Study of the properties of the prepared soot from burning Iraqi kerosene

Received : 7/12/2017
Accepted : 18/1/2018

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Abstract
The study involves the synthesis of nanoparticles soot from burning Iraqi kerosene. The prepared particles are treated by three ways: Hydrogen peroxide treatment, hydrochloric acid treatment and sodium hydroxide treatment, then subsequent sonication were performed for 1 hour. Finally, the nano soot particles were characterized by using FTIR, SEM, XRD, EDX and TGA. The change is in nature of bonding and impurities in preparing carbonic materials, which are studied using FTIR spectroscopy. Scanning Electron Microscopy (SEM) and X-ray diffraction (XRD) results show significant changes in the structure and morphology of the new materials. Thermal gravimetric analysis (TGA) analyses indicate a gradual weight loss in the temperature range from 0°C to about 700°C.

Key words: kerosene, soot, nanoparticles, FTIR, SEM, X-ray diffraction, EDX, morphology, TGA.

Introduction
Soot is a common by-product substance resulting from the combustion of fuels. Soot is formed as a by-product of combustion or pyrolysis of carbon-containing materials, such as coal, wood, fuel oil, waste oil, paper, plastics, and household refuse. Although it's chemical compositions, their property is highly variable and depends on the type of starting material and the combustion conditions. Soot formation is desirable in certain applications such as industrial furnaces since the presence of soot greatly enhances radiative heat transfer \(^1\), \(^2\). Soot has aggregation morphology of globules with a diameter of tens of nanometers that consists of concentrically wrapped graphite layers \(^3\). The soot aggregate morphology is of great importance point in experimental side, where experimental observations suggest that aggregate and particle size distributions should be taken into account to correctly model soot radiative properties. In particular, much of the current interest in control of soot emission is based on the observation that mutagen compounds can be adsorbed onto particle surfaces \(^4\), \(^5\), \(^6\). The challenge is to be able to control soot formation for a specific task. This requires a detailed understanding of the soot formation process \(^7\), \(^8\).

However the mechanism of soot formation is still not completely understood, unfortunately, the mechanisms responsible for soot formation remain difficult and not clear. In the recent past, the advances in analytical equipment in laboratory resulted in the ability to undertake a more important study of a wide range of
substances generated from the combustion of hydrocarbons \cite{9}, \cite{10}, \cite{11}, \cite{12}, \cite{13}. Therefore, it is necessary to search for cheap sources and simple techniques for preparation carbon nanomaterials.

In this study, we chose commercial kerosene because it is the cheapest and locally available, to be used as a raw material for the production of carbon nanomaterials, where kerosene is a complex mixture of aromatic and aliphatic hydrocarbons with carbon numbers predominantly in the C_9-C_16 range. Now, hydrocarbons are the most widespread precursors among carbon sources used in the production of carbon nanomaterials and carbon nanotubes \cite{14}, \cite{15}. In the present work, we report a method of preparing carbon nanomaterials by ultrasonic treatment. In comparison with previous work, this strategy is inexpensive, commercially available, and easy to obtain.

**Experimental Chemicals**

The kerosene used in this study was purchased from the South Refineries Company and used without further purification.

Ethanol (Scharlau 99.9%), Acetone (Scharlau 99%), Hydrogen peroxide (B.D.H 98%), Hydrochloric acid (B.D.H 37%), Sodium hydroxide (B.D.H 98%), were used without further purification.

**Instrument**

IR Spectra were recorded using Shimadzu FTIR8000 Series (Shimadzu). XRD Pattern

**Results and Discussion**

In this research, kerosene has been used as a carbon source for production of carbon soot. Carbon soot was collected by thermal decomposition of kerosene which performed by the breakup of long petroleum series to shorter ones. Then, collected carbon soot has been...
retreated via three routes, firstly with sodium hydroxide, secondly with hydrochloric acid and thirdly with hydrogen peroxide.

The morphological and structural properties of carbon soot were investigated by Fourier transform infrared FTIR, scanning electron microscope SEM, energy-dispersive X-ray EDX, X-ray diffraction XRD spectroscopy and Thermo gravimetric analysis TGA.

**FTIR analysis**

FTIR spectroscopic analysis was carried to investigate the presence of the functional group in carbon soot and treated carbon soot. Thermal decomposition of kerosene produces mainly carbon soot that has elemental carbon and carbonic material with low hydrogen content, it also may contain hydrocarbon residue. Figure 1 shows the FTIR spectra of carbon soot and treated carbon soot. The spectra indicated the presences of functional groups of hydrocarbon. Weak Peak at 3436 cm\(^{-1}\) is in the O-H stretch, peak at 2927 cm\(^{-1}\) is for C-H stretch. A very weak peak at 1630 is for C=C aromatic stretch. Peaks at 2400\(^{[16],[17]}\).

The raring and weakness of peaks indicates that soot involves mainly carbon.
Figure 1: FTIR spectra of CS (a), CS1 (b), CS2 (c) and CS3 (d)

SEM Analysis
The SEM micrographs of carbonic materials were performed to the characterization of surface morphology. SEM micrographs of prepared carbonic materials are presented in figure 2. The images clearly show the spherical, semispherical particles irregular shaped nanoparticles forms. The prepared particles have a size range as shown in Table 1. It is clear that all carbonic soot particles are in a size range below 100 nm and diameter average below 65 nm\textsuperscript{[18]}.

Table 1: Morphological properties of carbon soot specimens

<table>
<thead>
<tr>
<th>Size, nm Material</th>
<th>Diameter range</th>
<th>Diameter average</th>
<th>The particles form</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS</td>
<td>31-59</td>
<td>40</td>
<td>Spherical, semispherical</td>
</tr>
<tr>
<td>CS\textsubscript{1}</td>
<td>38-78</td>
<td>59</td>
<td>Spherical, semispherical</td>
</tr>
<tr>
<td>CS\textsubscript{2}</td>
<td>36-74</td>
<td>53</td>
<td>Spherical, semispherical</td>
</tr>
<tr>
<td>CS\textsubscript{3}</td>
<td>52-103</td>
<td>65</td>
<td>Spherical, semispherical</td>
</tr>
</tbody>
</table>
**EDX analysis**

Figure 3 shows the elemental analysis of prepared carbon soot materials. The EDX spectra indicate the presence of carbon in the case of untreated carbon soot and that treated via three routes. It is clear that carbon soot prepared in the study has suitable purity in comparison with previous studies. Some contaminated substances are detected in carbon soot and that treated with HCl, NaOH and H$_2$O$_2$ which indicates the adsorptive characteristic of carbon surface. Table 2 shows the EDX analytical data of four materials.

**Table 2: EDX analytical data of carbon soot**

<table>
<thead>
<tr>
<th>Data Material</th>
<th>C %</th>
<th>O %</th>
<th>Contaminations</th>
<th>C/O</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS</td>
<td>80.3</td>
<td>7.5</td>
<td>Na (10.5), S (2.0)</td>
<td>10.70</td>
</tr>
<tr>
<td>CS1</td>
<td>93.8</td>
<td>2.8</td>
<td>Cl (1.9), Na (1.6)</td>
<td>33.5</td>
</tr>
<tr>
<td>Cs2</td>
<td>80.4</td>
<td>7.2</td>
<td>Na (10.5), S (1.9)</td>
<td>11.16</td>
</tr>
<tr>
<td>CS3</td>
<td>74.1</td>
<td>11.4</td>
<td>Na (14), S (0.5)</td>
<td>6.5</td>
</tr>
</tbody>
</table>

Figure 2: SEM micrographs of CS (a), CS$_1$ (b), CS$_2$ (c) and CS$_3$ (d)
Figure 3: EDX spectrum of CS (a), CS$_1$ (b), CS$_2$ (c) and CS$_3$ (d)

XRD Analysis
The X-ray diffraction (XRD) patterns for soot materials are shown in figure 4. X-ray powder diffractometric analysis of carbon soot was performed out to characterize their crystal structure. The XRD spectra of carbon soot show that there are two Bragg diffraction peaks at near 2θ = 23.45° and 42.31° for CS. The Bragg diffraction peaks at 2θ = 23.58° and 41.39° for CS$_1$. Also, it has been found that CS$_2$ is characterized by two Bragg diffraction peaks centered at 2θ = 23.25° and 43.36° while CS$_3$ exhibited a peak at 2θ = 23.42° and 43.52°. These two intensively peaks correspond to hexagonal graphite lattice. The broad and high intensity peaks near 2θ = 23° is indicates the existence of amorphous carbonic material [19]. While, low intensity peak near 2θ = 42°, is an indication of the existence of the low quality of carbon nanomaterial [20],[21].
TGA analysis
Thermal gravimetric analysis (TGA) was carried out to investigate the thermal stability of the four carbon soot. TGA soot materials are presented in figure 5. The obtained thermal gravimetric curves indicate a gradual weight loss in the temperature range from 0°C to about 700°C. In all soot materials, a weight loss of not exceed 20% only of initial weight in the above temperature range [22].
Figure 5: TGA and DTA of CS (a), CS1 (b), CS2 (c) and CS3 (d)

References


