Development of a Hybrid Air Pollutant Adsorbent Using Graphene Oxide, Metal-Organic Frameworks (Fe-BTC), and Agro-Industrial Waste for Enhanced Removal of Air Pollutants

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Abstract

Air pollution refers to the presence of harmful substances in the air we breathe, and it has become one of the leading global environmental threats to human health, causing serious damage to the environment. Conventional adsorbents are limited by low adsorption capacity, high cost, and non-renewability. The objective of this research is to a new type of hybrid adsorbent consisting of advanced materials like GO and Fe-BTC functionalized with lower commoditized agro-industrial waste materials including fly ash, neem bark, banana peels and potato peels. The hybrid adsorbent is fabricated with a background to take advantage of the synergistic effects of these nanostructured materials for improving pollutant removal efficiency. To evaluate the physio-chemical properties of the adsorbents, FESEM, XRD, Contact Angle Meter, Raman Spectroscopy, FTIR, and DSC Scanning is applied. The performance of adsorption of hybrid materials concerning SO_2, NO_2, NH_3, and O_3 is measured through ultraviolet-visible spectroscopy. Additionally, the optimization of the adsorption procedure and the estimation of the effectiveness of pollutant removal in different conditions will be achieved through RSM modeling. This research is intended to assist in the development of sustainable, cost-effective, and high-performance materials for adsorbents for air pollution control, thereby securing mitigative strategy against pollutants effects on public health and the environment.

Keywords: Air pollutant; Hybrid adsorbent; Metal Organic Framework; Graphene oxide; Fly Ash; Agro-Industrial waste.

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INTRODUCTION

- **Background**: The rising concern of air pollution and its health impacts.
- **Problem Statement**: Limitations of conventional adsorbents (low adsorption capacity, high cost, and non-renewability).
- **Objective**: Development of a cost-effective, eco-friendly hybrid adsorbent for removing air pollutants (SO_2, NO_2, NH_3, O_3).
- **Key Materials**: Graphene Oxide (GO), Fe-BTC (Metal Organic Framework), agro-industrial waste.

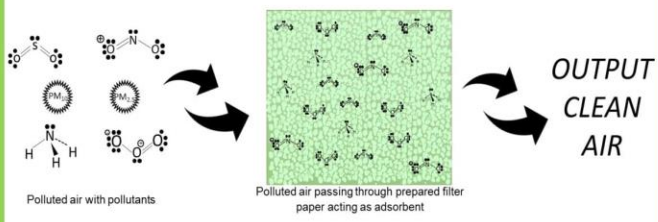

Fig.1. Graphical Representation

METHODOLOGY

Synthesis of Hybrid Adsorbent:

- Preparation of Fe-BTC via solvothermal method.
- Collection and processing of agro-industrial waste.
- Formation of hybrid adsorbent using ball milling & polymer binder.

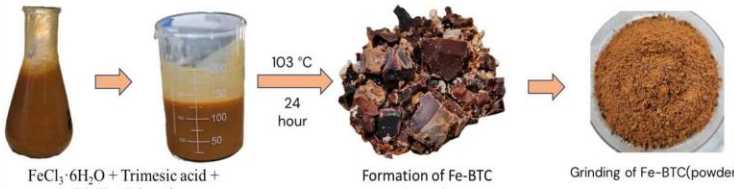

Fig.2. Preparation of sample filter paper

RESULTS AND DISCUSSION

1. Scanning Electron Microscopy (SEM):

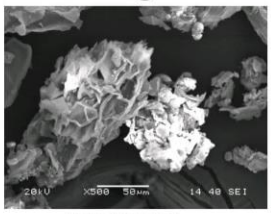
Fig.3. Sample 1

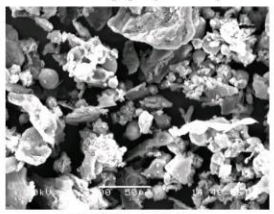
Fig.4. Sample 2

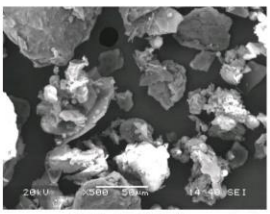
Fig.5. Sample 3

2. Contact Angle Measurement:

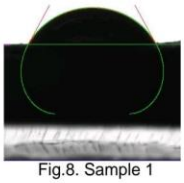
Fig.8. Sample 1

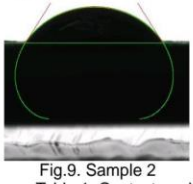
Fig.9. Sample 2

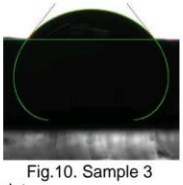
Fig.10. Sample 3

Table.1. Contact angle data

	Contact Angle (°)	Wettability	Hydrophilicity/ Hydrophobicity
Sample 1	60.7	Moderate wettability	Slightly hydrophilic
Sample 2	56.4	Higher wettability	More hydrophilic than Sample 1
Sample 3	51.3	Highest wettability	Most hydrophilic

3. X-Ray Diffraction (XRD):

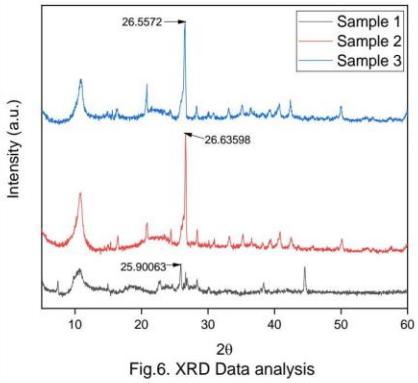

Fig.6. XRD Data analysis

4. Raman Spectroscopy:

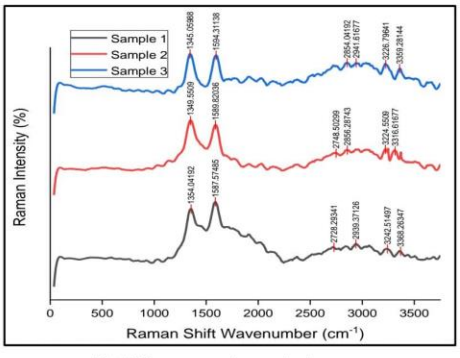

Fig.7. Raman spectra analysis

Peak (cm^{-1})	Sample 1 (Black)	Sample 2 (Red)	Sample 3 (Blue)	Assignment
~1350	Moderate	Strong	Strong	D-band(Defective Carbon)
~1580	Strong	Strong	Very Strong	G-band(Graphitic Carbon)
~1000-1100	Absent	Moderate	Weak	C-H Bending (Aromatic)
~500-800	Weak	Strong	Moderate	Metal-Oxygen (Fe-O, MOFs)
~2800-3100	Absent	Moderate	Weak	C-H Stretching (Aliphatic)

CONCLUSION

- The hybrid adsorbent prepared are amorphous in nature.
- The adsorbent shows high porosity and high surface area for higher adsorption.
- The filter paper shows hydrophilic nature hence good for adsorption.

Future work

- Comparison of concentration after using the prepared filter papers by UV-Vis Spectrophotometer.
- Optimization and evaluation of data.

References

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