Au°-Nanoparticles: Control Size and Morphology Stabilized by Tripodal Phosphine Based Ligands and Their Antimicrobial Activity

Bibek Jyoti Borah¹, Archana Yadav², and Dipak Kumar Dutta¹

¹Materials Science and ²Biotechnology Divisions, North East Institute of Science and Technology (CSIR), Jorhat 785006, India

Metal nanoparticles have attracted great attention due to their potential applications in the fields like electronics, opto-electronics, bioscience, catalysis, etc. New ligands 1,1,1-tris(diphenylphosphinomethyl)ethane [CH₃C(CH₂PPh₂)₃] and 1,1,1-tris-(diphenylphosphino methyl) ethane trisulphide [CH₃C(CH₂P(S)Ph₂)₃] for stabilization of Au°-nanoparticles having small core diameter were prepared. The Au°-nanoparticles are more active against Gram(+) bacteria, e.g., Staphylococcus aureus than Gram(−) bacteria. Among the two Au°-nanoparticles, the ligand 1 stabilized particles shows higher activity.

Keywords: Au°-Nanoparticles, Antimicrobial Activity, Phosphine, Surface Plasmon, Single-Crystalline.

1. INTRODUCTION

Metal nanoparticles have attracted great attention due to their potential applications in the fields like electronics, opto-electronics, bioscience, catalysis, etc.¹-⁵ Ligands stabilized metal nanoparticles are considered as important building blocks. A numbers of phosphines and thiols stabilized metal nanoparticles were studied⁶ but metal nanoparticles particularly Au°-nanoparticles stabilized by tripodal phosphines and its chalcogen functionalized have not been reported so far. We report new ligands 1,1,1-tris(diphenylphosphinomethyl)ethane [CH₃C(CH₂PPh₂)₃] 1 and 1,1,1-tris-(diphenylphosphino methyl) ethane trisulphide [CH₃C(CH₂P(S)Ph₂)₃] 2 for stabilization of Au°-nanoparticles having small core diameter and their antimicrobial activity against some Gram(+) and Gram(−) bacteria.

2. MATERIALS AND METHODS

HAuCl₄·3H₂O, 1,1,1-tris (diphenylphosphino methyl) etheane, elemental sulfur, Tetra-n-octylammoniumbromide and NaBH₄ were purchased from M/S Sigma Aldrich, USA. Phosphine stabilized Au°-nanoparticles were synthesized following the procedure of Hutchison et al.⁷ The synthesized Au°-nanoparticles were characterized by UV-Visible spectroscopy, XRD, TEM and HRTEM, etc. techniques and evaluated for antimicrobial activity by standard Agar-well-diffusion method.

3. RESULTS AND DISCUSSION

The broad surface plasmon bands (Fig. 1(A)) of Au°-ligands (1 and 2) at around ~520 nm indicate that the particles stabilized by ligand 1 are smaller than that of Au°-ligand 2.¹

The TEM images (not shown) for ligands 1 and 2 stabilized Au°-nanoparticles indicate narrow size distribution of 1.6±0.4 nm and 3.0±0.7 nm respectively. The HRTEM pattern (not shown) of Au°-nanoparticles stabilized by ligand 1 shows their single-crystalline nature.⁷

The XRD peaks of Au°-nanoparticles stabilized by ligand 1 could not be detected due to the small size (<2 nm),¹ while ligand 2 stabilized nanoparticles shows diffraction peaks (Fig. 1(B)) corresponding to the (111), (200), (220) and (311) surfaces of fcc gold, indicate the products are composed of crystalline gold.

The Au°-nanoparticles are more active against Gram(+) bacteria, e.g., Staphylococcus aureus than Gram(−) bacteria. Among the two Au°-nanoparticles, the ligand 1 stabilized one shows higher activity (Table I).
Fig. 1. (A) UV-Visible spectra and (B) Powder XRD pattern Au\textsuperscript{n}-nanoparticles stabilized by ligand 2.

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<thead>
<tr>
<th>Table I.</th>
<th>Antimicrobial activities of Au\textsuperscript{n}-nanoparticles.</th>
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<tbody>
<tr>
<td>Bacteria used</td>
<td>Inhibition zone diameter (mm)</td>
</tr>
<tr>
<td></td>
<td>Au\textsuperscript{n} ligand 1</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>17</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>10</td>
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References and Notes

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