrolytic oil

The steps for this production are as follow:

#### a. Preparation of raw materials

The pyrolytic oil was produced from used plastic bottles. The production principle consists of using these bottles as the feedstock in a pyrolysis reactor in the absence of oxygen and at high temperature to induce their chemical decomposition. The materials were prepared in defined proportions according to the desired yield. The plastic bottles were selected, cut, and then weighed. A total mass of 2 kg of plastic bottles was measured for the process.

#### b. Introduction into the reactor

According to the literature, the cooking temperature should range between 400 and 800°C to ensure proper decomposition of the plastics without generating microplastics. For our study, we used a simple and artisanal method with plastic bottles and a cylindrical tank. The bottles were introduced into the reactor, which was then sealed with silicone to ensure airtightness. The heating time varied and lasted approximately 1 hour and 37 minutes.



**Fig. 7:** Tank sealed with silicone

### c. Heating

The reactor was heated to a temperature ranging between 400 and 800°C.

### d. Collection of pyrolytic oil

During heating, the vapor produced in the reactor is directed through a pipeline and cooled by a water condenser (at ambient temperature). A fraction of the vapor condenses and is collected in a storage container, while the remaining portion consists of non-condensable gases.



**Fig. 8:** Pyrolysis setup used.

All these steps can be summarized in the following diagram:

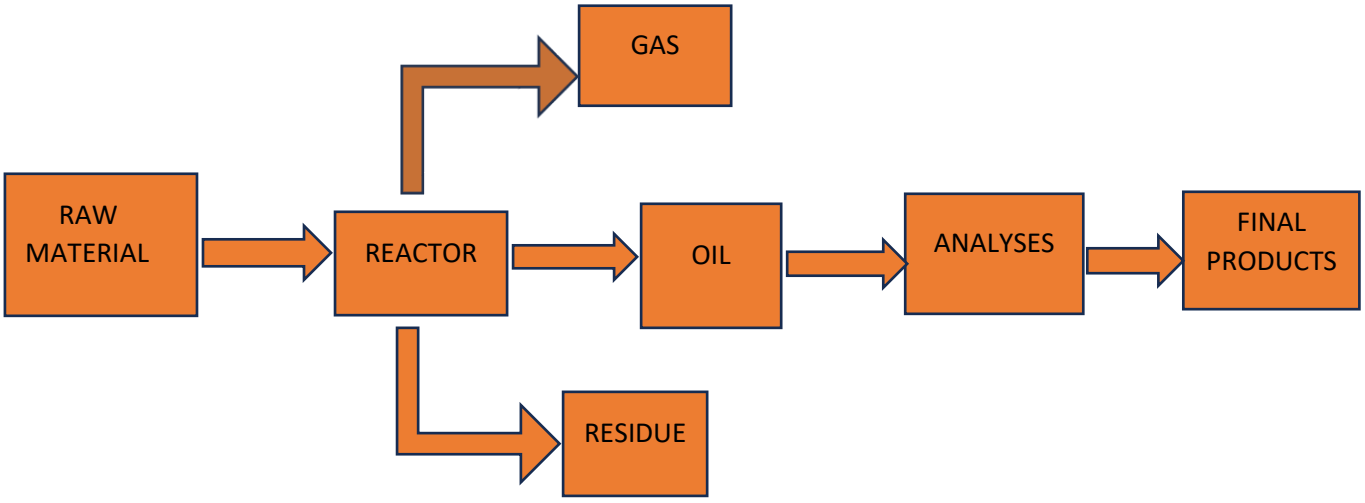



**Fig. 9:** Schematic diagram of pyrolytic oil production (Ulrich BERRY et al., 2025)

**Obtained products**

After pyrolysis, three products were obtained:

- Pyrolytic oil;
- Carbon black ;
- Non-condensable gases.




(a) Oil (b) Gas (c) Char

**Fig. 10:** The three obtained products.

**Characterization of pyrolytic oil**

After obtaining the products from pyrolysis, the quantities of oil collected during the two experiments were **mixed**, and the resulting mixture showed **two phases** due to density differences. We therefore decided to subject this oil to the following analyses and treatments:

**1. Decantation**

Decantation is the process of separating **immiscible phases**, at least one of which is liquid or gaseous, under the influence of gravity. In this study, we performed a separation of the two phases to collect the desired fraction.

- **Objective :** Obtain a single homogeneous phase.
- **Principle :** Separate the two liquid phases.
- **Procedure :** The biphasic mixture was poured into a beaker and then transferred into a separatory funnel. It was left to decant for **1 hour** to allow complete separation, resulting in two distinct phases, each collected in a separate beaker.



**Fig. 11:** Decantation of the pyrolytic oil.

**2. Filtration**

Filtration is a separation technique used for a mixture consisting of a continuous phase (liquid or gas) and a dispersed phase (solid or liquid) by passing it through a filter medium. The targeted fraction was filtered.

- **Objective:** Obtain a single homogeneous phase.
- **Principle:** Perform filtration to retain the remaining denser phase.

**3. pH**

To further characterize the oil, we measured its pH to compare it with conventional fuels.

- **Objective :** Characterize the obtained pyrolytic oil.
- **Principle:** Determine the pH of the pyrolytic oil.
- **Procedure:** pH paper was immersed in the oil, and the resulting color was compared to the pH scale.

**4. Density (mass per unit volume)**

The density was determined by the ratio of the mass to the volume of the obtained product.

**5. Specific gravity**

The specific gravity was determined as the **ratio of the pyrolytic oil density to that of water**.

### 6. Viscosity

Viscosity was measured using the **Höppler principle** (falling ball viscometer).

## RESULTS AND DISCUSSION

The analysis results are summarized in Table 1.

**Table 1:** Analysis results of pyrolytic oil

| Properties | Symbol | Values | Units |
|---|---|---|---|
| **Mass** | m | 0.07347 | kg |
| **Volume** | V | 0.000100 | $m^3$ |
| **Density** | ϱ | 734.7 | $kg/m^3$ |
| **Fall time** | t | 0.81 | s |
| **Fall height** | h | 0.183 | m |
| **Fall velocity** | V | 0.226 | m/s |
| **Color** | – | Dark red | – |
| **pH** | – | 4 | – |
| **Dynamic viscosity** | μ | 0.118 | Pa·s |
| **Kinematic viscosity** | ϑ | 0.00016 | $m^2/s$ |
| **Ball density** | ϱb | 2700 | $kg/m^3$ |
| **Ball radius** | R | 0.0025 | m |
| **Water density** | ϱw | 1000 | $kg/m^3$ |
| **Liquid density** | d | 0.7347 | – |

### Density and specific gravity

The density of the pyrolytic oil obtained in this study is 734.7 $kg/m^3$, corresponding to a specific gravity of 0.7347. This value is lower than those reported in the literature, suggesting that the product is lighter and potentially richer in light fractions (low molecular weight hydrocarbons). For comparison, Ulrich BERRY et al. (2025) obtained a density of 818.05 $kg/m^3$ (specific gravity 0.81805) from used inner tubes, while Ndrianome T.C.A (2021) reported an even higher density of 868.50 $kg/m^3$ (specific gravity 0.876). The significant differences between these values indicate that the chemical composition of pyrolytic oils strongly depends on several factors: the nature and composition of the initial waste, pyrolysis operating conditions (temperature, residence time, atmosphere), the

presence or absence of catalysts, and the condensation system used. The relatively low density obtained in this study may reflect a pyrolysis process favoring the formation of light hydrocarbons, such as short-chain paraffins and olefins. In contrast, the higher densities reported by BERRY et al. (2025) and Ndrianome T.C.A (2021) suggest a larger proportion of heavy or aromatic hydrocarbons in their pyrolytic oils. Thus, the results indicate that the oil produced here is less dense and more volatile, which can be advantageous for certain energy applications (close to light diesel or kerosene), but may also indicate a lower yield of heavier fractions. These variations highlight the importance of controlling operational parameters to direct the product distribution toward targeted energy fractions.

**pH**

The pyrolytic oil obtained has a pH of 4, indicating a moderate acidic character, which is typical of oils produced by pyrolysis. This pH is less acidic than those reported by Ulrich BERRY et al. (2025) (pH=3) and Ndrianome T.C.A (2021) (pH=2.6), suggesting a lower content of acidic compounds. Although this value is below the minimum pH of 5.50 required for diesel, it can be corrected by adding additives to reach neutrality (pH=7), in accordance with the recommendations of Irish Standard (2021) and ASTM D6751-2024. Therefore, the pyrolytic oil can be valorized as fuel after neutralization.

**Viscosity**

The pyrolytic oil obtained in this study exhibits a kinematic viscosity of 1.6 Cst, which falls within the range recommended by ASTM D6751-2024 and EN 14214 for diesel production. Viscosity is a critical parameter for fuel use as it directly affects fluidity, atomization, fuel injection into engines, and combustion efficiency. Compared to literature values, the measured viscosity here is lower than that reported by Ulrich BERRY et al. (2025) (2.4 Cst) and Ndrianome T.C.A (2021) (2.03 Cst). This difference suggests that the oil produced in this study contains a higher proportion of light hydrocarbons, which enhances fluidity and reduces the risk of injector clogging. Consequently, the pyrolytic oil from this process appears to be a promising product for energy valorization, suitable for use as diesel fuel or as a base for other liquid fuels.

## CONCLUSION

The conversion of used thermoplastics into hydrocarbons offers a promising solution to reduce the environmental impact of plastic waste in the Republic of Congo while producing alternative energy resources. Processes such as pyrolysis, hydrocracking, and gasification enable the transformation of these wastes into fuels, gases, and carbon. However, large-scale implementation still requires improvements in yield, product quality, and emission control, while ensuring the economic viability of the process. Therefore, this technology represents an important complement to mechanical recycling and could significantly contribute to a sustainable circular economy.

## REFERENCES

Global Plastics Outlook: Economic drivers, environmental impacts and policy options. (2022). *OECD Publishing*. https://doi.org/10.1787/de747aef-en (OECD)

Moukila, S. U. B., Nkeletela, L. B., Samba, R., Mabiala Mikanou, O., Makosso Voula, R., & Kiesse, D. S. (2025). Contribution to the production and physicochemical characterization of pyrolytic oil from used inner tubes for the production of conventional fuels in Congo Republic (RC). *International Journal of Current Advanced Research*, *14*(6), 289–292. https://doi.org/10.24327/ijcar.2025.0292.0061

National Standards Authority of Ireland. (2014). *I.S. EN 14214:2012+A1:2014&AC:2014: Liquid petroleum products - Fatty acid methyl esters (FAME) for use in diesel engines and heating applications - Requirements and test methods*. NSAI Standards.

Ndrianome, T. C. A. (2021). *Étude de la valorisation des pneus usés pour la fabrication de produits pétroliers* (Mémoire de fin d'études, École Supérieure Polytechnique d'Antananarivo, Université d'Antananarivo).