Electronic Supplementary Information (ESI)

Green Synthesis of Silver Nanoparticles Using *Artemisia vulgaris* Extract and Its Application toward Catalytic and Metal-Sensing Activity

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1. Chemicals and reagents

The following chemical reagents were used in this work: $AgNO_3$ (Fischer Scientific), distilled water, Ethanol, Whatman Filter Paper No. 1, NaOH, $CrCl_3$ (Himedia), $FeSO_4.7H_2O$ (Himedia), $ZnSO_4.7H_2O$ (E. Merk), As_2O_3, $HgCl_2$ (Fischer Scientific), $CdCl_2$ (Qualigens), $BaCl_2.2H_2O$ (Analar), $Ni(NO_3)_2.6H_2O$ (Merk), $CuCl_2.2H_2O$ (Fischer Scientific), $MnSO_4$ (Fischer Scientific), $NaBH_4$, 4-NP. The biosynthesis of AgNPs using *Artemisia vulgaris* extract was done by following a reported procedure [1] with some modifications. The Tribhuvan University Central Herbarium (TUCH) identified the plant. All the chemicals and reagents were used as provided by the laboratory without any further purification.

2. Characterization of silver nanoparticles

2.1 UV-Vis Spectroscopy

The optical property of AgNPs was determined by UV-Vis spectrophotometer (Specord, Germa 200 plus, Germany). After adding $AgNO_3$ to the plant extract, the spectra were taken at different intervals for up to 24 h between 300 nm to 700 nm. The UV-Vis spectra were taken by diluting (10 times) the nanoparticle dispersion. To check the stability of nanoparticles, the UV-Vis spectrum was taken for up to 1 month.

2.2 Fourier Transform Infra-Red (FTIR)

The synthesized silver nanoparticles' chemical composition was studied using an FTIR spectrometer **(**Perkin-Elmer LS-55- Luminescence spectrometer**)**. The dried powders were characterized in the range 4000–400 cm^{-1}.

2.3 X-ray Diffraction (XRD)

X-ray diffraction spectroscopy was used to ascertain synthesized silver nanoparticles' phase variety and grain size (Philips PAN analytical). The silver nanoparticles were studied using CUKα

radiation at a voltage of 30 kV, a current of 20 MA, and a scan rate of 0.03^0/s. X′ pert high score software with search and match capability was used to determine the different phases present in the synthesized samples. The working conditions were typically 2θ scanning between 20^0 and 80^0.

The size of the particle of the prepared samples was determined by using Scherrer′s equation:

$$D = \frac{K \times \lambda}{\beta \, Cos\theta}$$

Where, D = crystallite/grain size,

K= dimensionless shape factor, with a value close to unity (~0.9)

λ = wavelength of the radiation (0.154 nm for Cu Kα)

θ = Bragg's angle (the 2θ value of chosen peak) and

β = full width at half maximum (should be in radian)

2.4 Scanning Electron Microscope (SEM)

The morphological features of synthesized silver AgNPs were studied by Scanning Electron Microscope (JSM-6480 LV). To make the samples conductive, a thin layer of platinum was applied. The samples were then characterized in the SEM at 20 kV.

2.5 Metal sensing activity of AgNPs

The metal sensing activity of the synthesized AgNPs was checked by the colorimetric method [2] with slight modifications.

2.6 Preparation of metal salt solution

The solution of the 10 different heavy metal salts was prepared in deionized water. For the preliminary test, 0.01M solution of each metal salt was prepared.

2.7 Colorimetric metal sensing

In a regular sensing test, 1 mL of the metal solution was added to 4 mL of the noble metal nanoparticle dispersion. The ions used for the tests were Fe^{2+}, Ba^{2+}, Hg^{2+}, Cu^{2+}, Mn^{2+}, Zn^{2+}, As^{3+}, Ni^{2+}, Cr^{3+} and Cd^{2+} at a concentration of 0.01M. The color change of the resulting mixture was observed and analyzed by UV-Vis spectrophotometry. Metal ions detected from the first stage of the experiment were further analyzed by lowering their concentration. To determine the detection limit of the synthesized AgNPs, different volume (20-600 µL) of that metal ion was added to 1 mL of nanoparticle dispersion. The resulting dispersion was then analyzed by UV-Vis spectrophotometry.

2.8 Catalytic activity of the AgNPs

The catalytic role of the AgNPs was assessed using 4-NP by following the reported procedure with modifications in the presence of $NaBH_4$.The experiment was performed by mixing 2.5 mL of freshly prepared 10 mM $NaBH_4$, 200 µL of 1 mM 4-NP, and 10 µL of 1.5 mg/mL AgNPs suspension [3]. Nanoparticle suspension was sonicated for 45 minutes before the experiment. The absorption of the mixture was monitored periodically at different time intervals between the ranges of 250 nm to 550 nm by using a UV-Vis spectrophotometer. The stability of $NaBH_4$ with 4-NP was checked by scanning in the same range at different time intervals for 30 minutes before mixing the catalyst (AgNPs).

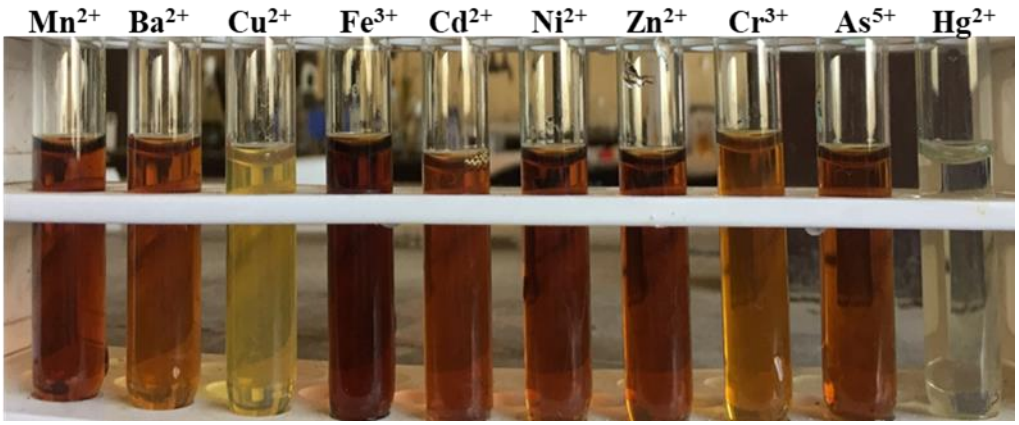

Figure S1: Color change of nanoparticle dispersion after addition of a metal solution.

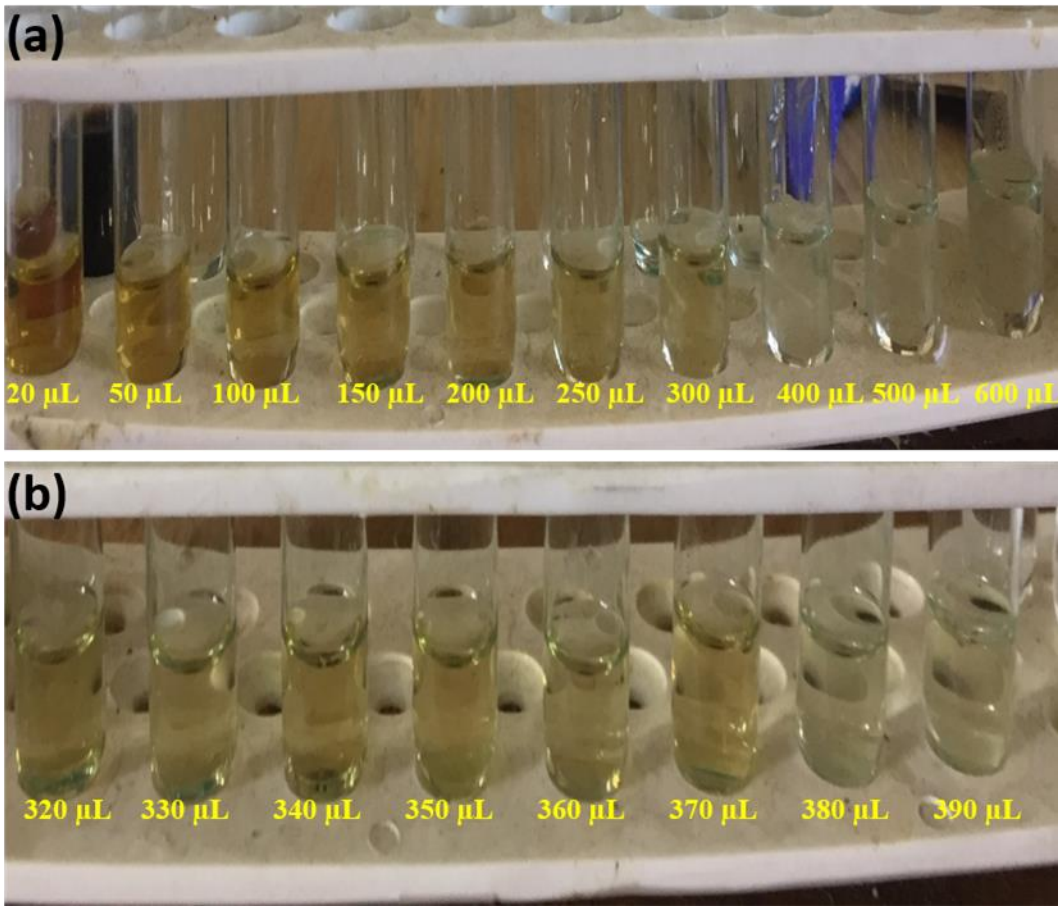

Figure S2: Color change on adding (a) 20-200 µL of Hg^{2+} and (b) 300-400 µL of Hg^{2+}.

Figure S3: Photographic image of *Artemisia vulgaris.*

3. References

[1] T. Wu, C. Liu, K.J. Tan, P.P. Hu, C.Z. Huang, Highly selective light scattering imaging of chromium (III) in living cells with silver nanoparticles, Analytical and Bioanalytical Chemistry, 397 (2010) 1273-1279.

[2] Nadzir, M.M.; Idris, F.N.; Hat, K. Green synthesis of silver nanoparticle using Gynura procumbens aqueous extracts. AIP Conf. Proc. 2019, 2124, 030018.

[3] Guo, Y.; Wang, Z.; Qu, W.; Shao, H.; Jiang, X. Colorimetric detection of mercury, lead and copper ions simultaneously using protein-functionalized gold nanoparticles. Biosens. Bioelectron. 2011, 26, 4064–4069.