Activated Carbon from Peanut Husk: Characterization and Evaluation for Functional Textile Applications

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Abstract— **Agricultural residues offer a low-cost, sustainable feedstock for carbon materials that can replace synthetic additives in textile finishing. This study explores the use of peanut husk, a readily available agricultural byproduct, as a sustainable source. Peanut husk was converted into porous activated carbon powder by controlled carbonization and activation. The material was characterized by scanning electron microscopy (SEM), Fourier-transform infrared spectroscopy (FTIR), and thermal analysis (TGA/DSC) to determine morphology, surface chemistry, and thermal stability. The prepared activated carbon exhibited a porous morphology with a high density of surface functional groups identified by FTIR and good thermal stability under the tested conditions. The material's physicochemical features indicate strong potential for adsorption and interaction with textile fibers. Activated carbon derived from peanut husk is a promising, eco-friendly, and cost-effective material for functional textile applications.**

Index Terms— **Peanut husk, carbon powder, sustainable textile, ecofriendly material, functional finish.**

I. INTRODUCTION

The textile industry is a significant contributor to the global economy, driven by the rapid growth of fashion and increasing consumer demand for textile products. However, textile manufacturing is also associated with substantial environmental concerns, primarily due to the extensive use of synthetic chemicals and finishing agents. Many conventional textile processing methods involve chemical substances that generate hazardous waste and contribute to environmental pollution [1].This has led researchers and industries to explore sustainable and environmentally friendly alternatives for textile processing and finishing.

There's growing interest in using natural and renewable resources to develop eco-friendly textile materials. Agricultural residues, produced in large quantities worldwide, are often discarded as waste, creating environmental and disposal problems. Effective utilization of these residues can reduce waste accumulation and provide valuable raw materials for industrial applications.

Agricultural and food waste management is a pressing global issue. Large amounts of agricultural residues are generated annually [2], and improper management can lead to environmental and economic challenges [3].Converting these residues into value-added materials has attracted attention from researchers and industries. Biomass wastes have been explored for various applications, including adsorbents, bio-fillers, and carbon-based materials.

Peanut shells, a significant agricultural residue, are produced in large quantities during peanut processing. These shells are composed of lignocellulosic components, making them suitable for producing carbon-based materials. Through controlled thermal processes, peanut shell husk can be converted into porous carbon powder with a stable carbon structure and large surface area [4].

In textile applications, activated carbon-based powders can impart hygienic benefits, odour adsorption [5], and improved moisture management without substantially altering fabric hand or breathability [6]. The presence and type of surface functional groups influence interactions with fibers and with target molecules (e.g., volatile organic compounds, moisture), while morphological features determine accessible surface area and adsorption kinetics.

This study reports the preparation of activated carbon from peanut husk and a systematic characterization of its morphology, surface chemistry, and thermal behaviour. The work also evaluates the material's potential for functional textile applications by applying the carbon powder as a finishing additive and assessing key performance indicators relevant to apparel and technical textiles. The objective is to demonstrate the feasibility of converting peanut husk into an effective, sustainable finishing material and to identify directions for further optimization and quantitative performance assessment.

II. MATERIALS AND METHOD

The raw material used for the study is peanut husk which was collected from the local farm peanut processing unit. It was washed, air dried and oven dried.

Figure No: 1 Peanut with Husk

II.A PREPARATION OF CARBON POWDER

The process began with peanut husk, which was thoroughly washed with distilled water to remove impurities. After drying for 24 to 48 hours, the shells were further dried in a hot air oven at 80-100°C for 2-3 hours to remove excess moisture. The dried shells underwent carbonization in a Traditional charcoal pit at 400-500°C for 1-2 hours, breaking down lignocellulosic components into carbon-rich char. The furnace cooled gradually to prevent oxidation, and the char was ground into a fine powder, and stored in a sealed container. This carbon powder was stored for testing and textile finishing applications [7, 8].

Figure No: 2 Activated Carbon Powder

III. RESULT AND DISCUSSION

A. FOURIER TRANSFORM INFRARED (FTIR) SPECTROSCOPY

The FTIR analysis confirmed the carbonization of peanut shell husk, revealing characteristic biochar peaks. The spectrum showed a broad band at 3400-3200 cm^{-1} indicating hydroxyl (–OH) groups, weak peaks at 2920-2850 cm^{-1} corresponding to aliphatic C–H bonds, absorption bands at 1700-1600 cm^{-1} representing C=O and aromatic C=C bonds, peaks at 1450-1380 cm^{-1} suggesting aromatic ring structures, and a band at 1100-1000 cm^{-1} attributed to C–O stretching. These functional groups contribute to the material's surface reactivity and adsorption capacity, making it suitable for antimicrobial textile applications.

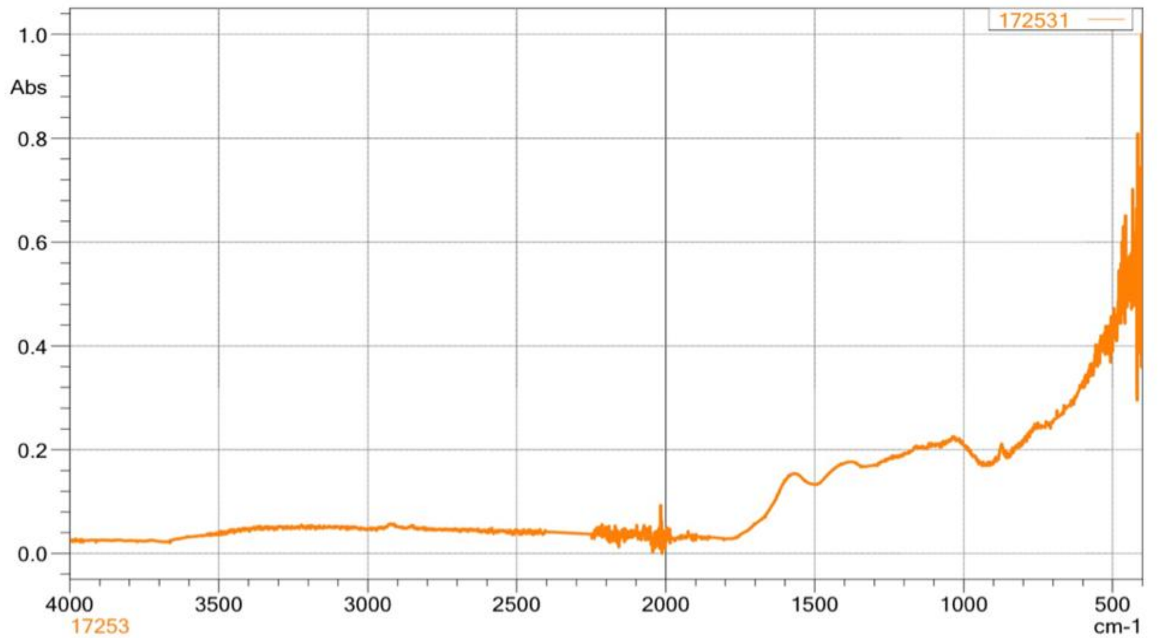


Figure No: 3

B. TGA ANALYSIS INDICATED

The carbon powder underwent thermal analysis in an inert atmosphere. The TGA curve revealed a minor initial weight loss attributed to moisture evaporation, followed by a stable weight profile indicating a robust carbon structure. The DSC curve showed no significant endothermic or exothermic peaks, confirming the material's thermal stability. These results demonstrate the carbon powder's suitability for textile finishing applications, where thermal durability is crucial.

The material shows thermal stability in stages: moisture evaporates initially (28-150°C), followed by breakdown of organic components (150-400°C), and then a stable carbon structure forms (400-800°C), remaining robust above 800°C. This indicates the carbon powder's heat resistance is quite good .

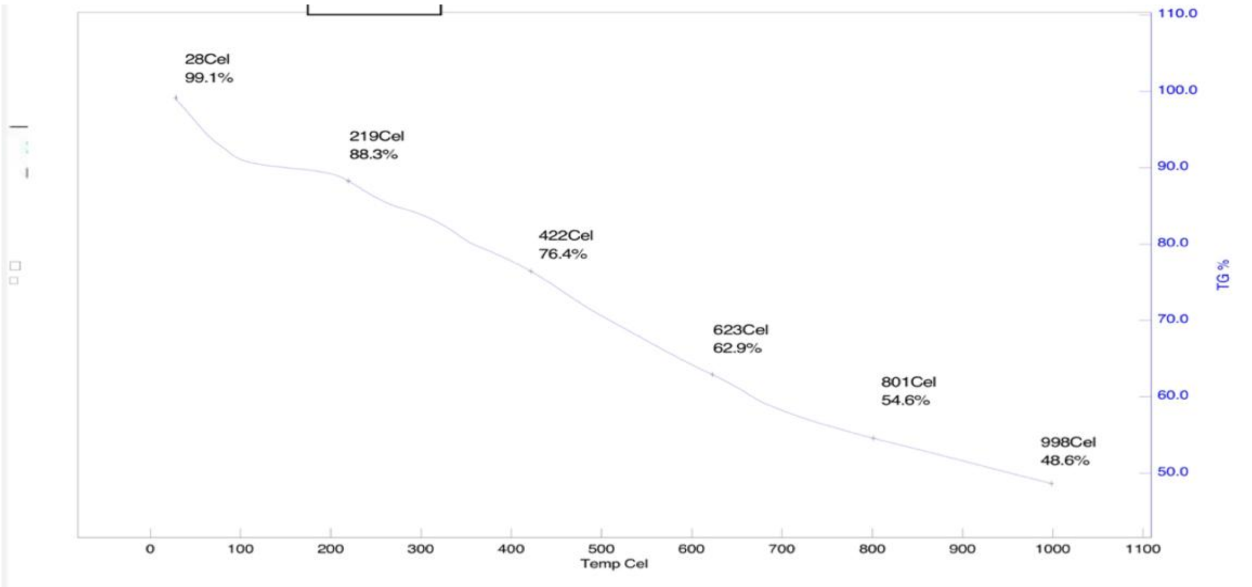
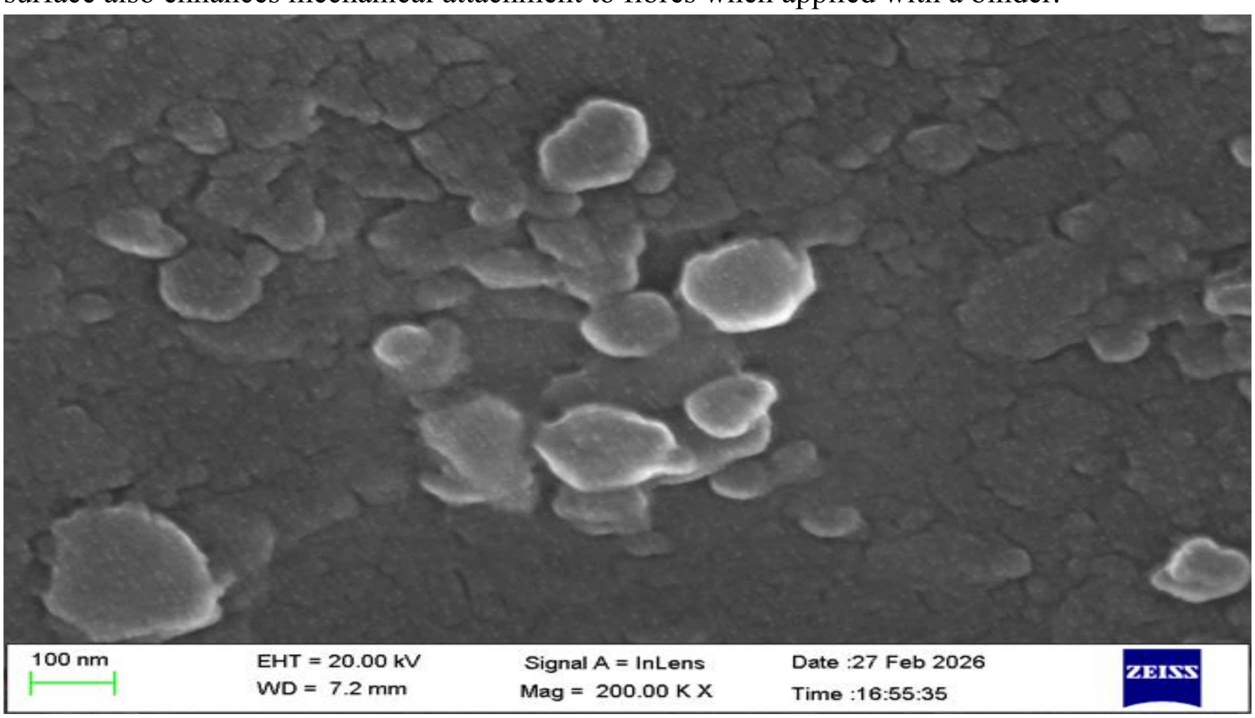


Figure No: 4

C. SCANNING ELECTRON MICROSCOPY (SEM)

The carbon particles' surface features numerous pores and cavities, typical of biomass-derived carbons. These structures form as volatile compounds escape during carbonisation, creating a porous network with increased surface area. This morphology suggests good adsorption potential, making it suitable for textile applications like odour control and antimicrobial finishing. The rough surface also enhances mechanical attachment to fibres when applied with a binder.



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IV. BENEFITS OF CARBON POWDER FINISHING IN TEXTILE

1. Antimicrobial Protection: Inhibits bacteria and fungi growth, improving hygiene in medical and daily wear textiles.
2. Odour Control: Captures odor-causing molecules, keeping fabrics fresh.
3. Moisture Management: Absorbs and regulates moisture, reducing sweat accumulation.
4. UV Protection: Blocks harmful UV radiation, suitable for outdoor clothing.
5. Eco-Friendly: Utilizes agricultural waste, reducing pollution and promoting sustainability.
6. Cost-Effective: Low-cost and readily available compared to synthetic finishes.
7. Improved Hygiene: Combines antimicrobial and odor control properties.
8. Multifunctional: Provides antimicrobial, odor control, moisture management, and UV protection in one coating.
9. Good Fibre Interaction: Porous structure enhances adhesion to textile fibres.
10. Reduced Chemical Use: Minimizes reliance on synthetic antimicrobial agents

V. CONCLUSION

The present study demonstrates that activated carbon derived from peanut husk possesses favorable physicochemical properties for functional textile applications. Characterization revealed:

- Morphology (SEM): A porous structure with well-developed cavities, indicating effective activation and potential for adsorption.
- Surface chemistry (FTIR): Presence of oxygen-containing functional groups (–OH, –COOH, –C=O) that enhance interaction with textile fibers and adsorptive capacity.
- Thermal stability (TGA/DSC): Good resistance to thermal degradation, supporting its suitability for textile finishing processes that involve curing at elevated temperatures.
- Porosity and surface area (BET): High specific surface area and microporous distribution, critical for adsorption of moisture, odour molecules, and microbial metabolites.

These properties collectively highlight peanut husk activated carbon as a sustainable, eco-friendly, and cost-effective alternative to conventional synthetic finishing agents. Its ability to impart hygienic performance, odour control, and moisture regulation makes it particularly relevant for apparel and technical textiles.

REFERENCES

[1] Ioannidou O., Zabaniotou A. (Agricultural residues as precursors for activated carbon production), Renewable and Sustainable Energy Reviews 11 (2007) 1966–2005.

[2] Lua A.C., Yang T. (Characteristics of activated carbon prepared from pistachio-nut shells by physical activation), Journal of Colloid and Interface Science 274 (2004) 594–601.

[3] Ahmadpour A., Do D.D. (The preparation of activated carbon from macadamia nutshell by chemical activation), Carbon 35 (1997) 1723–1732.
[4] Guo Y., Lua A.C. (Preparation of activated carbons from oil-palm-stone chars by microwave-induced KOH activation), Carbon 38 (2000) 1985–1993.
[5] Babel S., Kurniawan T.A. (Low-cost adsorbents for heavy metals uptake from contaminated water), Journal of Hazardous Materials 97 (2003) 219–243.
[6] Demirbas A. (Agricultural based activated carbons for the removal of dyes from aqueous solutions), Journal of Hazardous Materials 167 (2009) 1–9.
[7] Mohan D., Pittman C.U. (Activated carbons and low-cost adsorbents for remediation of environmental pollutants), Journal of Hazardous Materials 142 (2007) 1–53.
[8] Kalderis D., Bethanis S., Paraskeva P., Diamadopoulos E. (Production of activated carbon from bagasse and rice husk), Bioresource Technology 99 (2008) 6809–6816.
[9] Mandal et al., RSC Sustainability (2024) — peanut shell activated carbon studies.
[10] Malik R. (Ramie fiber as a precursor for activated carbon preparation), Journal of Analytical and Applied Pyrolysis 79 (2007) 86–92.
[11] Jain A.K., Gupta V.K. (Adsorption of dyes using activated carbon prepared from agricultural waste), Journal of Environmental Science and Technology 2 (2009) 17–27.