

# DETERMINATION OF Cd IONS BY SERS USING NANOPARTICLES

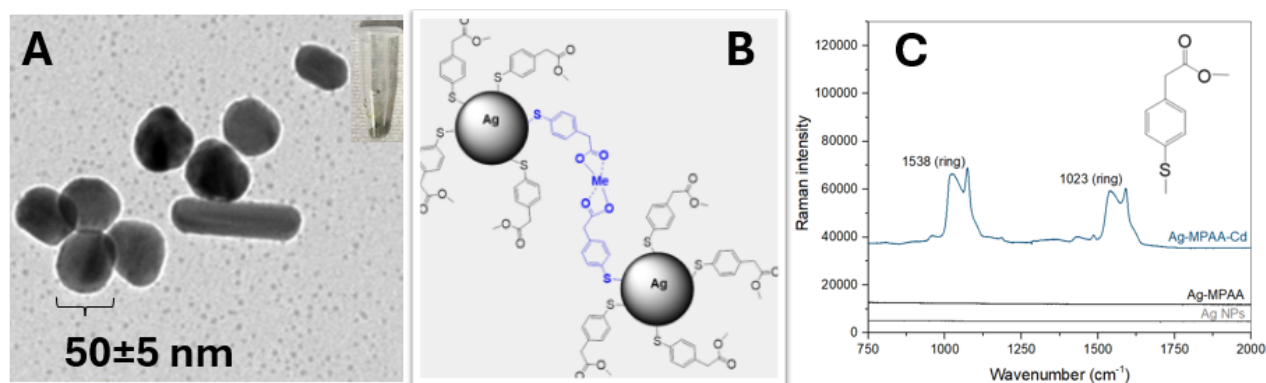
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Heavy metal toxicity is a significant health concern arising from the accumulation of elements that the human body cannot effectively excrete. Even prolonged, low-level exposure to Cd can lead to fatigue, cognitive impairment, and damage to the kidneys, liver, and nervous system [1]. In this study, carboxyl-functionalized silver nanoparticles were employed, which exhibited detectable spectral changes in the presence of Cd<sup>2+</sup> ions, as measured using UV-Vis spectroscopy and surface-enhanced Raman scattering (SERS) techniques.

Silver nanoparticles (Ag NPs) were prepared using the citrate reduction method and subsequently functionalized with 4-mercaptophenylacetic acid (MPAA) [2], providing carboxyl groups for effective Cd<sup>2+</sup> cations binding. UV-Vis spectroscopy and high-resolution transmission electron microscopy (HR-TEM) verified the formation of spherical nanoparticles and enabled estimation of their average size (50 ± 5 nm) (Fig.1A).

In the presence of metal cations, carboxyl-functionalized silver nanoparticles bind ions and form Ag-MPAA-Me-MPAA-Ag complexes (Fig. 1B). This interaction reduces the interparticle distance, leading to nanoparticle aggregation and a strong enhancement of the MPAA Raman signal (Fig. 1C). As a result, low cation concentrations can be detected using the SERS technique.



**Fig. 1.** (A) Photo and HR-TEM data of Ag NPs; (B) Scheme of Ag-MPAA-Me-MPAA-Ag complex; (C) SERS spectra of Ag NPs, Ag-MPAA and the complex with Cd<sup>2+</sup> ions.

In this study, a detection limit of 10<sup>-11</sup> M Cd<sup>2+</sup> was determined by the SERS method, using synthesized and modified silver nanoparticles.

- [1] Y. Yang, M. F. Hassan, W. Ali, H. Zou, Z. Liu, and Y. Ma, "Effects of cadmium pollution on Human Health: A Narrative review," *Atmosphere*, vol. 16, no. 2, p. 225, Feb. 2025, doi: 10.3390/atmos16020225.
- [2] T. Charkova, "Determination of barium ions by SERS using silver nanoparticles," *Nano-Structures & Nano-Objects*, vol. 43, p. 101511, Jun. 2025, doi: 10.1016/j.nanos.2025.101511.
- [3] D. Paramelle, A. Sadovoy, S. Gorelik, P. Free, J. Hogley, and D. G. Fernig, "A rapid method to estimate the concentration of citrate capped silver nanoparticles from UV-visible light spectra," *The Analyst*, vol. 139, no. 19, p. 4855, Jul. 2014, doi: 10.1039/c4an00978a.