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SYNTHESIS AND CHARACTERIZATION OF SILVER NANOPARTICLES USING GREEN METHOD

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ABSTRACT

This study examined how to create silver nanoparticles using plant extracts. Silver ions were transformed into silver nanoparticles using mango peel extract as a capping and reducing agent. The resultant silver nanoparticles were investigated using X-ray diffraction and UV-Vis spectrophotometry (XRD). The face-center-cubic (FFC) structure of the produced silver particles is evident from the X-ray diffraction study.

Keywords: Green synthesis, Mango Peel Extract, Silver Nanoparticles, XRD.

INTRODUCTION

Researchers have become interested in nanoparticles of sizes between 1 and 100 nm because of their optical, chemical, and mechanical characteristics [1]. Researchers have become interested in nanoparticles of sizes between 1 and 100 nm because of their optical, chemical, and mechanical characteristics [2]. Numerous uses, such as those in the medical, industrial, pharmaceutical, and agricultural industries, have been suggested [3, 4]

Metal nanoparticles can be generated using a variety of chemical and physical methods, including chemical reduction, thermal decomposition, electrochemistry, son chemistry, microwave energy, laser ablation, helium droplets, and sol-gel [5-7]. These methods could affect the environment badly because they used hazardous chemicals and solvents. However, in recent years, a new technique has been utilized to produce different metal and semiconductor nano-objects, which is called green synthesis [8]. This method depends on using different plant portions and bio-organisms such as fungus, yeast and bacteria to form nanoparticles [9]. It is expected that the bioactive compound which exist in plants and microbes could serve as capping and reducing agents.

Plant extract technique has more advantages when compared to other biological procedures, because it doesn't require culturing processes [10]. Furthermore, nanoparticles formed using plant extract methods are favored since they are profitable, single-step process for biosynthesis process and environment friendly [11]. Metal nanoparticle preparation methods include chemical reduction, thermal decomposition, electrochemical, son chemical, microwave, laser ablation, helium droplets, and sol-gel, among others [12].

Al Hindawi groups who used the peel extraction from Grapefruit (citrus paradise) to synthesis silver particles [13]. Additionally, silver nanoparticles with an FFC phase structure and a diameter of 65 nm were effectively created utilizing bitter orange peel extract [14]. Dyes are a group of organic chemicals that are frequently employed in the culinary, printing, and textile industries. The majority of dye effluents are poisonous and non-biodegradable, and they all have a significant detrimental impact on the environment. Reactive red dye is a carcinogenic and poisonous derivative of phenothiazine that is used to color fabrics [15, 16].

In this paper, silver nanoparticles have been prepared using mango peel extract, it is an active fruit contains many bioactive compounds such as phenols and flavonoid, [17] UV-visible spectrometer and X-ray diffraction technique (XRD) were utilized to characterization of the resulted silver particles. The photo-degradation ability of our prepared Ag nanoparticles was studied. The results show that biosynthesized Ag nanoparticles can act as a photocatalytic to remove toxic reactive red dye from wastewater.

MATERIAL AND METHODS

Synthesis of silver nanoparticles

In this project, deionized water was used as a solvent for dissolving starting materials. A solution of $AgNO_3$ (1mM) was prepared by adding silver nitrate into 100 mL deionized water and stirred for 15 minutes until no particle was observed. This solution was kept in a dark place to avoid the oxidation of silver. To prepare mango peel extract solution: 1- Mango peel was washed with deionized water and cut into small pieces. 2- Allowing these small mango peel pieces to dry under sun light for 3 days before grinding into fine powder. 3- Appropriate amount ten grams of the peel powder were dissolved in 100 mL deionized water. 4- The mixture was then heated to 70 ^{o}C for seven minutes, filtered and finally stored at ~4 ^{o}C.

To prepare silver nanoparticles, (7.5 ml) of the peel extract solution was mixed with (100 ml) of silver nitrate solution. Thereafter, this solution was stirred and kept for 4 hours at room temperature. The solution was then taken to the UV-Vis spectrometer to record the spectrum. For SEM and XRD measurements, the solution was centrifuged for a half an hour using 4000 rpm centrifuge then the participate was dried at 100 ^{o}C.

Photodecoloriation of reactive red dye

In this method, an appropriate amount of reactive red dye solution (100 ppm) was taken and (0.1 gm of $AgNO_3$ was added to 100 ml) of reactive red solution (RRS). The formed suspension solutions were subjected to UV-A light flux at intensity equal to (1.42×10^{-6} Einstein s−1). At different time intervals, approximately, 3.5 mL from the suspension solution were collected and filtrated by using centrifuge 4000 rpm for (10 min). The supernatant was then taken to record the absorption. The UV-Vis spectrum for the dye was (515 nm).

RESULTS AND DISCUSSION

Silver nitrate is made into a yellow solution when mango extract is added. Leaving the solution for (4 hours) under room temperature leads to change the color to brownish as shown in figure (1), indicating the formation of Ag NPs. silver nanoparticles. This changing means that silver ion is reduced by mango peel extract and free silver was formed which growth to form cluster then nanoparticles.

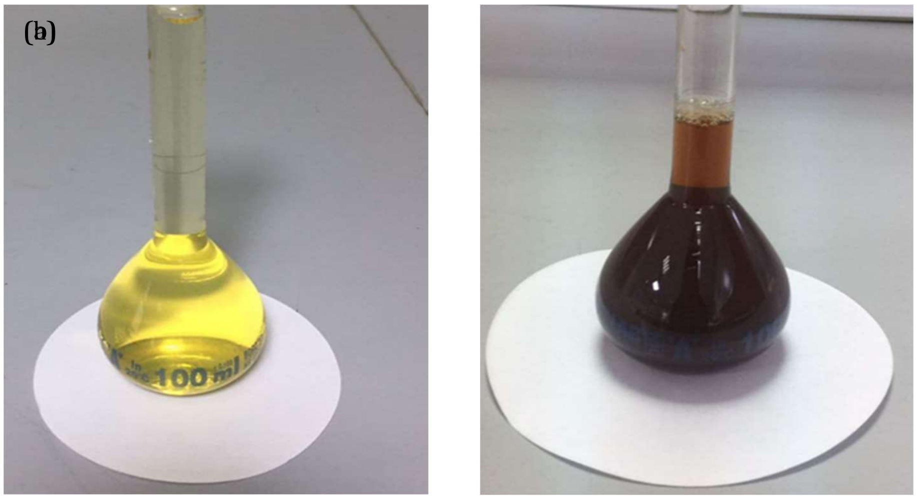

Figure 1 Ag nanoparticles prepared from silver nitrate and mango peel extract: (a) the solution after 0 hour mixing and (b) the solution after 4-hour mixing.

The UV-Vis absorption spectra provided confirmation that silver particles had formed (UV-1800 series Shimadzu spectrophotometer). Figure (2) shows that the maximum absorption peak of Ag particles is centered around 400 nm, that means there is a blue shift about 20 nm when compared to bulk silver [18]. The quantum size effect is responsible for this blue shift [19].

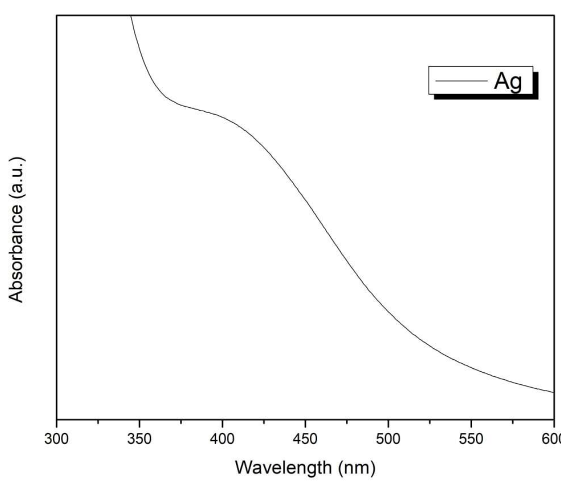

Figure 2: The Ag nanoparticles' absorption spectra when exposed to mango peel extract.

XRD analysis was used to examine the crystalline structure of the biosynthesized silver nanoparticles. The four summits are sharp. (see Figure 3) were observed in the XRD pattern at 2θ = 38.19°, 44.21°, 64.61° and 77.5°. These diffraction peaks, for Ag nanoparticles, correspond to the (111), (200), (221) and (311) planes, respectively, [20] suggesting the FCC phase structure for Ag nanoparticles. The size of the silver nanoparticles is calculated from the XRD data using (Scherrer's formula) [21]:

$$D = \frac{K\lambda}{\beta \cos\theta} \qquad \text{............(1)}$$

Where X-ray wavelength is expressed in nanometers (1.54 nm), peak width is expressed in radians (due to small crystallite size) and K is a constant relating to crystallite structure. 10 nm was discovered to be the crystallite size.

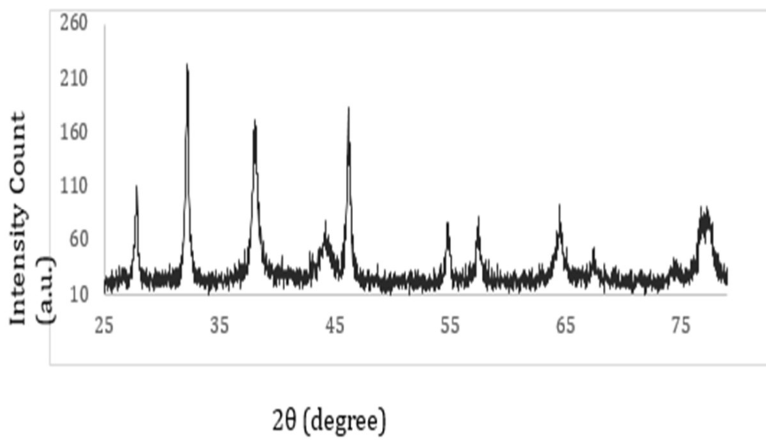

Figure 3 XRD pattern for Ag nanoparticles prepared using mango peel extract

Photocatalytic degradation of dye

Studying Ag nanoparticles' photocatalytic activity. By irradiating the dye solution with UV light while also including AgNPs as a photo catalyst, it was possible to decolorize reactive Red dye in solution. According to the following equations, the rate constant (kapp) of photocatalytic decolonization of reactive red dye was calculated using the Langmuir-Hinshelwood expression for first order kinetics: [22, 23].

$$C_{t=} C_o \, exp^{(-k_{app} \, .t \;)} \qquad \text{... (2)}$$

$$ln(\frac{C_o}{C_t}) = k_{app}.t \qquad \text{... (3)}$$

Here, Co is the dye's initial concentration (in mg/L), and Ct is the dye's concentration following irradiation throughout the time interval.

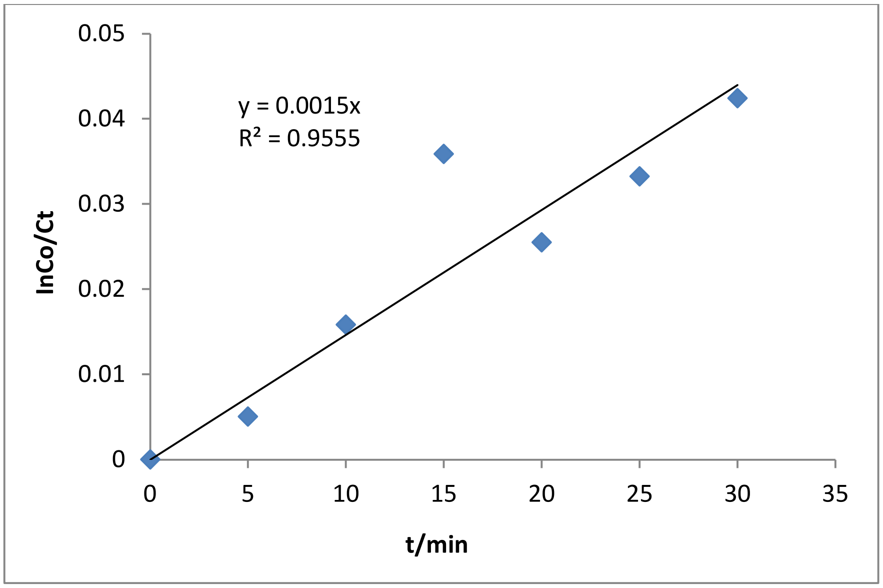

Figure 4 Relation between ln C_o/C_t as a function of irradiation time

The following equation is used to compute the photocatalytic decolonization efficiency (PDE) of the dye in the presence of AgNPs: [24].

$$PDF = \frac{(Co - Ct)}{Co} x100\% \qquad ....(4)$$

Figure 5 shows that the PDF curve gradually increases with time, with the best PDF being achieved after irradiation for 15 and 30 minutes.

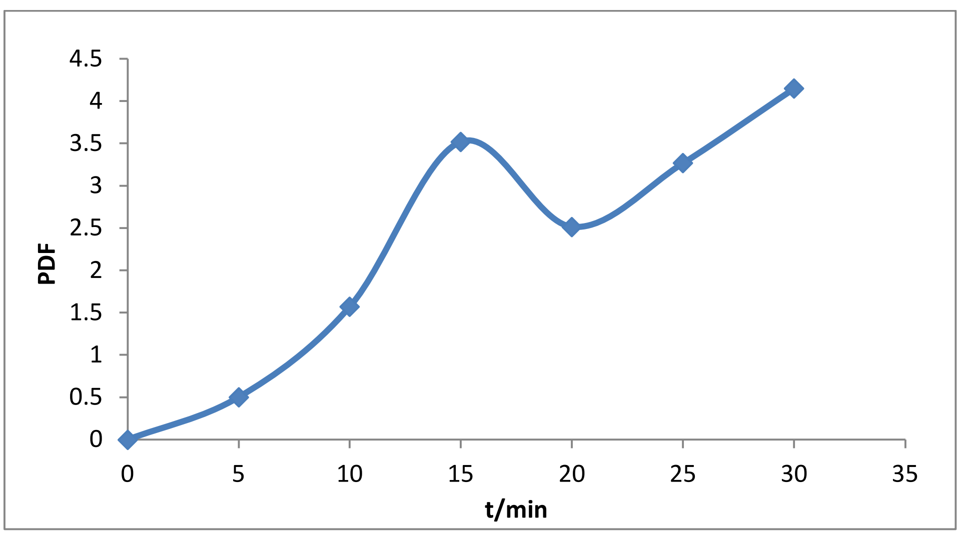

Figure 5: Showing the PDF as a function of time.

Conclusions:

Silver nanoparticles was synthesized successfully from cheap, simple and eco-friendly method. Silver nanoparticles are prevented from aggregating by the mango peel extract's decreasing and capping effects. The bio synthesized particles have crystalline structure (FCC phase) and have the ability to degradation the reactive red dye.

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