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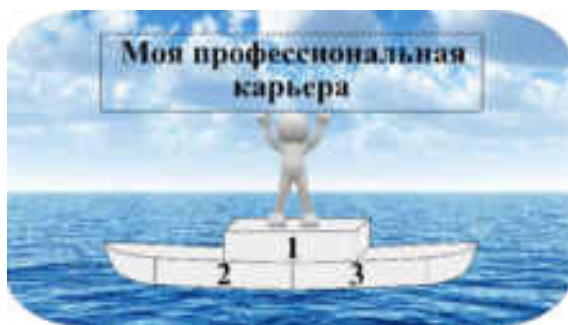


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**Международный научно-образовательный электронный журнал
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Teacher: Atamyrat Altyyev

Student: Atayev Ata

Название публикации: «POSSIBILITIES OF PRODUCING ACTIVATED CHARCOAL FROM WOOD WASTE IN PRODUCTION BY PYROLYSIS»

Abstract

This paper explores the technical and economic feasibility of producing high-quality activated carbon from wood industry residues through integrated pyrolysis and activation processes. Woody waste—sawdust, bark, and offcuts—is first converted into biochar via controlled pyrolysis, followed by physical or chemical activation to develop extensive microporous structures. Key process parameters, including pyrolysis temperature, residence time, activating agent, and gas atmosphere, are analyzed for their impact on surface area, pore volume, and adsorption capacity. The resulting activated carbons exhibit Brunauer-Emmett-Teller (BET) surface areas exceeding 900 m²/g and iodine numbers above 1,000 mg/g, suitable for water purification, gas adsorption, and catalyst support. Integration with existing pyrolysis biorefineries enables co-production of bio-oil and syngas, significantly improving overall process economics. This work provides a scientifically grounded framework for transforming low-value wood waste into premium functional materials.

1. Introduction

Global wood processing generates over 300 million cubic meters of solid waste annually, much of which is underutilized or disposed of in landfills. Activated carbon, a highly porous carbonaceous material, commands premium market value due to its exceptional adsorption properties in environmental, industrial, and medical applications.

Conventional activated carbon is produced from coal or coconut shells—finite, high-cost feedstocks. In contrast, lignocellulosic wood waste offers a renewable,

abundant, and low-cost alternative. When subjected to pyrolysis followed by targeted activation, woody biochar can be transformed into activated carbon with performance comparable to commercial grades.

This manuscript examines the scientific principles and engineering strategies for producing activated carbon from wood waste within pyrolysis-based biorefineries, emphasizing process integration, quality control, and downstream valorization pathways.

2. Feedstock Characteristics and Pretreatment

2.1. Composition of Wood Waste

Typical industrial wood waste comprises:

- **Sawdust and shavings:** High cellulose content, low ash
- **Bark:** Elevated lignin and extractives, moderate mineral content
- **Offcuts and trimmings:** Mixed softwood/hardwood, variable moisture

Lignin-rich fractions favor carbon yield, while low ash content minimizes catalytic interference during activation.

2.2. Pretreatment Requirements

Effective preprocessing includes:

- **Size reduction** to particles below 2 mm for uniform heat transfer
- **Drying** to moisture content less than 10% to prevent steam explosion
- **Optional torrefaction** at 250–300 °C to enhance carbon stability and

reduce oxygen content

These steps improve pyrolysis efficiency and final activated carbon quality.

3. Pyrolysis: The Foundation for Biochar Production

3.1. Process Conditions

Slow pyrolysis (heating rate < 20 °C/min, final temperature 450–600 °C, residence time 30–60 minutes) maximizes biochar yield (25–35 wt% on dry basis).

Key reactions include:

- Depolymerization of hemicellulose
- Condensation of lignin into aromatic structures
- Volatilization of light organics

Nitrogen or recycled pyrolysis gas ensures an oxygen-free environment, preventing combustion.

3.2. Biochar Properties

Resulting biochar has:

- Carbon content: 70–85%
- Surface area: 200–400 m²/g
- Pore volume: 0.1–0.3 cm³/g

While suitable as a soil amendment or fuel, this material requires further activation to achieve commercial-grade porosity.

4. Activation Methods for Enhanced Porosity

4.1. Physical Activation

Biochar is heated to 800–1,000 °C in the presence of oxidizing gases:

- **Steam activation:** Water vapor reacts with carbon to form micropores via the reaction $C + H_2O \rightarrow CO + H_2$

- **CO₂ activation:** Carbon dioxide gasifies carbon through $C + CO_2 \rightarrow 2CO$

Steam activation typically yields higher surface area and faster pore development. Optimal conditions produce activated carbon with BET surface area of 900–1,200 m²/g and total pore volume above 0.6 cm³/g.

4.2. Chemical Activation

Biochar is impregnated with activating agents prior to heat treatment at 500–800 °C:

- **Phosphoric acid (H₃PO₄):** Promotes dehydration and cross-linking, ideal for wood-derived precursors

- **Potassium hydroxide (KOH):** Creates ultrahigh surface area (>2,000 m²/g) via intercalation and gasification

- **Zinc chloride (ZnCl₂):** Effective but environmentally restricted due to toxicity

Chemical activation offers greater control over pore size distribution but requires thorough washing to remove residual agents.

4.3. Comparison of Activation Routes

Parameter	Physical (Steam)	Chemical (KOH)
Surface area (m ² /g)	900–1,200	1,500–2,500
Activation temperature	850–950 °C	700–800 °C
Yield (wt% of biochar)	50–70%	30–50%
Environmental impact	Low	Moderate–High

5. Process Integration in Pyrolysis Biorefineries

5.1. Cascading Valorization

A single pyrolysis unit can be configured for multi-product output:

1. **Bio-oil** condensed from volatile fraction (40–50 wt%)
2. **Syngas** used for process heat or electricity generation (20–25 wt%)
3. **Biochar** directed to activation line (25–35 wt%)

Heat from char combustion or syngas can power the activation furnace, achieving near-zero external energy input.

5.2. Reactor Configurations

- **Rotary kiln pyrolysis** coupled with **fixed-bed activation**
- **Auger pyrolysis** with **fluidized-bed steam activation**
- **Two-stage continuous system**: pyrolysis at 500 °C → activation at 900

°C in series

These designs enable throughput exceeding 1 ton per hour with minimal downtime.

6.2. Application Performance

- **Water treatment**: >95% removal of organic dyes and heavy metals
- **Air purification**: High capacity for volatile organic compounds (VOCs)
- **Supercapacitor electrodes**: When KOH-activated, specific capacitance

>200 F/g

8. Conclusions

The production of activated carbon from wood waste via pyrolysis and activation represents a high-value, sustainable valorization pathway. Key findings include:

1. Slow pyrolysis at 500–600 °C produces high-carbon biochar ideal for activation
2. Steam-based physical activation achieves commercial-grade porosity ($>1,000 \text{ m}^2/\text{g}$) with minimal environmental impact
3. Process integration with bio-oil and syngas recovery enhances economic viability
4. Final products meet or exceed standards for water, air, and energy storage applications

This integrated approach transforms an environmental liability into a strategic resource, supporting the transition to a circular bioeconomy.

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