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Investigation of Fluorescence, Structural and Some Optical Properties of Silver Nanoparticles and Its Biological Application and Evaluation of Photocatalytic Dye Analysis Activity

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ABSTRACT

Silver nanoparticles (Ag NPs) were synthesized at room temperature using Hibiscus sabdariffa L as a green reducing agent. Characterization techniques including XRD, Raman spectroscopy, EDX, FE-SEM, FTIR, UV-Vis-NIR spectroscopy, and fluorescence spectrum were employed to analyze their structural, optical, and chemical properties. The average crystallite size of the nanoparticles was determined to be 48.64 nm using Scherer's equation. The FTIR spectra covered a range of 400-4000 cm-1, while UV-Vis-NIR spectroscopy revealed absorption in a wavelength range of (200-1100) nm. The fluorescence spectrum exhibited a peak wavelength of 450 nm. These silver nanoparticles hold immense potential for applications in sensors, electronics, medical devices, and more .The photo catalytic tests for samples prepared using methylene blue as a colorant were successful using silver nanoparticles , while the percentage of color degradation varied between the various samples , the percentage of degradation for all enamels after two hours of exposure to sunlight exceeded 90% which confirms the success of the photo catalytic process using silver Nano crystalline.

Keywords: Silver NPs, Green chemical method, Fluorescence spectrum, EDX, FTIR , Photo catalysis

1. INTRODUCTION

The interest and the interest of researchers drives them to the synthesis of nanomaterials while they were utilized for nany important applications in biomedicine , medicine delivery, cancer treatment, bio-imaging, molecular detection, and ather applications [1, 2]. Recently, an obvious consideration is paid to nanoparticles for their wide and extensive applications in various areas like catalyst, medicine, biomedicine, environmental, food, cosmetic industry, agriculture , wastewater treatment, optical and super capacitor [3, 4]. As the nanotechnology continues to evolve, works continue to find the best ways to produce nanomaterials with lower cost and better specifications. The properties of a nanomaterials change by changing its size, shape, particle distribution and quantification. Nowadays, it is possible to engineer properties and size of the nanomaterial's in as wide scale of properties to enhance and widen the applications of nanomaterials in diverse fields of technology[5]. Nanoparticles plays an important role in different fields, such as biology, medicine, agriculture, cosmetics and engineering[6]. Silver nanoparticles were synthesis using Hibiscus sabdarriffa L plant, this biological method of parathion is a green and effective way to prepare nanoparticles[7, 8]. Nanocatalysis it is avery important fieldof research area that is developing swiftly which makes the using these nanomaterials as catalysts in many homogeneous catalysis applications , and heterogeneous catalysis applications very essential. Particularly, these photocatalysts which are based on nanoparticles , are considered among the based and most important environmentally friendly agents [9, 10]. There are several ways to prepare nanoparticles, the powder nanoparticles are usually resulted from physical methods while other forms of nanoparticles such as colloidal solutions is prepared by chemical methods[11]. There are many methods for preparing nanomaterials, the nanomaterials based on green

method are promising as an alternative chemical method due to its ease of use and eco-friendliness. The most desired advantage of nanoparticle biosynthesis is that the outer surface of the nanoparticles is free of toxic substances[12, 13]. The plants like Hibiscus rosasinensis is one of the plants which showed an accepted suitability for the synthesis of nanoparticles[14].The plant extracts have succeeded in manufacturing large quantities of silver nanoparticles , and these nanoparticles have been used in many fields due to their excellent electrical , thermal and optical properties , as well as being anti – bacterial, antimicrobial, virus, and fungal properties, there are many silver nanoparticles applications such as conductive inks, pastes ,fillers ,biosensors[15], photo catalysis, and nuclear medicine[16], which improves silver nanoparticles due to their their high electrical conductivity and low sintering temperatures . Additional applications include optical devices and molecular diagnostics . Silver nanoparticles synthesized by plant extracts have shown marked antibacterial effects. Silver nanoparticles are famous as antibacterial agents it makes it depentrate the living cell wall easily which leads to a significant change in the structure of the cell membrane through the continuous release of silver ions [17]. In the present work, the aim is to prepare nanomaterials by use the green method as a nontoxic, easy and cheap method . another important application of silver nanoparticles is in treating water pollution , Water pollution is a serious problem that affects life on earth . it makes it very difficult , especially since water is the main and important lifeblood for humans , animals and plants , water pollution is one of the serious problems that affects life on the serious of the earth , making it very difficult , especially since water is the main and important lifeblood for humans , animals and plants , and water pollution is any chemical or physical change in the quality of water , whether directly or indirectly . which has a negative impact on all living organisms **[18]** pollution is one of the things that leads to the depletion of very large amounts of dissolver oxygen in the water , which leads to a decrease in the number of aquatic organisms , the increases in the proportion of chemicals in the water makes it toxic , which leads to reducing its value as a source for human consumption , contaminated substances are substances or microbes that harm humans and cause many diseases , contaminated substances are foreign substances whose percentage has exceeded acceptable levels **[19]** water treatment using nanotechnology (water desalination , chemical treatment and ultraviolet treatment) , it leads to providing pure drinking water and reducing pollution , this includes three mechanisms photo catalysis , Nano filtration , and electrochemical oxidation . the use of nanomaterial's to treat water is considered more effective and efficient than using catalytic materials , as a result of their being characterized by a larger surface area for contact with the reacting materials , this method photo catalysis involves reactions activated by sunlight to destroy pollutants and living organisms . this is done using a photo activating substance , and silver nanoparticles have shown superior effectiveness against bacteria(*E.coli, Staphylococcus aureus bacteria*)**[20]** .

2. MATERIAL AND METHODS

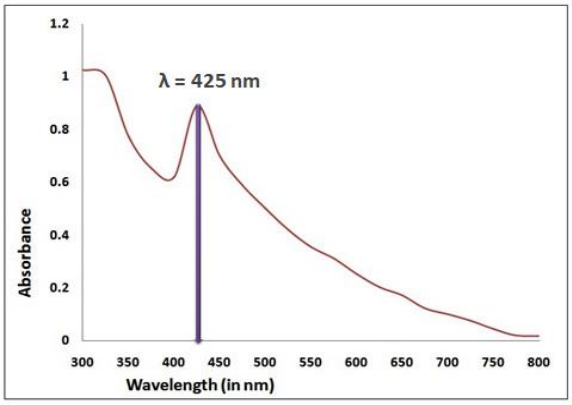
A quantity of Hibiscus sabdarriffa L plant was collected, washed well with deionized water and cleaned well, the leaves of the plant are collected and placed in a beaker, and water free of ions is added to it to clean it of suspended dust and dirt, and then dried well , crushed and weight about (155) gm of the plant. Later, (100) ml of ethanol was added and left for the next day. Then it was filtered by filter papers to get rid of plant residues, and (600) ml of silver nitrate solution was added to it . It is noticed that the color color of the solution has chang from light pink to dark pink as an clear and definitive evidence of the formation of silver nanoparticles .methyl blue dye was also prepared , Methyl blue dye is a cationic dye coloring agent , and its chemical formula is ($N_3Mc_{16}H_{18}Cs$) , its molar mass is 319.85 g/mole , and it is an organic molecule that is dark green in nature , and when in contact with water it turns blue , the methylene blue solution is prepared by dissolving 5 mil of solid methylene blue powder in 1 liter of distilled water , then we take four test tubes and put 4 mil of methylene blue solution in each tube and put 15.7 mil of the sample , and in each once we change the temperature , we then notice that the samples , and this is evidence of the MB formula under sunlight.

3.RESULTS AND DISCUSSIN

- **3.1 UV-Visible** absorption **Spectrum of silver nanoparticles**

UV-Visible spectrometry refers to absorption spectroscopy or reflectance spectroscopy in apportion of the ultraviolet rays and the adjacent full spectral

regions. Ultraviolet spectroscopy is based on measuring the energy of electromagnetic rays absorbed by some organic compound at wave length located in the range (200-380) nm. The results of the visual radiological examination of the extract of the Hibiscus sabdarriffa L plant showed the production of



silver nanoparticles at peak emission of (425) nm as show in figure (1).

Fig 1 : UV-Vis spectra of the Hibiscus Sabdarriffa L extract

3.2 Fourier transform Infrared Spectroscopy (FTIR)

The FTIR is one of the important laboratory tests , and it is also important to obtain accurate information about position of ions in the crystal structure , through the positions of the vibrations[14]. FTIR scale is used to determine the active groups, the identity of the compound is determined based on how chemical bonds are absorbed at the range (400- 4000) cm^{-1}.Each compound has its own absorption, as the results of the infrared spectroscopy of the nan scsilver extract showed the presence of difference pack ages, which indicate the multiplicity of active groups in this extract. clear infrared peaks appeared at (3741.65), (3438.84), (2337.58), (1627.81), and (1380.94) cm-1 in the intense broad band at (N-H), (O-H), (C≡N), (C=C),(CH3), this is due to the expansion mode and the binding of proteins. As shown in table (1) and figure (2).

Table1: The FTIR analysis information of Hibiscus Sabdarriffa L extract

Plant name	Functional groups	Absorbance peak (cm^{-1} /
Hibiscus Sabdarriffa L	N-H	3741.65 cm^{-1}
	C	3438.84 cm^{-1}
	C≡N	2337.58 cm^{-1}
	C=C	1627.81 cm^{-1}
	CH3	1380.94 cm^{-1}

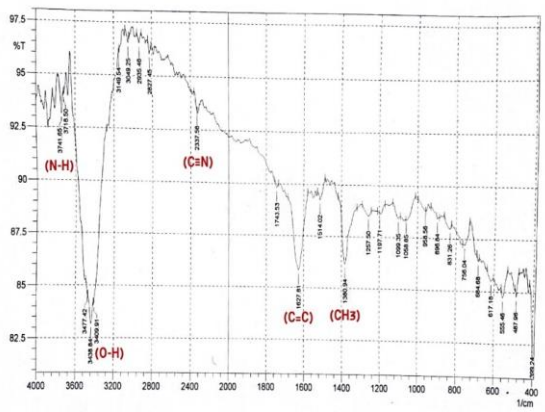


Fig 2: FTIR spectrum of Hibiscus Sabdarriffa L extract

3.3 Energy –Dispersive EDS Spectroscopy

This measurement is used to verify the elements that that make up the prepared samples. this examination shows the presence of the elements of the compound according to their weight and atomic ratios , it is used in order to known the type of chemical elements present in the prepared samples , and to verify the presence of silver in the sample, this results of EDX showed that a small silver Ag peak confirmed its presence in the extract, and this means that the measurement gives the qualitative and quantitative state of the elements that may participate in the formation of the nanoparticles [21] . Fig (3) shows the emergence of a high peak for the oxygen element at energy (1.25) Kev , and the emergence of a small top for the carbon element for energy . as shown in figure (3). and table (2), which shows the amount of percentage of elements present in the nanoscale sample.

Fig 3 : EDX of silver nanoparticles

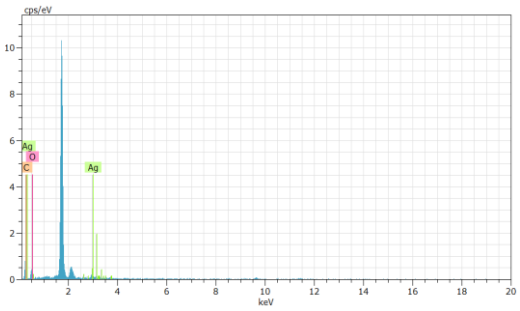


Table2 : EDX results shows percentage of elements in resulting suspension

El	AN.	Series	Exp. [wt.%]	Atomic [wt.%]
C	6	K-series	46.93	57.52
O	8	K-series	44.95	41.37
Ag	47	L-series	8.12	1.11
		Total:	100.00	100.00

3.4 X-Ray Diffraction

Fig (4) shows X-ray diffraction spectrum of the silver nanoparticles (AgNPs) prepared using plant extract. the liquid material (plant nanoscale extract) was thermally . dried on a bottle at a temperature of 7 ^{O}C for a period of 3 hours. the distinctive diffraction peaks of Ag silver due to the cubic crystal structure of the FCC type are noted from the figure, which was inferred through the peaks of the angles corresponding to the crystalline planes and shown in the figure (4). The characteristic diffraction peaks are observed in (111),(200), and (220) at the angles (38,50) ,(44,30), and(64,98). the width of the XRD peaks is related to the size of the crystals, and the average crystal diameter was determined from the diffraction peaks using the schere equation [22].

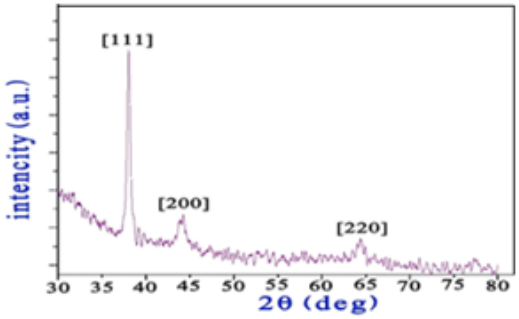


Fig (4): X-Ray diffraction patterns of silver nanoparticles

3.5 Field Emission Scanning Electron Microscopy

The FE-SEM measurement shows that the silver particles uniformly disturbed over cell surfaces . the particle analysis reveals the presence of individual oval-shopped multiple silver nanoparticles, as well as in the form of irregularly shaped aggregates, and this measurement photographed the surfaces of the prepared materials at high magnification and high accuracy , showing the shape and size of the particles of the used sample, as the results showed that silver nanoparticles are oval shape , and spread on the surface of the nanoscale extract . the figure (5) stows that the size of the silver nanoparticles range between (28.17-65.20) nm . and with an average size (48.64)nm. as shown in the figure (5).

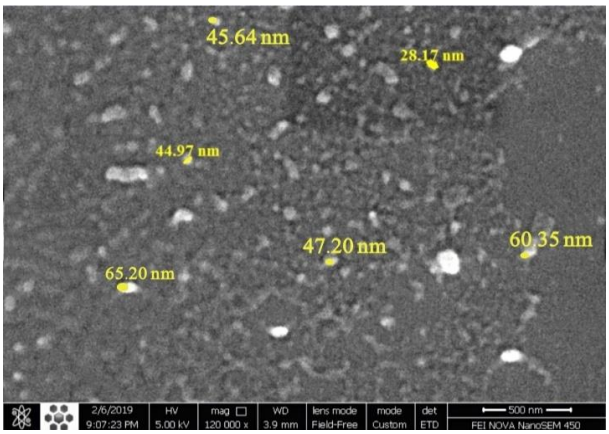


Fig 5 : FE-SEM images of silver nanoparticles

3.6 Fluorescence test results

Figure (6) show the fluorescence excitation and emission spectra for silver nanoparticles. The excitation wavelength peak was fixed at 450 nm and the emission spectra were recorded for system. This was almost identical to the results of the absorption spectrum of the solution of nanoparticles of silver.

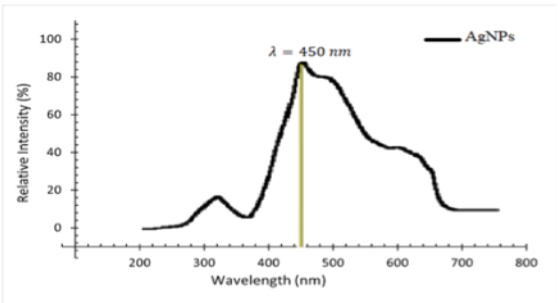


Fig 6: Illustrates the fluorescence measurement of silver nanoparticles

Colloidal solutions of nanoparticles were examined by fluorescence assay , and we note through the figure6. that the peak value is at (450) nanometers for silver nanoparticles which corresponds to the absorbance peak values in the infrared scan

4.ANTIBACTERIAL ACTIVITY OF *HIBISCUS SABDARRIFFA L* EXTRACT OF SILVER NANAOPARTICLES

The study findings indicated that E. coli bacteria and Staphylococcus aureus bacteria exhibited antimicrobial properties, which were evaluated using the pit diffusion method, as shown in fig. 7 and 8 , a clear efficacy of the extract of the plant Hibiscus Sabdarriffa L and silver nanoparticles on E. coli was greater compared to Staphylococcus aureus bacteria , as the rate of inhibition of the extract was 9 nm and silver nanoparticles 14 nm in E.coli bacteria . As for Staphylococcus aureus bacteria, the inhibition rate of the plant extract was 7 nm and silver nanoparticles was 13 nm. the inhibitory activity of the plant , the resent is due to the presence of many Effective chemical compounds that are present in the plant, which have their properties against bacteria, fungi and viruses.

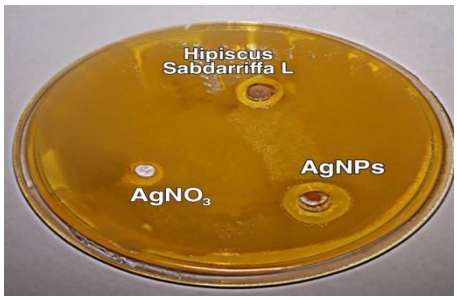


Fig 7:Antimicrobial activity of plants against E.coli bacteria

Fig 8: Antimicrobial activity of plants against Staphylococcus aureus bacteria

5-Photocatalysis :

In this measurement , semiconducting materials are exposed to light with energies equal to or greater than the energy of the gap , then the electron absorbing energy in the valence band moves to the conduction band , leaving behind a positive hole , as the charges can move to the semiconducting surface with possibility that these charges will combine again , others , or it helps them in oxidation or reduction reactions with molecules present in the water and close to the semiconducting surface , these materials undergo a series of reactions that represent the photo catalytic process . the process of catalysis is affected by many factors , including the initial concentration of the colored solution. the amount of catalyst , the effect of the intensity of light rays , the mixing process , the effect of acidity and the effect of time , figure (9) shows the absorbance of the MB formula in terms of the wavelength of the silver nanoparticles , and we notice a decrease in the absorbance value , and then in the concentration of the methylene blue solution with the passage of time concentration of the colored solution by the photo catalysis process for different times (o, 30 , 90 , 150 , 210) min , but the detection process varies from one sample to another, and figure (10) shows that the rate of deterioration of the dye was low at first and then increased with increasing exposure time .fig shows the dye efficiency for the times (0,30,90,150,210) min .

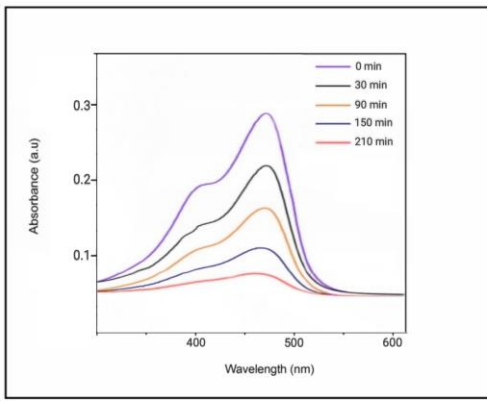


Fig (9) UV spectra indicate photocatalysis of methyl blue dye with reaction time

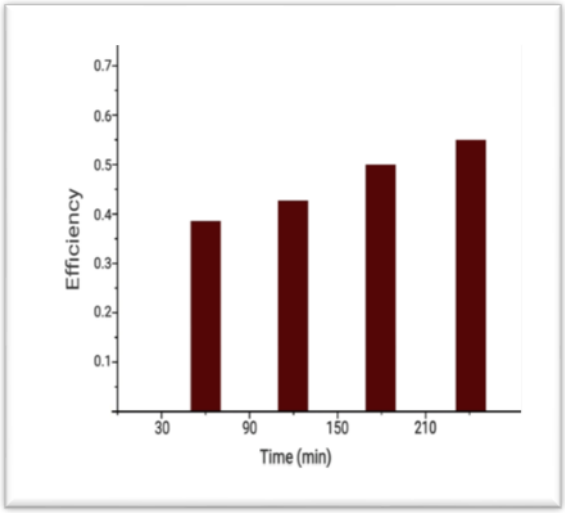


Fig (10) represents the percentage of dye degradation at the time of exposure

5.CONCLUSIONS

The green synthesis method of nanoparticles is considered one of the easy methods , clean , efficient, non-toxic , eco-friendly . we can use a lot of different plant extracts in creating silver nanoparticles , An easy green synthesis of silver nanoparticles using Hibiscus rosa-sinensis flowers extract at room temperature was successfully synthesized . A simple and environmentally friendly green method is sought to efficiently and economically synthesize silver nanoparticles. The optical characteristics of the AgNPS were examined across a wavelength range of (200-1100) nm. These findings make the silver nanoparticles appropriate for utilization in sensors, as well as various electronic, and electrical, and medical applications , In this work we noticed that, The results of fluorescence of silver nanoparticles spectra the peak values is (425) nm. This is ralmost identical to the absorption spectrum results . it is expected that results will be very useful to use metal-enhanced fluorescence in different application such as bio sensing and optoelectronics. The synthesised silver nanoparticles present antibacterial activity antimicrobial activities against some kinds of bacteria such as Staphylococcus aurous and Escherichia coli . Advantages of utilizing green synthesis is that cost efficient energy effective , saving human health and surroundings . Due to its environmentally friendly nature, this green synthesis method could serve as an alternative to conventional chemical and physical methods. As a result, it holds great potential for various applications, including biomedical and medical fields. The word photo catalysis is a compound word made up of two parts , the first part is photo , which means light , the second part is catalysis , which means stimulation , the process of catalysis depends on a substance that increases the rate of transformation of the reactants without being affected by this substance , this substance is known as catalysis , meaning catalysis . the rate of the reaction is increased by reducing the activation energy required for it , the process of photo catalysis is a reaction in which light is used as an activator for the substance , which works to increase the rate of the chemical reaction without having a role in the reaction .

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