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Nobel Metal Nanoparticles in Bio-LED

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1. Introduction

Nanomaterials are well known for their interesting physical chemical properties [1-7]. Recently, noble metal nanoparticles have attracted attention [9-15] due to their optical property of surface plasmon resonance. Surface plasmon resonance produces hot light spots due to a stronger electromagnetic field. Because of their low toxicity, ease of delivery, and strong and tunable surface plasmon resonance, noble metal nanoparticles are used in the field of the photothermal ablation therapy to treat cancer [10]. Plants help people confront the global warming by absorbing CO_2 in the photosynthesis process. If plants were able to do the photosynthesis process day and night, absorbing CO_2 will act in day and night.

In this paper, we investigate the life time of noble metal nanoparticle colloids on plants specifically. The buds of Floppers, Bryophyllum pinnatum (Lam.) Kurz., are watered the noble metal cluster colloids. The buds are recorded for six weeks. The results show that noble metal nanoparticle colloids exit plant growth, with the Pt nanoparticles aggregating on the leaf. We expect that this research has potential applications in the fields of biosensing, bio-LED, bioimaging, nanophotonics, photothermal ablation therapy, and nanotoxicity.

2. Experimental produre

Chemicals and materials. We prepared 10 L standard solution by adding MgCl= 10.0 ppm, KCl=0.5 ppm, NaCl= 8 ppm, and $FeCl_3$= 0.04 ppm in Milli-Q water. Trisodium citrate (99%) and $HAuCl_4$, $AgNO_3$, and H_2PtCl_6 were purchased from Showa Chemical Co. (Tokyo, Japan) and Alfa Aesar Chemical Co. (Lancashire, England) and used as supplied, respectively. Milli-Q water was obtained from the Milli-Q Element system (Massachusetts, USA), which employs ultra-clean materials and a succession of optimized water purification technologies to produce 18.2 MΩ/cm resistivity ultrapure water (at 25 °C), ideal for trace analysis methods. The solution used in this work was freshly prepared and deoxygenated by bubbling nitrogen gas for at least 30 min prior to use. All materials and apparatus were sterile.

Preparation of noble nanoparticles. Au NPs were prepared by a chemical-reduction method with Au, Pt, Ag-salt and Na-cit standard solutions. 1.5 ml of freshly prepared 0.34 M trisodium citrate$_{(aq)}$ solution was added to 15 ml of 0.5 mM $HAuCl_{4(aq)}$ solution, $AgNO_{3(aq)}$

solution, and $H_2PtCl_{6(aq)}$ solution at room temperature and under vigorous stirring for 48 hours. These solutions were stirred for 30 min to control the reaction rate of Au, Ag, and Pt nanoparticles, respectively. All materials and apparatus were sterile.

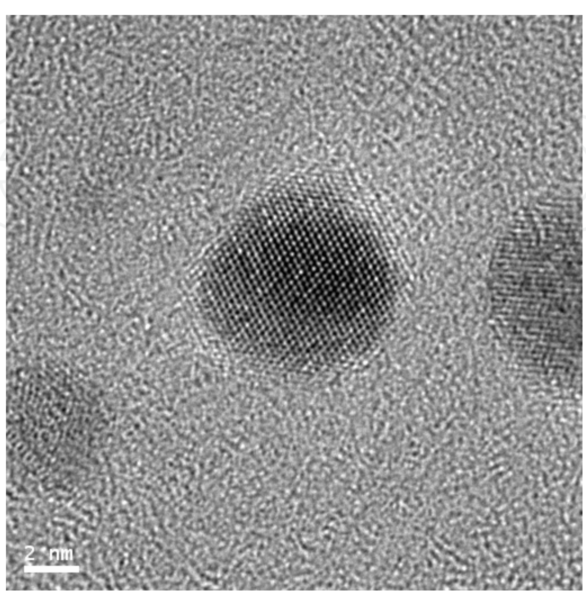
Preparation of Floppers, Bryophyllum pinnatum (Lam.) Kurz. We cut 40 leaves from the plant Bryophyllum pinnatum (Lam.) Kurz., and these were then placed in a 50 ml glass bottom and watered with standard solution. The environment was controlled at 300 K, with 100mW/square-cm radiation with sun lamps and 60% humidity. Buds grew at the edges of the leaves, and when the length of a bud reached 5.980 mm, it was cut, and put at the bottom of a 3 ml glass bottom. The cut buds were hold in a 300 K environment with 100mW/square-cm radiation with sun lamps and 60% humidity. A total of 697 buds were tested using either standard solution or noble metal colloids. The buds were watered with 0.5 ml of the standard solution or noble metal colloids. And all materials and apparatus were sterile.

Instruments and Measurements. Dark-field spectroscopy, zetasizer, and TEM were used in the analysis. The morphology of the noble metal nanoparticles was observed by TEM. The as-grown product was observed with a Hitachi model HF-2000 transmission electron microscope operating at 200 kV. The sample was directly dispersed onto a 200-mesh holey carbon film on a Cu grid for TEM analysis. After being watered with standard solution or noble metal colloids for six weeks, the leaves and roots of the buds were observed via dark-field spectroscopy.

3. Results

3.1 Morphology of Au, Ag, and Pt nanoparticles

The concentration of the citratic acidic group modifies the noble metal nanoparticles to control their size. The average size for Au, Ag, and Pt nanoparticles was measured with a zetasizer, and was 6.3 nm, 3.2 nm, and 5.8 nm, respectively. From the TEM observation in Fig. 1, the size of the Au, Ag, and Pt nanoparticles is in good agreement with the zetasizer measurements.



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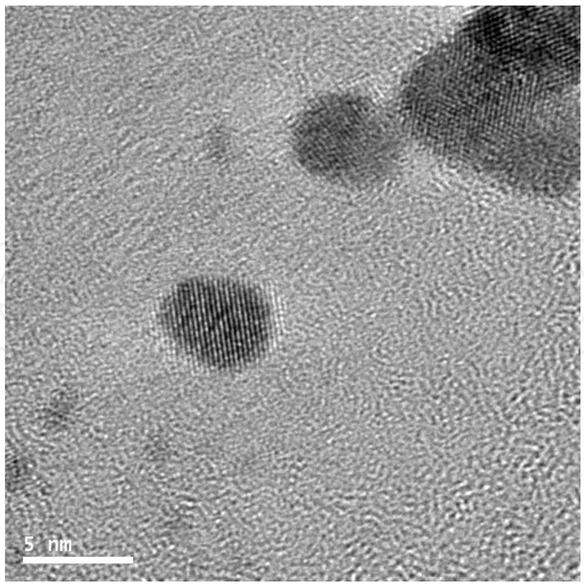

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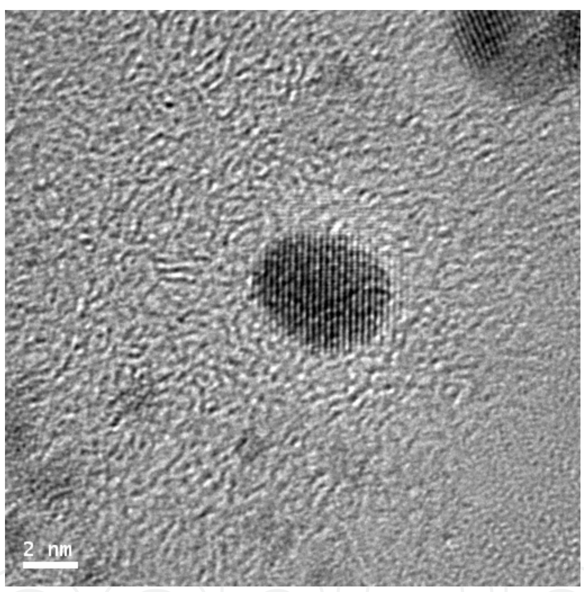

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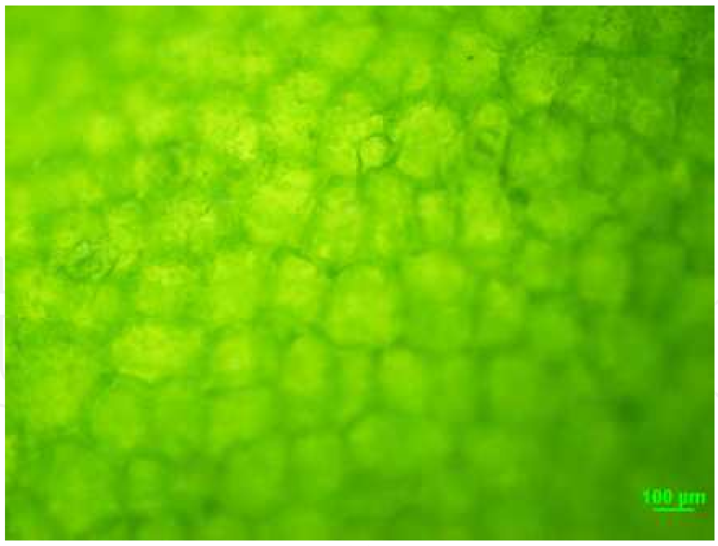
Fig. 1. Morphology of (a) Au, (b) Ag, and (c) Pt nanoparticles under TEM observation.

3.2 Buds watered with standard solution or noble metal colloids for six weeks

After being watered with standard solution or noble metal colloids for six weeks, dark-blue masses on the leaves are seen under the dark-field microscopic observation in Fig. 2. The leaves scatter green light, as shown in Fig. 2 (a). Metal clusters usually scatter strong light due to surface plasmon resonance [9,14]. And as the size of the particles (clusters) increases, so does the damping factor and the absorption. On the other hand, the light scattering gets weaker, as the size of particles (clusters) increases [14,15]. Thus, the metal cluster presents the dark-blue masses. In addition, the nanoparticles aggregate on the surface of leaves, and Fig. 2 shows that Pt nanopartcles aggregate together the most.



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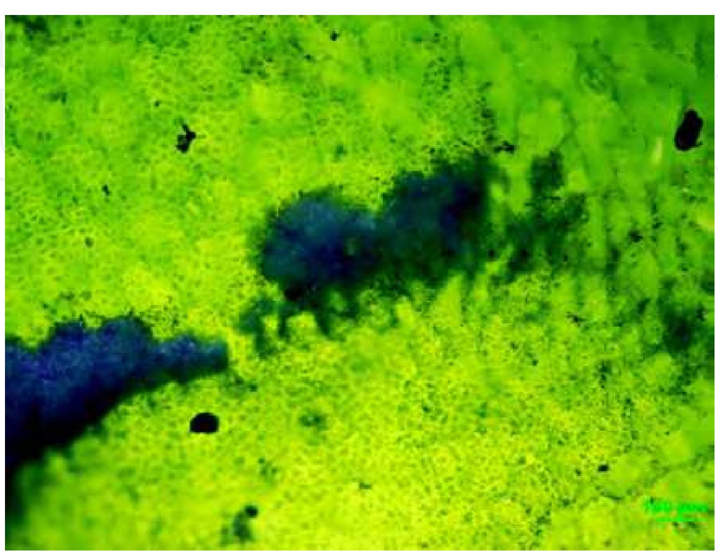
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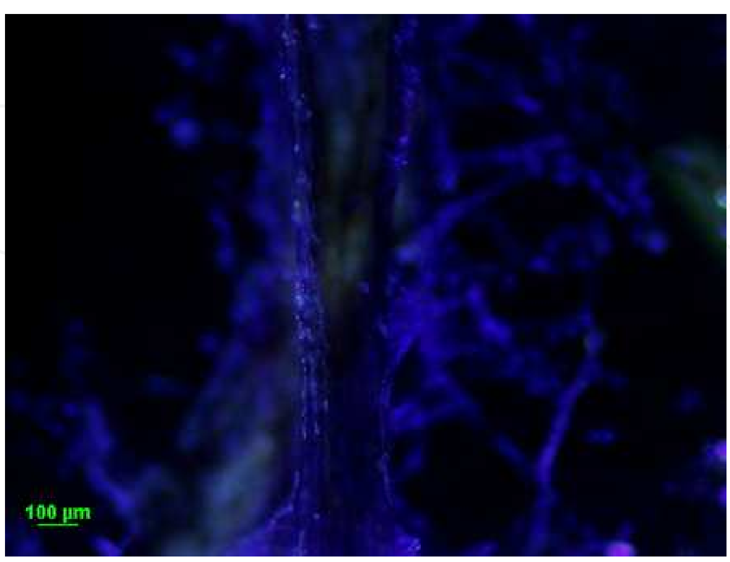
(d)

Fig. 2. Dark-field microscopic image of leaf on the bud watered with (a) standard solution, (b) Au colloids, (c) Pt colloids, and (d) Ag colloids for six weeks.

In Fig. 3, the dark-field microscopic observation shows the roots scatter the weak light, while the metal clusters scatter stronger light. As the size of the metal clusters decreases, the surface plasmon resonance increases, as does the scattering of light [14,15]. Therefore, the particles (clusters) size on the roots are smaller than these on the leaves. However, the light scattering of Pt clusters is weaker than that of the Au or Ag clusters, and Pt nanopartcles also aggregate together more seriously than the others on the roots.



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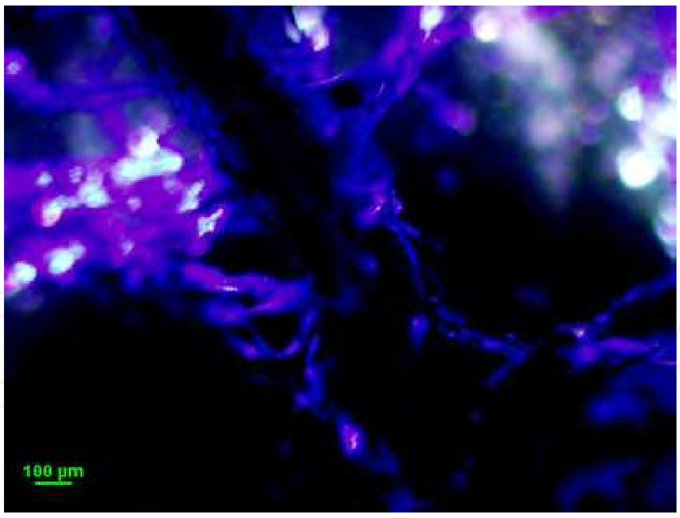

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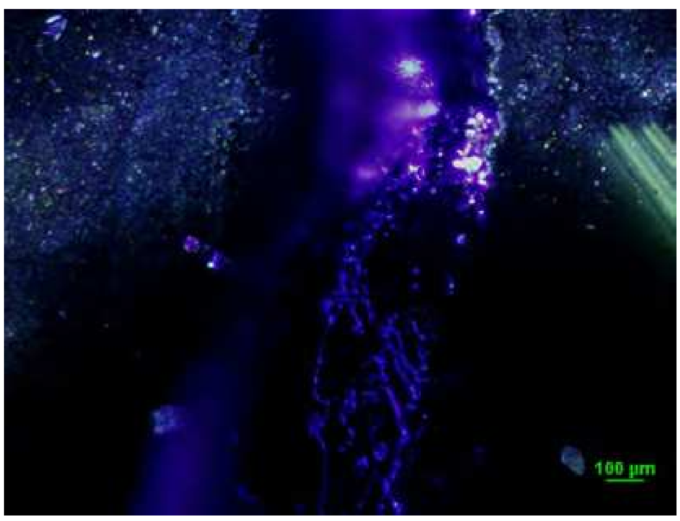

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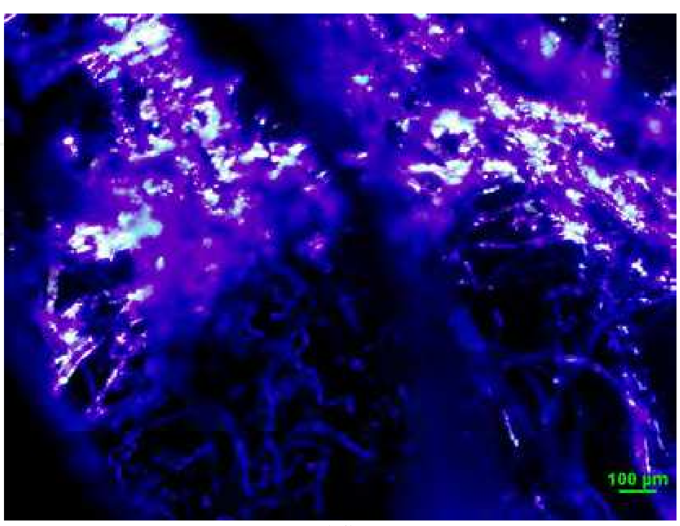

(d)

Fig. 3. Dark-field microscopic image of roots on the bud watered with (a) standard solution, (b) Au colloids, (c) Pt colloids, and (d) Ag colloids for six weeks.

According to Fig. 2~3, we observe the noble will not be corroded in leaves and roots. Install, noble metal nanoparticle will aggregate together in vein of leaves or the surface of roots.

4. Conclusions

We found that noble metal colloids significantly exit Floppers, Bryophyllum pinnatum (Lam.) Kurz. for several weeks. Future detailed studies should be performed to understand how the mechanism of nanoparticle leaves the plant body.

5. Acknowledgments

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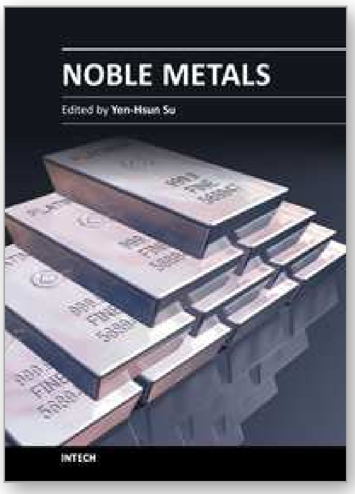

Noble Metals
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This book provides a broad spectrum of insights into the optical principle, resource, fabrication, nanoscience, and nanotechnology of noble metal. It also looks at the advanced implementation of noble metal in the field of nanoscale materials, catalysts and biosystem. This book is ideal not only for scientific researchers but also as a reference for professionals in material science, engineering, nonascience and plasmonics.

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