Article

Green Cobalt nanoparticles used as a photocatalytic agent for the degradation of methylene blue dye

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Abstract

The nanoparticles of cobalt synthesized by adding of Pomegranate peels to cobalt nitrate salt. The cobalt nanoparticles appear rapidly with change in color. The cobalt characterized by UV Visible Absorption Spectrometer and Scanning Electron Microscopes (SEM). By using spectrophotometer, the wavelength of the plasmon was around 350-400 nm, while SEM shows the size of cobalt nanoparticles around 25 nm. The prepared cobalt nanoparticles were used for degradation of methylene blue dye in polluted water.

Keywords: Aqueous extract, Pomegranate peels, Cobalt nanoparticles, SEM.

Introduction:

Both chemical and biological methods can be used to create nanoparticles. Because several harmful chemicals are present in chemical synthesis processes, numerous negative effects have been linked to them [1]. The biological manufacturing of nanoparticles employing microorganisms [2,3] enzymes [4], fungus [5], plants or plant extracts [6, 7] is an environmentally acceptable alternative to chemical and physical processes.

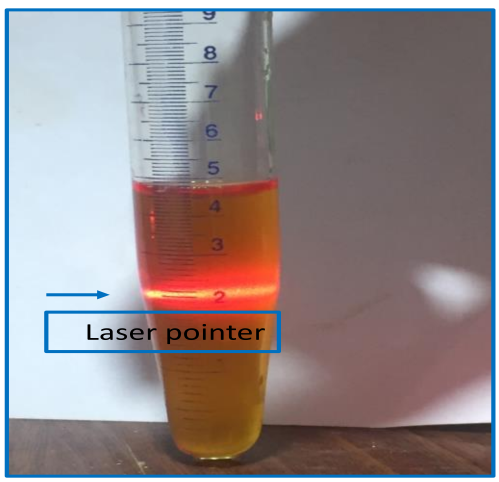
Pomegranate (Punica granatum) is a nutrient-rich fruit known for its juicy arils, but it's often-discarded outer layer, the peel, holds a wealth of bioactive compounds with potential health benefits. Packed with polyphenols, flavonoids, and tannins, pomegranate peels have garnered attention for their antioxidant properties. Antioxidants play a crucial role in neutralizing free radicals, thus mitigating oxidative stress and reducing the risk of various chronic diseases. This introduction explores the potential health benefits of pomegranate peels, shedding light on their antioxidant capacity and the implications for human health [8-12].

Plants appear to be a cheap and naturally helpful source of metal nanoparticles when used as reactive components, and the methods used to extract these elements are safe both in terms of energy and chemicals [13]. Recent research [14–16] indicates that the use of green synthesis strategies to produce metal oxide nanoparticles is highly relevant. The procedure of creating metallic nanoparticles involves the use of metal and metal oxide-based dyes that degrade and cause the solution to become less populated. Metal nanoparticles offer a wide range of characteristics, including electrical and optical qualities, because of their large surface area and application as electron carriers in numerous industries, including electronics, medicine, and agriculture [17]. Plants utilized as reactive components to create metals nanoparticles seem to be inexpensive and naturally beneficial, and the processes employed to utilize these materials are chemically and energy-safe [13]. In order to create catalysts with nearly 100% selectivity, extraordinarily high activity, minimal energy consumption, and extended lifetimes, transition metal NPs are frequently employed. Controlling the pore size and properties of the used nanoparticles results in increased selectivity and activity of the catalysts based on nanoparticles [18]. Many of methods were used for synthesis of nanocobalt While chemical methods can provide cobalt oxide nanoparticles, we have employed a more ecologically friendly approach in this study, employing powdered plant leaves as a possible biosynthesis [19-21] to create green cobalt oxide nanoparticles.

Experimental

Plant material conditions firstly, the purchased of Pomegranate peels. It was washed with water and left to dry at air then it's crushed by mechanical molter and then filtered by mesh 60 micrometers at size. 30 grams of ground pomegranate peels was added to 500 ml of ionic water to it, then heat it for an hour at a temperature of 100 °C while stirring using a magnetic stirring device. The filtration process is carried out through Whatman No.1 filter paper. 25 ml from the filtered extract was added to 25 ml of cobalt's salt $Co(NO_3)_2 \cdot 6H_2O$ at the concentration 1000 ppm. (Fig. 1, a) shows these results. However, (Fig. 1, b) shows cobalt nanoparticles and leaser pointer demonstrations Tyndall Effect. The color change of the solution during experiment indicates for the reduction of cobalt ions. The color of fresh extract of Pomegranate peels was orange. However, after addition of Cobalt nitrate and constant shaking at 80°C the solution color changed gradually into light brown after 10 min which indicated the formation of Cobalt nanoparticles. Biosynthesized by Pomegranate peels were visualized using SEM type (FESEM, Zeiss in Islamic Republic of Iran). The prepared cobalt nanoparticles applied for degradation study, a constant volume of 15 ml of cobalt nanoparticles were used, a light source (tungsten lamb), at the power (30 W) used for degradation and methylene blue dye prepared in a volume of (25 ml) and a concentration was (2.5 ppm).

(Fig. 1,a) shows the staged of Pomegranate peels to cobalt nanoparticles solution



(Fig. 1, b) displays laser pointer passing through cobalt nanoparticles solution illustrations of Tyndale scattering.

Results and discussion

1-charctrisation of cobalt nanoparticles

Cobalt nanoparticles were characterized using Field Emission Scanning Electron Microscopy (SEM) and plasmon spectra as following:

Field Emission Scanning Electron Microscopy (SEM)

From this examination the particle morphology and structural surfaces of the prepared nanoparticles and imaging of the nanoparticles using a scanning electron as can be seen in (Fig. 5). SEM images demonstrated their uniform distribution, spherical shape, and nano- FESEM photographs specified monodisperse nanoparticles that were sphere-shaped in nature at size of 25 nm.

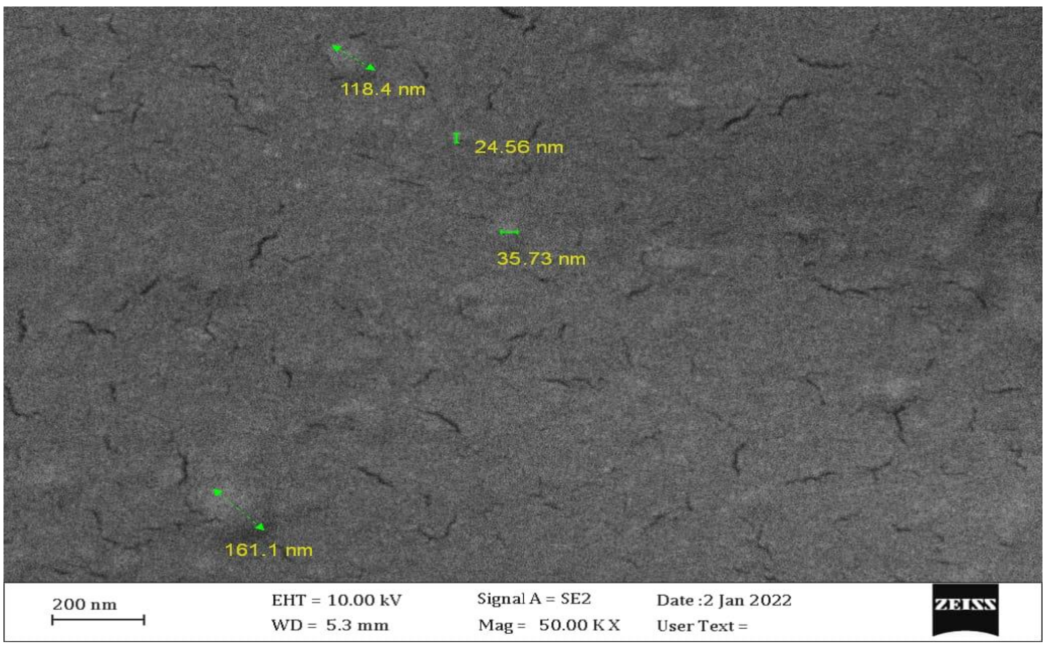


Fig 2. Shows SEM image for prepared cobalt nanoparticles

Uv -visible spectroscopy (plasmon spectra)

For the examination of the cobalt nanoparticles plasmon spectrum was done using **Uv-visible spectroscopy.** The oscillating vibration and collective movement of free electrons that are present on a nanoparticle's surface as a result of electromagnetic or electrical radiation striking it are represented by the plasmon spectrum. Using a (UV-Vis) spectrometer, a solution of the produced cobalt nanoparticles was obtained at a concentration of 1000 ppm in order to determine the plasmon spectrum. When scanning wavelengths between 300 and 700 nm, the plasmon appear at 400 nm as can be seen in figure3.

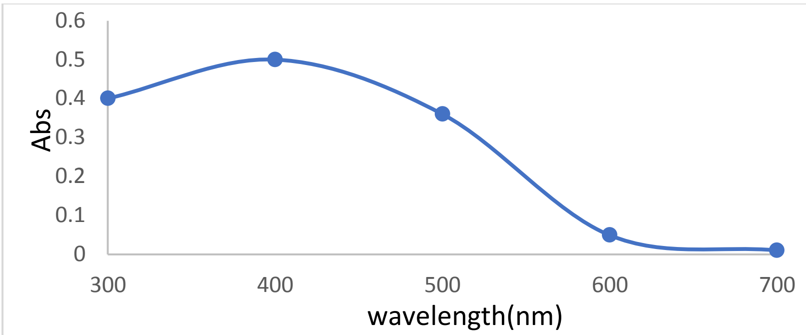


Fig.3 shows plasmon spectra for cobalt nanoparticles

2- Application

Degradation of methylene blue dye using Cobalt nanoparticles

The standard curve was fixed at 663 nm as the optimum wavelength for methylene blue, and the concentrations were determined for methylene blue with good application using the lambert-Beer law, ranging from 1 to 8 ppm. Figures 4 and 5 show these results.

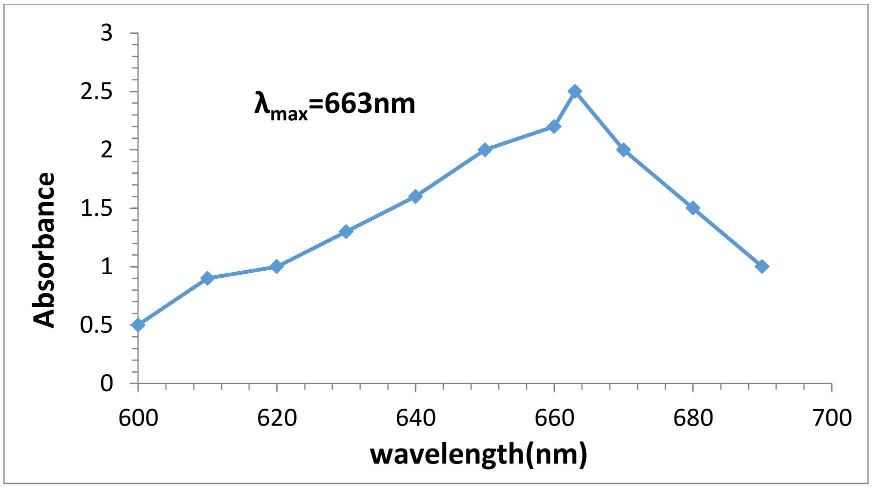


Fig. 4 shows the methylene blue dye's maximum wavelength

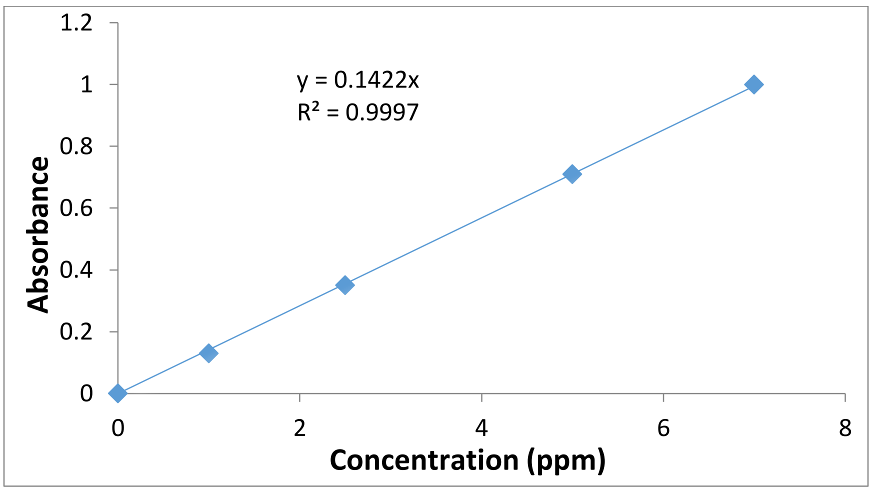


Fig.5 shows the methylene blue dye's typical calibration curve.

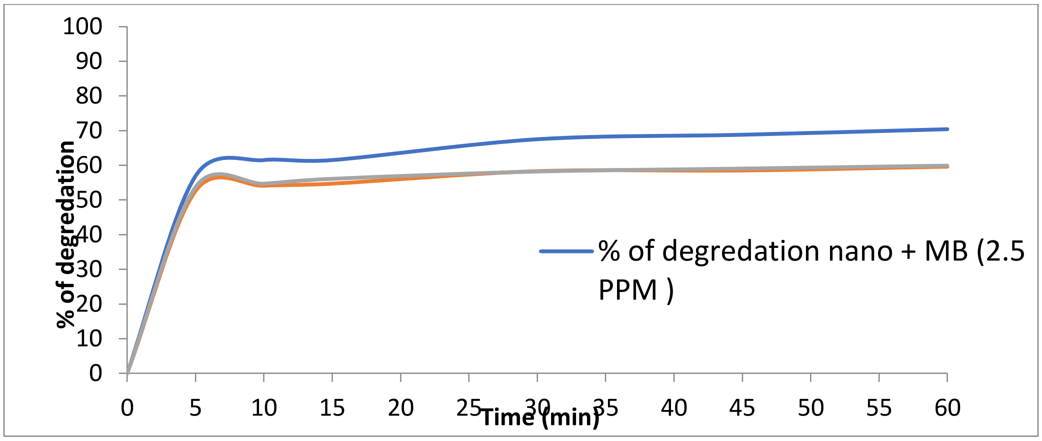
The degradation was carried out under ideal circumstances utilizing tungsten light intensities (30 watts) and various dye concentrations (2.5 and 5, 7.5) ppm. The removal efficiency was calculated according to the equations below using spectrophotometer

Removal % = $C_o - C_e / C$. 100 ……….1

where C_e is the equilibrium concentration of methylene blue dye (ppm) , C_o is the initial concentration of methylene blue dye (ppm).

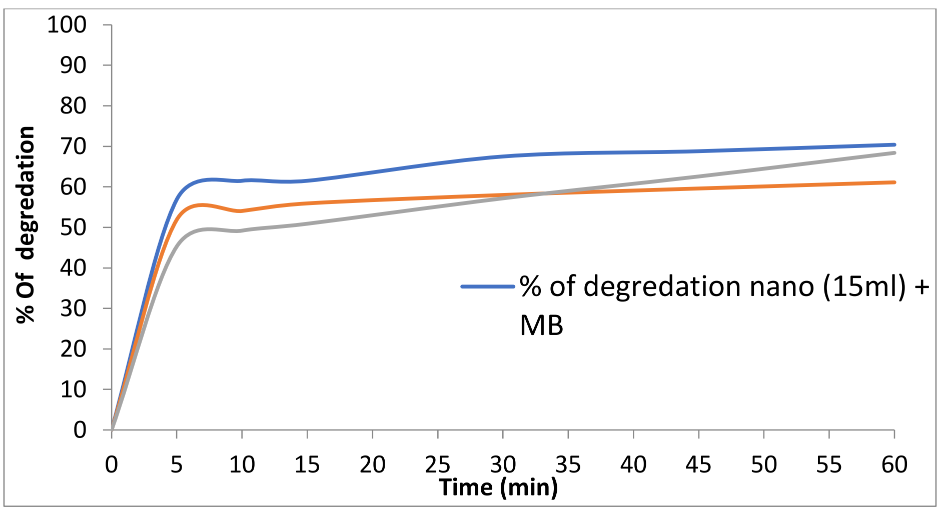
Degradation of Methylene Blue Dye using cobalt nanoparticles at different concentrations

Degradation of Methylene Blue Dye Using Cobalt nanoparticles. The optimum wavelength of methylene blue was measure at 663 nm. The degradation was done by optimum conditions using lights power (30) W and different dyes concentrations (2.5, 5 and7. 5 ppm). In this work, methylene blue dye was used in a volume of 25 ml at three distinct concentrations (2.5 ppm 5 ppm and 7.5 ppm) in conjunction with a constant volume of produced cobalt nanoparticles and a constant light source (30 W). Figure 10 presents the results. The percentage of breakage (70.4%) and the percentage of degradation (better) of methylene dye prepared at a concentration of 2.5 ppm with cobalt nanoparticles as a catalyst are higher than those of methylene dye prepared at a concentration of 5 ppm and 7.5 ppm which has a degradation rate of 59.9%. Figure 10 shows these findings.



Degradation of Methylene Blue Dye using cobalt nanoparticles at different volumes

In this study, different sizes (5ml, 10ml, 15ml) of prepared Cobalt nanoparticles were used, and these different sizes of nanoparticles were added to (25ml) of the prepared methylene blue dye at a concentration of (2.5ppm), thus leading to obtaining results. As shown in Fig. (4), that is, the larger the size of the nanoparticles used, the greater the percentage of breakdown of Cobalt nanoparticles. In the presence of the catalyst, Cobalt nanoparticles were broken down. The highest percentage of breakdown of the methylene blue dye (68.4%) appeared when (15 ml) of Cobalt nanoparticles was taken and was Higher than the crushing rate of the rest of the sizes used.



Conclusion

Research clearly showed how to synthesise Cobalt nanoparticless nanoparticles and indicated that the plant extract contained a number of phytochemicals that work as a capping and stabilising agent for the Cobalt nanoparticles. It was possible to create cobalt nanoparticles in an easy, affordable, quick, and environmentally friendly manner. Based on the results of the investigations, it is clear that the precursors were important in determining the structure and surface shape of Cobalt nanoparticless n. Cobalt nanoparticles can be employed with visible light (tungsten lamb) to degrade the dye methylene blue in contaminated water. The photodegradation studies of these nanoparticles demonstrate very good photocatalytic activity on methylene blue dye, with a 68.39% degradation rate at a dye concentration of 2.5 ppm.

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