LEAF TO LAB: FROM PLANT EXTRACT TO COBALT FERRATE ($COFE_2O_4$) NANOPARTICLES FOR THE DETECTION OF HYDROGEN SULFIDE GAS

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Introduction:

Cobalt Ferrate ($CoFe_2O_4$) is a spinel-structured ferrimagnetic material known for its excellent chemical stability, high coercivity, and strong magnetic properties. These characteristics make it highly suitable for applications such as catalysis, gas sensing, and environmental remediation. In recent years, nanostructured ferrites have gained significant attention due to their enhanced surface activity and improved physicochemical behavior compared to bulk materials. Conventional synthesis methods often involve toxic chemicals and high energy consumption. To overcome this, green synthesis using plant extracts has emerged as an eco-friendly and cost-effective alternative. Plant extracts contain phytochemicals that act as reducing, stabilizing, and capping agents, enabling nanoparticle formation without hazardous reagents.Hydrogen Sulphide (H_2S) is a toxic and corrosive gas commonly found in industrial emissions, biogas, and petroleum refining processes. Its removal is crucial due to its harmful effects on both human health and equipment. This project focuses on synthesizing Cobalt Ferrate nanoparticles using a plant-assisted combustion method and evaluating their effectiveness in adsorbing H_2S gas.

Objectives:

1. To synthesize cobalt ferrate nanoparticles using plant extract of Coleus amboinicus eliminating the use of a chemical fuel
2. To pass Hydrogen sulphide gas over the synthesized nanoparticles and monitor the changes in the samples before and after passing the gas.
3. To analyse the samples using various characterization techniques and Document the changes noticed

Methodology:

The synthesis of Cobalt Ferrate nanoparticles was carried out using a plant-assisted combustion method. Cobalt nitrate and ferric nitrate were used as precursor materials in a 1:3 ratio. These were dissolved separately in distilled water and then mixed under continuous stirring at around 60°C to form a homogeneous solution. Fresh leaves of Coleus amboinicus were crushed using a mortar and pestle to obtain plant extract. This extract was added dropwise into the precursor solution while stirring to ensure uniform mixing and controlled reaction. The phytochemicals in the extract acted as reducing and stabilizing agents. The prepared mixture was then transferred to a preheated muffle furnace. Initially heated at 500°C and later increased to 600°C for about 2 hours, the combustion process resulted in the formation of fine Cobalt Ferrate nanoparticles. Hydrogen Sulphide gas was generated by reacting sodium sulphide with dilute hydrochloric acid. The gas was passed over the synthesized nanoparticles in a closed setup to study adsorption behavior. Characterization was performed using SEM to analyze morphology and particle size, and EDAX to determine elemental composition before and after exposure to H_2S gas.

Results and Conclusions

The synthesis process successfully produced Cobalt Ferrate nanoparticles with nanoscale dimensions and uniform morphology, as confirmed by SEM analysis. The particles appeared as fine, agglomerated clusters typical of combustion-synthesized nanomaterials. EDAX analysis before H_2S exposure confirmed the presence of Cobalt, Iron, and Oxygen in appropriate proportions, indicating correct formation of $CoFe_2O_4$ with high purity. After exposure to Hydrogen Sulphide, EDAX results showed the presence of Sulphur, confirming successful adsorption of H_2S onto the nanoparticle surface. SEM images also showed morphological changes after gas exposure, with increased aggregation and surface modification, indicating interaction between the gas and nanoparticles. Overall, the study proves that green-synthesized Cobalt Ferrate nanoparticles are effective for Hydrogen Sulphide adsorption and have strong potential for gas sensing and environmental applications. The method is sustainable, cost-effective, and environmentally friendly.

Scope for Future Work

1. Perform advanced characterization techniques such as FTIR, XRD, BET, and UV analysis.
2. Improve adsorption efficiency through doping with other metals.
3. Optimize synthesis parameters like temperature and reaction time.
4. Develop real-time gas sensing devices using these nanoparticles.
5. Study regeneration and reusability of nanoparticles.
6. Scale up the process for industrial applications.
7. Explore applications in biogas purification and industrial emission control.
8. Investigate long-term stability and performance under real conditions.
9. Design continuous flow systems for practical gas monitoring.
10. Conduct comparative studies with other adsorbent materials.