Characterization of silicon quantum dots' properties and kidney toxicity in mice

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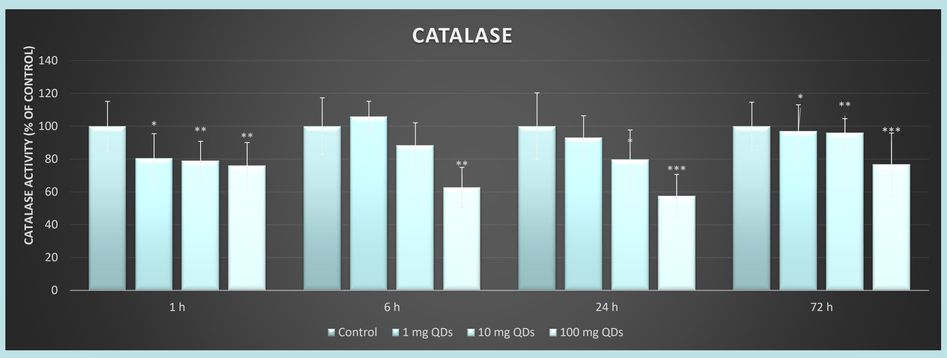
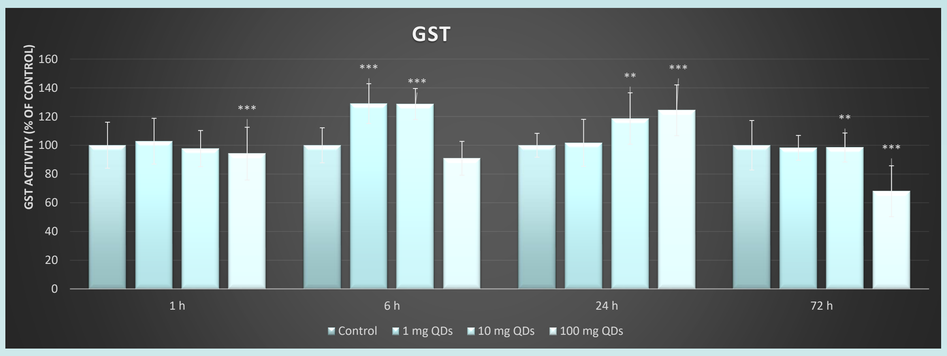
Background

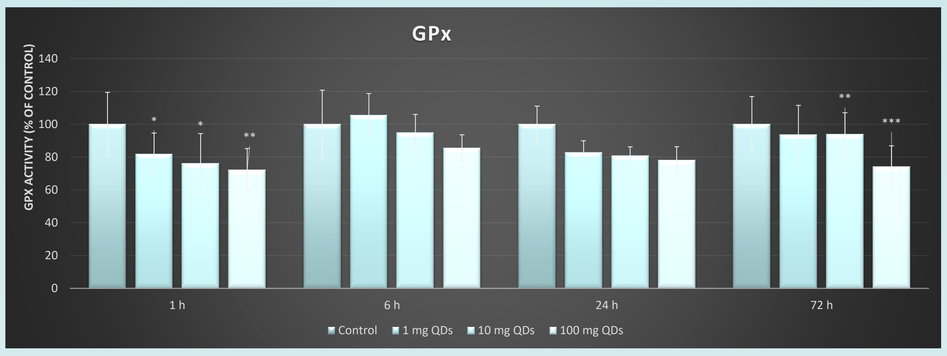
Due to their various optical and electronic features that offer advantages for medical purposes compared to traditional nanoparticles (NPs), quantum dots (QDs) represent an emerging tool for *in vivo* imaging, tumor biology investigation, and cancer treatment. Notwithstanding, QDs can also trigger toxicity effects in healthy cells, as previously reviewed by Zhu et al. [1]. Given that, we further aimed herein to characterize the silicon-based QDs obtained by laser ablation and evaluate their *in vivo* kidney toxicity.

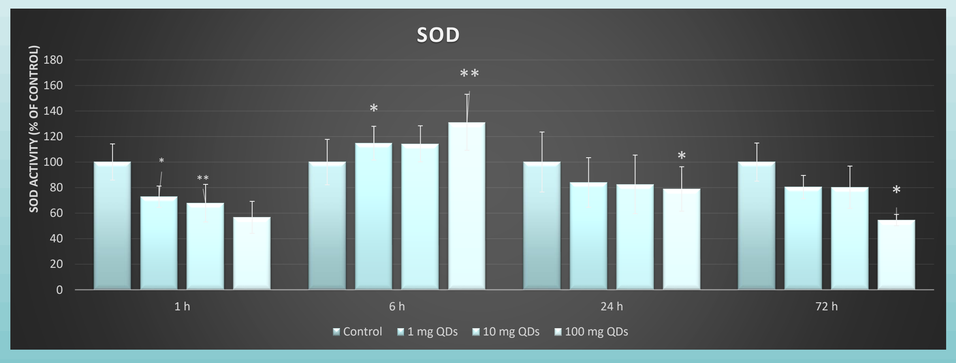
Materials and Methods

The studied NPs exhibited at transmission electronic microscope a core-shell structure with a crystalline silicon core and an amorphous silica shell with a diameter ranging between 6 and 10 nm. Their tendency to aggregate led to the formation of aggregates with sizes of hundreds of nanometers. QDs dispersion in water revealed a hydrodynamic diameter around 200 nm and a negative zeta potential of -14 mV. To test their *in vivo* toxicity, different doses of QDs (0, 1 10 and 100 mg QDs/ kg body weight) prepared in 0.9% saline were injected in the caudal vein of the Swiss mice. The animals were sacrificed at 1, 6, 24 and 72 hours, and the kidney tissue was harvested. The effects of silicon QDs on the antioxidant defense of kidney cells were investigated throughout the assessment of antioxidant enzymes' activities (catalase, superoxide dismutase, glutathione peroxidase, glutathione reductase and glutathione S-transferase).

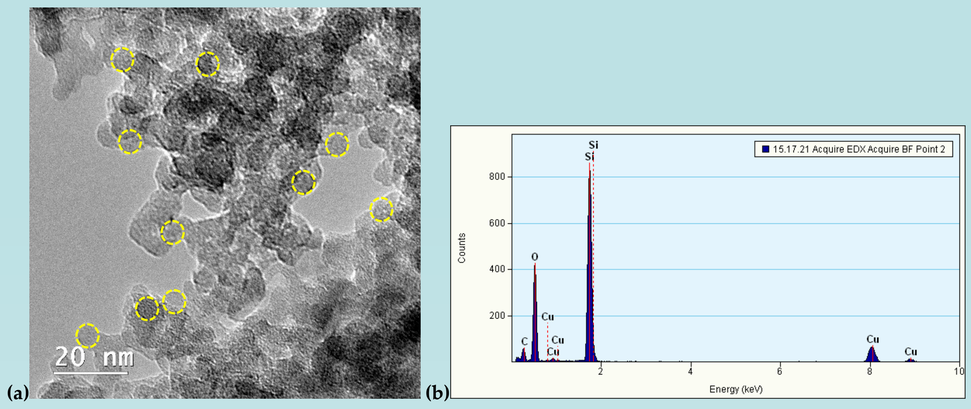








Si/SiO_2 QDs



Characterization of Si/SiO_2 QDs by TEM (**a**) and EDXS (**b**) investigations. Note the spherical shape of QDs marked by yellow dot circles (**a**).

RESULTS

The administration of the highest dose of QDs induced a significant reduction in catalase activity, the level being half of the control after all periods of exposure. A time-dependent decrease in glutathione reductase activity was noticed for all doses administered compared to control animals. After 24 and 72 h, glutathione peroxidase and glutathione S-transferase were diminished in the kidney cells of mice that received 10 and 100 mg/kg b.w. compared to control, revealing that these enzymes were vulnerable to oxidative damage of high doses of silicon QDs. Yet, no significant changes were observed regarding the activity of superoxide dismutase in the kidney of treated mice compared to control, suggesting that the QDs administration would not generate superoxide anions inside kidney cells.

CONCLUSION

This study highlighted the possible damaging effects of high doses of silicon-based QDs (>10 mg QDs/kg b.w.) on kidney cells, providing useful information for further clinical studies on humans.

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