

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

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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 its 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^{[9], [10], [11], [12], [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 C₉-C₁₆ range. Now, hydrocarbons are the most widespread precursors among carbon sources used in the production of carbon nanomaterials and carbon nanotubes^{[14], [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.

Instruments

IR Spectra were recorded using Shimadzu FT.IR8000 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

was recorded using XRD-600. SEM images and EDS were recorded using TESCAN VEGA3. Thermo gravimetric analysis was performed using LINSEIS-STA PT-1000. Labtcc-410 sonication bath was used for the dispersion of prepared materials. Triumph Ultracentrifuge was used for separation of soot.

Synthesis of soot

Commercial kerosene was put in the simple laboratory lamp with a combustible cotton material. The material was saturated for one day. The lamp lit is allowed to burn. A clean Pyrex beaker was placed above the lamp to accumulate soot emitted from it and compiled accumulated soot (approximately 10g) from burning of kerosene. The black material washed by using a variety of organic solvents (ethanol, acetone) sequencers to get rid of the remnants of unburned fuel. Then converted it to the emulsion in ethanol and separated by a micro centrifuge. This particle treated by three ways: The hydrogen peroxide treatment, hydrochloric acid treatment, and treated with sodium hydroxide. The samples were exposed to ultrasound for one hour, then re-set them in the same machine at the highest rotation speed (20000 rpm) of acquiring nanomaterial particles.

The soot named as CS: pristine soot, CS₁: treated with H₂O₂, CS₂: treated with NaOH, CS₃: treated with HCl.

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.

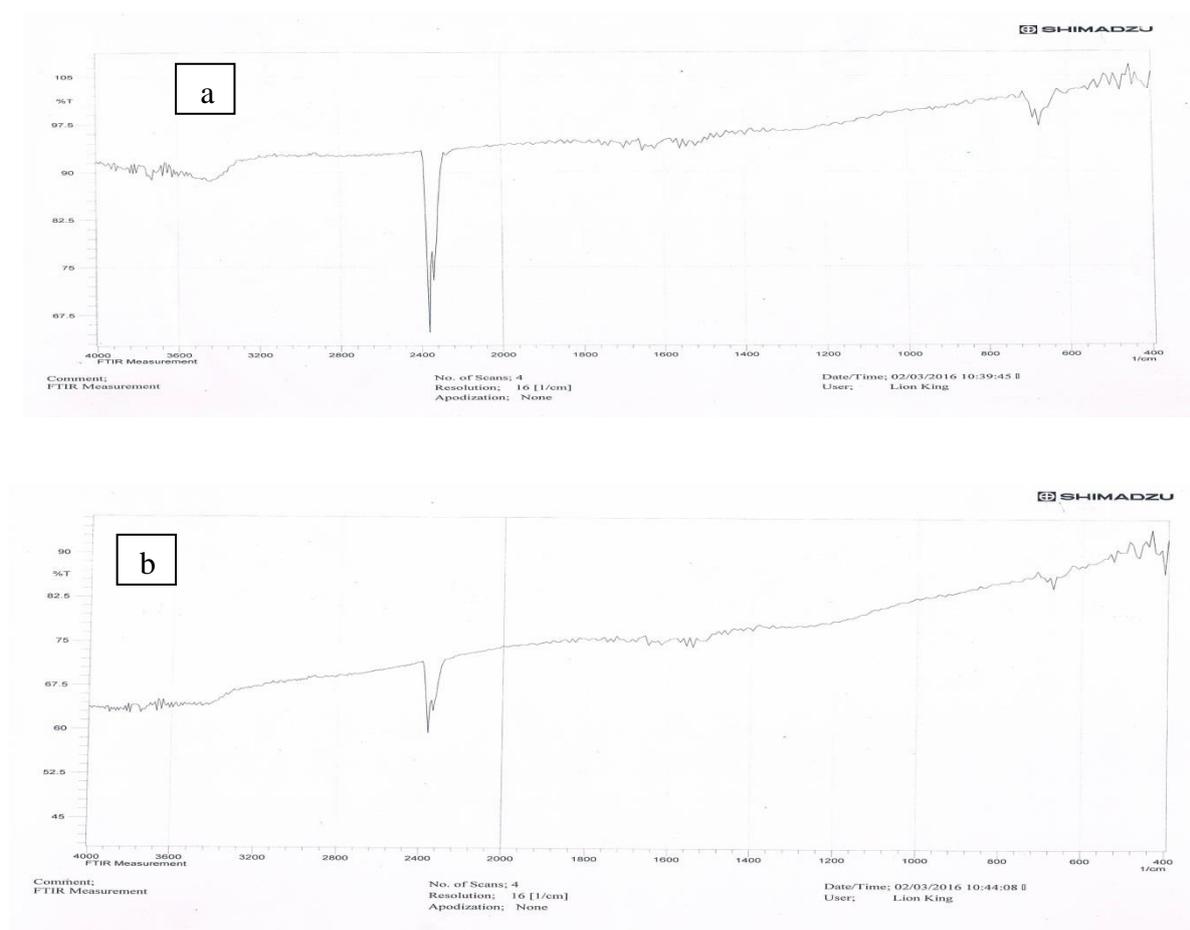
The morphological and structural properties of carbon soot were investigated by Fourier transform infrared FTIR, scanning electron microscope SEM, energy-dispersive X-ray EDX, X-ray diffraction XRD spectroscopy and Thermo gravimetric analysis TGA.

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 3436cm^{-1} is in the O-H stretch, peak at 2927cm^{-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.



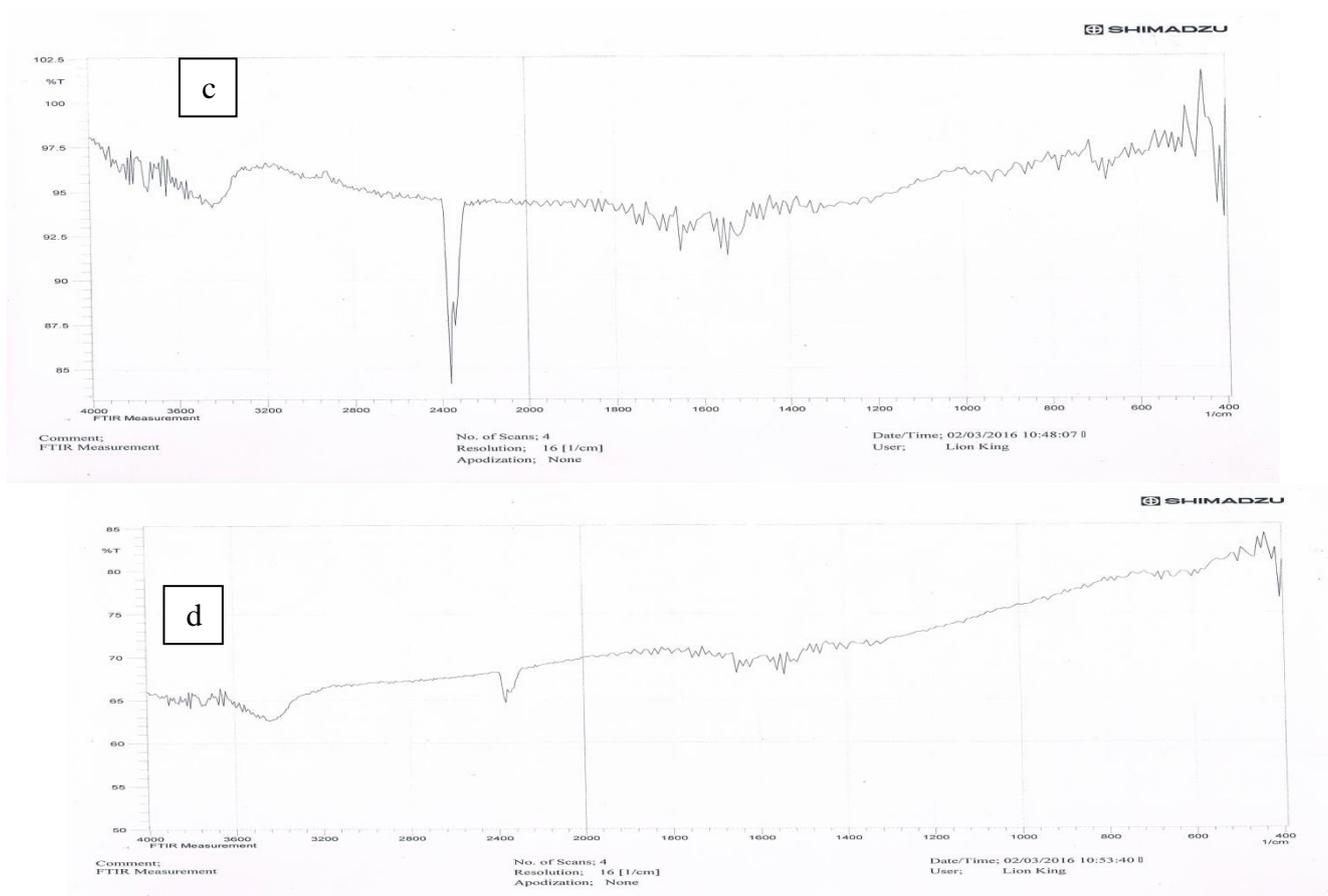


Figure 1: FTIR spectra of CS (a), CS1 (b), CS2 (c) and CS3 (d)

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^[18].

Table 1: Morphological properties of carbon soot specimens

Size, nm Material	Diameter range	Diameter average	The particles form
CS	31-59	40	Spherical, semispherical
CS ₁	38-78	59	Spherical, semispherical
CS ₂	36-74	53	Spherical, semispherical
CS ₃	52-103	65	Spherical, semispherical

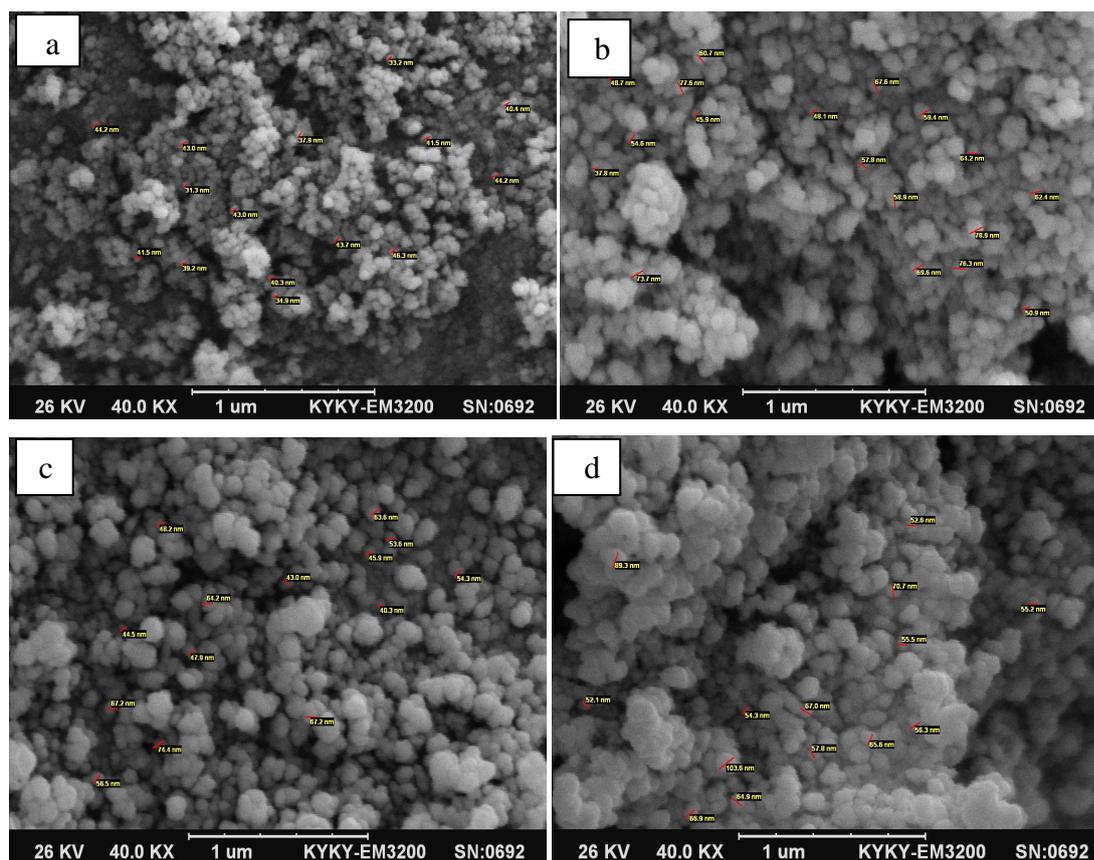


Figure 2: SEM micrographs of CS (a), CS₁ (b), CS₂ (c) and CS₃ (d)

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 H₂O₂ 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

Data Material	C %	O %	Contaminations	C/O
CS	80.3	7.5	Na (10.5), S (2.0)	10.70
CS1	93.8	2.8	Cl (1.9), Na (1.6)	33.5
CS2	80.4	7.2	Na (10.5), S (1.9)	11.16
CS3	74.1	11.4	Na (14), S (0.5)	6.5

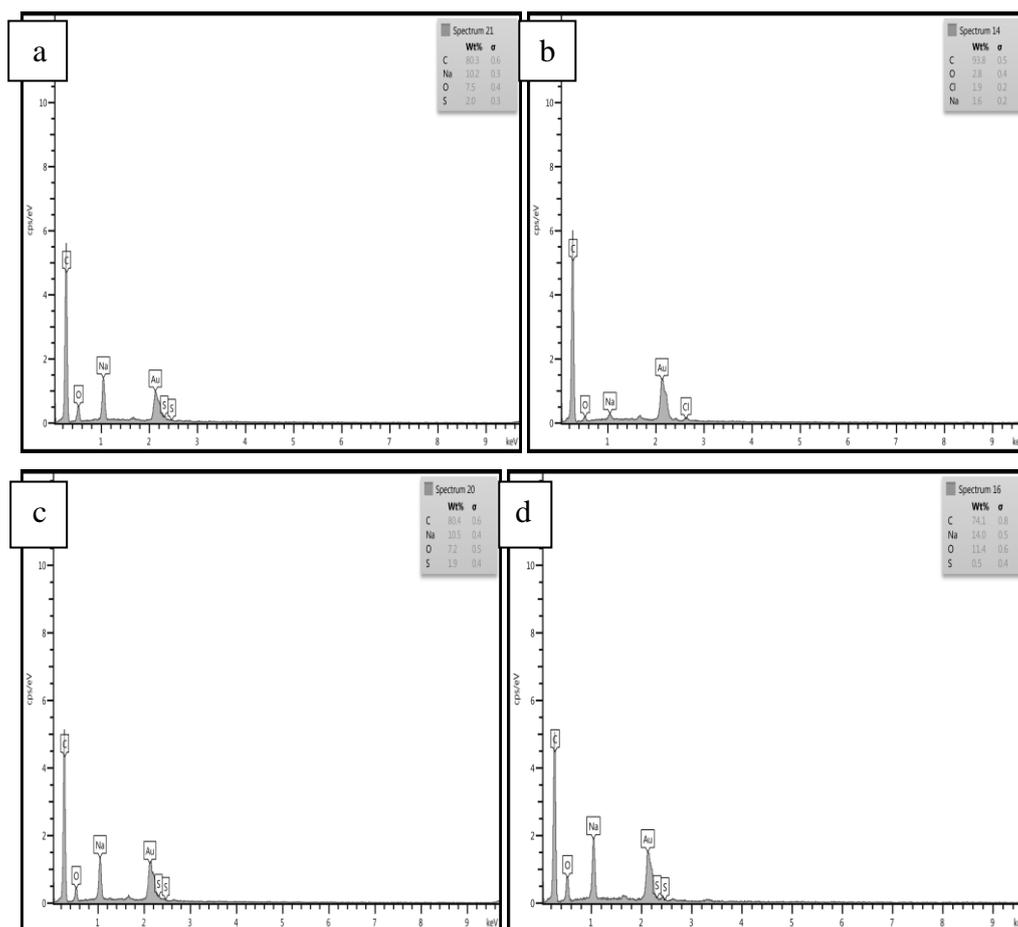


Figure 3: EDX spectrum of CS (a), CS₁ (b), CS₂ (c) and CS₃ (d)

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 $2\theta = 23.45^\circ$ and 42.31° for CS. The Bragg diffraction peaks at $2\theta = 23.58^\circ$ and 41.39° for CS₁. Also, it has been found that CS₂ is

characterized by two Bragg diffraction peaks centered at $2\theta = 23.25^\circ$ and 43.36° while CS₃ exhibited a peak at $2\theta = 23.42^\circ$ and 43.52° . These two intensively peaks correspond to hexagonal graphite lattice. The broad and high intensity peaks near $2\theta = 23^\circ$ is indicates the existence of amorphous carbonic material [19]. While, low intensity peak near $2\theta = 42^\circ$, is an indication of the existence of the low quality of carbon nanomaterial [20], [21].

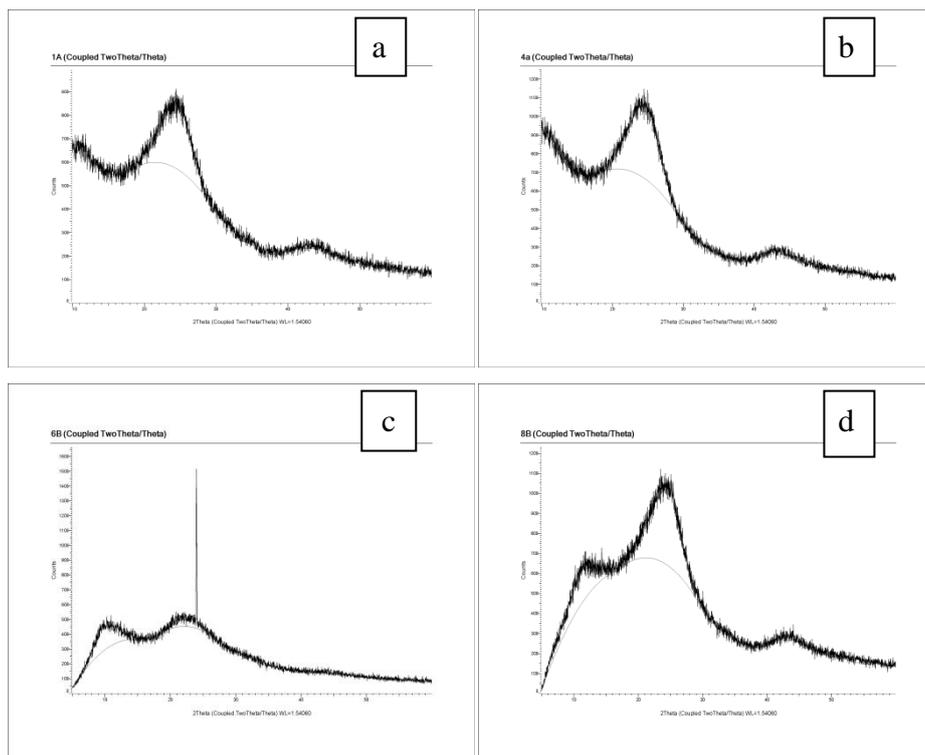
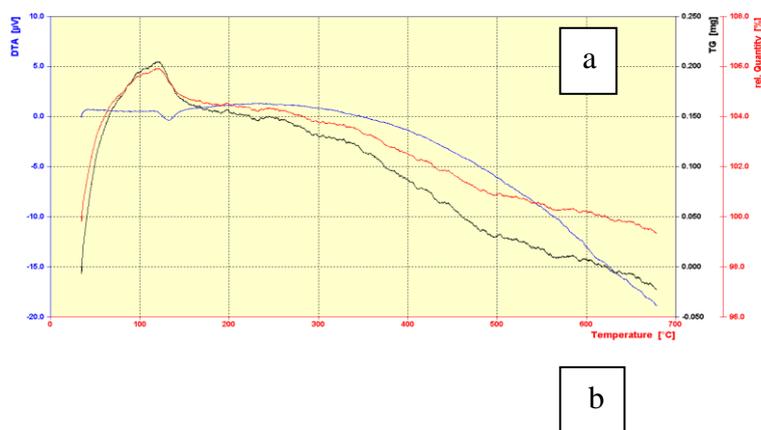


Figure 4: X-Ray Diffraction (XRD) of CS (a), CS₁ (b), CS₂ (c) and CS₃ (d)

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].



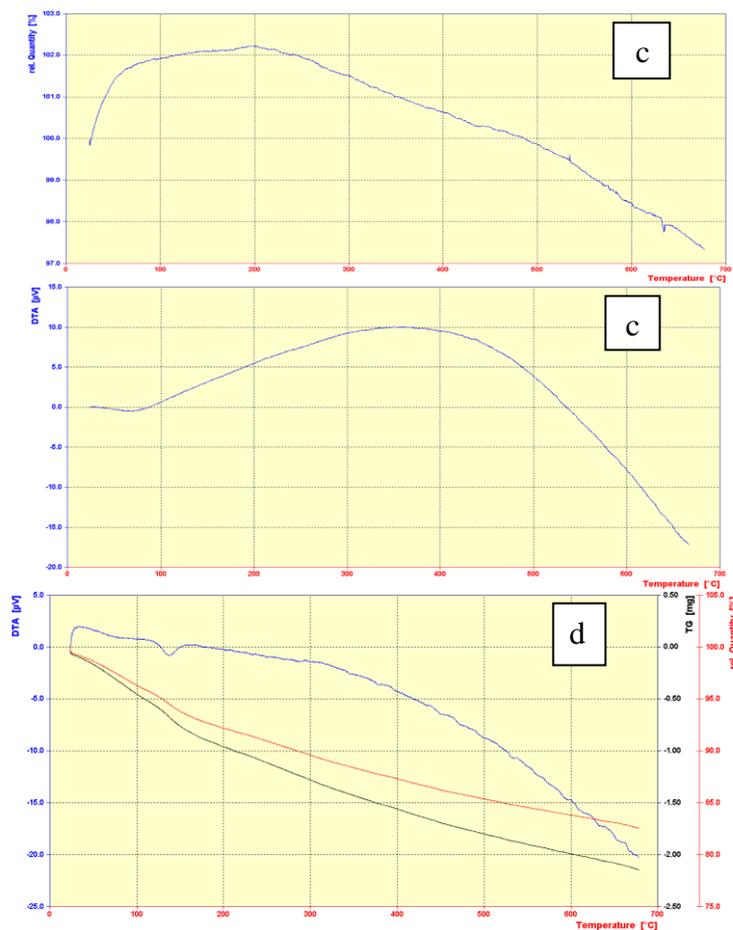


Figure 5: TGA and DTA of CS (a), CS₁ (b), CS₂ (c) and CS₃ (d)

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