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Antibacterial application of polyvinylalcohol-nanogold composite membranes

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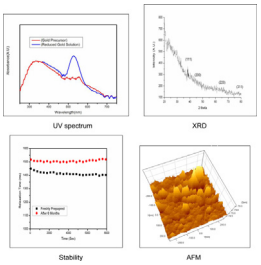
HIGHLIGHTS

- Green synthesis of spherical gold nano particles.
- Composite membranes of PVA-AuNPs.
- Ultra-stable AuNPs for 6 months without capping.
- High antibacterial efficacy of composite membrane with ZOI 10 mm.

GRAPHICAL ABSTRACT



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ABSTRACT

The present invention explores the antibacterial efficacy of ultra stable gold nanoparticles (GNPs), embedded polyvinyl alcohol (PVA) hybrid membranes. A green approach to synthesize the ultra stable GNP's using *Phyllanthus emblica* (amla) extract was adapted. These GNP's were impregnated in PVA matrix to fabricate hybrid PVA-nanogold membranes by solvent casting technique. The facile green synthesis resulted in spherical gold nanoparticles with an average diameter of 2–4 nm. The Xigo analysis suggested the ultra high stability of these nanoparticles for more than 6 months. The interaction of GNP's with PVA matrix was studied using FTIR and the surface topology was studied using AFM. Antibacterial efficacy of these hybrid membranes was assessed using disc diffusion method against Gram positive and Gram negative bacterial strains. The inhibitory effects of the hybrid membranes resulted in a zone of inhibition of 0.8–1.0 cm over a period of 24 h.

1. Introduction

Stupendous efforts have been concentrated for the development of efficient methodologies on synthesis of gold nanoparticles possessing unique optical, chemical and optoelectronic properties. Synthesis of mono-dispersed nanoparticles with desired shape and size has been a great challenge in the field of nanotechnology. Although various physical [1,2] and chemical [3,4] methods are known, the most common method for synthesis of gold nanoparticles (GNP's) is the aqueous reduction of gold salt using sodium citrate [5,6]. Other methods such as microemulsion, reversed micelles, seeding growth, sonochemistry, photochemistry and radiolysis [7] are also proposed for nanogold synthesis, however, the use of toxic chemicals and stability of reduced gold nanoparticles is of paramount concern. Thus researchers have focused on the development of clean, biocompatible, non-toxic, eco-friendly methods as prime requirement for synthesis of GNP's. Green chemistry approaches emphasizing the use of biological entities such as plants, plants extract, bacteria, fungi, algae, actinomycetes, and viruses [8–10] for synthesis of gold nanoparticles is gaining significant importance due to its simplicity and

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immediate response towards the reducing agent [11]. *Alfalfa*, *Parthenium hysterophorous*, *Diopyros kaki*, *Azadirachta indica*, *Hibiscus rosasinensis*, and *Capsicum anuum* [12–16] have been extensively studied for the synthesis of gold nanoparticles. Green approach involves exposure of gold salt to aqueous plant extract which results in formation of extracellular as well as intracellular gold nanoparticles. These extracts consist of reducing agents like citric acid, ascorbic acid, flavonoids, reductases, dehydrogenases and extracellular electron shuttlers which lead to biosynthesis of gold nanoparticles [17].

In the present study, gold nanoparticles were synthesized using *Phyllanthus emblica* fruit extract. *P. emblica* consists of active ingredients like quercetin, phyllaemblic compounds, gallic acid, tannins, flavonoids, pectin and vitamin C with various polyphenolic compounds [18] which results in formation of spherical gold nanoparticles with an average diameter of 2–4 nm under ambient temperature. These GNP's were then dispersed in polyvinyl alcohol (PVA) matrix and casted in form of membrane. Membranes are the interphase between two adjacent phases which regulate the transport of substances and act as a selective barrier. High molecular weight and high degree of hydrolysis (98.99%) PVA was selected as the membrane material due the presence of large number of hydroxyl group and extensive hydrogen bond which results in formation of stable membranes. The fabrication of such membranes possesses wide range of tuneable antibacterial properties via chemical casting method. This cost effective method eliminates use of elaborated sophisticated equipments to fabricate membranes for biomedical application like wound healing, antibacterial, antifungal, etc. [19]. The surface topology and the functional group analysis of the membranes were studied using AFM and FTIR, respectively. The antibacterial activity was measured using disc diffusion method against *E. coli* and *S. aureus* as test bacterial strains.

2. Experimental

2.1. Materials

Chloroauric acid and polyvinyl alcohol (PVA; 98–99% hydrolyzed, Mw 146,000–186,000) were procured from Sigma–Aldrich. Phosphate buffer solution (pH 7.4) was purchased from Thomas Baker. The bacterial strains; Gram-negative (*Escherichia coli* ATCC 25922) and Gram-positive (*Staphylococcus aureus* ATCC 25923) were incubated overnight at 35 °C in

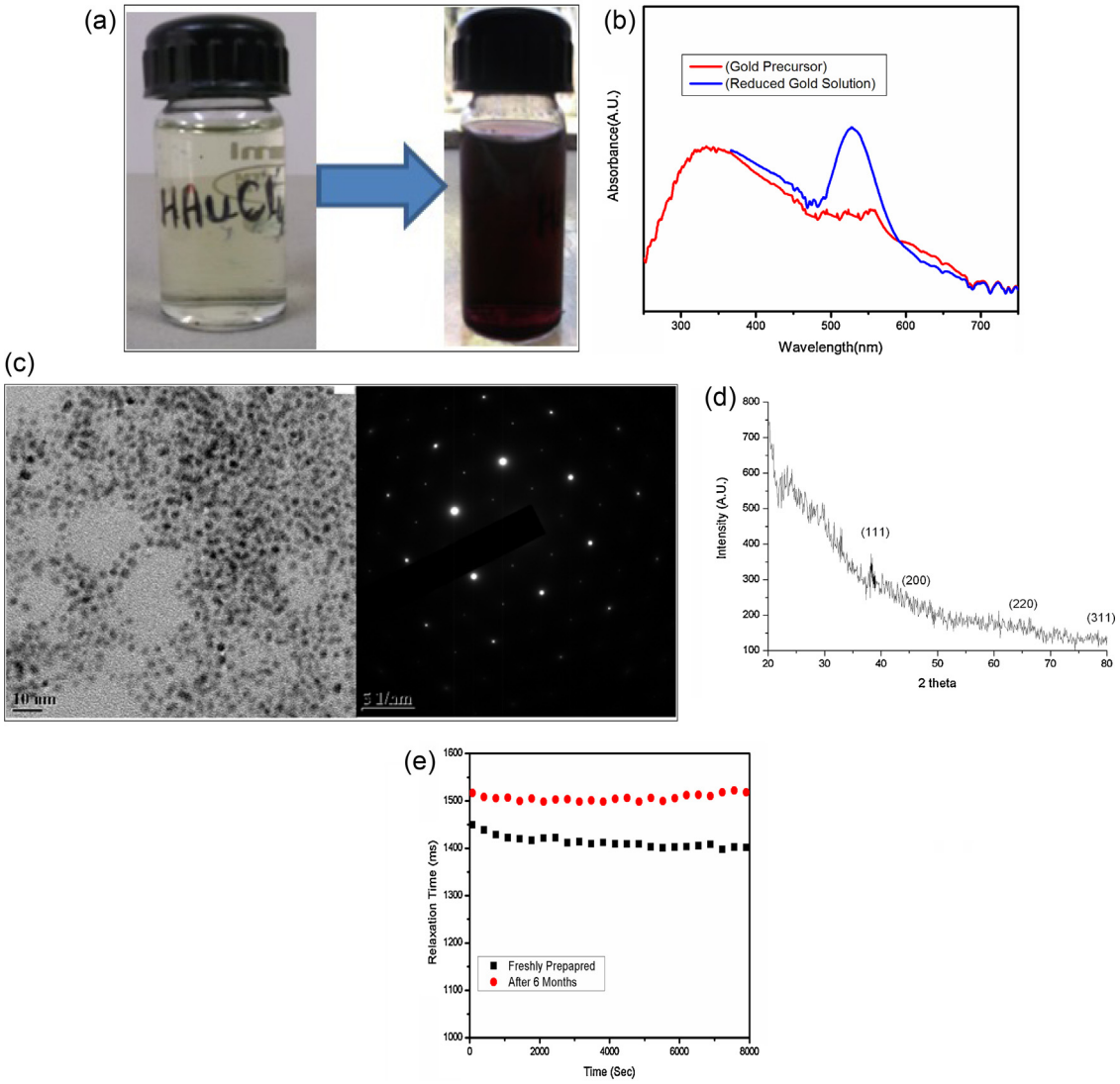

Fig. 1. (a) Change in the colour of gold precursor via *P. emblica*, (b) UV–vis spectrum of gold precursor and reduced gold solution, (c) TEM and SAED analysis of gold nanoparticles, (d) XRD of gold nanoparticles reduction of gold precursor via and (e) stability of GNP's.