Adsorption and inhibition of CuO nanoparticles on *Arabidopsis thaliana* root

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Abstract. CuO NPs, the size ranging from 20 to 80 nm were used to detect the adsorption and inhibition on the *Arabidopsis thaliana* roots. In this study, CuO NPs were adsorbed and agglomerated on the surface of root top after exposed for 7 days. With the increasing of CuO NPs concentrations, CuO NPs also adsorbed on the meristernatic zone. The growth of *Arabidopsis thaliana* lateral roots were also inhibited by CuO NPs exposure. The Inhibition were concentration dependent. The number of root top were 246, 188 and 123 per *Arabidopsis thaliana*, respectively. The number of root tops after CuO NPs exposure were significantly decreased compared with control groups. This results suggested the phytotoxicity of CuO NPs on *Arabidopsis thaliana* roots.

1. Introduction

With the development of nanotechnology, engineered nanomaterials have been implicated into diverse commercial field [1]. Nanoparticles (NPs) will be released into the water and soil environment during their growing production and usage [2]. Because of NPs widespread release and their relatively high toxicity to ecosystem [3], NPs have raised more and more health and environmental concerns in recently [4]. The interaction and impact of NPs on living systems, with their unique physical and chemical properties, has only recently been explored [5]. CuO NPs, as one of the most important NPs, have a mixing characteristic of metal materials and nano particles [6]. CuO nanoparticles (NPs) are widely used in many kinds of commercial applications [7]. As a primary producer in the ecological system, plants, especially model plants play an important role in the ecotoxicology researches [8]. To date, the toxicity of CuO NPs on plants has been studied. Perreault et al. [9] used chlorophyll a fluorescence imaging to evaluate that CuO NPs induced strong inhibition of photosynthetic processes resulting in a decrease of plant growth in *Lemna gibba*. Similarly, it was reported that a significant decrease of chorophyll was observed in *Landoltia punctata* stressed by CuO NPs [10]. While, the morphologic observation of roots after CuO NPs exposure and adsorption were still defectiveness. Therein, different concentrations of CuO NPs were used to research the interaction of CuO NPs and *Arabidopsis thaliana* roots. Optics imagines were used to observe the adsorption of CuO NPs on the *Arabidopsis thaliana* roots, and the growth of the *Arabidopsis thaliana* roots. The inhibition of CuO NPs on *Arabidopsis thaliana* roots were analyzed by the root scanner. This work will provide a useful data for the phytotoxicity of CuO NPs.

2. Materials and methods

2.1 Materials

CuO NPs, purchased from Beijing Nachen S&T Ltd were used in our work. 50 mg CuO NPs were dissolved in distilled water (1 L). In order to increase particle dispersion, the CuO NPs suspensions were sonicated (100 W, 40 kHz) for 30 min. The morphology characterization of CuO NPs were observed by transmission electron microscopy (TEM) (H-7650, Hitachi, Japan).

2.2 Sorption and inhibition experiments

The *Arabidopsis thaliana* seeds were sterilized firstly and then germinated in the culture dishes. After germinating for 10 days, the seedlings were placed in dicotyledonous nutrient solution. Additional 3-day culture, *Arabidopsis thaliana* were exposure to CuO NPs sulution (0, 20 and 50 mg/L). The morphology of *Arabidopsis thaliana* roots in each exposure were observed by optical microscope after exposure for 7 days. The morphology of *Arabidopsis thaliana* roots were scanned and analyzed by WinRHIZO Pro 2005b (Regent instruments Inc., Canada). All the samples were run in triplicates.

2.3 Data analysis

Microsoft office excel (2017) was used for data analysis. Significant difference was tested by Statistical Product and Service Solutions with a LSD test using SPSS statisics. "$p < 0.05$" was used for the statistical significance.

3. Results and discussion

3.1 Characterization of CuO NPs

The morphology of CuO NPs were observed by TME (Fig. 1). It was found that the CuO NPs were roundness and oval. The size of CuO NPs were mainly 20-80 nm which were obtained from TEM imaging.

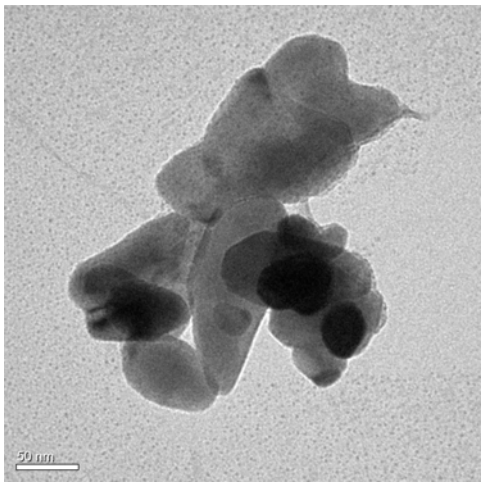

Fig. 1. TEM image of CuO NPs. Scale bar: 50 nm.

3.2 Adsorption of CuO NPs on the surface of Roots

The optical microscope images of *Arabidopsis thaliana* roots after CuO NPs exposure for 7 days were observed. As shown in Fig. 2, the normal root top were smooth (Fig. 2a). While, after exposed to 20 mg/L CuO NPs for 7 days, CuO NPs were adsorbed and agglomerated on the surface of root top (Fig. 2b). With the increasing of the CuO NPs concentration, CuO NPs were not only adsorbed on the top of root, but also on the surface of meristernatic zone (Fig. 2c). In addition, the root top was damaged at 50 mg/L CuO NPs exposure. CuO NPs were shown to be strongly adsorbed on the *wheat* root surface. In addition, the uptake and adsorption of CuO NPs increased with increasing exposure concentrations of CuO NPs [11], which were in agreement with our results.

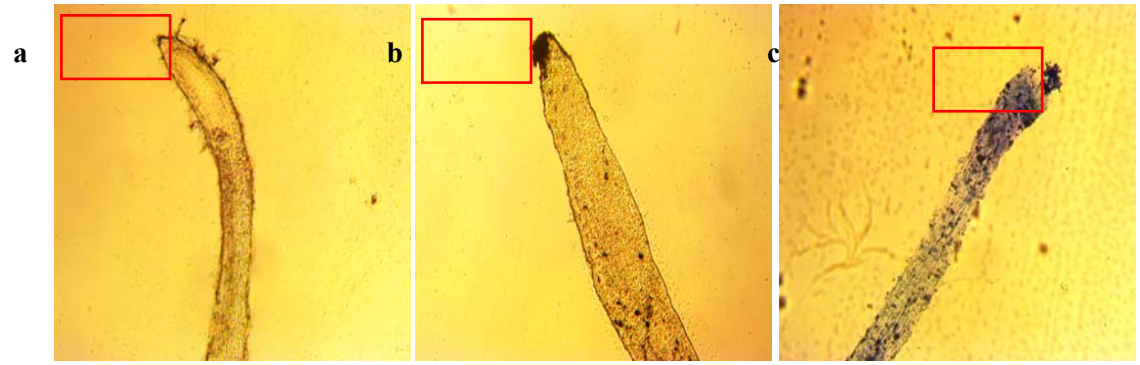

Fig. 2. Images of the roots after CuO NPs adsorption: (a) 0 mg/L CuO NPs; (b) 20 mg/L CuO NPs; (c) 50 mg/L CuO NPs.

3.3 Inhibition of CuO NPs on Roots

The growth of *Arabidopsis thaliana* lateral roots induced by CuO NPs were detected. Abundant of lateral roots were observed for the normal *Arabidopsis thaliana* (Fig. 3a). The growth of lateral roots were inhibited by CuO NPs exposure, which were concentration dependent (Fig. 3b,c).

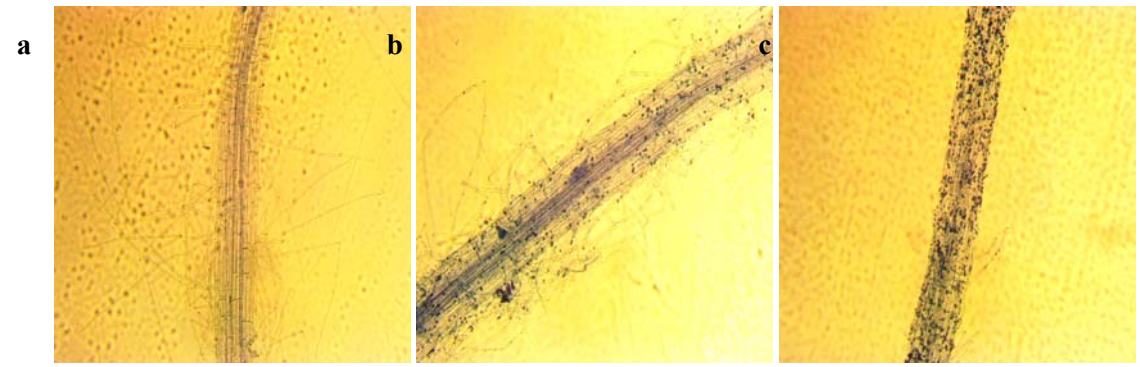

Fig. 3. Inhibition of CuO NPs on the lateral root: (a) 0 mg/L CuO NPs; (b) 20 mg/L CuO NPs; (c) 50 mg/L CuO NPs.

Analyzing the number of root tops, we found that the number of root top were 246, 188 and 123 per *Arabidopsis thaliana*, respectively (Fig. 4). With the increasing of CuO NPs exposure concentrations, the number of root top were significantly decreased.

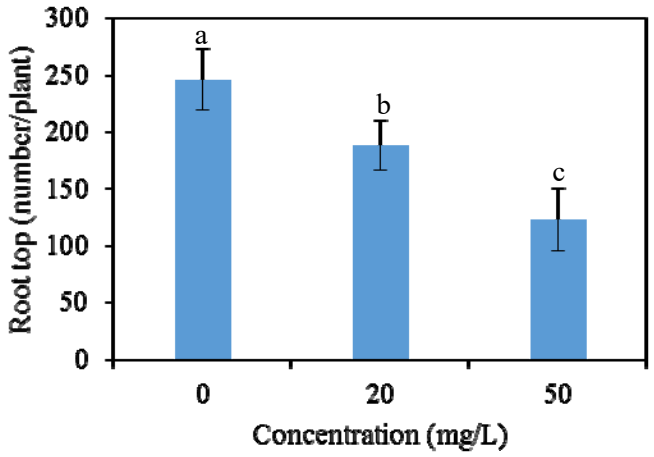

Fig. 4. The number of root tops after CuO NPs (0, 20 and 50 mg/L) exposure.

4. Conclusions

The adsorption and inhibition of CuO NPs on *Arabidopsis thaliana* roots were detected in the work.

The results of this work showed that CuO NPs could be absorbed on the surface of root tops and meristernatic zone. 50 mg/L CuO NPs also induced the damage of root tops. After CuO NPs exposure, the growth of lateral roots were inhibited. The number of root tops were significantly decreased after CuO NPs exposure. The conclusions in this work verified the toxicity of CuO NPs on plants which could provide useful data for the application of CuO NPs.

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