Functionalized CeO_2 nanoparticles with antioxidant activity: the role of synthesis conditions in regulating the physico-chemical properties.

Noemi Gallucci,[1,2,*] Giuseppe Vitiello,[2,3] Rocco Di Girolamo,[1] Oreste Tarallo,[1] Alessandro Vergara,[1] Paola Imbimbo,[1] Daria Maria Monti,[1] Irene Russo Krauss,[1,2] Luigi Paduano.[1,2]

[1] University Federico II, Department of Chemical Sciences, Naples, Italy.

[2] CSGI, Center for Colloid Surface Science, Sesto Fiorentino, Italy.

[3] University Federico II, Department of Chemical, Materials and Production Engineering, Naples, Italy.

*e-mail: noemi.gallucci@unina.it

Cerium oxide nanoparticles (CeO_2-NPs) are attracting a great interest in the biomedical field due to their red-ox properties, which can be opportunely modulated to inhibit or promote the oxidation processes.[1] Particularly, CeO_2-NPs have been found to show both antioxidant and pro-oxidant behavior on different cells, mostly depending on: *i.* the presence of defects in the lattice structure, *ii.* the Ce^{3+}/Ce^{4+} ratio on the nanoparticle surface, and *iii.* the surface functionalization.[2] In this respect, we recently synthesized CeO_2-NPs by thermal decomposition of $Ce(NO_3)_3 \cdot 6H_2O$ salt, using as capping agents either octylamine or oleylamine, to evaluate the effect of alkyl chain length and two different temperatures on the physico-chemical properties of NPs.[3] A wide physico-chemical investigation, carried out by a combination of several techniques, such as XRD, TEM, DLS, UV-vis, Fluorescence, Raman, and FTIR spectroscopy, allowed us to define the role of synthesis conditions in affecting the shape and size of NPs as well as their optical properties. In fact, octylamine increases the concentration of Ce^{3+} resulting in a wide absorption throughout the whole UV-vis region. On the other hand, oleylamine increases the relative quantum yield of CeO_2-NPs. Furthermore, among the synthesized CeO_2-NPs those with the smallest size and the best separation in solution were functionalized by the interaction of the alkyl chain of capping agents (oleylamine) and those of another amphiphilic molecule (sodium oleate). The functionalization modifies the physico-chemical properties of CeO_2-NPs, above all the optical properties, which are different from those of single CeO_2-NPs. Finally, MTT assays on eukaryotic cells and ROS scavenging tests confirm a significant biocompatibility and antioxidant activity of functionalized CeO_2-NPs.

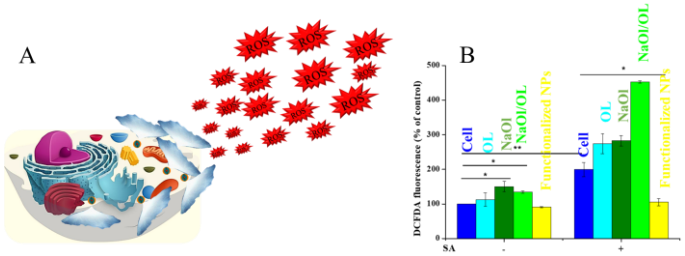

Figure 1. (A). Antioxidant action of cerium oxide nanoparticles in a eukaryotic cell, **(B).** Determination of intracellular ROS levels by DCFDA assay on HaCaT cells.

References

[1] Rajeshkumar, S., Naik, P., Synthesis and biomedical application of cerium oxide nanoparticles- A review. *Biotechnology Reports* 2018, 17, 1-5.

[2] Grulke, E., Reed, K., Beck, M., Huang, X., Cormack, A., Seal, S., Nanoceria: Factor affecting its pro-oxidant and anti-oxidant properties. *Environmental Science: Nano* 2014, 5, 1, 429-444.

[3] Gallucci, N., Vitiello, G., Di Girolamo, R., Imbimbo, P., Monti, D. M., Tarallo, O., Vergara, A., Russo Krauss, I., Paduano, L., Towards the development of antioxidant cerium oxide nanoparticles for biomedical application: Controlling the properties by tuning synthesis conditions. *Nanomaterials*, 2021, 11, 542-558.