PHYTOSYNTHESIS OF GOLD NANO-PARTICLES BY USING MARINE ALGAE (*CLADOPHORA*) AND IT'S APPLICATION IN PHOTO-DEGRADATION OF ORANGE G

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Abstract:

The phytochemicals present in algae are one of the important sources of reducing and capping agents for the synthesis of nanoparticles (NPs). This paper reports the phytosynthesis of gold nanoparticles (NPs) by using marine algae (*Cladophora*) as reducing and capping agent due to simple procedure and inexpensive cost required. The morphology, size and composition of Au NPs were confirmed by scanning electron microscope (SEM), energy dispersive x-ray analysis (EDX) and transmission electron microscopy (TEM) analysis. The Phytosynthesized gold NPs was used for the photoctalytic degradation of environmental pollutant Orange G under solar light. The degradation was studied with UV-Visible spectral analysis. Due to the smaller size of Au NPs, exhibit great photocatlytic performance.

Keywords: Phytosynthesis, algae, gold nanoparticles, photodegradation, Orange G.

I Introduction

Nanomaterials have gained powerful consideration due to their potential function in drug delivery, sensing, imaging and chemotherapy in recent period [1-3]. Synthesis of nanoparticles and their self-assembly into nanostructured materials are amongst the most studied topics in chemistry, physics and material science. Nanometals are presently adopted in different areas such as electronics, biotechnology, chemical and biological sensors, DNA labeling, drug delivery, cosmetics, coatings and packaging [4 and 5]. Metal in nano size shows excellent catalytic activity due to their high surface area-to volume ratio, which high differ from those of bulk material [6].

Gold in nano size display unique properties and have diverse activities that make it suitable for therapeutic use and broad applications in nanotechnology [7, 8]. Gold nanoparticles and nano rods have promising applications in fields such as bilogy[9], biomedicine [10], and catalysis [11]. Gold nanoparticles were synthesized by physical, chemical methods. Chemical methods are most frequently used methods for the synthesis of Gold nanoparticles [12 and 13]. The main disadvantages of using these chemical methods are the use of harsh chemical conditions and generation of toxic chemicals at the time of synthesis and functionalization of nanoparticles. There is a need to develop ecofriendly methods for the synthesis of metal nanoparticles to evade such risky and costly synthetic roots. Nanobiotechnolgy give successful and environmental friendly protocols alternative to commonly used chemical and physical methods. Hence, synthesis of nanoparticles by biological methods, using plants, algae, bacteria and fungi is an alternative and ecofriendly method [14 and 15]. Phytochemicals are the secondary metabolites present in plant and algae acts as reducing as well as capping agents due to the presence of functional groups such as hydroxyl, aldehyde and carboxyl groups [16, 17].

One of the rich sources for the many varieties of natural products is oceans. Marine Algae is the seaweed contains phytochemicals such as proteins, lipids, carbohydrates, carotenoids, vitamins and many other secondary metabolites with broad range of biological activities [18, 19, and 20]. Some algae such as Acanthophora spicifera [21], Chlorella pyrenoidusa [22], Kappaphycus alvarezii [23], and Sargassum wightii [24], have been used for the synthesis of gold nanoparticles. Literature survey found that the marine green algae Cladophora is a source of flavonoids, saponins, tannins, carbohydrates, protein, sugar, glycosides and phenolic compounds [25]. This secondary metabolite acts as reducing and capping agents for the synthesis of gold nanoparticles.

Organic dyes are one of the major pollutants produced from textile, plastic, medicine and many other industries. Therefore, it must be eliminated from the water that has been already contaminated by industrial activity. Biosynthesized gold nanoparticles used as catalyst for the degradation of azodye (orange G) [26 and 27]. This paper presents the phytochemical synthesis of gold anoparticles and it is used for the photodegradation of dye orange G.

II Materials and methods

The biosynthesis of Au NPs from Marine algae (*Cladophora*) was carried out as described below.

Materials

Cladophora algal extract, hydrogen tetrachloroaurate (III) ($HAuCl_4.3H_2O$, 99.98%), which was used as a gold precursor, was supplied by sigma-Aldrich. Whatman number 1 filter paper, distilled deionized water.

Collection of Algae and preparation of algal extract

The marine green Algae (*Cladophora*) was collected from the Visakhapatnam coastal area, Andhra Pradesh, India, in the month of April. The marine green seaweed was soaked in water for 1hour to remove the sand and mud and then thoroughly washed with fresh water and distilled water to remove the salt minerals and metallic compounds on the external part of the seaweed. Clean seaweed was dried at a shady place for ten days i.e. until the weight of the dried seaweed remains constant. The dried seaweed was ground into fine powder. 10 g of algal powder was mixed with 200 mL of distilled water in the 500mL beaker and boiled, extract was filtered through Whatman Filter Paper No.1, collected the supernatant and stored at 4^o C for nanoparticle synthesis.

phytosynthesis of Au nanoparticles from (Cladophora) algal extract

30mL of *Cladophora* algal extract was added drop wise to 70mL of 1mM $HAuCl_4 .3H_2O$ solution in Erlenmeyer flask under continuous stirring for 30min. The progress of the reaction was monitored by recording the spectra from 200-800nm SHIMADZU UV-2450 double beam UV-Vis spectrophotometer operated at 1nm resolution. The formation of gold nanoparticles was identified by color change to dark violet. The Au nanoparticles were obtained by repeated centrifugation of the resulted colloidal solution at 8000rpm for 15min. The obtained pellets were washed thoroughly and re-dispersed in deionized water dried in an oven at 80^o C.

Characterization

The formed gold nanoparticles structure and composition were examined by scanning electron microscopy (SEM, Hitachi S-3700N), energy dispersive X-ray spectroscopy (EDS, sigma), transmission electron spectroscopy and selected area diffraction analysis.

III RESULTS AND DISCUSSIONS

UV-Visible spectroscopic studies of Au nanoparticles

Figure 1 depicts UV-Visible absorption spectra in the range of 200-800 nm for phytosynthesized nanoparticles. The characteristic band is appeared at 532 nm represents surface plasmon resonance (SPR) characterized by gold NPs and was not obtained by bulk materials.

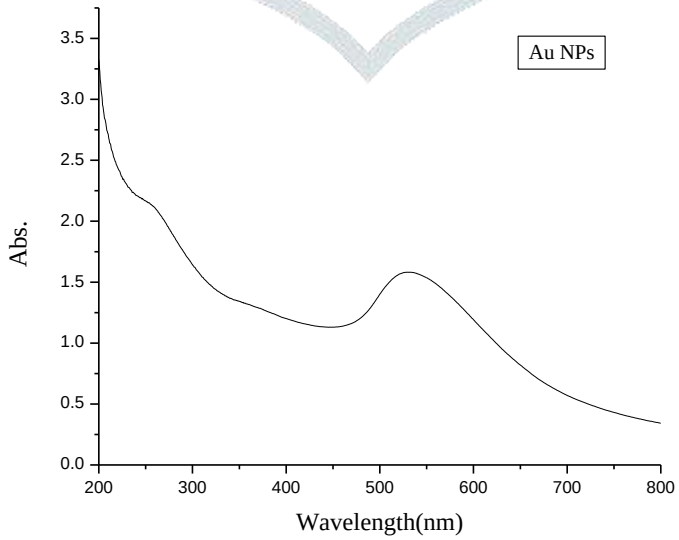

Figure 1: UV-Visible spectra of Au NPs.

Scanning electron microscope studies

The morphology of biosynthesized Au nanoparticles was studied by using a scanning electron microscope (SEM, Hitachi S-3700N). The images obtained at different magnifications were shown in Figure 2. The SEM images clearly indicated that the particles are in nano size.

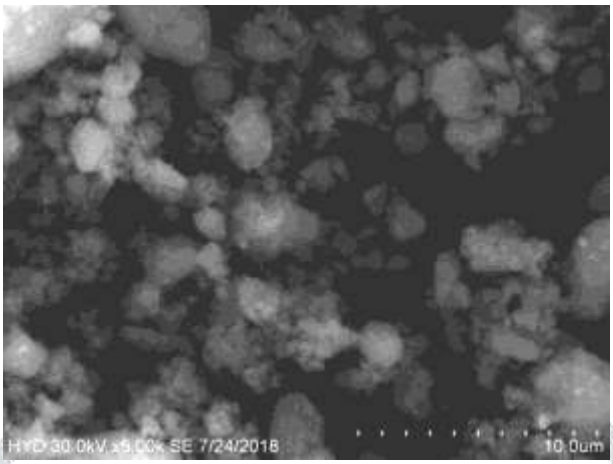

Figure 2: SEM images of Au NPs.

Energy dispersive X-ray analysis

Energy dispersive X-ray was used to study basic component of biosynthesized Au nano sample and their relative weights. The EDX spectra recorded was shown in figure 3. It was observed that carbon from used algal extract is the basic that represent major fraction of the sample and the other peaks in the figure represent gold nanoparticles.

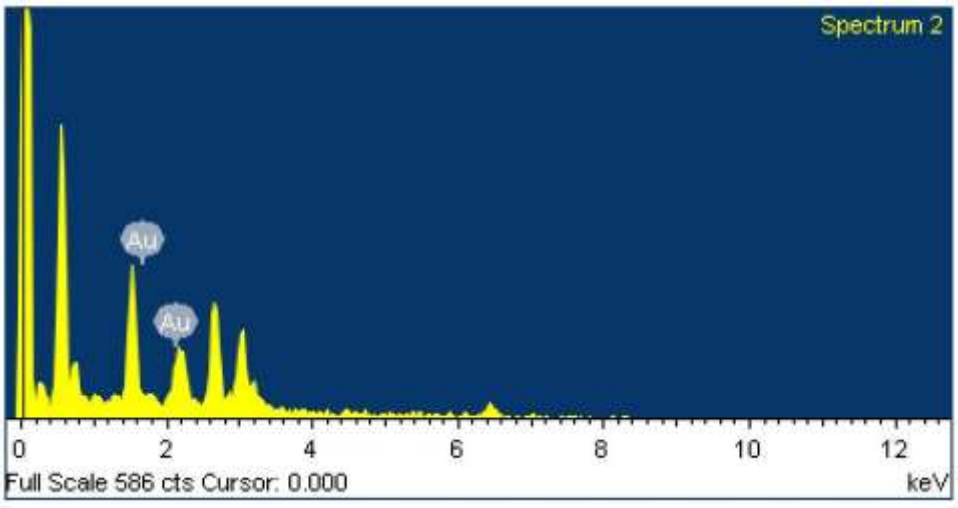

Figure 3. EDX spectra of biosyntesized Au NPs.

Table 1: Quantitative results of Ag-Ni NPs.

Element	Weight%	Atomic%
C K	67.06	97.14
Au M	32.94	2.90
Totals	100.00	

Transmission Electron Microscopy studies

The transmission electron microscopy (TEM) image along with selected area electron diffraction (SAED) pattern of biosynthesized Ag-Ni NPs were shown in Figure.4. It was shown that the nanoparticles are amorphous and spherical in shape.

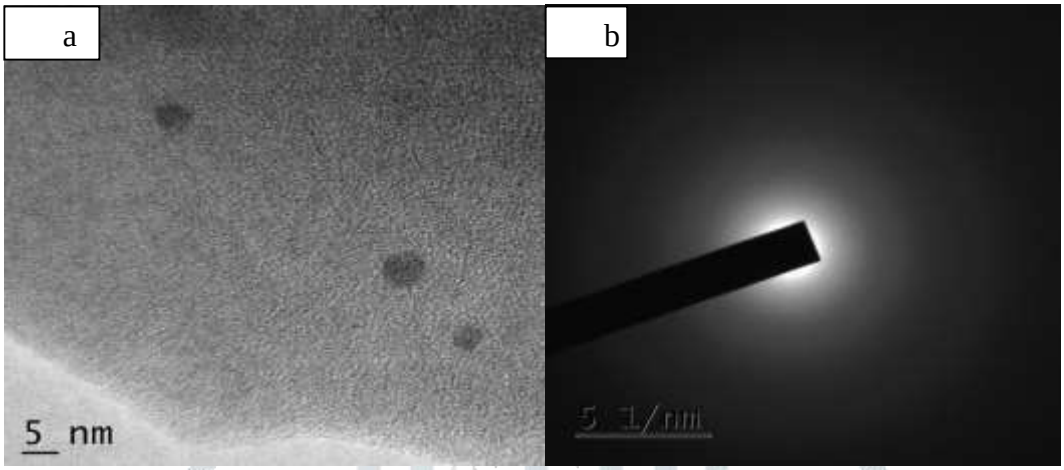

Figure 4: a) TEM image b) Selected area electron diffraction (SAED) image

IV Photodegradation of Orange G

The photocatalytic activity of biosynthesized Au NPs was studied by photo degradation of Orange G. The aqueous solution of Orange G was found to be stable even after 90min in the absence of photocatalyst. There was a decrease in the concentration of dye solution in the presence of gold NPs. Initially, the 10 ppm of dye solution was prepared by addition of 0.001 of Orange G in 1L of deionized water. To 100mL of 10ppm concentrated dye 0.05mg of biosynthesized Au nanocatalyst was added. The maximum absorbance of Orange G was found at 485 nm by UV-Vis spectrophotometer. The initial intensity of Orange G solution was measured before the addition of nanocatalyst. The suspension was kept under magnetic stirrer continuously in dark for 45min to establish the adsorption-desorption equilibrium. For this experiment sun light acts as a major source. The setup was kept under sunlight in between 11am to 3pm in May. At frequent intervals (every 30 min) of given irradiation time, 5mL of suspension was collected and centrifuged to remove the particles. The resultant solution was monitored in the wavelength range 200-800nm in a UV-Visible spectrophotometer. Distilled water is used as a reference. The absorbance of Orange G in solution as a function of time is shown in Figure 5 shows the decrease in the intensity of peak at 485 nm due to the decrease in the concentration of Orange G in the solution on solar irradiation.

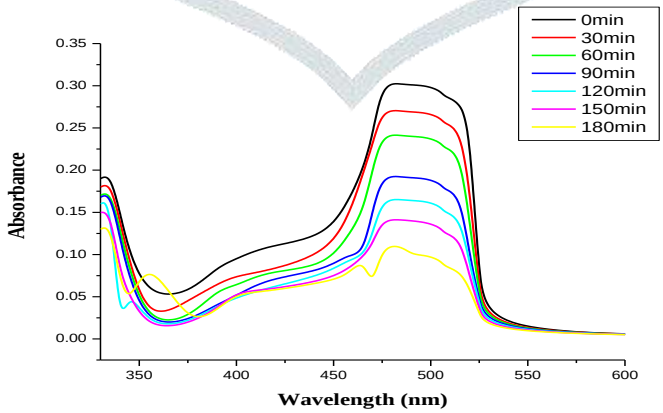

Figure 5: The photodegradation of dye as a function of time.

VI. CONCLUSIONS

Phytosynthesis of Au NPs with the size below 100nm was successfully obtained by using marine algae (*Cladophora*). The formation of Au nanoparticles was confirmed by SPR band at 532 nm. The size Au NPs was confirmed by scanning electron microscope. The composition of Au NPs was studied by energy dispersive X-ray analysis (EDX). The shape and size of Au NPs were confirmed by transmission electron microscope (TEM) and selected area electron diffraction (SAED) experiment. The degradation of environmental pollutant Orange G can be successfully achieved up to 73.4% by using phytosynthesized Au Nps in presence of solar energy.

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