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Biomimetic synthesis of silver nanoparticles using the fish scales of Labeo rohita and their application as catalysts for the reduction of aromatic nitro compounds

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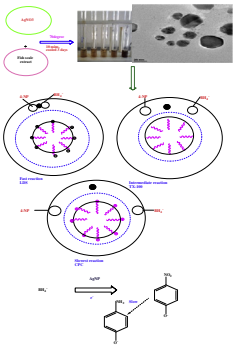
HIGHLIGHTS

- Silver nanoparticles are synthesized using fish scales of Labeo rohita.
- Size tailoring of nanoparticles is achieved by varying the reaction parameters.
- The method is simple, economic, and environmental friendly.
- The catalytic property of silver nanoparticles is investigated in aqueous and micellar medium.
- Silver nanoparticles have excellent potential for catalytic reduction of aromatic nitro compounds.

GRAPHICAL ABSTRACT



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ABSTRACT

In this article, a cleaner, greener, cheaper and environment friendly method for the generation of self assembled silver nanoparticles (Ag NPs) applying a simple irradiation technique using the aqueous extract of the fish scales (which is considered as a waste material) of Labeo rohita is described. Gelatin is considered as the major ingredient responsible for the reduction as well as stabilisation of the self assembled Ag NPs. The size and morphology of the individual Ag NPs can be tuned by controlling the various reaction parameters, such as temperature, concentration, and pH. Studies showed that on increasing concentration and pH Ag NPs size decreases, while on increasing temperature, Ag NPs size increases. The present process does not need any external reducing agent, like sodium borohydride or hydrazine or others and gelatin itself can play a dual role: a 'reducing agent' and 'stabilisation agent' for the formation of gelatin–Ag NPs colloidal dispersion. The synthesized Ag NPs were characterised by Ultraviolet–Visible spectroscopy (UV–Vis), Transmission electron microscopy (TEM) and Selected area electron diffraction (SAED) analyses. The synthesized Ag NPs was used to study the catalytic reduction of various aromatic nitro compounds in aqueous and three different micellar media. The hydrophobic and electrostatic interaction between the micelle and the substrate is responsible for the catalytic activity of the nanoparticles in micelle.

Introduction

Noble metal nanoparticles (NPs) especially silver nanoparticles (Ag NPs) have shown enormous interest to many research groups for their fascinating applications in the field of electronics, catalysis,

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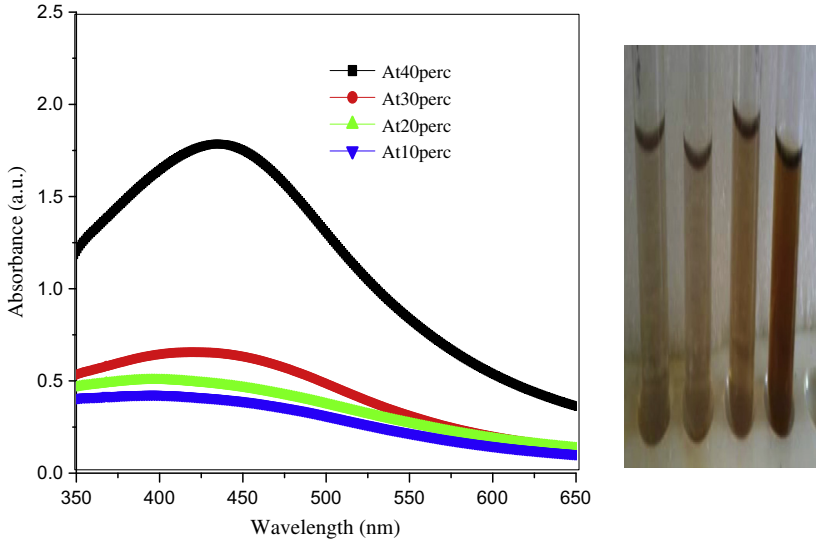

Fig. 1. UV–Vis absorption spectra recorded of synthesized Ag NPs with different concentrations of fish scale extract (10%, 20%, 30%, and 40%) solution treated to 0.1 M $AgNO_3$ solution. The colours of the solution shown in the inset after 3 days in increasing order of concentration from left to right. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

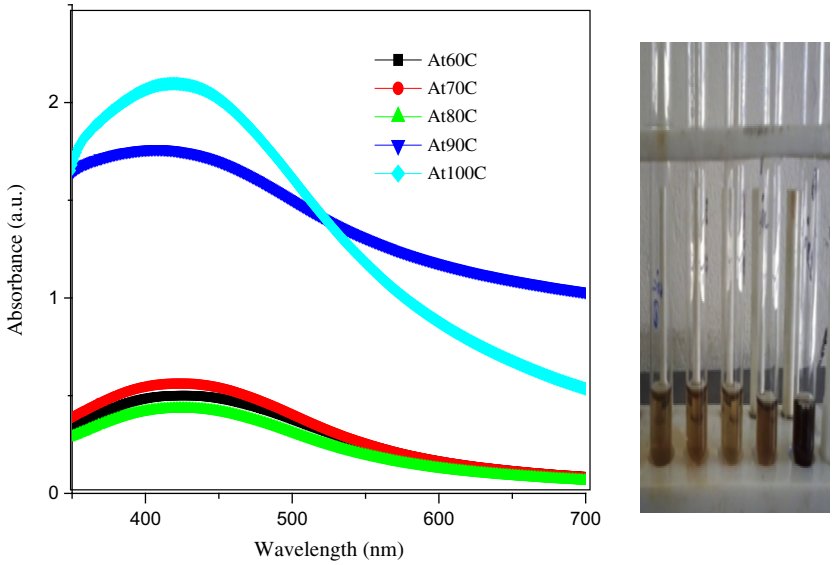

Fig. 2. UV–Vis absorption spectra recorded for Ag NPs at different temperatures (60, 70, 80, 90 and 100 °C) when 10 ml of 0.1 M silver nitrate solution treated to 10 ml of 10% extract. The colours of the solution after 3 days in increasing order of temperature from left to right. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

and pharmaceuticals etc. [1]. These applications are based on different chemical and physical properties attributed with nanomaterials due to their unique electronic structure and extremely large surface area which were not observed from those of the bulk and atomic species. However, various methods have been developed [2] for the synthesis of Ag NPs in organic solvents, using toxic reducing agents like sodium borohydride and N, N-dimethyl formamide.

Hence, for cleaner preparation of these noble metal nanoparticles, various biomimetic approaches [3,4] are being explored. Green technology, in the niche of preparative protocols of nanomaterial stands for switching to environmentally benign starting material and reducing agent, water as the reaction medium and selection of non-toxic substances of Ag NPs stability [5] with minimal wastage in terms of energy and raw materials [6–27].

Hence, in this paper, we develop an ecofriendly, clean, non-toxic, facile chemically preparative method, for the generation of Ag NPs using the extract of fish scales of Labeo rohita, acting as reducing as well as stabilising agent. The effects of various reaction parameters, such as temperature, pH and concentration of the extract in the synthesis of Ag NPs were also investigated. We have also studied the catalytic activity of these synthesized Ag NPs in the reduction of several aromatic nitro compounds in aqueous and micellar medium. The present synthesis process and the catalysis reaction are simple, environment friendly, and robust.

Experimental details

Materials

Silver nitrate ($AgNO_3$), p-nitro phenol (4-NP), o-nitro phenol (2-NP), p-nitro aniline (4-NP), sodium borohydride ($NaBH_4$), lithium dodecyl sulphate (LDS), cetyl pyridinium chloride (CPC), and triton x-100 (TX-100) of A.R Grade was purchased from