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Article

# Treatment of Poisoning Cases from Certain Narcotic Substances Using a Nanocomposite

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**Abstract:** This work focuses on the development of new type of activated carbon produced from waste branches of Melia azedarach collected in Samarra city. Characterization studies demonstrated that the prepared carbon is in nanometer size. The microparticle sizes were confirmed to be smaller than 100 nm by X-ray diffraction and specific sizes of 7.48 nm, 6.06 nm, and 2.71 nm were obtained. The free vibration peak in FT-IR did not appear, which showed that the activated carbon was chemically inactive. The SEM images for the particles at 10 μm and 200 nm scale indicated that the particles consisted of abundant pore structure like transparent, thin, folded, and fluffy sheet. Energy-dispersive X-ray spectroscopy indicated the high carbon content of the synthesized material. The fabricated carbon was used in the adsorption of Chlorpheniramine from aqueous solutions. Adsorption mechanism was investigated using Freundich and Temkin isotherm, and the result showed that the Freundlich model, whose correlation coefficient ($R^2$ = 0.9993) was closer to unity than the Temkin model ($R^2$ = 0.982). The thermodynamics study revealed that the process of adsorption is spontaneous ($\Delta G^o < 0$), with falling in randomness ($\Delta S^o < 0$) and that it is exothermic ($\Delta H^o$ = -60,535.9 J/mol). Moreover, the kinetic study revealed that the adsorption was of pseudo-first-order type.

**Keywords:** Nanocomposite, Poisoning, Melia Azedarach, Activated Carbon

## Introduction

Drugs are chemical substances that directly affect the central nervous system, leading to changes in perception, awareness, mood, and behavior. These effects occur by disrupting the balance of neurotransmitters in the brain, such as dopamine, serotonin, and norepinephrine. The mechanism of addiction is based on the disturbance of this natural neurotransmitter balance. Drug use causes overstimulation of the brain's reward system, initially resulting in feelings of euphoria and comfort, but later leading to psychological and physical dependence due to structural changes in the brain[1]. Addiction progresses through several interconnected stages. It begins with experimentation, where an individual tries the drug for the first time out of curiosity or due to social pressure. This stage is commonly associated with adolescents and young adults, whose prefrontal cortex is not yet fully developed, making them more impulsive and less capable of assessing risks. With repeated use, the individual enters the stage of regular use, characterized by drug consumption in specific situations or under psychological stress[2]. During this phase, the reward system becomes increasingly active, and the brain starts to reduce its natural dopamine production due to continuous artificial stimulation. Over

time, the individual transitions into the dependence stage, where the body can no longer function normally without the drug. Withdrawal symptoms, such as anxiety, insomnia, tremors, sweating, and gastrointestinal disturbances, emerge when trying to stop drug use. Eventually, the person reaches the final stage—full addiction[3]—characterized by complete loss of control, where the drug becomes a central priority in the person's life[4].

Green chemistry was introduced in the United States in 1990 following the enactment of the Pollution Prevention Act, which aimed to protect the environment by reducing harmful emissions from chemical reactions. As a result of this legislation, the U.S. government provided grants to develop chemical products through various institutes and universities, aiming to minimize the risks of chemical substances. These grants later expanded to include the development of environmentally friendly chemical compounds that reduce pollution and offer alternatives to traditional chemicals whose extraction processes harm the environment.

Green chemistry seeks to transform chemistry into an integrated science by minimizing pollution generated from pharmaceutical, petroleum, and plastic industries[5]. Researchers and scientists use various terms to describe green chemistry, such as safe chemistry, sustainable chemistry, clean chemistry, environmentally friendly chemistry, harmless chemistry, or benign chemistry. Despite the different terminologies, they all converge on the same concept agreed upon in both Arabic and international literature: Green Chemistry refers to the design of chemical substances, products, and processes that aim to reduce or eliminate the use and generation of hazardous materials. Green chemistry also strives to provide innovative solutions to environmental issues and to reduce the negative impact of chemical processes and products on human health and the environment. Its principles are applied throughout the entire life cycle of a chemical product, from design and manufacture to usage and final disposal[6]. The main objectives of green chemistry include enhancing energy efficiency in chemical processes, reducing waste generation, and producing innovative products that require smaller amounts of natural resources. Additionally, it seeks to develop alternative reaction methods and pathways, thereby helping to create materials and products that meet current needs while preserving the interests of future generations[7].

## Materials and Methods

### Materials Used

The drug (Chlorpheniramine) was obtained from the Pharmaceutical Laboratory in Samarra. Sodium hydroxide (0.1 N) was supplied by Merck. Concentrated hydrochloric acid was purchased from B.D.H. Ethanol (99%) was provided by Scharlau. Deionized water was also obtained from the Pharmaceutical Laboratory in Samarra.

1. Instruments and Equipment
2. Muffle furnace: Carbolite
3. Analytical balance (accuracy up to four decimal places): Sartorius Lab-BL 210S
4. Drying oven: Temaks Model 104544 NO—S
5. X-ray diffractometer: Model 6000
6. Scanning Electron Microscope (SEM): Model AI2300C
7. Fourier-Transform Infrared Spectrophotometer (FT-IR): IR IS-Affinity
8. Energy Dispersive X-ray Spectroscopy (EDX): Penta FET Precision
9. UV-Visible Spectrophotometer: Model PC1650
10. Shaking Water Bath: Model YCW012S

### Preparation of Activated Carbon

A total of 10 grams of powdered tree branch residue was weighed and placed in a ceramic crucible. It was then mixed with 10 mL of sodium hydroxide solution (0.1 N), and the mixture was stirred using a glass rod. The mixture was then subjected to carbonization in a muffle furnace at 650 °C for two hours to obtain activated carbon[8].

The resulting char was ground using a ceramic mortar to obtain fine granules. These granules were washed with distilled water and filtered using a filter paper with a pore size of 150 μm to remove ash. Subsequently, 10 mL of hydrochloric acid (0.1 N) was added to neutralize the residual sodium hydroxide and to eliminate any remaining chemical residues. The sample was filtered again and washed repeatedly with distilled water to remove excess acid and base.

The washed carbon was dried in a drying oven at 100 °C for one hour to eliminate moisture. The dried activated carbon was then ground into fine particles. The resulting powder was sieved using mesh sizes of 500 μm, 800 μm, and 1000 μm. These fractions were used as adsorbent materials after determining the most suitable particle size for adsorption.

## Results and Discussion

### Fourier Transform Infrared Spectroscopy (FT-IR)

The FT-IR analysis of the activated carbon revealed the absence of significant functional groups. A noticeable shift in the O–H stretching absorption was observed at 3430 $cm^{-1}$, which may be attributed to oxygen deficiency between molecules[^source]. The C=O group showed an absorption peak at 1736 $cm^{-1}$, while the C=C group was detected at 1631 $cm^{-1}$. Additionally, absorptions for the C–N group at 1269 $cm^{-1}$ and the C–O group at 1113 $cm^{-1}$ were observed. Figure (1) illustrates that the prepared carbon lacks chemically active groups, indicating that the surface is chemically inert. This is a favorable property for adsorption processes, particularly in drug adsorption applications.

### X-ray Diffraction (XRD)

XRD is one of the most widely used techniques for confirming the formation of nanostructured materials by determining their crystallinity and particle size. Sharp and well-defined peaks indicate a crystalline structure, whereas broad and overlapping peaks suggest an amorphous material. Using Miller indices, the crystal structure—such as cubic or cylindrical—can be identified based on the lattice planes. Furthermore, the Debye-Scherrer equation was applied to calculate the average particle size of the nanoparticles, as shown in Figure (2) and Table (1)[9].

### Energy Dispersive X-ray Spectroscopy (EDX)

According to Figure (3) and Table (2), carbon was the dominant element in the activated carbon sample, with a concentration of 96.81%, followed by oxygen (3.07%) and sulfur (0.12%). The high carbon content confirms the efficiency of the carbonization process and supports the material's suitability for adsorption applications[^10], as shown in Figures (3–4).

### Scanning Electron Microscopy (SEM)

SEM analysis revealed significant variation in the particle sizes and pore structures of the adsorbent material. The SEM images showed various morphologies of the carbon particles, including transparent and thin layers, semispherical shapes, and spherical structures with fluffy and folded textures, which are characteristic features of the synthesized nanocarbon material[11], as shown in Figures (4) and (5).

### Chlorpheniramine Drug Preparation

A standard solution of chlorpheniramine was prepared at a concentration of 400 ppm by dissolving 0.04 g of the drug in deionized water and diluting it to 100 mL in a volumetric flask. From this stock, a series of diluted solutions with concentrations ranging from 5 to 50 ppm were prepared.

### Determination of λmax and Calibration Curve

The wavelength corresponding to the maximum absorbance (λmax) was determined using a UV–Vis spectrophotometer in the range 200–800 nm, using quartz cells. The λmax for chlorpheniramine was found to be 270 nm. A calibration curve was established by plotting absorbance against concentration for eight standard solutions within the range of 5–50 ppm, and their absorbances were recorded at 270 nm.

**Determination of Equilibrium Time**

To determine the equilibrium time between the adsorbent and the adsorbate, 0.5 g of activated carbon was added to 20 ppm of chlorpheniramine in ten volumetric flasks. These mixtures were placed in a temperature-controlled shaking water bath at 25 °C. Samples were taken at regular time intervals and analyzed for concentration changes. It was found that 20 minutes was the optimal time to reach adsorption equilibrium.

**Effect of Temperature**

The drug solution was prepared at the optimal concentration of 20 ppm, and an equal amount of activated carbon was added to each sample. The mixtures were shaken at various temperatures: 17.5°C, 27.5°C, 35.5°C, and 47.5°C, and the actual temperatures were verified using a calibrated thermometer. After each temperature treatment, the solutions were filtered, and the absorbance was recorded, as shown in Figure (8).

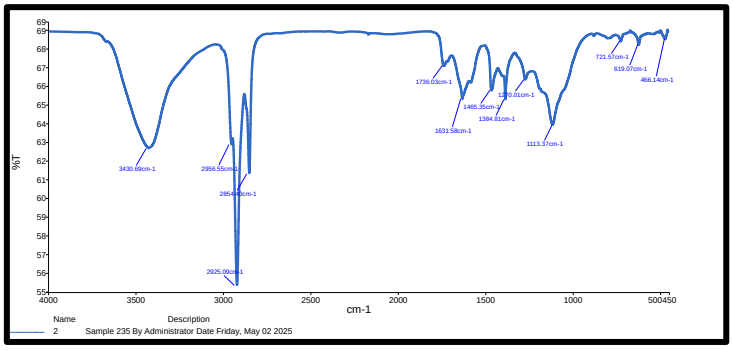


**Figure 1.** FT-IR spectrum of the prepared activated carbon.

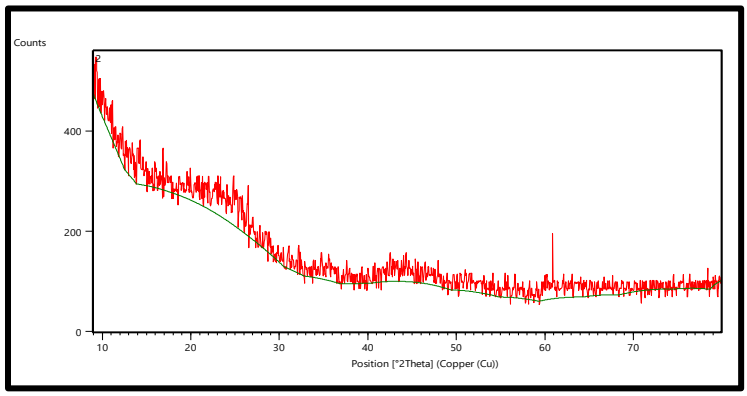


**Figure 2.** XRD pattern of the synthesized activated carbon.

**Table 1.** Data of the three strongest peaks in the XRD pattern of the synthesized activated carbon

| NO | 2Theta (degree) | I/II | FWHM |
|---|---|---|---|
| 1 | 62.1432 | 100 | 1.2463 |
| 2 | 16.9654 | 78 | 2.9770 |
| 3 | 24.6650 | 67 | 1.3421 |

**Table 2.** Elemental composition percentages of the prepared activated carbon.

| Element | Weight% | Atomic% |
|---|---|---|
| C | 96.81 | 95.64 |
| O | 3.07 | 4.04 |
| S | 0.12 | 0.32 |
| Totals | 100.00 | 100.00 |


**Figure 3.** EDX spectrum of the prepared activated carbon.

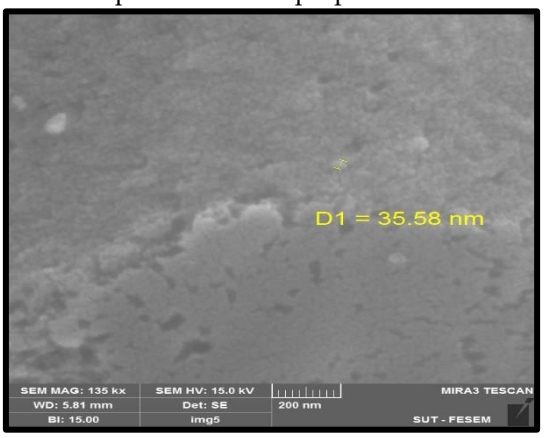


**Figure 4.** SEM image of the prepared activated carbon at a magnification of 200 nm

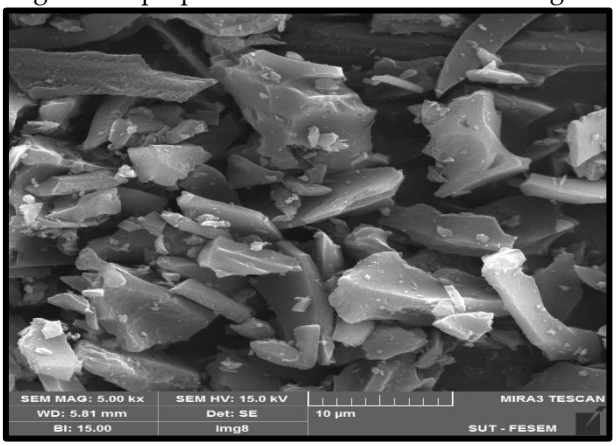


**Figure 5.** SEM image of the prepared activated carbon at a magnification of 10 µm.

**Adsorption Isotherm Determination**

To determine the adsorption isotherms of the drug (chlorpheniramine), five different concentrations of the drug were prepared in 100 mL volumetric flasks. Activated carbon (0.5 g) was added to each flask, and the mixtures were placed in a shaking water bath at room temperature. After reaching the equilibrium time (20 minutes), the solutions were filtered, and their absorbance was measured using a UV-Vis spectrophotometer at the maximum wavelength of the drug. The equilibrium concentrations (Ce) in mg/L were determined from the calibration curve, and the amount of adsorbed drug (Qe) in mg/g was calculated using Equation (1):

$$Qe = \frac{co-ce}{M} \text{ X V} \quad \text{.....(1)}$$

where MMM is the mass of activated carbon in grams (g), VVV is the volume of the solution in liters (L), C0C_0C0 is the initial drug concentration, and CeC_eCe is the equilibrium drug concentration.

**Freundlich Isotherm**

The adsorption data were analyzed according to the linearized Freundlich isotherm equation as shown in Figure (6) and Table (3).

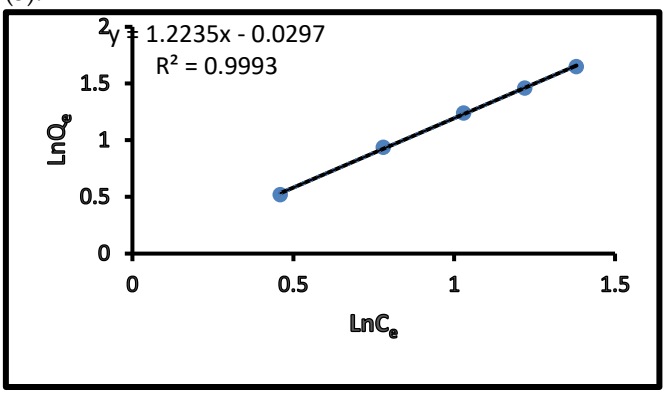


**Figure 6.** Freundlich Isotherm for the Adsorption System under Study

The Freundlich isotherm was applied to the adsorption data as shown in Figure (6). Additionally, the Temkin isotherm model was applied to the data, with results presented in Figure (7) and Table (4).

**Table 3.** Experimental Freundlich Constants and Correlation Coefficient Root Values for the Adsorption System under Study

| Kf(mg/g) | )L/mg(n | $R^2$ |
|---|---|---|
| **1.02** | **0.68** | **0.999** |

**Table 4.** Experimental Temkin Constants and Correlation Coefficient Root Values for the Studied System

| $B_T$ | b(J/mol) | $K_T$(L/g) | $R^2$ |
|---|---|---|---|
| **3.8237** | **649.84** | 1.08 | **0.982** |

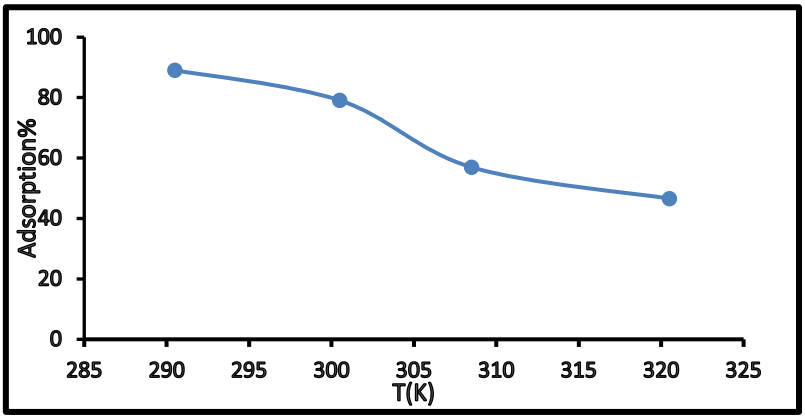


**Figure 7.** Temkin Isotherm for the Adsorption System under Study.

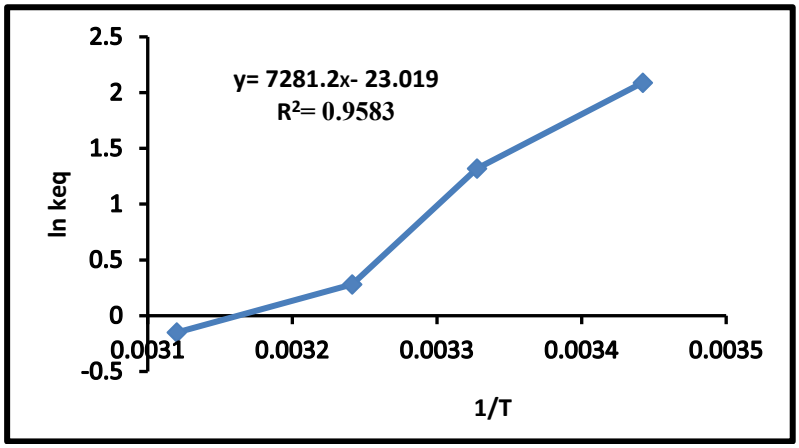


**Figure 8.** Decrease in Adsorption Efficiency with Increasing Temperature for Chlorpheniramine.

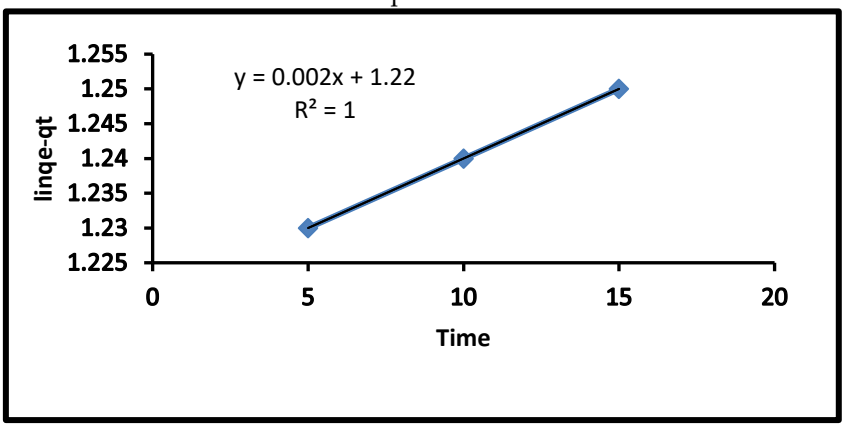


**Figure 9.** Van't Hoff Plot for the Adsorption of Chlorpheniramine on the Prepared Activated Carbon Surface.

**Table 5.** Thermodynamic Parameters for the Adsorption of Chlorpheniramine on the Surface of the Activated Carbon.

| T(k) | 1/T ($k^{-1}$) | ΔGº (kJ/mol) | ΔH (kJ/mol) | ΔSº (J/mol.k) |
|---|---|---|---|---|
| **290.5** | 0.003442 | -5060.42 | -60535.9 | -190.965 |

**Thermodynamic Study and Adsorption Kinetics**

From Table (5) and Figure (9), the negative values of enthalpy change (ΔH°) indicate that the adsorption of chlorpheniramine onto the surface of the prepared activated carbon is an exothermic process, and the interaction is physical adsorption in nature. This suggests that weak forces, such as Van der Waals interactions, are responsible for the adsorption process. Moreover, the negative values of the Gibbs free energy change (ΔG°) suggest that the adsorption occurs spontaneously under the experimental conditions. The decrease in ΔG° values with increasing temperature further supports the exothermic nature of the process. The negative entropy change (ΔS°) indicates a decrease in the randomness at the solid-solution interface during the adsorption. This suggests that the adsorbed molecules become more ordered and restricted in movement compared to their free state in the solution before adsorption. These observations confirm that the system becomes more structured as the drug molecules bind to the adsorbent surface [12].

Based on the results presented in Table (6) and Figure (10), despite the high value of the correlation coefficient ($R^2$), a comparison between the calculated theoretical adsorption capacity and

the experimentally determined capacity reveals only a slight deviation. This indicates that the adsorption process follows the pseudo-first-order kinetic model [13].

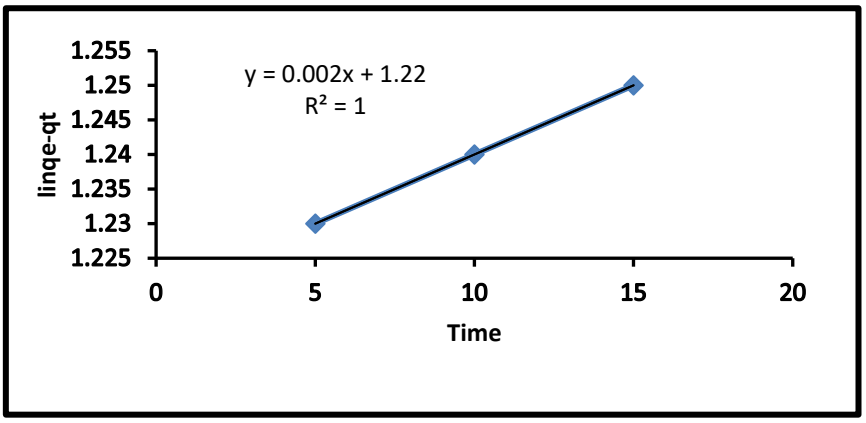


**Figure 10.** Application of the pseudo-first-order Lagergren model for the adsorption system under study.

**Table 6.** Parameters of the pseudo-first-order kinetic model for the adsorption system.

| Experimental($Q_e$) (mg/g) | Theoreetical($Q_e$) (mg/g) | $K_1$ ($min^{-1}$) | $K_{-1}$ ($min^{-1}$) | $R^2$ |
|---|---|---|---|---|
| **3.6** | **3.3** | **0.00161** | **0.00038** | **1** |

## Conclusion

Activated carbon was prepared from Melia azedarach tree branches ,The analyses showed that the prepared carbon has a nanostructured framework ,The adsorption process was spontaneous and exothermic,The prepared activated carbon was effective in removing chlorpheniramine ,The adsorption followed a pseudo-first-order kinetic model.

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