



The Effects of Multi-Walled Carbon Nanotubes on Rosmarinic Acid Production in Leaves of *Salvia Verticillata* L.

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Salvia verticillata L. (Lamiaceae family) is a potent medicinal plant, which is used for health purposes in Iranian traditional medicine. Similar to the other species of *Salvia* genus, *S. verticillata* contains phenolic compound specially rosmarinic acid (RA) and is a candidate for Alzheimer's and vascular dementia drugs [1]. As a result of rapid growth in the production of various types of nanomaterials, recently many projects have been conducted on the study of their effects on physiology and development of plant systems. For this reason, the present study was carried out to explore the uptake of multi-walled carbon nanotubes (MWCNTs) at different concentrations (0, 50, 100, 250 and 500 mg L⁻¹) and their potential effects on RA production in the leaves of *S. verticillata*. MWCNTs powder was dissolved in deionized water and sonicated for 30 min before treatment. Different concentrations of MWCNTs were sprayed on leaves surface of two-month old plants and leaves were harvested after 10 days. Transmission electron microscopy and Raman spectroscopy analysis of the treated leaves showed that MWCNTs could penetrate through the cell walls and possibly distribution in parenchyma cells layers. RA content in the treated leaves was estimated by HPLC method and chromatographic data revealed that RA production improved significantly at 50-100 mg L⁻¹ concentrations of MWCNTs, while a rapid decrease was observed in RA content of the treated leaves with 250-500 mg L⁻¹ of the nanotubes. In addition, oxidative injury indices including H₂O₂ and malondialdehyde content dramatically increased according to the rise of MWCNTs concentration. In conclusion, our finding demonstrated that MWCNTs can effectively penetrate to plant cells and trigger oxidative stress responses via production of reactive oxygen species. Also, the effect of MWCNTs on RA production was dose-dependent, so that at the low concentrations (50-100 mg L⁻¹) could act as an elicitor for enhancement of biosynthesis of RA in the leaves of *S. verticillata*, while at the higher concentrations this nanomaterial was toxic.

Keywords: MWCNTs, Rosmarinic acid, *Salvia verticillata* L.

References

[1] Habtemariam, S. *Int. J. Mol. Sci.* **2018**, *19*: 458-483.