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Synthesis of Carbon Nanoparticles by Using Seed Oils

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Abstract: Synthesis of carbon nanoparticles was carried out by using different seed oils (olive oil, linseed oil, almond oil, eucalyptus oil, lemon oil, and cardamom oil). Simple combustion technique was applied and it was efficient. Nanoparticles of carbon having nano range were synthesized by using the above-stated oils with the help of this simplistic and inexpensive technique. The average size of carbon nanoparticles by using olive oil, linseed oil, almond oil, eucalyptus oil, lemon oil and cardamom oil was observed that was 24nm, 57nm, 3.46nm, 3.042nm, 4.69nm and 4.70nm, respectively as explored by using powder X-ray diffraction technique. Surface morphology of these synthesized carbon nanostructures was predicted by the help of scanning electron microscopy technique.

Keywords: scanning electron microscope, X-ray diffraction technique, carbon nanoparticles

Introduction

Nanoparticle is a particle that has at least one of its magnitudes in nano range i.e., 1 to 100 nm (Rik *et al*., 2005). Due to exceptional properties such as excellent pharmaceutical and electronic capabilities, resistant to corrosion (Wang *et al*., 2002) and increased bio/chemical compatibility for different uses such as carcinogenic, respiration, antimicrobial, hydrogen storage, nanocomposites, filtration, catalysis and biotechnology (Baughman *et al*., 2002) carbon nanoparticles are very much progressive particles of modern ages that have high demand in many fields largely based on the progress of excellent, simple and cheaper method for its synthesis. Carbon nanoparticles are used in many biomedical sectors such as antimicrobial, pulmonary exposure, lungs exposure and carcinogenic applications. In both these cases, the internal structure consist of a layer of atoms of carbon which is sp^2 hybridized and also found a π bond that is very week which is formed when partially filled atomic orbitals overlap parallel.

Many techniques like thermal carbonization, sonication, and exfoliation and laser irradiation were used for manufacturing of nano fibers/particles/tubes (Hu *et al*., 2004). The raw material is a basic factor that is controlling the yield of carbon nanoparticles and structure morphology. Coal, ethanol (Gallego *et al*., 2011), scrap tire rubber (Yang *et al*., 2012), arc discharge and thermal plasma jet (Ying *et al*., 2011) are used to synthesize carbon nanoparticles.

The excellent methods in all these are scrap tire rubber and chemical vapor deposition (CVD) of coal but both of these methods produce a mixture of many carbon nanoparticles. Carbon nanoparticles can be produced from the techniques of catalytic decomposition of hydrocarbon gases or ethanol at a temperature of more than 400-1000 °C. Arc discharge and thermal plasma jet methods are quite expensive to synthesize better quality carbon nanoparticles, therefore, these cannot be used for large-scale synthesis.

Different sources and different techniques are attempted for the production of carbon nanoparticles. High temperature, complications in handling and usage of non-recycled materials are the shortcomings of these methods.

Production of carbon nanoparticles from alternate sources with low cost and negligible impurities is therefore the most important work to do. Generally, these techniques require raw material that is carbon-based to manufacture a polymer. The coal and oil pitches, rayon, ethylene gas, polyvinyl alcohol, candle wax and mineral oils are the important carbon precursors. The source of these precursors is petroleum fossils.

It is thought that for the formation of carbon nanoparticles, "Arc Discharge Method" is the best method. It has various benefits including short duration and less setting cost. The arc discharge was used to

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produce carbon nanoparticles at first by Iijima (1991). There were some drawbacks and shortcomings in the discussed method i.e., low yields, requires purification and intake of a high amount of energy.

There is a high requirement to find alternate sources of carbon to synthesize carbon nanoparticles. Because of high carbon concentration and inexpensive raw materials, the seed oils have got great importance for the synthesis of carbon nanoparticles on an international level. Seed oils appear to be promising because of their availability and high carbon concentration (Sahoo *et al*., 2011).

Materials and Methods

Plants are the source of the seed oils. These are slippery when touched and are not soluble in water. Seed oils have double caloric concentration relative to food items which are a very significant characteristic of seed oils. Seed oils are thought to be a rich source of important fatty acids. A number of different precursors such as kerosene oil, wax items, diesel oil, lignin and organic hydrocarbons are used usually to synthesize carbon nanoparticle but here different samples of seed oils including olive oil, linseed oil, almond oil, eucalyptus oil, lemon oil and cardamom oil were procured from supermarket shops of Akbari Mandi Lahore, Punjab, Pakistan and used for further analysis. Processing factors and proficiencies were predicted to produce carbon nanoparticles. XRD studies were used to check particle size of seed oils.

Olive oil. It is natural oil and contains largely fatty acids, phenolic compounds, sterols, tocopherols, glycerides and hydrocarbons. Olive oil is considered the best source for the synthesis of carbon nanoparticles because it has different organic compounds. The fatty acid chain ranges between 14- 24 carbon atoms in olive oil (Ajana and Antari, 1998). Generally, fatty acids differ due to variation in length and type of chemical bonds. It contains the maximum percentage of oleic acid (78%) among all the fatty acids. The second most abundant fatty acid is palmitic acid (14.5%). Similarly, linoleic acid presence is only10.4%. The least amount of fatty acid is the linolenic acid which is 3.1%.

Linseed oil. Linseed oil is gained by the flax seeds (Bayrak *et al*., 2010). Argentina, Canada, USA, China, India, and Pakistan are the major countries for the production of linseed oils. Normally, linseed plants have 30% dietary fibres, 40% oil, 20% proteins, 6% moisture and 4% ash (Wang *et al*., 2008). The flax seeds is the largest source of polyunsaturated fatty acids (PUFA) for humans which contains 36-40% of the oil. However, the most authentic analysis of fatty acid composition shows that it has the highest percentage of linolenic acid (53.21%) and other unsaturated fatty acids have 18.51% and a linoleic acid having only (17.25%). But saturated fatty acids occurred in small amount e.g., stearic acid (4.58%) and palmitic acid (6.58%) (Nykter *et al*., 2006).

Almond oil. For active substances, Almeida *et al*. (2009) evaluated the use of almond oil for the preparation of nanoparticulate delivery systems (nanocapsules and nanoemulsions). Interfacial testimony of preformed polymer or emulsification was used to produce it. Nano metric size, negative zeta potential, poly dispersity index under 0.30 and globular designed particles were obtained. These systems entrapped benzophenone-3. Physicochemical characteristics of the nanoparticle dispersions were not changed by this storage. It was enough to use as a storage for six months. It was also noted that these storage prevent the degradation of the benzophenone-3 from UV radiation (Srafino *et al*., 2008). Fatty acids composition of the lipid fraction of sweet almond is linoleic acid (C18:2) is 20-30% and oleic acid (C18:1) 62-86%**.**

Eucalyptus oil. It is distilled from the leaf of eucalyptus, belongs to Myrtaceae family of plants. This oil has many applications such as fragrance (Elaissi *et al*., 2012), a flavouring agent, antibacterial, industrial and pharmaceutical applications. The leaves were steam distilled and oil was produced. In eucalyptus oil with the help of GC/FID and GC/MS, total 25 components were identified and their biological activities were determined. Three groups of fungal strains and four groups of bacteria were tested by their compassion levels to eucalyptus oils. In eucalyptus oil, there are different cytotoxic effects and the antiviral activities (Joshi *et al*., 2013).

Lemon oil. Following components were present in the lemon oil Ψ-terpinene, α-pinene, β-pinene, myrcene, *d*- limonene, *n*-heptanal, 1,8-cineole, *n*-hexanol, *n*-octanal, *n*-nonanal, methyl heptenone,, linalool, citral, *n*-decanal, citronellyl acetate, citronellal, tetrahydro geraniol, decyl acetate, geraniol, α- terpineol, Citronellol, *n*-undecanal, neral, geranyl acetate, and *d*-carvone when lemon oil was observed with the help of gas-liquid chromatography (Cudzilo *et al*., 2007).

Cardamom oil. α-terphenyl, 1-phellandrene, trans-sabinene hydrate, bicyclogermacrene, δ-3-carene, α-terpinene, isopinocarveol, ledenoxid-II, longifolena-ldehyde and α-terphenyl acetate are present in the oil of cardamom (Bernhard, 1960).

Combustion method. Combustion method gives carbon nanoparticles for basic studies and for biological screening. This method uses high temperature and it is a self-propagating process. The following procedure is the simplest and effective for the synthesis of carbon nanoparticles, exfoliated graphite (Cudzilo *et al*., 2005) and encapsulates silicon carbon nanowires. Koch investigated carbon nanotubes and carbon nanocarpet rolls. By utilizing organic sources carbonaceous entities with various uses are synthesized by combustion method which is also known as high-temperature technique. It is true that the better quality nanoparticles are obtained by using chemical vapor deposition and arc discharge techniques but these techniques are very much costly which is the big shortcoming of these techniques. To produce carbon nanoparticle, a simple, easy and inexpensive technique is required. So combustion of seed oils competes for the necessities and demands in these circumstances.

Preparation of seed oils soot. Firstly, different seed oils including olive oil, linseed oil, castor oil, almond oil, eucalyptus oil, lemon oil and cardamom oil were retained in a chemical lab lamp with a combustible wick. Absorption of respective seed oils by cotton or wick these lamps were left for 36 h. Lamps were lighted and allowed to burn, a china dish was inverted and positioned above the flame of a lamp to obtain carbon soot. The experiment was finished after collection of 5-10 g of carbon soot.

Characterisation of carbon nanoparticles. The produced carbon nanoparticles by combustion of seed oils (olive oil, linseed oil, castor oil, almond oil, eucalyptus oil, lemon oil, and cardamom oil) were analyzed by powder x-ray diffraction to check the particle size. Surface morphology was analyzed by SEM technique.

Results and Discussion

Various seed oils like olive oil, linseed oil, castor oil, almond oil, eucalyptus oil, lemon oil and cardamom oil were burnt and carbon nanoparticles were produced. The complete and incomplete burning of seed oils at high temperature is possible. Less amount of carbon dioxide and water are produced in incomplete burning because this process occurs in less amount of oxygen. It is difficult to achieve complete burning process experimentally due to the creation of major and minor material including pure carbon and carbon monoxide, at the time of chemical equilibrium. Likewise, various oxides of nitrogen as NO, NO_2, and N_2O are also produced when combustion is done in the environment containing 78% nitrogen.

XRD results. To measure the size of carbon nanoparticle, powder X-ray diffractometric studies were applied. Particle size determination was done by the Debye Scherer formula. Powder X-ray diffraction technique was used for different samples of carbon nanoparticles. Confirmation about the nano range size of most of the carbon particles was achieved by powder XRD studies.

XRD analysis of carbon nanoparticles of olive oil. Three Bragg diffraction peaks $2\theta = 24.62°$, 45.08° and 52.11°, were viewed by XRD spectrum of carbon nanoparticles which was prepared from olive oil. The occurrence of different types of carbon nanoparticles was verified by the high-intensity broad peak of $2\theta = 24.62°$ and low- intensity peak of $2\theta = 24.62°$ and low-intensity peak of $2\theta = 45.08°$ and 52.11°. Different sized nanoparticles are prepared and examined. The range of size is as follows; 66.6% particles having size of 19 nm and 33.3% particles with a size of 34nm. At last, 24 nm size was found to be the average particle size of carbon nanoparticle (Table 1). Verification can be achieved by studying XRD spectral data.

XRD analysis of carbon nanoparticles of linseed oil. Carbon nanoparticles were synthesized from linseed and analyzed by XRD and it displayed two Bragg diffraction peaks at near $2\theta = 24.85$. The high-intensity peak at near $2\theta = 24.85$ is the first peak and it showed the presence of carbon nanoparticles, whereas low-class carbon nanoparticle material showed the 2^{nd} peak at $2\theta = 44.08$. All this carbon nanomaterial contains 50% 37nm sized particles and remaining 50% contain the particles whose size is 77 nm. Lastly, carbon nanoparticle of average size was measured which was 57nm in size. All this detail is proved by investigating XRD spectral data (Table 2).

XRD analysis of carbon nanoparticles of almond oil. A graph was plotted between intensity and 2θ, two values were taken from the two sides of the curve one from the left side that was 2323.5 and the other from

Table 1: XRD spectral data of olive oil

Pos. [°2Th.]	FWHM [°2Th.]	K	λ [Å]	k*λ	2θ°/2 = θ°	Cos θ°	FWHM [°2Th.]	Size [Å]=k*λ/FWHM *Cos θ°	Size nm
24.62	0.728	0.89	1.542	1.372	12.31	0.977	0.7112	1.930	19.30
45.088	0.768	0.89	1.542	1.372	22.54	0.9235	0.7093	1.935	19.35
52.116	0.44	0.89	1.542	1.372	26.05	0.8983	0.3952	3.473	34.73

Table 2. XRD spectral data of linseed oil

Pos. [°2Th.]	FWHM [°2Th.]	K	λ [Å]	k*λ	2θ°/2 = θ°	Cos θ°	FWHM [°2Th.]*Cosθ°	Size [Å]=k*λ/FWHM [°2Th.]*Cos θ°	Size nm
24.85	0.182	0.89	1.542	1.372	12.42	0.9764	0.1777	7.724	77.24
44.08	0.392	0.89	1.542	1.372	22.04	0.9269	0.3633	3.778	37.78

the right side was 2321. One value was noted at maxima i.e. 2661 and calculated the full-width half maxima (FWHM) i.e. 3.95 as shown in Table 3 that was used to calculate the particle size by the following formula, where k=0.89 and λ=1.5, D= k*λ 10^{-10}/FWHM.Cos θ°= 3.46nm.

XRD analysis of carbon nanoparticles of eucalyptus oil. A graph was plotted between intensity and 2θ, two values were taken from the two sides of the curve, one from the left side that was 2590 and the other from the right side was 2597. One value was noted at maxima i.e. 3161 and calculated the full-width half maxima (FWHM) i.e. 4.5, that was used to calculate the particle size (Table 4) by the following formula:

D= k*λ 10-10/FWHM*Cos θ°= 3.042 nm.

where:

k=0.89 and λ=1.5

XRD analysis of carbon nanoparticles of lemon oil. A graph was plotted between intensity and 2θ, two values were taken from the two sides of the curve one from the left side that was 2667 and the other from the right side was 2675.5, one value was noted at maxima i.e. 2949, and calculated the full-width half maxima (FWHM) i.e. 2.75, that was used to calculate the particle size (Table 5) by the following formula:

D= k*λ 10-10/FWHM*Cos θ°= 4.69 nm.

where:

k=0.89 and λ=1.5

XRD analysis of carbon nanoparticles of cardamom oil. A graph was plotted between intensity and 2θ, two values were taken from the two sides of the curve one from the left side that was 2086 and the other from the right side was 2085, one value was noted at maxima i.e. 2330, and calculated the full-width half maxima

Table 3. XRD spectral data of almond oil

Pos. [°2Th.]	FWHM [°2Th.]	K	λ [Å]	k*λ	2θ°/2 =θ°	Cos θ°	FWHM [°2Th.]*Cos θ°	Size [Å]=k*λ/FWHM [°2Th.]*Cos θ°	Size nm
25.10	3.95	0.89	1.542	1.372	12.55	0.9761	3.855	0.3560	3.560

Table 4. XRD spectral data of eucalyptus oil

Pos. [°2Th.]	FWHM [°2Th.]	K	λ [Å]	k*λ	2θ°/2 = θ°	Cos θ°	FWHM [°2Th.]*Cos θ°	Size [Å]= k*λ/FWHM [°2Th.]*Cos θ°	Size nm
25.51	4.5	0.89	1.542	1.372	12.75	0.9753	4.388	0.3127	3.127

Table 5. XRD spectral data of lemon oil

Pos. [°2Th.]	FWHM [°2Th.]	K	λ [Å]	k*λ	2θ°/2 = θ°	Cos θ°	FWHM [°2Th.]*Cos θ°	Size [Å]= k*λ/FWHM [°2Th.]*Cos θ°	Size nm
24.81	2.75	0.89	1.542	1.372	12.40	0.9766	2.685	0.5111	5.111

Table 6. XRD spectral data of cardamom oil

Pos. [°2Th.]	FWHM [°2Th.]	K	λ [Å]	k*λ	2θ°/2 = θ°	Cos θ°	FWHM [°2Th.]*Cos θ°	Size [Å]= k*λ/FWHM [°2Th.]*Cos θ°	Size nm
24.78	2.91	0.89	1.542	1.372	12.39	0.9767	2.842	0.4830	4.830

(FWHM) i.e. 2.91, that was used to calculate the particle size (Table 6) by the following formula:

D= k*λ 10-10/FWHM*Cos θ°= 4.70 nm.

where:

k=0.89 and λ=1.5

Scanning electron microscope (SEM) analysis. At different magnification, SEM was utilized to examine the surface of carbon nanoparticles morphologically. (Fig. 1-2), with a format of JEOL/EO and 1.1version, SEM tool was JSM-6480 and the acceleration voltage was 20 volts in many experiments. It was examined that surface morphology of carbon nanoparticles obtained from seed oils (olive, linseed, almond, eucalyptus, lemon and cardamom oil) was not uniform after SEM studies of carbon nanoparticles. Little scraps of carbon nanoparticles were shown in the SEM micrograph. Rounded carbon particles ranging from 3-77 nm were non-uniform but the most uniform particle of them was

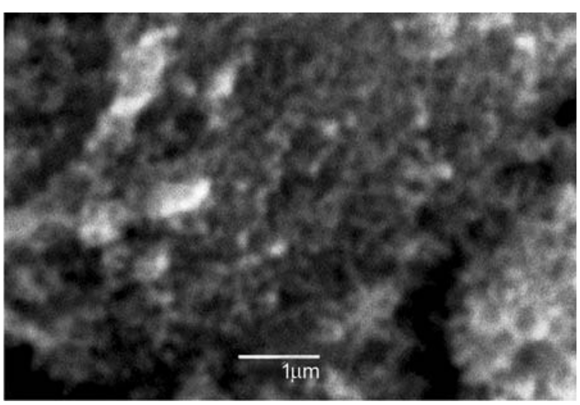

Fig. 1. SEM micrographs of carbon nanoparticles synthesized from olive oil with18,000 times magnification power.

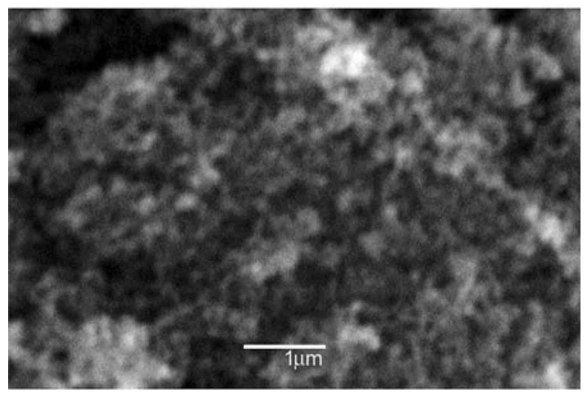

Fig. 2. SEM micrographs of carbon nanoparticles synthesized from linseed oil with18, 000 times magnification power.

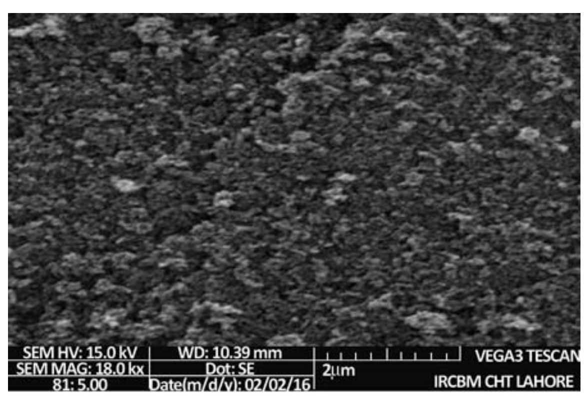

Fig. 3. SEM micrographs of carbon nanoparticles synthesized from almond oil with 18000 times magnification power.

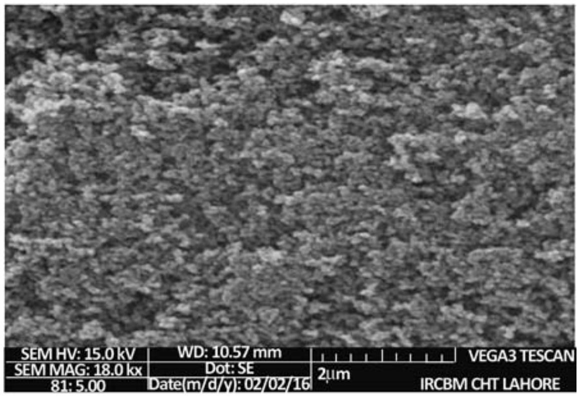

Fig. 4. SEM micrographs of carbon nanoparticles synthesized from Eucalyptus oil with 18000 times magnification power.

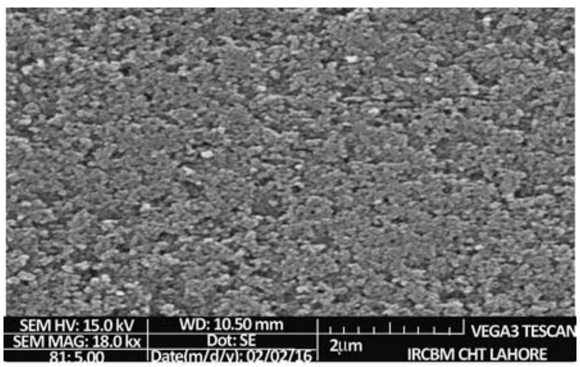

Fig. 5. SEM micrographs of carbon nanoparticles synthesized from lemon oil with 18000 times magnification power.

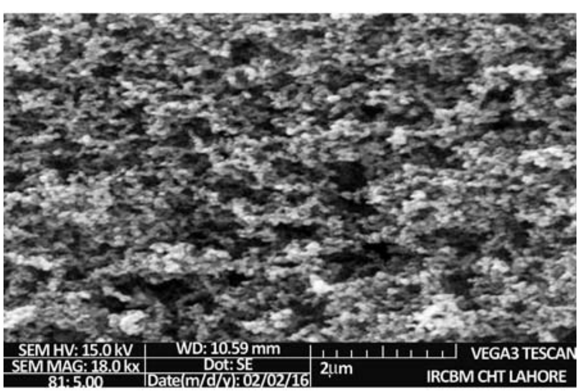

Fig. 6. SEM micrographs of carbon nanoparticles synthesized from cardamom oil with 18000 times magnification power.

of 19 nm in size. Due to the burning of seed oil, carbon nanoparticles were formed. These carbon nanoparticles were present in the combination of carbon in its elemental form. The study of SEM micrograph showed that carbon nanoparticles were magnified to 18,000 times as depicted in Fig. 3-6.

Conclusion

Combustion method is an inexpensive and simple technique to synthesize carbon nanoparticles and this study was taken for the synthesis of carbon nonopartiles by using different seed oils including olive oil, linseed oil, almond oil, eucalyptus oil, lemon oil and cardamom oil. It was observed by the scanning electron microscope (SEM) that spherical carbon nanoparticles are different from each other with respect to their particle size. The average size of carbon nanoparticles by using olive oil, linseed oil, almond oil, eucalyptus oil, lemon oil and cardamom oil was observed that was 24nm, 57nm, 3.46nm, 3.042nm, 4.69nm and 4.70nm, respectively. It was confirmed that the examined particles are having a little percentage of hexagonal graphite with a high percentage of carbon nanoparticles by the use of powder X-ray diffraction. It was proved and concluded that by using this technique of combustion, the carbon nanoparticles are produced from the seed oils and this technique can offer an outstanding platform for examining the biological activities of these carbon nanoparticles.

Conflict of Interest. The authors declare no conflict of interest

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