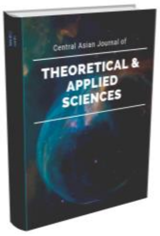


CENTRAL ASIAN JOURNAL OF
THEORETICAL AND APPLIED
SCIENCE

https://cajotas.centralasianstudies.org/index.php/CAJOTAS
Volume: 06 Issue: 01 | January 2025 ISSN: 2660-5317

Article

Reducing and Determination Black Carbon and Carbon Dioxide Emissions into Atmosphere to Reduce Global Warming

Ahmed A. Alibrahimi[1]

Ali A. Abdullatif[2]

Wisam O. Toamah[3]

1. 3. Thi-Qar General Directorate of Education, 64001 Nasiriya, Iraq
2. Student in Gifted Guardianship Committee
* Correspondence: ahmedoudah501@gmail.com

Abstract: One of the most important causes of global warming is sooty smokes emissions in the atmosphere containing both solid fine particles of black carbon and carbon dioxide gas. To reduce and determination these emissions into the atmosphere, we divided the work into two steps, step one is separating the black carbon (BC) molecules from the smoke directly, leaving only the gas behind such as CO_2 gas absorbed and reacted with NaOH solution, Na_2CO_3 results. Reaction the resulting crop withe $Ca(OH)_2$ for give $CaCO_3$ as salts. These steps can be done first by locking the smoke which is produced by the burnings of fossil fuels in the industries, electric power plants…etc, then by using air pumps we can drag these amounts of smoke through heat-tolerant pipes (we used heavy iron pipes) continuously first into cooling chamber –then we can use strong plastic pipes to reduce the cost- and after it is cooled then transported into the solid-gas separating chamber and to the other processes . The study is characterized by low cost and economic feasibility achieved of the work. The materials used are inexpensive and already available.

Keywords: Global warming, Carbon dioxide, Black soot powder, Sodium hydroxide, Calcium hydroxide and Economic feasibility.

Citation: Alibrahimi A. A., Abdullatif A. A.,Toamah W. O. Reducing and Determination Black Carbon and Carbon Dioxide Emissions into Atmosphere to Reduce Global Warming. Central Asian Journal of Theoretical and Applied Science 2025, 6(1),23-33.

Received: 10th Dec 2024
Revised: 11th Dec 2024
Accepted: 16th Dec 2024
Published: 20th Jan 2025

1. Introduction

Carbon dioxide is a colorless gas with acidic sharp odor at high concentrations, it dissolves in water and produce a weak acid called carbonic acid (H_2CO_3) [1] . CO_2 can be produced mostly through burning of fossil fuels (such as coal, oil and gas) and deforestation, the gas acts as blankets cover the surface and keeps it warmer that it would be otherwise, because it absorbs the infrared radiation emitted by the surface of Earth. This is called the 'greenhouse effect [2].While all the carbon-containing fuels produce CO_2 , only the poor combustion produces BC which is commonly known as soot, that absorbs visible light, transfers the energy to the atmosphere and prevents sunlight of reaching the ground [3].After the industrial era the ratios of CO_2 increased and reached the highest levels recorded which equal in April 2023 to (419 ppm) [4], it causes a directly health effects in which at low carbon dioxide concentrations, the breathing rates increase and skin becomes better and flushed. But with more exposure, and exhausting breathing occurs causing headache, faintness and loss consciousness. Nobody can enter area with more than 3 percent carbon dioxide without special equipment of breathing to prevent adverse effects like causing asphyxiation quick without any warning [5]. The health impacts of particles such as black carbon in soot are influenced by their sizes and the substances they carry on their surfaces. These particles range from ultrafine (less than 0.1 μm) to fine (approximately 2.5 μm and smaller), with the smaller ones generally posing greater health risks. After being inhaled, particles larger than 4 μm and those smaller than 0.002 μm are more likely to settle in the mouth and throat, while particles sized between 0.002 μm and 0.2 μm can reach the alveoli in the lungs [6]. Although the sole source of black carbon (BC) production is the combustion of biomass and fossil fuels. (since it is produced by incomplete burning), The impacts of black carbon (BC) vary depending on its various forms. Any mechanism which is efforts aimed at decreasing black carbon (BC) emissions should be aimed in all combustion processes [7].There are many techniques to decrease carbon dioxide ratios including marine microalgae fixation [8], separation by membranes [9], underground storage [10], chemical looping combustion [11], and terrestrial vegetation [12]. The chemical techniques are widely used because of its advantages like high absorption efficiency, simple and high economic value [13] . This document will show an economic way with high efficiency to reduce CO2 gas and BC produced by combustion of carbon-containing materials via chemical-physical way with alkaline solution NaOH, Ca(OH)2 and the cyclone separator model in a mechanical effective method. The study is characterized by low cost and economic feasibility achieved from the work. The materials used are inexpensive and readily available.

2. Materials and Methods

2.1. Instrumentation

1. Vacuum pumps
2. Liquid filtration equipments
3. Digital balance.
4. Fossil fuels burning source.
5. Water pumps
6. Plastic beakers.
7. Iron and plastic pipes.
8. Plastic connecting tubes.
9. Cyclone separator.
10. Soot and CaCO3 collecting chambers.

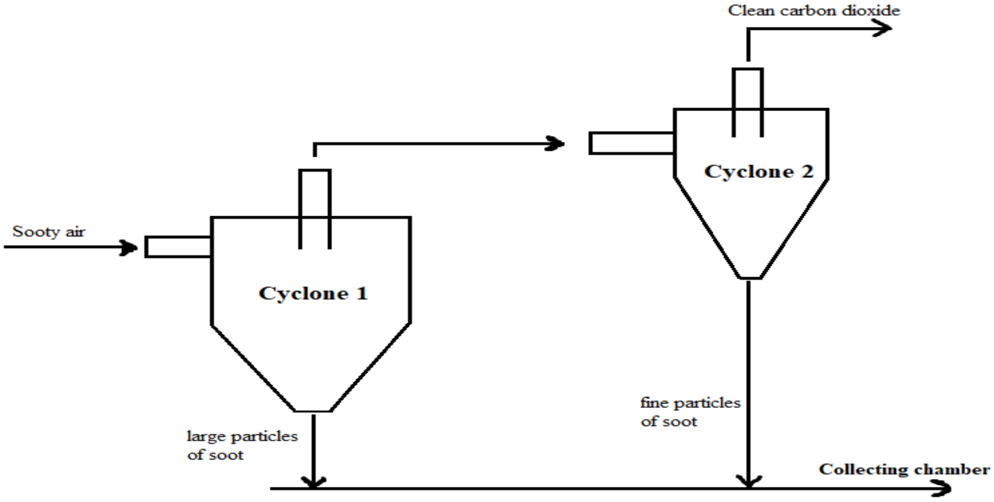
2.1.2. General Reagents

1. Sodium hydroxide.
2. Calcium hydroxide.
3. Black carbon (BC).
4. Carbon dioxide.
5. Distill water.

2.2. Preparation Methods of Stationary Phases

2.2.1. Physical Method

Cyclone separators offer an economical and low-maintenance approach to eliminating particulate matter from air or gas streams. Cyclones function as centrifugal separators, comprising an upper cylindrical section called the barrel and a lower conical section known as the cone. Their primary function is to convert the inertia force of gas particle flows into centrifugal force through the creation of a vortex within the cyclone body [14]. So here we use cyclone separator in order to separate BC from CO2 , it is a very effective method to separate the very fine particles like soot from the air. Depending on the separated particles, the density of air, and the load on the cyclone, you can decide either to use a single cyclone or series multiple cyclones. Here, it is better to use a combination of two cyclones in series in which the first one is for the large particles of BC, and the other for the fine ones because the overall optimized two-stage cyclone separator has the advantages of high efficiency, low energy consumption and load-balanced separation performance [15]. Then soot this collected in large amounts to be compressed into molds that could be stored or used in different applications. See figure (1):



Scheme 1: Physical process its two stage cyclone separator.

2.2.2. Chemical Method

2.2.2.1. Chemical reactions

CO2 can be captured by absorbing it into NaOH aqueous solution [16]. Therefore the mechanism for the reaction between CO2 gas and NaOH solution is as follows:
The NaOH is ionized in water and be Na+ and OH- , and then CO2 gas is absorbed to be CO2 in aqueous state [17].

$CO_2 (g) \rightarrow CO_2 (aq)$ ………. Eq (1)

$CO_2(aq) + OH^- \rightleftharpoons HCO_3^-(aq)$ ……….Eq (2)

$HCO_3^-(aq) + OH^- \rightleftharpoons H_2O(l) + CO_3^{2-}(aq)$ ………. Eq (3)

$CO_3^{2-}(aq) + 2Na^+ \rightarrow Na_2CO_3 (aq)$ ………. Eq (4)

Hence, the overall reaction would be :

$CO_2 (g) + NaOH(aq) \rightarrow Na_2CO_3 (aq) + H_2O(l)$ ………. Eq (5)

Here, carbon dioxide absorption is directly proportional to the NaOH solution concentration [18], So we prepared a solution of 5M (molar) concentration more concentration means more absorption- then after the absorption done, we reacted the product of eq.5 with calcium hydroxide $Ca(OH)_2$ as the equation :

$Na_2CO_3 (aq) + Ca(OH)_2 (s) \rightarrow 2NaOH(aq) + CaCO_3 (s)$ ………. Eq (6)

We did this reaction for three reasons:

1- To reduce the cost because the sodium hydroxide is more expensive that calcium hydroxide.
2- To ease the filtration process since $CaCO_3$ is a precipitate and it is very easy to be filtrated using simple filtration techniques.
3- To decrease the time needed for the filtration process , see figure (1).

2.2.2.1.1. Test for sodium carbonate Na_2CO_3 (aq)

From equation (5) above which indicated that the reaction between CO2 gas and NaOH will give us sodium carbonate soluble in water , to test if this resulted or not , we used two chemical analysis methods for testing according following :

2.2.2.1.1.a. Detection for carbonate anion

In qualitative analysis this we detected by adding dilute acid from HCl (1 M) to the compound. Carbonate anions reacted with hydrogen ions of acid to form CO2 , see figure (2).

$CO_3^{2-} (aq) + 2H^+(aq) \rightarrow CO_2 (g) + H_2O(l)$ ………. Eq (7)

We took the produced CO_2 and react it with water, CO_2 with will turn it cloudy after their reaction together as an indication of forming calcium carbonate white precipitate insoluble in water.

$$CO_2\,(g) + Ca(OH)_2\,(aq) \rightarrow CaCO_3\,(s) + H_2O\,(l) \qquad \ldots\ldots\ldots.\ \text{Eq}\ (8)$$

2.2.2.1.1.b. Detection for sodium by flame

We used flame test with easily for sodium detection. First we cleaned the platinum rod by dipping it into hydrochloric acid, then we brought our sample (which we think its sodium carbonate) and burn it by Bunsen burner, it gave us a golden yellow color that indicates the presence of sodium in the compound.

2.2.2.1.2. Test for calcium carbonate $CaCO_3$ (s)

In same way that used in the test of sodium carbonate, calcium carbonate in equation (6) that precipitates in the bottom is tested as follow:

2.2.2.1.2.a. Detection for carbonate anion

As in section (2.2.2.1.1.a.), carbonate anion is detected by adding dilute HCl (1 M) into the salt (as equation 7 indicates) the result is carbon dioxide gas that can react with lime water and make it cloudy because of the precipitant (as in equation 8).

2.2.2.1.2.b. Detection for calcium

By using the same equipment's used in sodium test , Flame test for the sample gave us orange-red color that indicates there is calcium in the sample , as with carbonate test and equation (6) from which we got the compound , we can say that the compound is calcium carbonate salt

Figure 1
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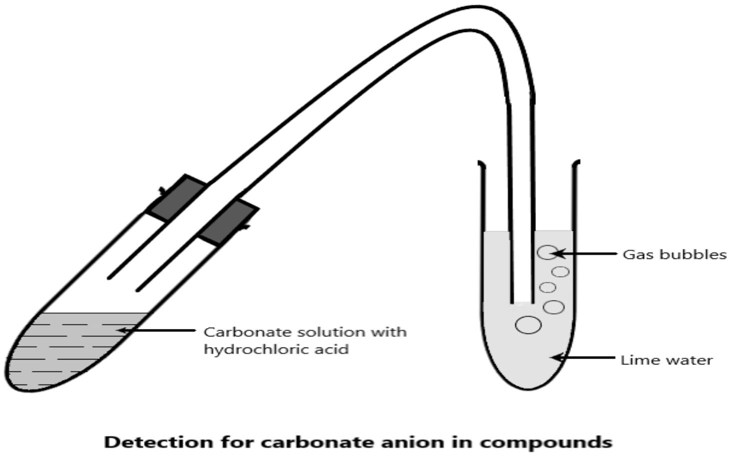
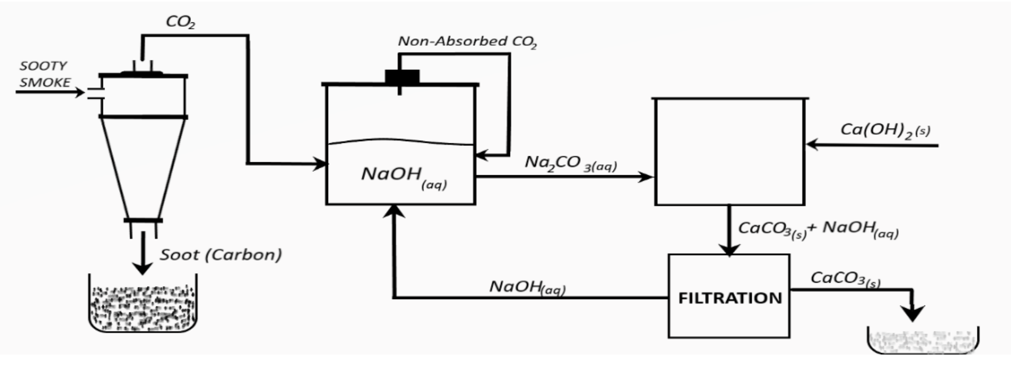


Detection for carbonate anion in the samples.



Scheme 2: Stages of removing BC and carbon dioxide from the atmosphere.

Figure 2: Samples of soot BC.

Figure 3: Calcium carbonate products.

3. Results and discussion

3.1. Processes Characterization of carbon material

3.1.1. Scanning electron microscope (SEM)

SEM figures were conducted using usually a JSM model 6510 to observe the morphology of the carbon samples. The magnifications used were the magnifications used were free size x, 200nm, 1μm, and 5μm is image from review articles for different samples. The carbon samples were dried for 2 hours at 110–120 °C. The SEM figures show the porous structure of the adsorbent materials, providing a clear visualization of their characteristics. As show in figure 5, 6, 7 and 8.

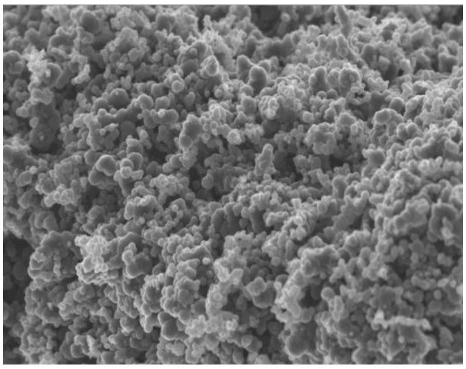


Figure 5: SEM image of BC at free size BC [19].

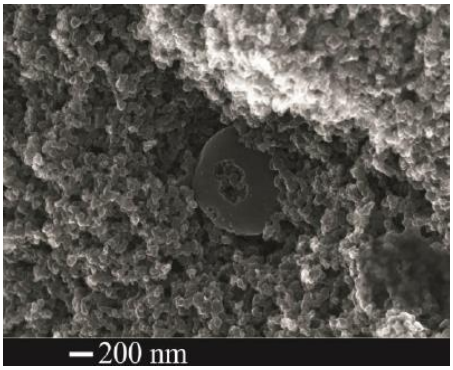


Figure 6: SEM image of BC at 200 nm [20].

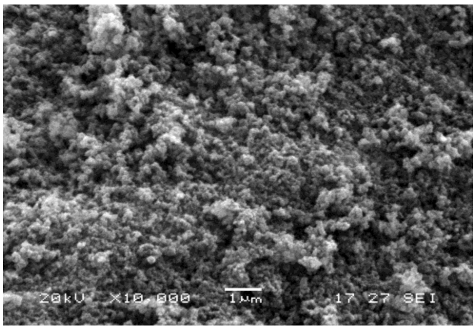


Figure 7: SEM image of BC at 1μm [21].

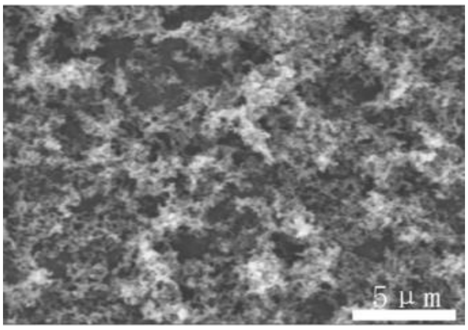


Figure 8: SEM image of BC at 5μm [22].

FTIR spectroscopy:

FTIR spectra were show in the range of (4000 to 100) cm-1 using a Mattson 4000 FTIR spectrometer. Discs were prepared by initially mixing 1 mg of dried carbon sample with 500 mg of KBr (Merck for spectroscopy) , followed by pressing the resulting mixture at 5 tons/cm2 for 5 minutes and 10 tons/cm2 to an otherwise 5 minutes down vacuum.

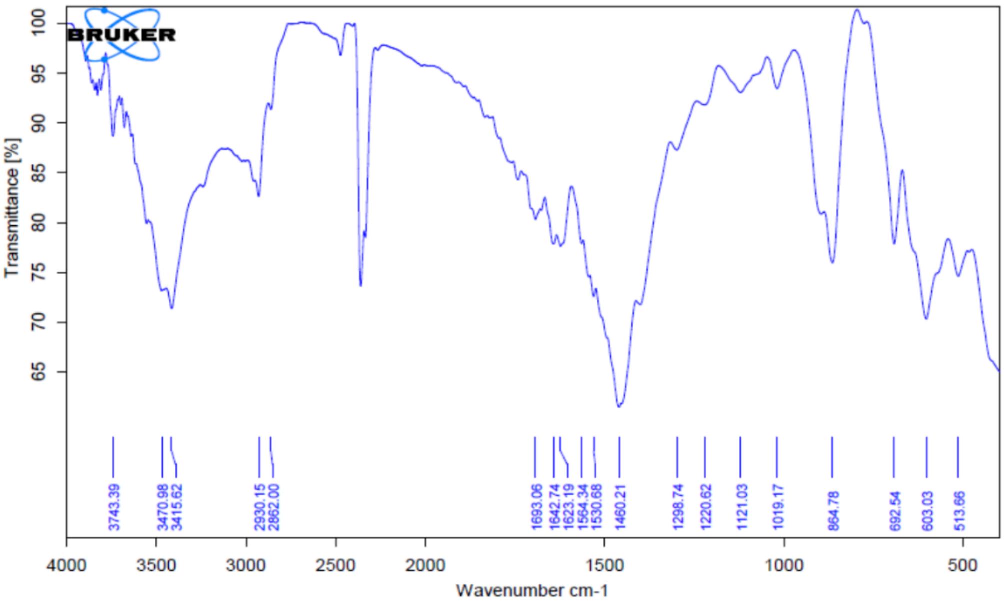


Figure 8: FTIR spectrum of calcium carbonate $CaCO_3$.

Fig (8) and table (1) shows FTIR spectra for samples ($CaCO_3$). Observation of the absorption bands show to calcium carbonate [23 - 26].

Table 1 :shows FTIR spectra for samples ($CaCO_3$).

3.1.3. Surface area measurement:

Function group	**Wave Number (Cm)**
O-H stretching mode of hexagonal group	(3415-3470) cm^{-1}
(C-H) Aliphatic	(2862-2930) cm^{-1}
C=C stretching in aromatic ring	(1693-1530) cm^{-1}
(C-C) Aliphatic	1460 cm^{-1}
C-O bonds such as those in ethers, phenols and esters.	(1300 -1000) cm^{-1}

The surface area of black carbon samples was compared at three different Z averages (Z-Average: 4204.7 nm PI: 1.576, Z-Average: 675.9 nm PI: 0.743, Z-Average: 578.7 nm PI: 0.954). The figure clearly shows that as the Z averages lowered, the surface area increased. This suggests achieving enhanced efficiency in the process of minimizing the percentage of materials that need to be disposed of. Black carbon samples with smaller particle sizes may exhibit higher porosity or roughness at the nano scale, leading to increased surface area per unit mass compared to larger particles. The surface area of the black carbon samples increases. This is due to the increased number of smaller particles contributing to the overall surface area. The decrease in Z averages observed in the samples correlates with an increase in surface area, likely influenced by the particle size distribution and uniformity within the samples [27]. These findings are crucial for understanding the properties and potential applications of black carbon samples in various fields.

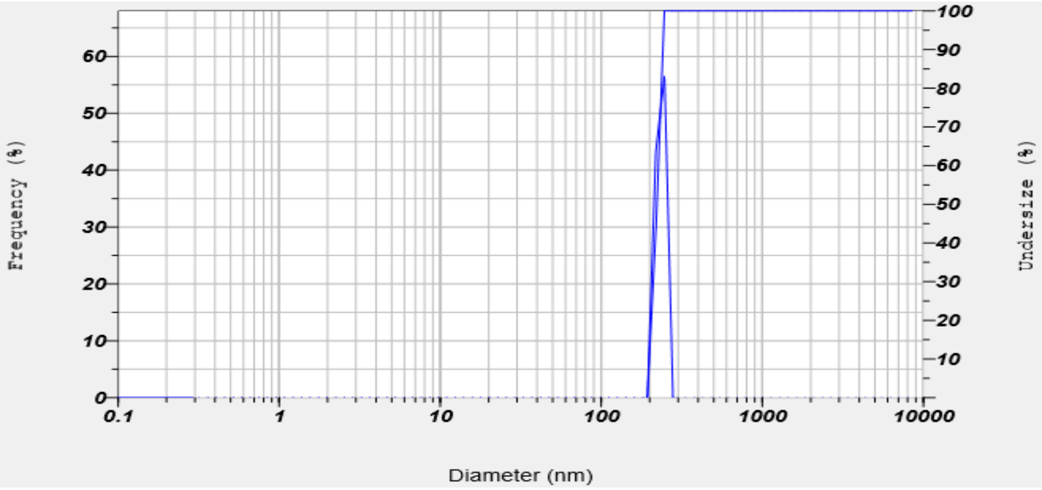


Figure 9: The surface area pattern of the CA sample at Z-Average : 4204.7 nm PI : 1.576

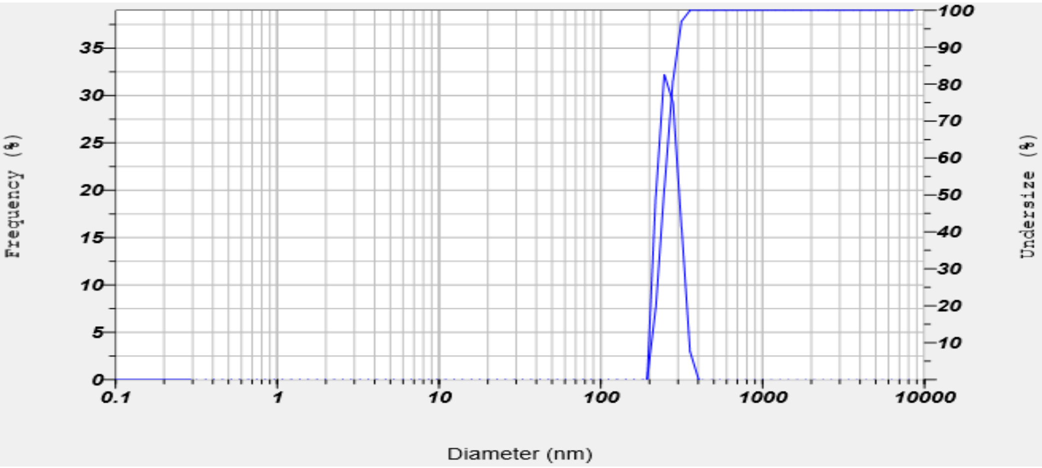


Figure 10: The surface area pattern of the CA sample at Z-Average : 675.9 nm PI : 0.743

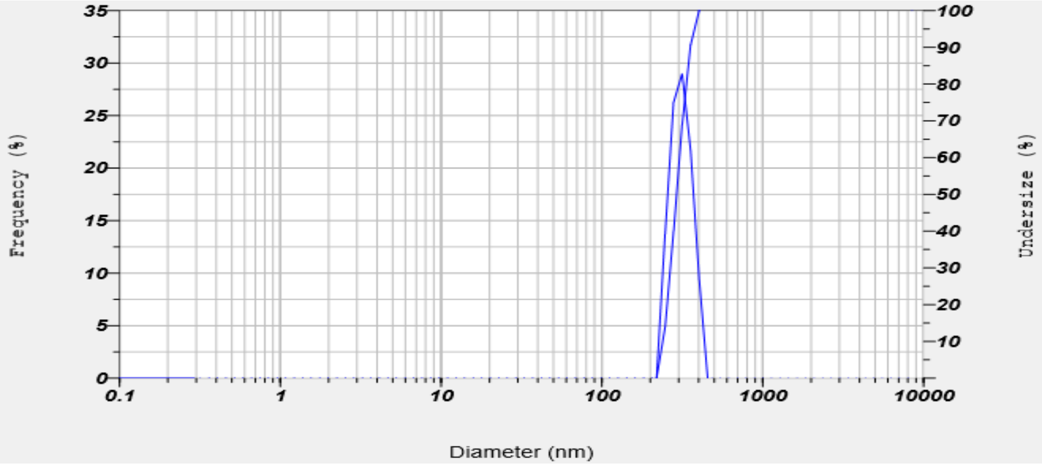


Figure 11: The surface area pattern of the CA sample at Z-Average : 578.7 nm PI : 0.954.

3.1.4. XRD pattern of CA sample:

The XRD patterns of CA sample showed in figure (3-11) has been observed different shapes of diffraction phases become clear at 35 , 57 and 63 This means that there is a significant decrease in the content of the substance, then it increases again significantly at 35, after that the decrease continues, and it increases at 57, then it decreases, and finally it increases at 63.

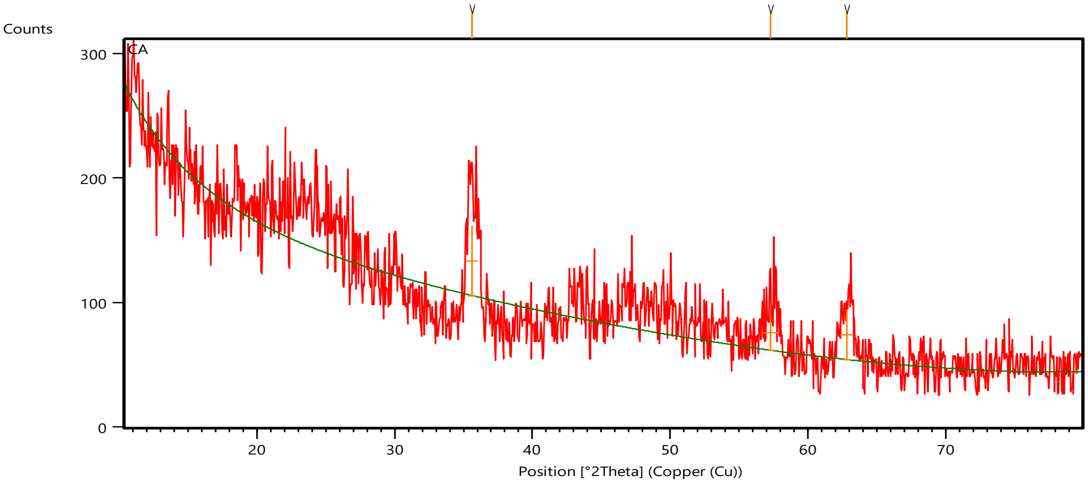


Figure 12 : The XRD pattern of the CA sample.

The crystallite size D and strain ε are determined using both the Scherrer method and Williamson-Hall methods in this study. The Scherrer equation, commonly employed to estimate D based on diffraction peak profiles, may be less accurate when the instrumental broadening, indicated by the full width at half maximum (FWHM), surpasses the physical broadening [27].

The typical approach in the Scherrer Equation involved computing crystallite sizes and then averaging them. Table 2 displays the data utilized for determining the average crystallite sizes according to the Scherrer equation [28,29]. According to table 2 :
Table 2: Calculated crystallographic parameters of the XRD pattern for the Black Carbone.

Pos. [°2Th.]	**Height [cts]**	**FWHM Left [°2Th.]**	**d-spacing [Å]**	**Rel. Int. [%]**	**Tip Width**
35.64(2)	56(3)	0.88(6)	2.51730	100.00	1.0603
57.32(4)	27(7)	1.06(9)	1.60605	48.92	1.2755
62.83(3)	40(6)	0.91(5)	1.47781	71.55	1.0953

3.2. Influencing factors

3.2.1. Effect of interaction period

The longer the period of time allowed for the reacting materials to be in direct contact with each other for a long period, the better the reaction will be, and thus the expected products will be the best if the conditions for the reaction are ideal. Of course, this is in the case of irreversible reactions. This is what is achieved in the reactions that are relied upon. This research, as we notice clearly in the figure (13). We find that the mass of carbon formed increases gradually with increasing time and reaches its maximum value at 60 minutes. It is noted that the mass of carbon absorbed from carbon-contaminated air within 60 minutes and deposited on the absorber filter is approximately 50 grams.

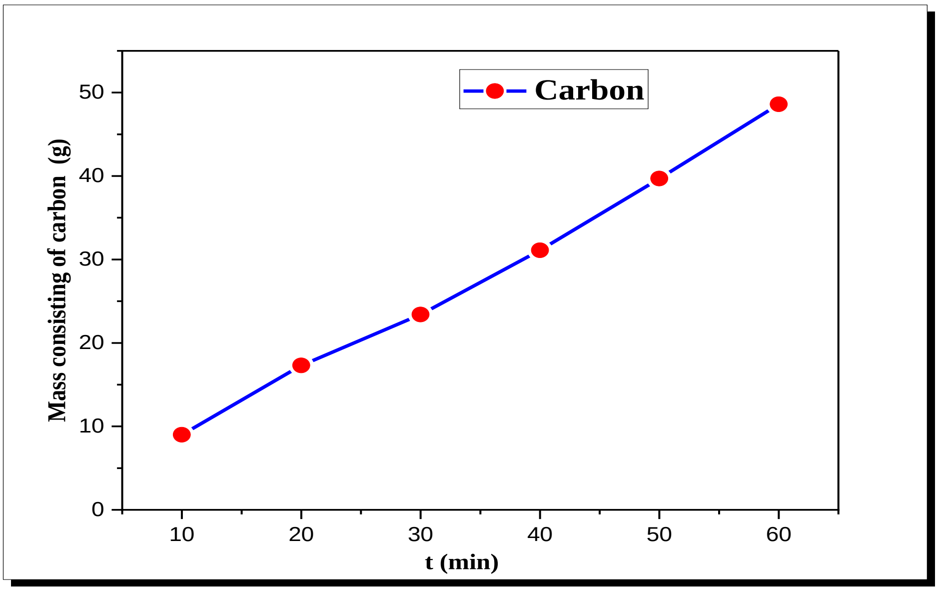


Figure 13: Effect of interaction period

3.2.2. Effect of reagents concentrations

This research depends mainly on the reagents used in it, as they have an important role in the sedimentation processes as well as in the separation processes, which are considered the main focus on which the research is based. As is clear in the figure (14), we find that the greater the mass of the reagents used of (NaOH), the greater the mass of the precipitating salt of Na2CO3 to result in first flask and moved to second flask the contains Ca(OH)2 . In addition to increasing the mass of calcium carbonate moved from second flask, as a result of the reaction of calcium hydroxide (added in an increasing amount) with the sodium carbonate moved from the first flask. In the form of sodium hydroxide and calcium hydroxide , the highest mass is precipitated at a mass of 500 grams of sodium carbonate and calcium carbonate [30,31] .

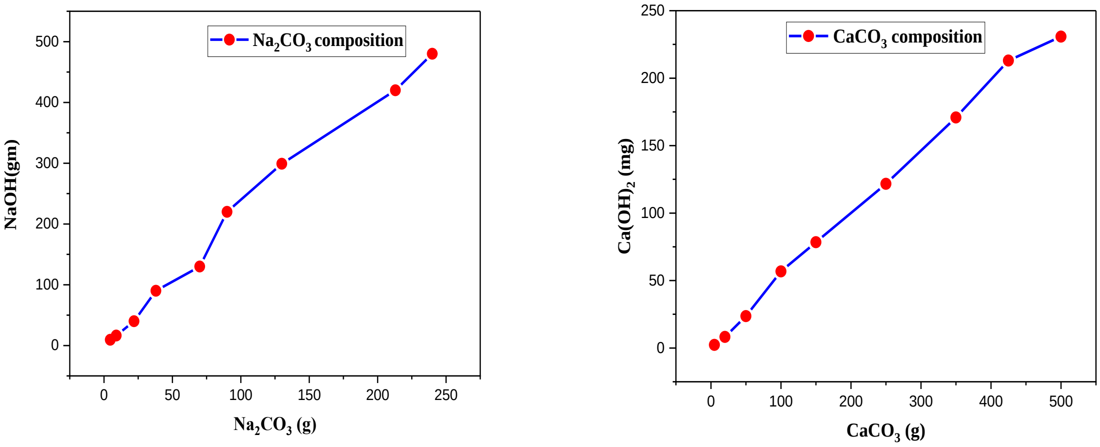


Figure 14: Effect of reagents concentrations for salt composition Na2CO3 and CaCO3.

4. Conclusion

It can be concluded from this research that some air pollutants, represented by black carbon and carbon dioxide, are removed using appropriate chemical reagents that are characterized by their abundance, ease of obtaining, and low cost, meaning they have economic feasibility. The time consumed was very little, and these reagents are (sodium hydroxide and calcium hydroxide), which were Precipitation of pollutants in the form of a precipitate that can be easily separated. As the study showed the amounts of carbon deposited in the smoke puller used, every 1 minute gives 1 gram of carbon . The deposited carbon can be used by adding a commercial silicate resin, compressing or compressing it, and forming cubes of coal for various commercial uses. We noticed that the amount of sodium carbonate formed in the first decanter increases with time and with the flow of carbon dioxide from the puller to the first decanter. Where the amount of carbonate formed was 1 g per 1.5 g sodium hydroxide used . In addition to the amount of calcium carbonate formed in the second decanter, it also increases with time and with the flow of sodium carbonate from the first decanter to the second decanter . The amount of calcium carbonate formed was 1.5 g per 2 g calcium hydroxide used in the second decanter . It can be made excellent use of salts formed in the laboratory and commercial works.

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