

## Analysis of nano carbon obtained from mustard oil soot

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**Abstract:** Nano phase carbon was obtained from the soot of burning mustard oil in open atmosphere. The obtained soot was characterized by Laser Raman (Fourier Transform-Raman) and FT-IR (Fourier Transform Infra Red) spectroscopic analysis. The crystalline nature of the soot has been confirmed with Powder X-ray diffraction. The surface morphology was studied by SEM (Scanning Electron Microscopy). The obtained results are reported.

### I. Introduction

Carbon is considered a singular element because of its rather unique ability to form long chains whose central core is constituted exclusively by carbon atoms, thus giving rise to molecules able to create new materials or even life through Mother Nature. Since 1970 pioneering works in the development of carbon nanomaterials through technically sophisticated, cumbersome and time consuming processes has been reported. In the last three decades, closed-shell carbon nanostructures has been studied with great attention with the prime objective being to use their properties for electronic, medical and mechanical applications.

Several methods were used to develop the carbon nanomaterials. Thin films of carbon nanotubes and their allotropes such as fullerene, carbon nano tubes (CNT's) and diamond –like carbon can be prepared by chemical vapor deposition method. Pyrolysis of synthetic precursors such as polyfurfuryl alcohol, acetylene and natural precursors such as different plant fibers, resins, oils etc.can give carbon nanomaterials. Hot wire method, Laser ablation process are also used to produce nano carbon. Nano structured carbon is prepared from soot obtained by burning vegetable oils. Soot represents one of the very first nanostructured materials, although it has rarely been considered as such. The process of soot formation has been the object of numerous investigations for more than 100 years and such investigations did not lose their significance to the present day.

Amongst the above mentioned methods, the simplest and most promising way to synthesis carbon nanoparticles is the flame method. In the synthesis of carbon nanoparticles using flames, part of the fuel is consumed in heating of the mixture, and part is used as a reactant, which makes this method more cost effective than other methods. In this paper carbon soot obtained from conventional method of burning mustard oil and its subsequent characterization is presented.

### II. Experimental Section- Chemical used

The mustard oil of edible quality used in this experiment was procured from local market and is used as such. Normally vegetable oil contains glycerides of a mixture of several types of fatty acids. Mustard oil is comprised of 76 % monosaturated, 23 % polyunsaturated and 1 % saturated fatty acids like oleic acids, linoleic, linolenic acids (all 18- carbon chain with unsaturation) and archidic acid (20 – carbon chain, saturated). Amongst the other edible oils, mustard oil has an edge over others, because it contained very highunsaturated fatty acids and cheap in price.

### III. Apparatus Set Up To Collect Soot

Mustard oil of about 10 mL is taken in clay lamp. Cotton wick of length 8 cm is used for burning the oil. The soot formed is collected on substrates made of different materials like glass, copper, stainless steel, brass and ceramic in open air under identical conditions. The process of soot collection is automated. The experimental set up is given in Figure 1.



Figure 1: Experimental set up to collect soot

Two thin metallic rods of equal length are welded together at their middle such that they are mutually perpendicular to each other. At the ends of each rod, a circular metal piece having a hole is welded. A similar circular metal piece is placed at the bottom. The distance between the two plates can be adjusted by a bolt and screw arrangement. The substrates can be held intact in between the cylindrical metal plates by the screw and bolt arrangement. The substrates are mutually separated by 90 degree to each other. A 5 volt DC motor is attached to the bottom of the vertical pipe holding the metal rods. The metal rods and hence the substrates can be rotated in counter clockwise sense using the motor. The number of rotations per minute can be controlled. The lamp can be placed on a wooden stand in a fixed position below the substrates. The distance between the lamp and substrates can be varied by means of an adjusting screw.

The soot from the burning wick of oil lamp can be collected on the substrates either in static mode, in which both the substrate and lamp are kept stationary or in dynamic mode, in which lamp is kept stationary while the substrates can be rotated continuously. In the present work, soot collection on different substrates having identical dimensions in dynamic mode. The vertical distance between the substrate and lamp is varied from 2 to 4 cm. With all the four substrates the time period of rotation is 4 second. The soot deposited on substrates are collected and kept in an air tight container. The collected soot's are subjected to various characterizations. The results of soot deposited on copper substrate are presented here.

#### IV. Characterization of Sample

A Fourier Transform Infrared (FTIR) spectrum of the sample was recorded with Perkin Elmer Spectrum one spectrometer in the scanning range  $450\text{ cm}^{-1}$  to  $4000\text{ cm}^{-1}$ . Laser Raman Spectra of the sample were recorded by using Alpha 300, WITec confocal Raman microscope. The sample was excited by 514 nm wavelength obtained from an  $\text{Ar}^+$  Laser. Powder X-Ray diffraction of the sample was taken using X-ray diffractometer (Bruker D8 Advance) in the range 0 to 90 degree. The SEM analysis of the samples was imaged using FEI Quanta FEG200 instrument.

#### V. Results and Discussions

The FTIR spectrum of the sample is given in Figure 2.

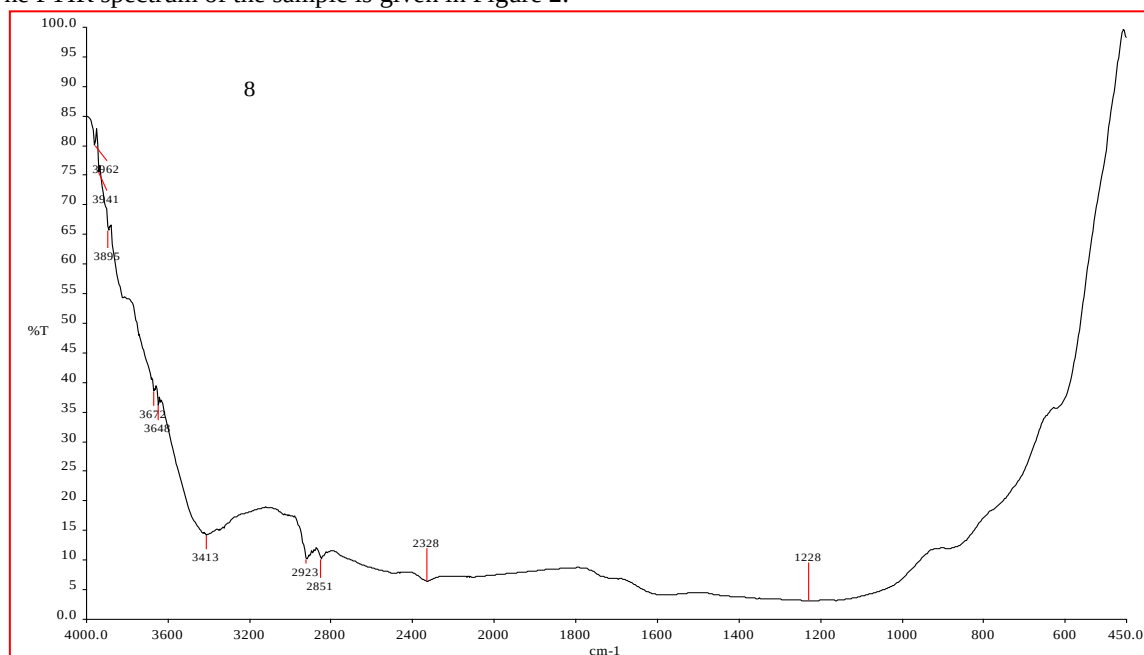


Figure 2: FTIR spectrum of the sample

The peak around  $3413\text{ cm}^{-1}$  shows the presence of absorbed moisture or  $-\text{OH}$  moieties of water in the sample. The peaks around  $2923\text{ cm}^{-1}$  and  $2851\text{ cm}^{-1}$  originate due to symmetric and asymmetric C-H bond stretching. The peak at  $2328\text{ cm}^{-1}$  is attributed to the presence of unburnt hydrocarbons, contamination and surface functionalities. The peak around  $1228\text{ cm}^{-1}$  is attributed to the C-O bond stretching. From the observed peaks, it is inferred that the sample contains carbon.

Raman spectroscopy is one of the main experimental techniques successfully employed for qualitative and quantitative analysis of carbon nanostructures. It is used to identify the presence of D, G and 2D (or G') lines, which are characteristics of carbon nanostructures. The Raman spectrum of the sample is given in Figure 3.

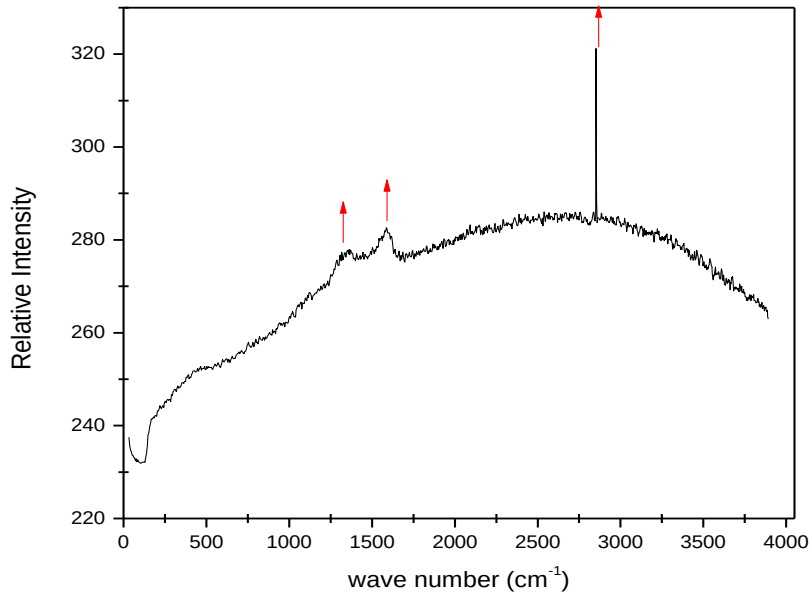


Figure 3: Raman spectrum of the sample.

Three peaks are observed with a noisy background. Two slightly broad and relatively less intense peaks are observed around  $1354\text{ cm}^{-1}$  and  $1586\text{ cm}^{-1}$ . A very sharp intense peak is observed at  $2852\text{ cm}^{-1}$ . The peak around  $1354\text{ cm}^{-1}$  is called the D-line. It is linked with the presence of the disorder in the graphitic materials. The defect can be amorphous, disordered carbon with fullerenes etc. G-line composed of a group of peaks in the region of  $1550\text{ cm}^{-1}$  to  $1600\text{ cm}^{-1}$ . In the present study a peak is observed around  $1586\text{ cm}^{-1}$ . The G-band reveals the vibrations of carbon atoms in planar ( $\text{SP}^2$ ), hexagonal lattice. This peak is a measure of the graphitization of the sample. The line in the region  $2700\text{ cm}^{-1}$  is the second harmonic of D-mode. It is denoted as 2D. In the present case with a shift of  $152\text{ cm}^{-1}$ , 2D band appears at  $2852\text{ cm}^{-1}$ . This line indicates the distant of order in the sample structure and it appears in the process of double-back ground scattering. From the above observation it is concluded that the soot obtained under open atmospheric conditions is a mixture of amorphous and graphitized one.

The Powder X-Ray diffraction of the soot is given in Figure 4.

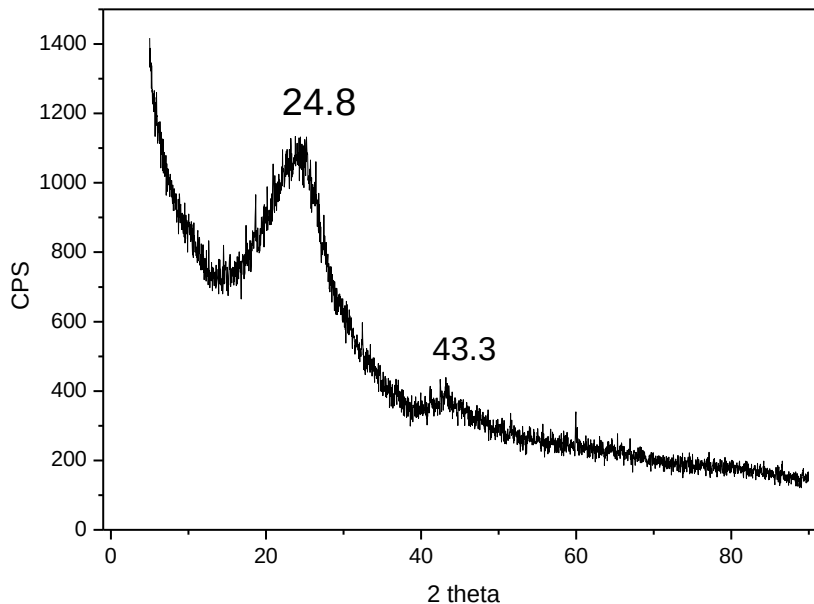


Figure 4: Powder X-Ray diffraction of the soot

The soot exhibits broad diffused peak at  $\sim 24.8^\circ$  and  $\sim 43.3^\circ$ . These are observations are in line with earlier reports. These peaks are attributed to (002) and (100) plane diffraction of graphitic carbon respectively. The SEM images of the sample are shown in Figure 5 (a), (b) and (c).

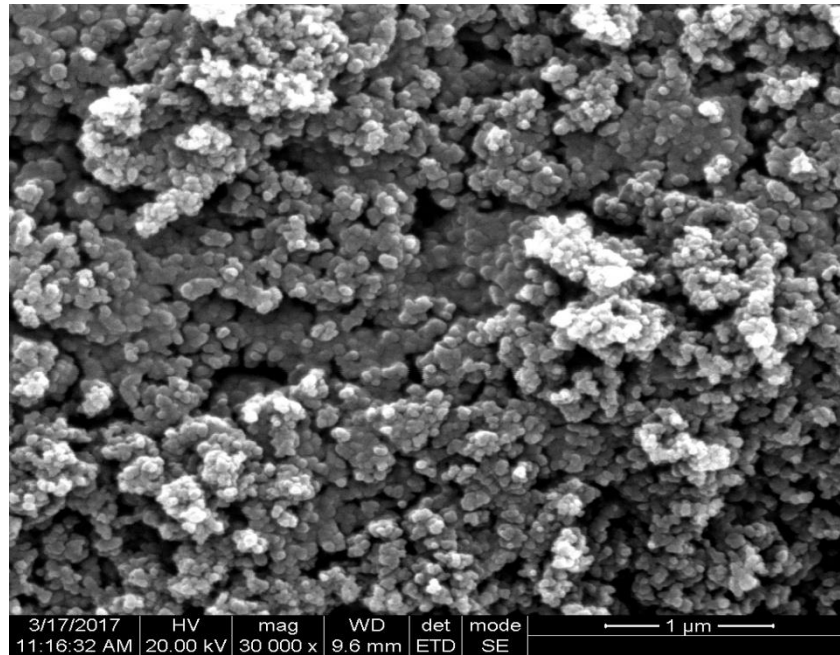


Figure 5 (a)

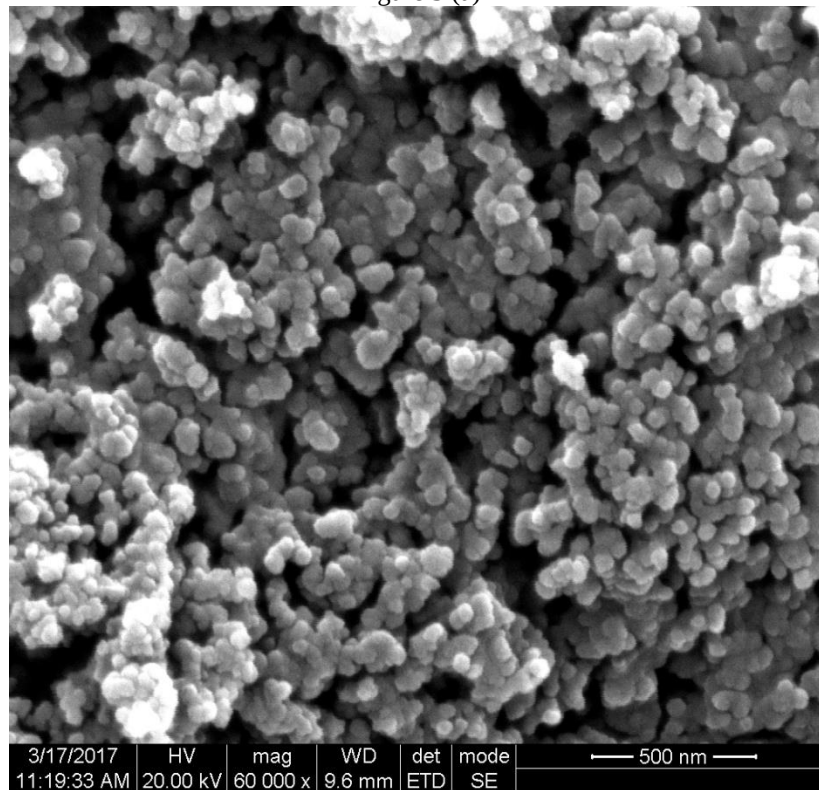


Figure 5 (b)

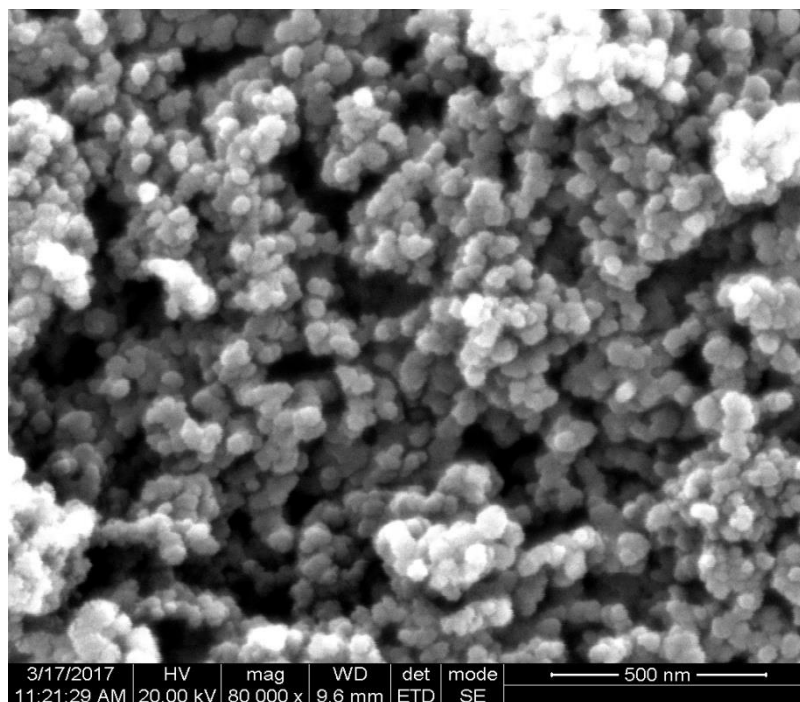


Figure 5 (c)

From Figure 5(a), it is inferred that the soot particles have uniform size and shape with many visible porous channels and having sponge type morphology. The high resolution SEM images in Figure 5 (b) and (c) shows, that the soot contains interconnected carbon nodular grains which are fused together forming sufficient porous channels for surface accessibility. Similar results are reported earlier for hydrophilic carbon synthesized from mustard oil.

## VI. Conclusions

Edible quality mustard oil is burnt in open air by conventional method. The soot is collected on copper substrate by a in house designed automatic set up. From the FTIR spectrum presence of amorphous form of carbon is confirmed. Appearance of D, G and 2D lines in the Raman spectrum confirms the graphitization of the sample. The graphitization of the sample is further confirmed by the results obtained from powder X-ray diffraction. SEM images reveal the sample is having interconnected carbon nodular grains forming porous channels. This method shows very simple way to obtain graphitic carbon soot at low temperature from a easily available precursor. Further work is in progress to functionalize the carbon soot to evaluate possible practical applications. Also work in progress to understand the effect of various substrates on the nature of soot formation.

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