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Camphor Oil-Derived Carbon Nanofibers for Textile Effluent Treatment: Synthesis and Characterization

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Abstract: **-**Nowadays, population is increasing globally, because of this there is increase in industries to satisfied the needs of people. While considering types of wastewaters, Industrial wastewater plays a major role in environmental pollution as compared to domestic wastewater. Recently easy and ecological way to synthesize carbon nanomaterial has been increasing. This study involves synthesis of Carbon nano fibres (CNFs) using Camphor oil and characterised by using XRD, SEM, Surface area analyser, TGA, FTIR. CNFs synthesized from camphor oil at 800°C using cobalt catalyst in presence of inert atmosphere. This CNF are used for the treatment of textiles effluents and improves quality of water. The purified CNF having surface area of 35.33 m2/gm which adsorbs the heavy metals, dyes and some organic impurities which helps to improve quality of water and effecting the concentration level of BOD, COD, TDS and conductivity. This experiment helps and contributes to reduce contaminant level of textile effluent water by using CNFs.

Keywords*: Camphor Oil, Carbon Nanofibers, Environmental, Textile effluent water, wastewater.*

1. Introduction

Textile industries are among the biggest contributors to water pollution globally. Textile manufacturing requires a large amount of water, and the wastewater that is generated during the process is often contaminated with a range of chemicals and dyes. These pollutants can have serious environmental and health impacts if they are not treated properly before being discharged into water bodies. Some of the common pollutants found in the wastewater from textile industries include: heavy metals such as lead, mercury, and chromium. Textile manufacturing also generates a range of organic compounds, such as solvents, dyes, and bleaching agents[1]. Textile wastewater often contains high levels of suspended solids, such as fibers and lint, which can clog waterways and harm aquatic life. The textile manufacturing process often involves the use of acids and alkalis, which can alter the pH of water bodies and harm aquatic life. To reduce the impact of textile industry on water pollution, it is important for textile industries to adopt sustainable production practices and implement effective wastewater treatment processes. Governments can also regulate the discharge of industrial wastewater and enforce stricter environmental regulations to ensure that textile industries comply with water pollution control standards[2].

Nanotechnology has shown promise as a potential solution for treating textile effluent water. There are several nanotechnology-based approaches that can be used to remove pollutants from textile wastewater, including: Nanofiltration, Nano catalysis, Nano adsorption and Nanobubbles[3].

Carbon Nanomaterials can be used as adsorbents to remove pollutants from textile wastewater. These materials have a large surface area and can adsorb a wide range of pollutants, including heavy metals and organic compounds[4].

Overall, nanotechnology-based approaches have the potential to significantly improve the treatment of textile effluent water. However, more research is needed to optimize these technologies for large-scale implementation and to assess their environmental impact.

There are several non-renewable precursors and methods are used for the synthesis of carbon nanomaterials. To obtained the economical carbon nanomaterial natural and renewable sources of precursors are becomes a highlight of the research[5], [6]. Carbon nanofibers (CNFs) synthesized from camphor oil have shown potential for use in textile effluent water treatment. Camphor oil is a natural product that is abundant and inexpensive, making it an attractive source for the synthesis of CNFs. In textile effluent water treatment, carbon nanofibers synthesized from camphor oil can be used in several ways. They can be added directly to the wastewater to adsorb pollutants, or they can be incorporated into filtration membranes to remove pollutants during the filtration process[7]. Camphor oil mainly contains Camphor, terpenoids, Linalool etc. Camphor oil has been explored as a potential source for the synthesis of carbon nanofibers due to its unique chemical properties using Chemical vapor deposition (CVD) method. Camphor oil can be used as a precursor for the synthesis of carbon nanofibers[8]. Carbon nanofibers have many potential applications in textile effluent water treatment[9]. In this paper we discussed about synthesis, characterization and application of CNFs obtained from camphor oil by CVD method.

2. Experimental

2.1. Preparation of Catalyst

Cobalt nanoparticles were obtained by dissolving Cobalt nitrate powder in distilled water (10M). A reducing agent sodium borohydride added dropwise to the cobalt nitrate solution at75°C and stirred continuously at 500 rpm to reduce cobalt ions to cobalt metal particles, and again further stirred for 30 min. Stabilizing agent polyvinyl alcohol is added to the reaction mixture to prevent the aggregation of cobalt metal particles. Heat the reaction mixture to a high temperature to promote the formation of cobalt nanoparticles and to remove any residual stabilizing agents. All synthesized Cobalt oxide nanoparticles were washed thrice with distilled water at 75°C and dried in an oven at 90°C. The dried precursors of Cobalt oxide nanoparticles were heated for 2 h at 400°C and form Cobalt catalyst [10].

2.2. Synthesis of carbonnano fibres

In this experiment The CNFs was prepared from camphor oil using Cobalt catalyst by CVD process. Cobalt catalyst was kept in quartz boat and placed inside the tube furnace. Argon gas was passed in to the furnace tube at the flow rate of 0.4 cc/min to create inert atmosphere. After 10 min. of passing Argon gas the pyrolysis was tried at 800^0C. As soon as the temperature reached, the Camphor oil sprayed to pass very slowly using spraying pump, and heating was continued for 3h at constant temperature in an inert atmosphere of argon. The furnace was allowed to cool down to room temperature, and then the pyrolyzed material was collected from the furnace[11].

2.3. Purification of carbonnano fibres

CNFs were purified by soaking with 10% HCl and 10% Nitric acid for 5 hrs to remove any residual catalyst particles. This acid treatment also helps to removes any amorphous carbon and graphitic impurities[12].

2.4. Characterization

Characterize the synthesized cobalt catalyst and CNFs using various analytical techniques such as XRD, SEM, TGA and FTIR to determine the particle size, morphology, and chemical composition of the cobalt nanoparticles and CNFs.

2.5. Wastewater treatment

The purified CNFs were used for the textile wastewater treatment. The chromatography column were prepared using burette containing sintered part and then covered it with cotton plug. The effluent water is slowly passed with the flow rate of 5 ml/min, through the chromatography column[13][14].

2.6. Analysis of waste water

The quality of Textile effluent and the eluent collected after treatment with CNFs were analysed using BOD, COD, TDS, TSS, pH and conductivity parameters [15].

3. Result and discussion

Camphor oil is pyrolyzed to a high temperature in the presence of a Co catalyst. At 800°C temperature the camphor molecules decompose into smaller molecules, which then form carbon nanofibers on the surface of the Cobalt catalyst.

The impurities associated with as obtained CNF were removed by using 10% HCl and 10% Nitric Acid solution. The catalyst and purified CNF were characterize using various analytical techniques such as SEM, XRD, TGA, and FTIR to determine the particle size, morphology, and chemical composition of the cobalt nanoparticles.

Scanning Electron Microscope

Figure 1 SEM image of a cobalt catalyst showing uniform structure with average size of 27 nm shown in Figure 1. (The average size calculated using ImageJ Software).

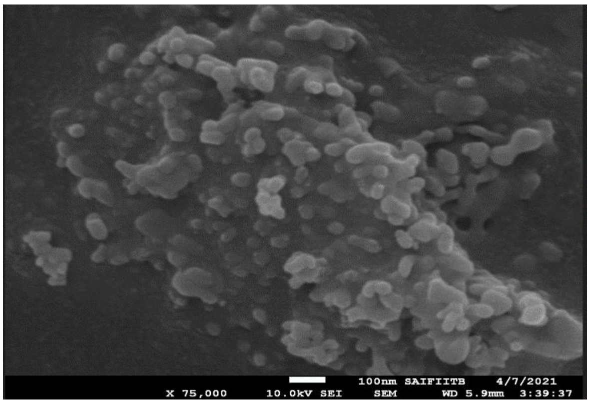

Figure 1SEM Image of Co Catalyst obtained by Coprecipitation method

Figure 2 SEM image of CNFs synthesized from camphor oil helps to understand the morphology of CNFs observed in Cylindrical and tubular structure having diameter in size range of 62 nm to 79 nm.

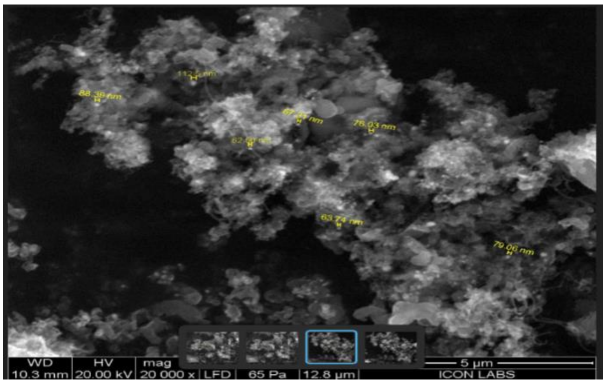

Figure 2SEM Image of CNFs obtained from Camphor Oil

Fourier Transform Infrared Spectroscopy

Synthesized Carbon nanofibers obtained from Camphor oil were analysed by using FTIR-ATR technique. The absorption peak at 2954 cm^{-1} is attributed to the stretching vibration of aliphatic (-CH) groups, which can be present in the carbon backbone of the camphor oil. The absorption peak at 1332 cm^{-1} resulted This peak is attributed to the bending vibration of C-H groups and the stretching vibration of C-O groups, which can be present in the carbon backbone and the surface of the CNF. The FTIR spectrum of the purified CNF has at 786 cm^{-1}attributed to the stretching vibration of C-H and C-O groups, which can be present in the carbon backbone and the surface of the CNF shown in *Figure 3.*

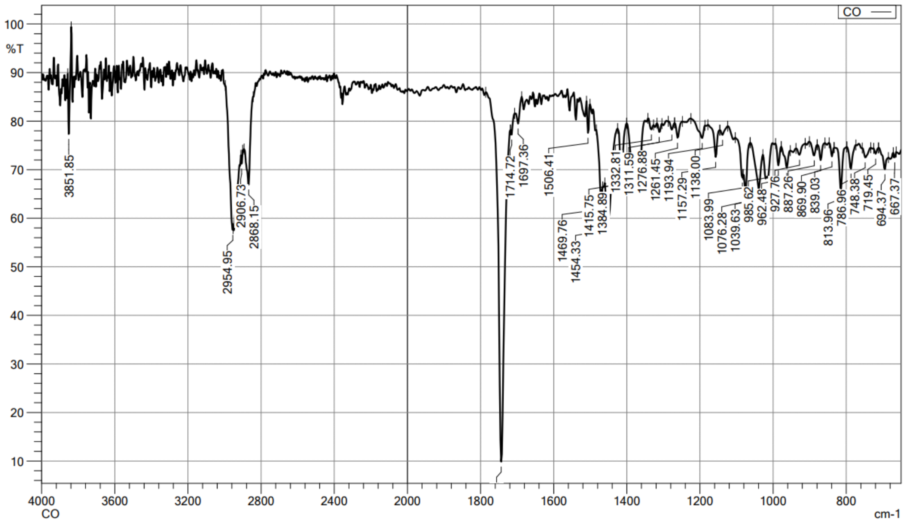

Figure 3FTIR spectra of CNFs obtained from Camphor Oil

X-Ray diffraction

Synthesized Carbon nanofibers obtained from Camphor oil analysed for XRD by using Bruker XRD. XRD of Carbon nanofibers used to understand physical and chemical properties of CNFs obtained from Camphor oil shown in Figure 4. The CNF starting material showing (002) line at 26.478, a very strong line (101) at 44.473. From Bragg's equation d-spacing into this graph observed as 0.21 nm[16].

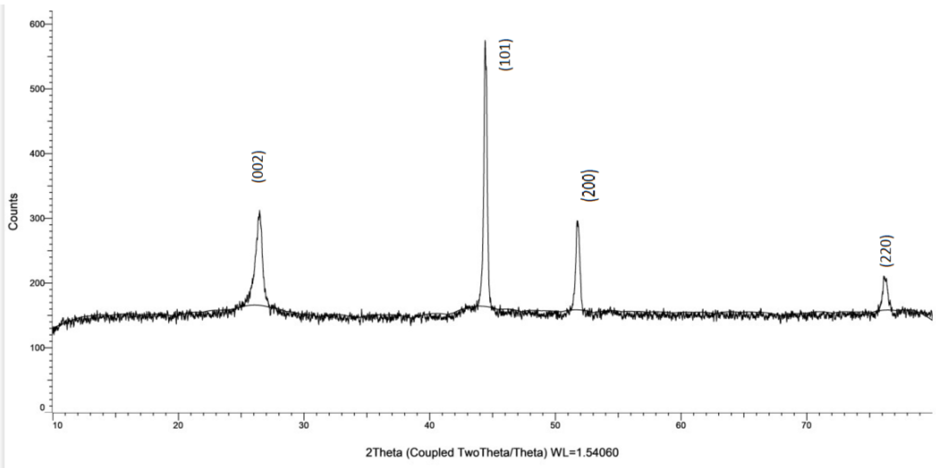

Figure 4XRD of CNFs obtained from Camphor Oil

BET Surface Area

The active surface area of as grown CNF was observed to 35.33 m^2/gm and after acid treatment there is a 10% enhancement.

Thermogravimetric Analysis (TGA)

Synthesized Carbon nanofibers obtained from Camphor oil analysed for TGA. Figure 5 shows the TGA graph, where the temperature at 607.7°C which CNF started to decomposed, that means 95.8 % wight loss at temperature of 607.7°C showing the thermal stability of CNF synthesized from camphor oil using Cobalt catalyst.

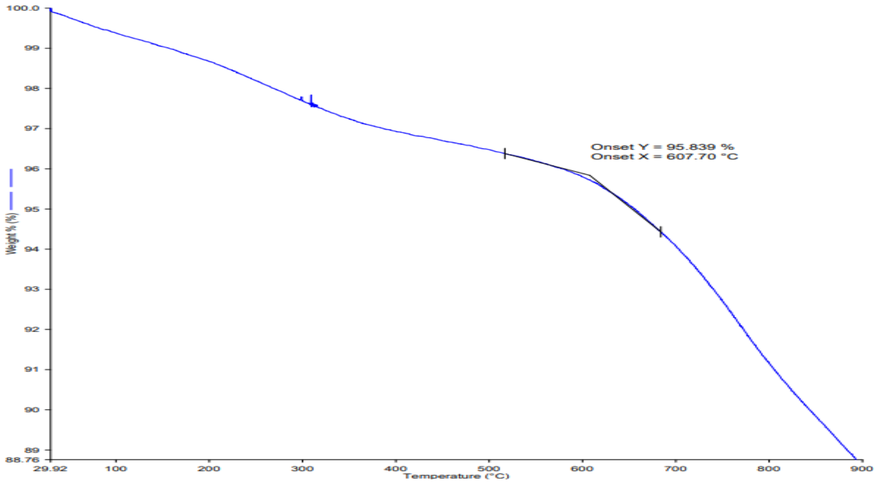

Figure 5TGA of synthesized CNF obtained from Camphor oil

The carbon nanofibers are then collected and purified for use in water treatment applications.

Results of pH, conductivity, TDS, COD, BOD obtained from textile effluent water treatment using CNFs synthesized from camphor oil over Cobalt catalyst mentioned in Table 1.

Table 1Observations of textile effluent water before and after treatment using CNFs synthesized from Camphor Oil

Parameters	**Observations**	
	Before Treatment	**After Treatment**
pH	9.3	7.3
Conductivity	0.2729 ms/cm	0.1722 ms/cm
TDS	1575 ppm	861 ppm
BOD	212 mg/l	102 mg/l
COD	370 mg/l	222 mg/l

4. Conclusion

The qualitative and quantitative synthesis of CNFs using camphor oil as renewable natural precursor successfully achieved over cobalt catalyst. The resulting CNFs possess uniform diameter in the range of 62-79 nm. Carbon nanofibers having porosity and large surface area that make them effective for textile effluent treatment. The results shows that the CNF can adsorb a wide range of pollutants, including organic compounds, heavy metals, and dyes.1 gm of CNF purified 1Ltr of water. They are also highly stable and can be easily regenerated for reuse. Overall, the synthesis of carbon nanofibers from camphor oil shows promising as a sustainable and cost-effective approach to textile effluent water treatment. However, more research is needed to optimize the synthesis process and evaluate the environmental impact of using carbon nanofibers in water treatment.

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