



RESEARCH ARTICLE

NON-PYROLYTIC FIELD METHOD FOR THE PRODUCTION OF RESINOUS WOOD TAR FROM MANGIFERA INDICA (MANGO TREE)

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Abstract

Resinous wood tar is a dark, viscous liquid of hydrocarbons and free carbon which is a by-product of the high temperature carbonization or pyrolysis of resin producing woods like pine and mango woods in anoxic conditions. Pyrolysis produces flue gases that contain pollutants, such as carbon monoxide, nitrogen oxides, and sulfur dioxide, which can pollute the air and water. This study provides an alternative technology for the production of wood tar using non-pyrolytic method which is comparatively a less complex process, save cost due to low energy consumption and mitigate environmental pollution. The two main objectives considered in the study were to determine the wood tar production efficiency of mango tree resin and some physical properties of the wood tar produced. The experimental method basically involves the immersion of the mango wood bark chips in water for 72 hrs so that the resin in the chips will adequately dissolve in water. The solution is boiled at 100°C to allow water to evaporate under controlled environment leaving a dark brown tarry concentrate. The 5000ml of resin solution obtained from the 5kg bark chips immersed in water yielded 300ml of liquid wood tar and 168g of concentrated wood tar. The wood tar produced has a pH of 4.37 (acidic) and density of 1.06g/cm³.

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Introduction:-

Mangifera indica, commonly known as mango, belongs to the flowering plant in the Anacardiaceae family of flowering plant. The bark of a mango tree (Mangifera indica) produces a reddish-brown resin which contains mangiferin, flavonoids and flavonol as the major components. The flavonoids and flavonol constituents include quercetin, catechin and epicatechin. The phytochemical screening of the raw material showed that polyphenols, terpenoids, sugars and saponins were present in mango stem bark (Donatus et al 2008).

Resinous wood tar is a dark, viscous liquid of hydrocarbons and free carbon which is a by-product of the high temperature carbonization of resin producing woods like pine and mango woods in anoxic conditions. The process is usually referred to as destructive distillation, dry distillation or pyrolysis. Pyrolysis is the thermal degradation of a solid fuel in an inert atmosphere, free of oxygen, generating a liquid or gaseous fuel and a solid residue, known as char, which comprises the ash and fixed carbon contents of the fuel (Thallada et al 2013). Wood tar contains over 400 organic chemicals, including acids, alcohols, aldehydes, ketones, phenols, furanes, benzenes, sugars, and bitumen.

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Wood tar is a very important product used for several purposes, especially in rural communities. It is used as caulking material to seal off leaks in roofs, painting of foundations, as wood preservative, antiseptic and hoof care treatment for cattle.

As compare to incineration, which produces toxic ash, Biomass pyrolysis is more environmentally and economically friendly as it immobilizes metals into the char's pore structure and has low gas emissions. Thermal conversion of biomass into charcoal by pyrolysis changes the biomass properties to provide a much better fuel with less pollutive effect (Field et al. 1998; Walker 2000). Furthermore, the gases produced by pyrolysis can be used as fuel, hence reducing the need for external fuel.

Despite these advantages of pyrolysis, it has some disadvantages mainly the complexity of the process which requires specialized equipment and skilled operators, its high operational and investment costs and Flue gases produced need to be treated in an air purification installation. Pyrolysis is a an excellent process but not very suitable for poor rural communities that cannot afford the equipment and the operational skills.

This study provides an alternative technology for the production of wood tar using non-pyrolytic method which is comparatively a less complex process, save cost due to low energy consumption and mitigate environmental pollution.

The method basically involves the immersion of the wood bark chips in water for 48 hrs so that the resin in the chips will adequately dissolve in water. The solution is boiled at 100°C to allow water to evaporate under controlled environment leaving a dark brown tarry concentrate. The concentrate is allowed to cool down and kept in an environment at room temperature for 72 hrs. The end product is a concentrated resin wood tar.

Problem Analysis

Despite the advantages of pyrolysis over other methods like incineration, biomass pyrolysis has some challenges which include its complexity and high investment cost that requires specialized equipment and skilled operators, high energy consumption as the process requires high temperatures and long residence time. Biomass pyrolysis also have the problems of air pollution, feedstock selection, and the need for efficient separation and purification of the end products. The pyrolytic process produces flue gases that contain pollutants, such as carbon monoxide, nitrogen oxides, and sulfur dioxide, which can pollute the air and water. To comply with regulations, these gases must be treated in air purification systems, which adds to the cost and complexity of the process. The ashes produced during pyrolysis can contain high concentrations of heavy metals, making them hazardous waste that requires proper disposal.

The moisture content of the feedstock can affect the success of pyrolysis. High moisture content can lead to too much water production, while low moisture content can lead to dust instead of oil. Bio-oil derived from pyrolysis can have poor quality, such as low heating value, stability, and high acidity. Different types of reactors can have different challenges, such as product variability, sintering of catalyst, and low production rate.

An affordable and more environmentally friendly options must be sort to further mitigate the effect of air pollution caused by biomass carbonization or pyrolysis.

Aim and Objectives of the Study:-

The study aims at providing an affordable and more environmentally friendly alternative to pyrolysis, which is considered as a complex process with high energy consumption, high capital cost, air pollution and ash disposal problem.

The following objectives are pertinent to the study (a) To determine the wood tar production efficiency of mango tree resin using non-pyrolytic technique (b) To determine some physical properties of the wood tar produced.

Literature Review:-

Pyrolysis is one of the technologies available to convert biomass to an intermediate liquid product that can be refined to drop-in hydrocarbon biofuels, oxygenated fuel additives and petrochemical replacements. Biomass

pyrolysis is a promising renewable sustainable source of fuels and petrochemical substitutes. It may help in compensating the progressive consumption of fossil-fuel reserves (Tamer et al 2020).

There are basically three types of industrial pyrolyses namely slow, flash and fast pyrolyses depending on time and temperature of the process. Slow pyrolysis takes a longer time and carried out at temperature not exceeding 500°C at a slow heating rates from 0.1 to 2°C, with char and tar as the main products (Researchgate.net/publication/325803601). The flash and fast pyrolytic processes are normally conducted at relatively high temperatures (up to 1000°C); bio-oils and biogas are the primary products.

Fractional distillation of the wood tar at the full temperature range from the initial evaporating point to the coking point (110~300 °C), was investigated by Haiqing et al 2022. Results showed high yields (~15.4 wt%) of the heavy distillates (b.p. 250~300 °C) and a significant reduction in water content (~4.5 %) while high heating value (~30 MJ/kg). Oumaima et al (2024) examined the properties of wood tars in Morocco, including yield, pH, and density. The investigation involved pyrolysis processes using 1200 grams of wood. Their results for the pH analyses revealed acidity levels in the tar. Commercial liquid wood tar had pH values ranging from 2.507±0.259 to 4.403±0.256, and commercial thick wood tar ranged from 2.963±0.441 to 4.393±0.121. Density variations were observed in liquid wood tar samples, which ranged from 0.775±0.019 to 1.069±0.084, and in thick wood tar samples, which ranged from 0.837±0.167 to 1.195±0.

A study done by Thawatchai et al (May 2013) to investigate and analyze the tar yields and structural changes of tar formed during a high temperature thermal cracking process. revealed that the amount of tar decreased continually to 90% reduction as temperature increased from 600 to 1,200°C resulting from thermal cracking of tar into the lighter products. In chemical analysis, at a low temperature range, the aromatic compounds were dominant in tar compositions. Meanwhile, these phenomena were adverse at higher temperatures and polycyclic aromatic hydrocarbons dominated. These resulted in higher than the average molecular weight as the temperature increased. Wood tar contains six major compounds: α -Himachalene, β -Himachalene, methyl-1,4 cyclohexadiene and low percentages of trans-cadina-1(6),4-diene, 6-camphenol and Sabinene hydrate (Jaouadi et al., 2020). Kurt et al (2012) compared constituents of tars produced from wood by traditional methods and modern laboratory methods. In terms of their qualitative and quantitative chemical properties, significant differences were observed between the wood extractives produced by the two methods. Quality of wood used for extraction, extraction temperature and duration also appear to be among the several factors that influence the chemical quality and quantity of extracts (Kurt et al 2012, Kurt et al 2008).

Methodology:-

Experimental Procedure

Mango tree bark chips were peeled from a mango tree, estimated to be 20 years old, at Towama village in Bo District, Southern region of Sierra Leone. 5kg of the bark chips were put in a rubber bowl and 5000ml of clean water added. The rubber bowl containing the immersed chips was kept at room temperature for 72 hours. This allowed most of the resin to dissolve in water. 3000ml of the light brown resin solution is put into a pot and slowly heated to boiling point (100°C) and temperature maintained for approximately 90mins to allow considerable amount of water to evaporate. The solution is allowed to cool for 4 hours producing a dark brown liquid wood tar, whose volume was measured in millilitre. The liquid wood tar was simmered for 30mins to produced a sticky dark brown wood tar which was measured in grams. Figure 1 presents the various experimental stages involved.



Mango wood bark chips

Chips put into container

5000ml water addition

Resin solution after 72hrs



Liquid wood tar

Concentrated wood tar

Wood tar produced in grams

Figure 1:- Experimental stages of the resinous wood tar production.**Determination of pH and density**

The pH of the diluted wood tar was determined using a Bench-top pH orp Meter, PH-B100B.

Density. The density of the wood tar was measured using CANNON automated Bench-top D155 Densitometer. Results presented in Table 1

Discussion of Results:-

The experimental results showed that the resin from mango tree is a suitable candidate for the production of resinous wood tar using non-pyrolytic method. The 5000ml of resin solution obtained from the 5kg bark chips immersed in water yielded 300ml of liquid wood tar and 168g of concentrated wood tar as presented in Figure 2.

Non-pyrolytic technique is an environmentally friendly alternative method to pyrolysis, which has comparatively high initial investment and high operation cost which most rural communities cannot afford. Unlike pyrolysis, the non-pyrolytic technique is very simple to learn and can be easily operated by villagers using local materials. Furthermore, The use of this technology in rural communities will considerably cut down on wood consumption as the technology does not only depend on wood as a source of energy for heating the resin solution; charcoal, biochar and other forms of fossil fuels could be used, especially with improved stoves. Pyrolysis or biomass carbonization mainly depends on wood.



Resin solution (1000mlx5)

Liquid wood Tar yield (300ml)

Concentrated wood tar yield (168g)

Figure 2:- Readings for liquid and concentrated wood tar yields.

Experimental results of some physical properties of the wood tar yield are presented in Table 1.

Table 1:- Results of the physical properties of the wood tar produced.

Property	Value
pH	4.37 (Acidic)
Density	1.06g/cm ³

Appearance	Darkish brown
Plasticity	Very sticky
Odour	Pleasant aromatic

Conclusion:-

The pyrolytic process produces flue gases that contain pollutants, such as carbon monoxide, nitrogen oxides, and sulfur dioxide, which can pollute the air and water. This study provides an alternative technology for the production of wood tar using non-pyrolytic method which is comparatively a less complex process, save cost due to low energy consumption and mitigate environmental pollution.

The study aims at providing an affordable and more environmentally friendly alternative to pyrolysis, which is considered as a complex process with high energy consumption, high capital cost, air pollution and ash disposal problem.

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