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Antibacterial finish of textile using papaya peels derived silver nanoparticles

Rashi Agarwal[1,a], Neelam Garg[2], Sonu Rani Kashyap[2] & R P Chauhan[3]

[1]Department of Biotechnology, Shobhit University, Meerut 250 110, India

[2]Department of Microbiology, Kurukshetra University, Kurukshetra 136 119, India

[3]Department of Physics, National Institute of Technology, Kurukshetra 136 119, India

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The present study is aimed at the extracellular synthesis of highly stable silver nanoparticles for the development of nanosafe textile using the extracts of yellow papaya peel. Fabric is treated with nanoparticles using dip and dry method to observe the effect of antibacterial activity. The synthesized nanoparticles are also characterized and quantified. Due to their potent antibacterial activity, papaya peels derived silver nanoparticles can be incorporated into fabrics and the manufacturers can make textiles free from spoilage by microorganisms.

Keywords: Antibacterial activity, Metabolites, Nanosafe textile, Silver nanoparticles

Bio-nanotechnology has emerged as integration of biotechnology and nanotechnology for developing biological and environmently benign technology for synthesis of nanoparticles. The most widely studied nanoparticles in the recent past are those made from the noble metals such as silver, gold and platinum. There is an increasing commercial demand for nanoparticles due to their wide applicability in various areas, such as electronics, catalysis, chemistry, energy and medicine[10]. Also in the textile sector, nanotechnology is expected to hold considerable potential for the development of new materials. Apart from improving their functionality, the use of nanotechnology could lead to the production of textiles with completely novel properties or the combination of various functions[9]. These multifunctional textiles can be antistatic textiles, reinforced textiles, antibacterial[5], self-cleaning textiles[13], bleaching resistant, etc. and can open the way for the use of its products in other fields outside the traditional industries[8].

Among all nanoparticles, silver nanoparticles are of particular interest due to their strong and wide-spectrum antimicrobial activities. For protection against microbial contamination, silver has been incorporated into various forms of plastics e.g. catheters, dental material, medical devices, implants, and burn dressings. These nanoparticles have also been used for durable finish on fabrics. As bactericides, the silver nanoparticles may help in solving the serious antibiotic resistance problem.

Several strategies are employed for the synthesis of silver nanoparticles including chemical techniques, physical techniques and recently via biological techniques[1]. Biological techniques have received much attention as a viable alternative for the development of metal nanoparticles[12]. Many bacterial as well as fungal species have been used for silver nanoparticles synthesis[3,16]. But most of them are reported to accumulate silver nanoparticles intracellularly. On the contrary, plant extract mediated synthesis i.e. green synthesis always takes place extracellularly, and the reaction times remain very short as compared to microbial synthesis.

Extracts of several plants such as ***Pelargonium graveolens, Medicago sativa, Azadirachta indica, Lemongrass, Aloe vera, Cinnamomum, Camphora, Emblica officinalis, Capsicum annuum, Diospyros kaki, Carica papaya, Coriandrum, Boswellia ovalifoliolata, Tridax procumbens, Jatropha curcas, Solanum melongena, Datura metel, Citrus aurantium,*** and many weeds have shown the potential of reducing silver nitrate for the formation of silver nanoparticles without any chemical ingredients[15,11].

Carica papaya (papaya) is a native of northern India and has been cultivated and naturalized over the whole Mediterranean region since ancient times. It is a medicinal plant. Different parts of this plant including flower and fruits are used for the synthesis of silver nanoparticles. Main edible portion of the plant is fruit, peel of which is generally discarded. Fewer reports related to the synthesis of silver nanoparticles using peel extracts are available. In this study, we explored for the first time the potential of the peels of yellow papaya as non-toxic

[a]Corresponding author.
E-mail: agarwal.rashi7@gmail.com

biological systems for the biosynthesis of green silver nanoparticles.

Experimental

Bioextract of yellow papaya peels were prepared, washed in distilled water, dried, finely chopped and then mashed into sterile distilled water. The product was boiled for 1 h and filtrate was used as bioextract.

Preparation of Silver Nanoparticles from Bio-extract

The aqueous solution of 1mM silver nitrate ($AgNO_3$) was prepared and used for the synthesis of silver nanoparticles. To 80 mL of this solution, 20 mL of bio-extract was added and kept at room temperature. The reduction of Ag+ was observed by measuring the absorption of the solution.

Characterization

Silver nanoparticles were characterized using ultraviolet-visible spectroscopy, dynamic light scattering (DLS) technique and X-ray diffraction (XRD).

Coating of Fabric with Silver Nanoparticles

The fabric was treated with silver nanoparticles to make the nano safe textile and used to detect antibacterial activity against test organism, i.e. ***Staphylococcus aureus*** zone of inhibition was investigated. Durable textile finish test was also performed [14].

Results and Discussion

Ultraviolet –Visible Spectral Analysis

It is well known that silver nanoparticles exhibit yellowish brown colour in aqueous solution due to excitation of surface plasmon vibrations in silver nanoparticles. It is generally accepted that UV–Vis spectroscopy could be used to examine size- and shape-controlled nanoparticles in aqueous suspensions. Figure 1 shows the UV-Vis spectra of silver nanoparticles. Absorbance peak and broadening of peak at around 450 nm indicated that the particles are polydispersed. The present result agrees well with the earlier findings[2].

Dynamic Light Scattering

The DLS (Dynamic light scattering) pattern reveals that silver nanoparticles synthesized by this method have a zeta average diameter range of 20-140 nm (Fig. 2). The highest fraction of silver nanoparticles present in the solution was of 50nm. Huang ***et al***.[6] have reported that the DLS measured size is slightly bigger as compared to the particle size measured by any other method because dynamic light scattering method measures the hydrodynamic radius.

XRD pattern of the yellow papaya peel derived silver nanoparticles shows three intense peaks in the whole spectrum of 2θ values ranging from 20° to 75° (Fig. 3). The exact nature of the silver particles formed can be deduced from the XRD spectrum of the sample. XRD spectra of pure crystalline silver structures have been published by the Joint Committee on Powder Diffraction Standards (JCPDS). A comparison of our XRD spectrum with the standard confirmed that the silver particles formed in our experiments are in the form of nanocrystals. The average estimated particle size of this sample is

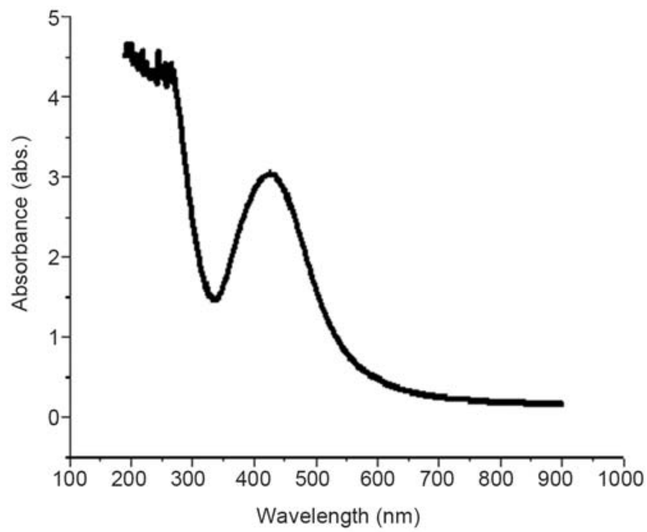

Fig. 1—UV-Vis spectra of silver nanoparticles

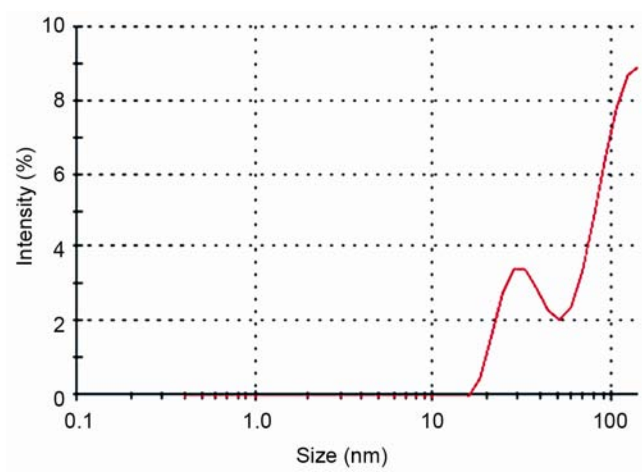

Fig. 2—Dynamic light scattering pattern of papaya peel derived silver nanoparticles using X-ray diffraction

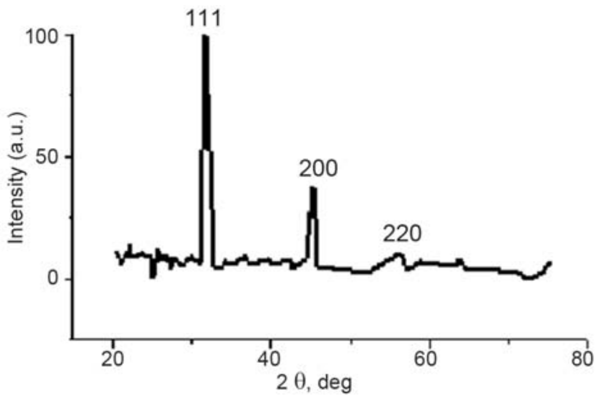

Fig. 3—XRD of green silver nanoparticles

Fig. 4—Antibacterial activity of silver nanoparticles 1 & 2 test samples and 3 & 4 are controls

20 nm derived from the FWHM of peak corresponding to (111) plane using Debye Scherrer formula.

Antibacterial Activity Assessment of Textile Material

Figure 4 reveals that the zone of inhibition in case of finished fabric is about 2.5 cm whereas in case of finished fabric, after washing with water in order to check the durability is found to be 1.5cm. Zone of inhibition is 0 in both the controls.

The mechanism for the antimicrobial action of silver ions is not properly understood. However, it is suggested that when the silver ions penetrate inside the microbial cell the DNA molecule turns into condensed form and loses its replication ability, leading to cell death. It has also been reported that heavy metals react with proteins by getting attached with the thiol group and the proteins get inactivated [4].

The silver nanoparticles show efficient antimicrobial property compared to other metal nanoparticles due to their extremely large surface area, which provides better contact and thus effective control of microorganisms such as bacteria and fungi. Silver is inherently anti-microbial and antibacterial substance. The antimicrobial activity of silver nanoparticles derived from green papaya peels show enhancement in activity due to synergistic effect of secondary metabolites like alkaloids, terpenoids, saponins, tannins, flavonoids [7].

Among the different methods for nanoparticles synthesis, green synthesis method has advantage in controlling particle size and morphology very effectively. This method is also convenient and fast as compared to other conventional methods. Due to their potent antibacterial activity, papaya peel derived silver nanoparticles can be incorporated into fabrics and the manufacturers can make textiles free from spoilage by microorganisms. The significant reduction in reaction time with fruit peel extract is an important result and will enable nanoparticle biosynthesis methods to compete with other routes for the formation of nanoparticles that are currently much more rapid and reproducible.

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