BIOLOGICAL ACTIVITIES OF TIN OXIDE NANOPARTICLES SYNTHESIZED USING PLANT EXTRACT

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ABSTRACT

SnO₂ nanoparticles was prepared by using Cleistanthus Collinus plant methanolic extract. The formation of tin oxide nanoparticles were confirmed by XRD, SEM and EDAX. The average crystallite size of SnO₂ nanoparticles was found to be 49.26nm. The antibacterial activities of SnO₂ nanoparticles were studied by using Escherichia coli and S. aureus and antifungal activities were studied by using Asperjillus Nigar and T. viridea. Furthermore, the antioxidant activities of SnO₂ nanoparticles were studied by DPPH Scavenging method.

Keywords: Green synthesis, Metal oxide nanoparticles, Biological activities, Cleistanthus Collinus

INTRODUCTION

Metal oxide nanoparticles are used for a large variety of applications including catalysis, sensors, optoelectronic materials and environmental remediation [1]. Controlled syntheses of metal oxide nanoparticles are essential for the several applications and solution phase methods provide a large degree of control over the synthesis products. [2] SnO₂ is an important material due to its properties such as high degree of transparency in the visible spectrum, strong physical and chemical interactions with adsorbed species, low operating temperature and strong thermal stability in air (up to 500° C). It is an n-type semiconductor with a band gap of 3.6 to 3.8 eV [3].

The preparation of SnO₂ and other nanoparticles uses variety of methods including sol-gel [4], precipitation [5], electrochemical [6], sonochemical [7], solid-state reaction [8], alcohothermal [9], microwave irradiation techniques [10] involving toxic organic solvents and harsh reducing agents. Many of these reducing agents have been associated with environmental toxicity or
biological hazards. Therefore it was a challenge to find convenient, mild, non-toxic, natural products to produce metal oxide nanoparticles in an aqueous environment. The biological synthesis of metal oxide nanoparticles using plants has received more attention as a suitable alternative to chemical procedure and physical methods. Extracts from plants may act both as reducing and capping agents in nanoparticle synthesis. This is cost effective and therefore can be used as an economic and viable alternative for the large scale production of metal and metal oxide nanoparticles. In the present study, the SnO$_2$ nanoparticles are prepared by using the methanolic extract of Cleistanthus Collinus plant. Cleistanthus Collinus contains lignan lactone glucosides like Cleistanthin A and Cleistanthin B. Genin (Diphyllin) is the major metabolite of these lignan lactone glycosides. The other lignin glycoside in this plant is collinusin. These are toxic aryl naphthalene lignin lactones. Cleistanthin A is used in Chinese medicine as sheng bai xin. So this extract was chosen for the synthesis of the SnO$_2$ nanoparticles and their biological activities are measured.

MATERIALS AND METHODS

Materials

All analytical reagents used in this experiment were of highest purity and obtained from sigma (Bangalore, India) and media components were purchased from Hi-Media (Mumbai, India). Fresh and green leaves of Cleistanthus Collinus plant were collected from Mallur village (Tamil Nadu, India) in Salem district.

Synthesis of Tin oxide nanoparticles

The leaves of Cleistanthus Collinus plant were dried at room temperature and powdered well. Then 10 g of dried powder was mixed with 100 ml of ethanol and the mixture was heated at 60°C for 2 hours. It was filtered by using Whatmann filter paper (No.1) and the filtrate was collected. This ethanolic extract was used as stock solution for the study. 10 ml of Cleistanthus Collinus plant ethanolic extract was mixed with 90ml of 1mM tin oxide aqueous solution in 250 ml conical flask. The reaction mixture was heated at 80°C for one hour. The greenish yellow coloured solution changed into pale yellow which showed the formation of Tin oxide nanoparticles.

Characterization

The SnO$_2$ nanoparticles synthesized by Cleistanthus Collinus leaves extract were subjected to the X-ray diffraction. This was carried out using Cu-K$_\alpha$ radiation source in PANalytical X’pert PRO model X-ray powder diffractometer.
The size, shape and morphology of SnO$_2$ are examined by FESEM and elemental analysis of those nanoparticles was done by EDAX method. 10 mg of the nanoparticles was mixed with 1.7 ml of 100µM DPPH solutions along with control DPPH Solution which do not contain any nanoparticles. Then this mixture was vortexed for 3 minutes. The time dependant DPPH scavenging was studies at an interval of 0 and 5 minutes. After mixing, the supernatant was centrifuged for 2 minutes. The absorption of supernatant was measured at 517nm using UV spectrometer. The scavenging activity of these nanoparticles calculated by

DPPH scavenging activity (%) = \( \frac{\text{Abs Blank} - \text{Abs Sample}}{\text{Abs Blank}} \times 100 \)

Where, Abs Blank = Optical density of Control.
Abs Sample = Optical density of sample extract

Antimicrobial activities of the synthesized Ag doped Bismuth oxide nanoparticles were performed against both Gram-negative \((E.\text{coli})\) and Gram-positive \((S.aureus)\) bacteria. The antibacterial activity was done by modified Kirby-Bauer disk diffusion method. Solvent blank was used as negative control. Antibiotic streptomycin was used as a positive control. Antifungal activity of Cleistanthus Collinus plant extract capped SnO$_2$ nanoparticles was studied using antifungal susceptibility test. \(Aspergillus \text{niger}\) and \(T.viridea\) fungi samples were used to study the antifungal activity of this nanoparticles.

RESULTS AND DISCUSSION
The X-ray diffraction patterns obtained for the SnO$_2$ nanoparticles synthesized using Cleistanthus Collinus plant methanolic extract confirmed the formation of tetragonal primitive lattice structure of SnO$_2$ nanoparticles \[18\]. The average grain size of SnO$_2$ nanoparticles are 49.26 nm.

The SEM of SnO$_2$ nanoparticles has been represented in figure 1. The SEM micrograph enabled the computation of the particle size and its reveals the presence of SnO$_2$ nanoparticles which ranges from 20-40 nm. The EDAX results also confirm the formation of SnO$_2$ nanoparticles (Figure 2).
BIOLOGICAL STUDIES

ANTIMICROBIAL STUDIES

The table 1 shows the inhibition of bacterial growth on agar plates as a function of the 25 μg, 50 μg and 75 μg concentrations of the SnO₂ nanoparticles. When the concentration of SnO₂ nanoparticles was increased, the antibacterial effect also got increased. Nanoparticles tend to adsorb on the bacterial cell and undergo dehydrogenation due to respiration process which occurs at the cell membrane of bacteria. After reaction with nanoparticles, the bacteria had inactivated their enzymes, generating hydrogen peroxide that causes bacterial cell death [19]. The *Escherichia coli* shows more significant activity than *S.aureus*. Because, *Escherichia coli* was not having cell wall but *S.aureus* having cell wall. So the nanoparticles easily entered the *E.coli* and caused more cell damage than that of *S.aureus*. 
Table 1: Antimicrobial activity of SnO$_2$ nanoparticles

<table>
<thead>
<tr>
<th>Name of Microorganism</th>
<th>Antibacterial Activity Zone of Inhibition (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standard</td>
</tr>
<tr>
<td><strong>Bacterial activity</strong></td>
<td></td>
</tr>
<tr>
<td><em>Escherichia coli</em></td>
<td>14</td>
</tr>
<tr>
<td><em>S.aureus</em></td>
<td>15</td>
</tr>
<tr>
<td><strong>Fungal activity</strong></td>
<td></td>
</tr>
<tr>
<td><em>Aspergillus Nigra</em></td>
<td>10</td>
</tr>
<tr>
<td><em>T.viridea</em></td>
<td>9</td>
</tr>
</tbody>
</table>

ANTIOXIDANT ACTIVITY

Table 2: Antioxidant activity of SnO$_2$ nanoparticles

<table>
<thead>
<tr>
<th>Concentration of SnO$_2$ Nanoparticles</th>
<th>Initial (%)</th>
<th>After 5 minutes (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 μg</td>
<td>5.82</td>
<td>20.5</td>
</tr>
<tr>
<td>50 μg</td>
<td>13.49</td>
<td>38.15</td>
</tr>
<tr>
<td>75 μg</td>
<td>18.67</td>
<td>59.64</td>
</tr>
</tbody>
</table>

Antiradical activity assay is based on the reduction of 1,1-diphenyl-2-picrylhydrazyl (DPPH). Due to the presence of an odd electron it gives a strong absorption maximum at 517 nm. The antioxidant property of synthesized nano particles was determined by DPPH free radical scavenging assay method. SnO$_2$ nanoparticles show significant DPPH scavenging activity. The antioxidant activity also increases with an increase in the concentration and time $^{[20,21]}$. 

CONCLUSION

The SnO$_2$ nanoparticles are green synthesized by using Cleistanthus Collinus plant extract. XRD, SEM and EDAX methods confirm the formation of SnO$_2$ nanoparticles. SnO$_2$ nanoparticles showed more significant antibacterial activity against *Escherichia coli* than that of *T.viridea*. The antifungal activity SnO$_2$ nanoparticles was confirmed by Potato Dextrose Broth antifungal assay method. The SnO$_2$ nanoparticles show potential antioxidant property.

REFERENCES


