

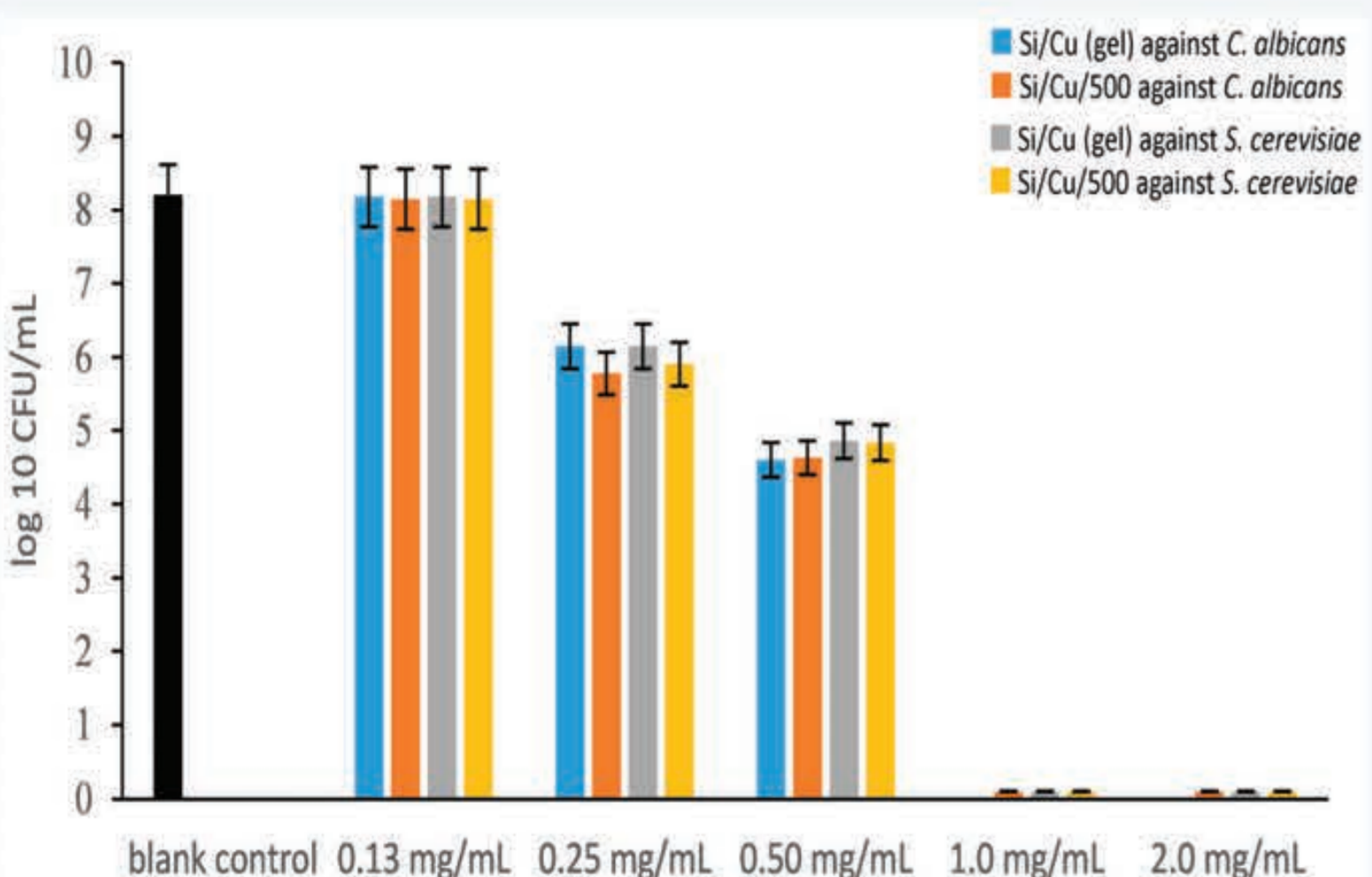
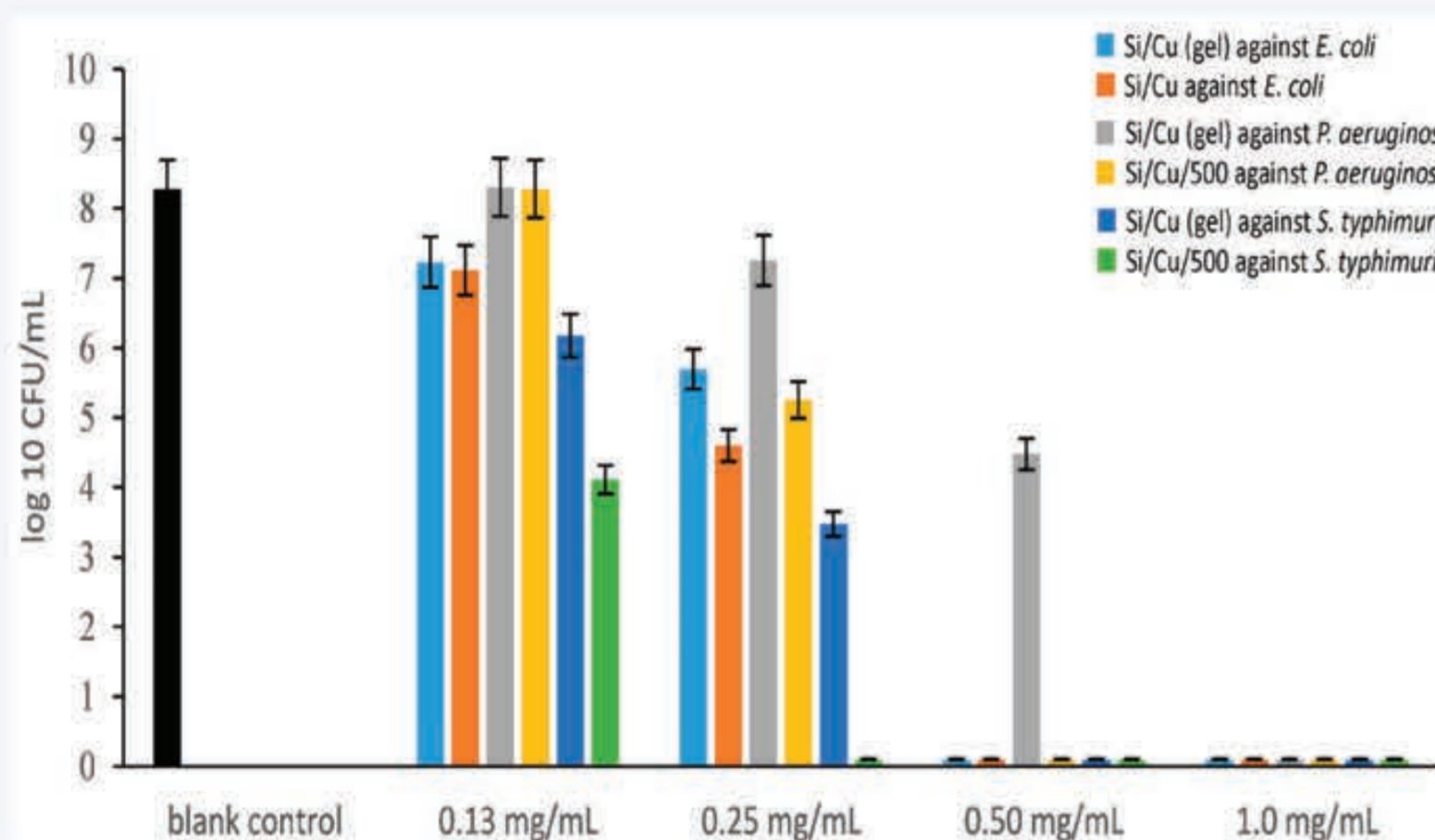
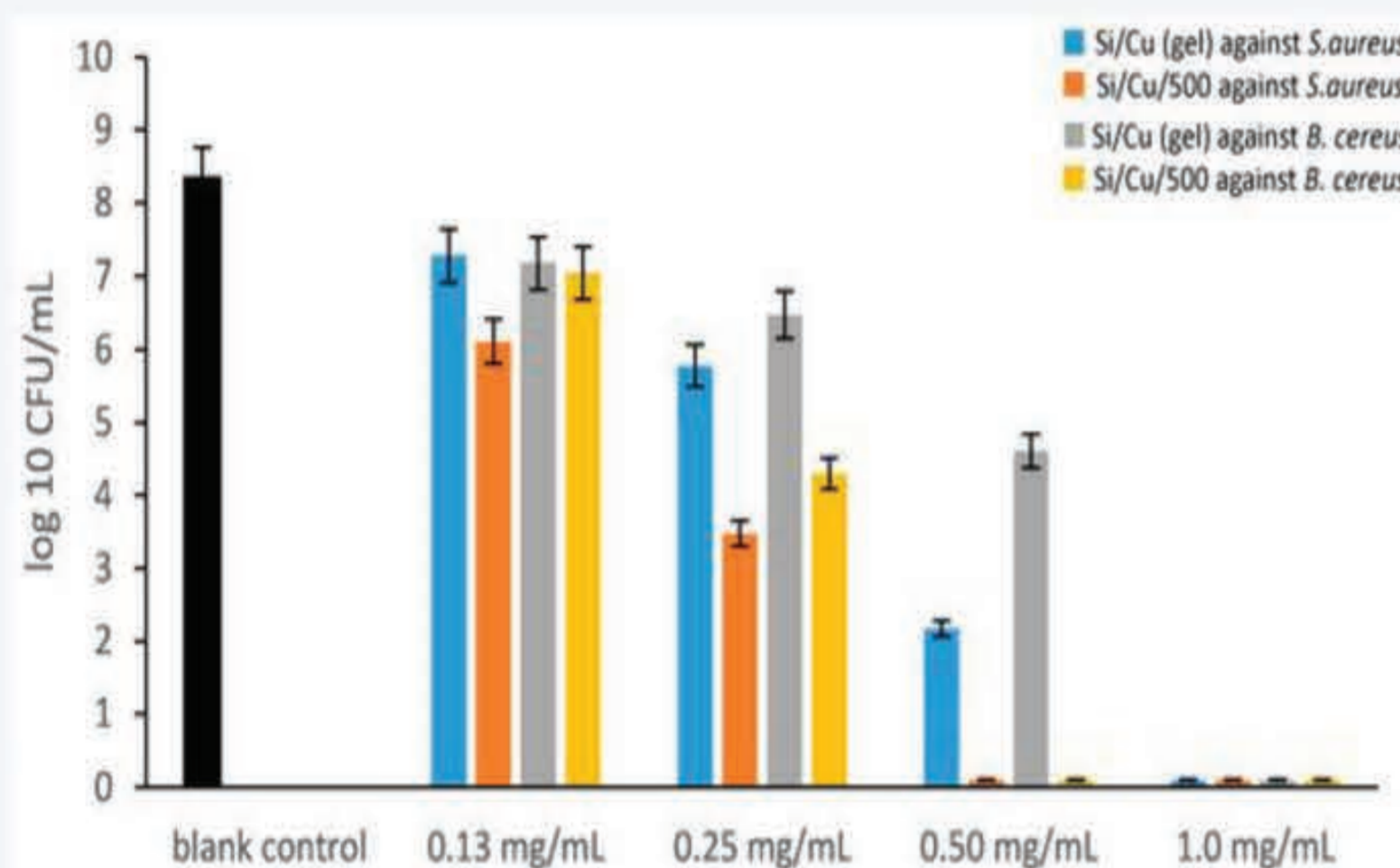
Research Group: Green synthesis of nanoparticles and study of their antibacterial and cytotoxic effects
Research field: Bionanotechnology

BIOLOGICAL ACTIVITY OF SOL-GEL-DERIVED SILICA NANOMATERIALS

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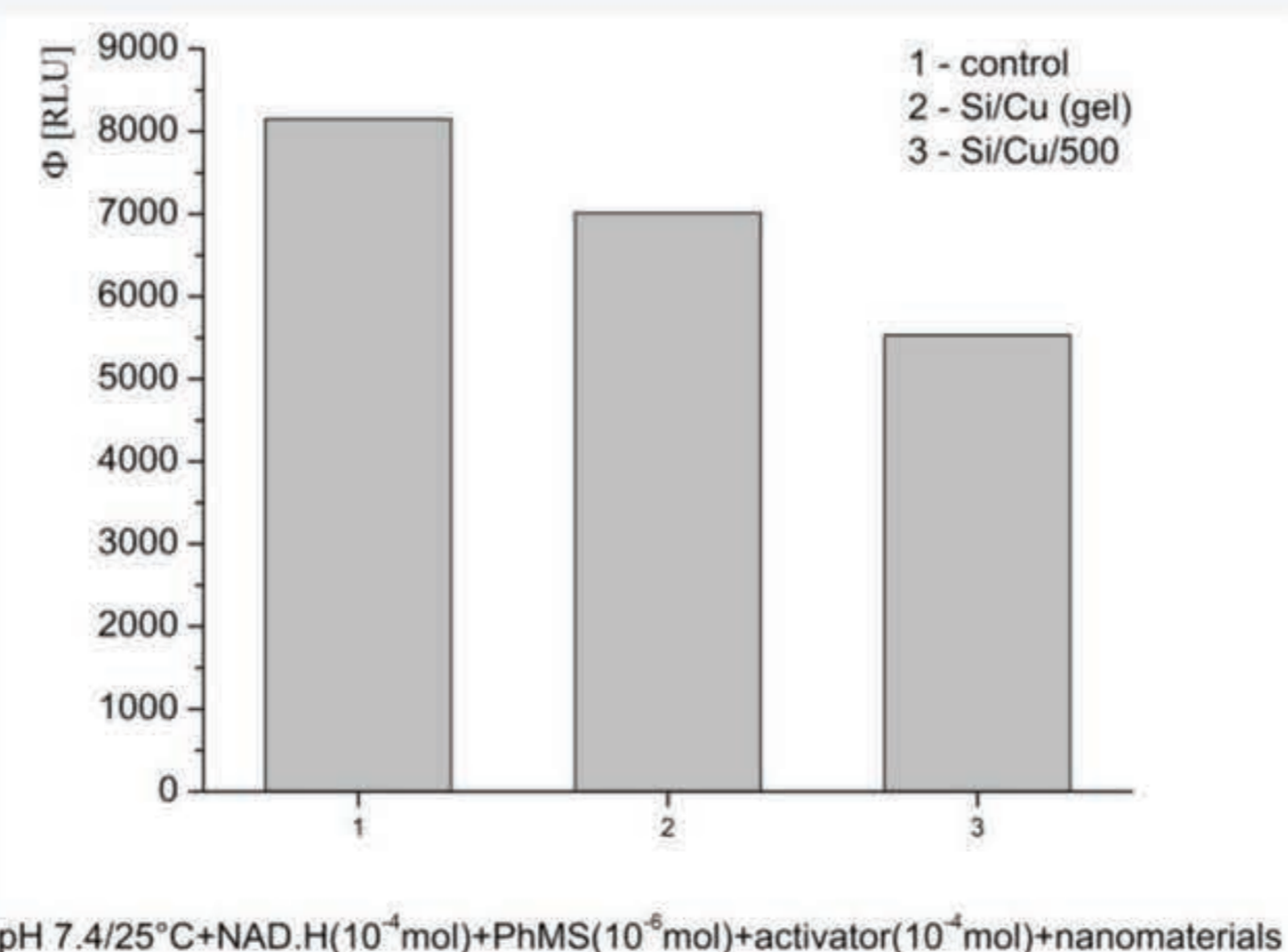
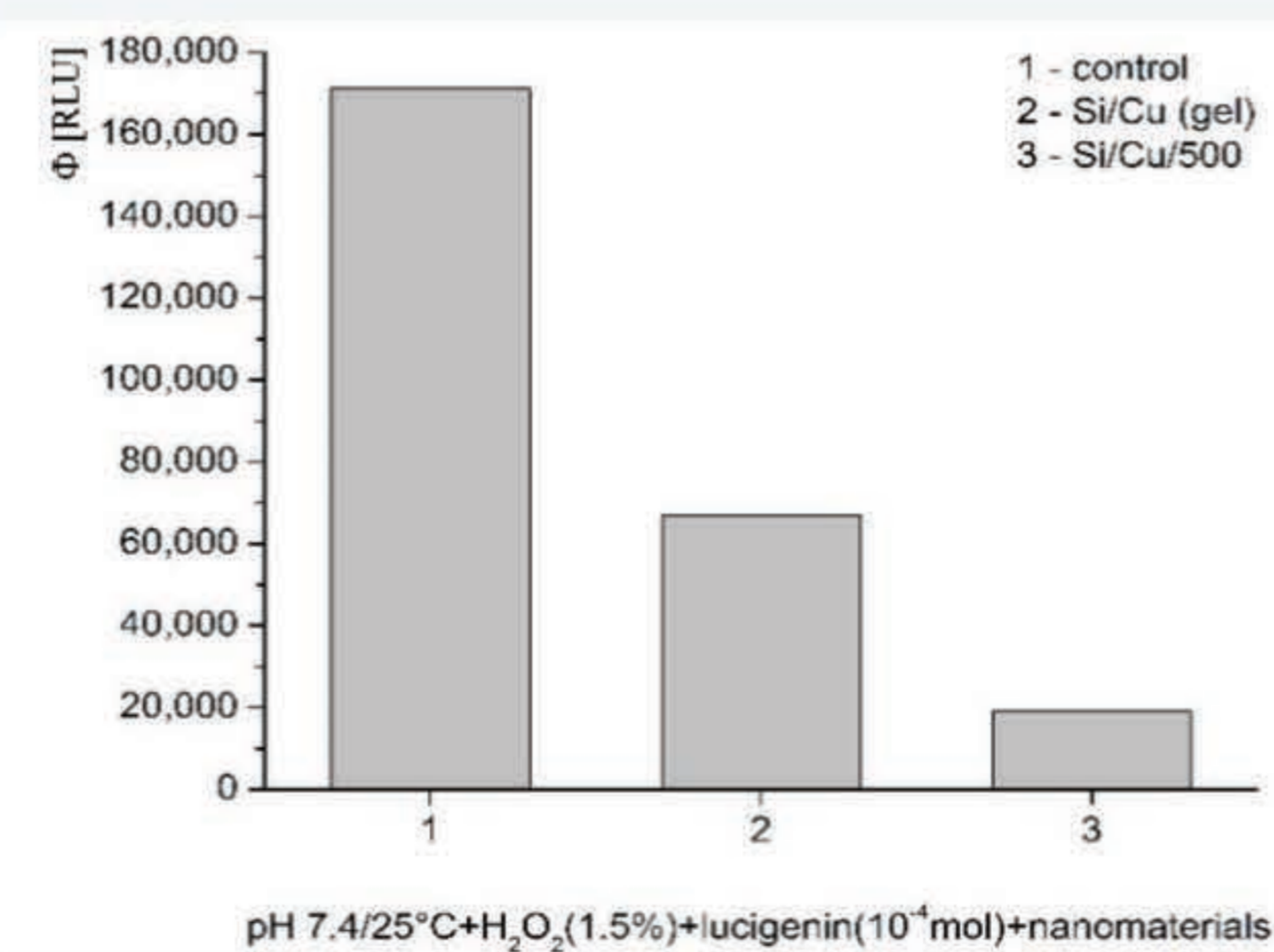
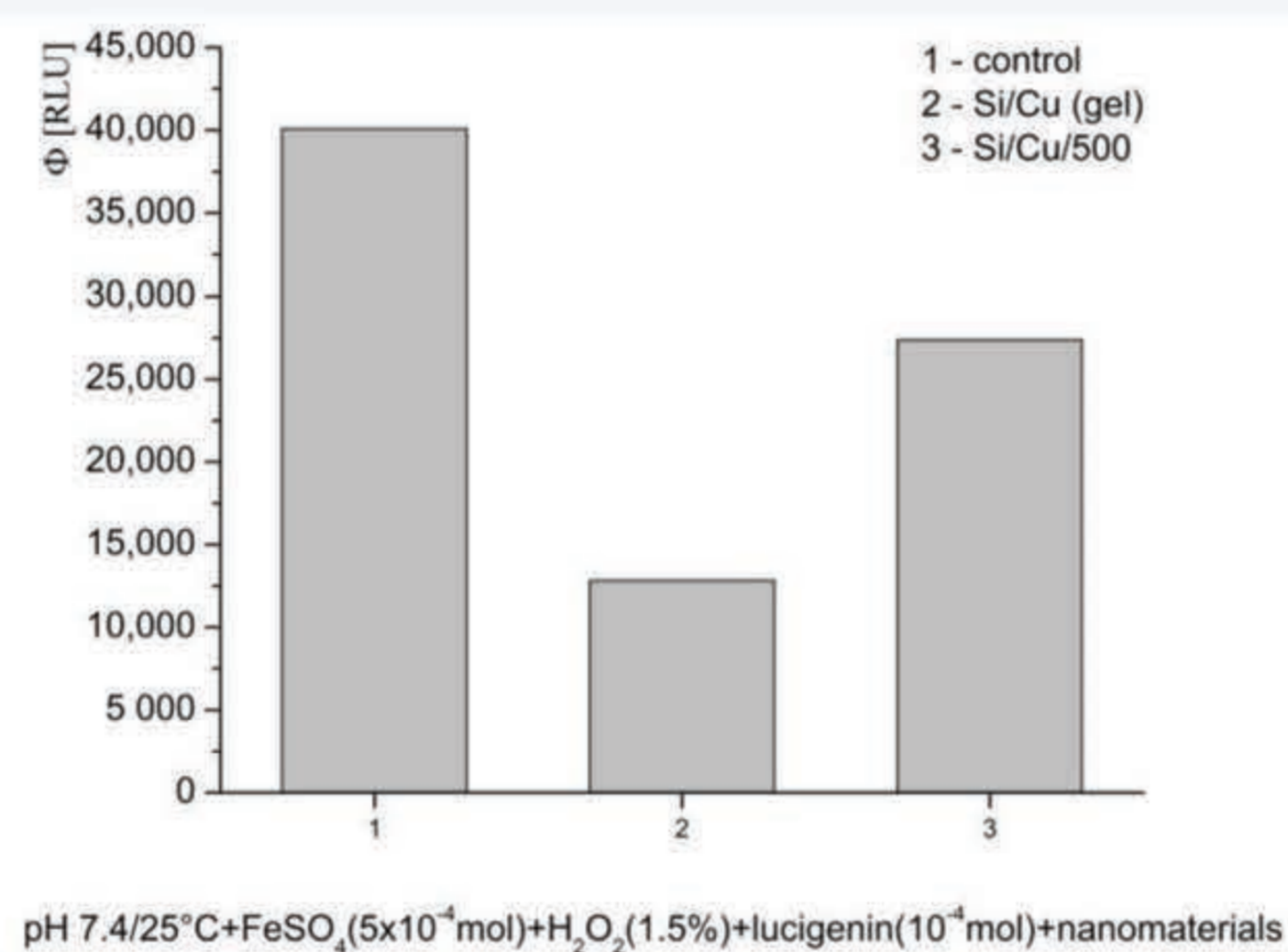
Antimicrobial Activity

In this study, we evaluated the antimicrobial efficacy of Si/Cu (gel) and Si/Cu/500 and nanocomposites against a range of microorganisms, including Gram-positive bacteria *Staphylococcus aureus* ATCC 25923 and *Bacillus cereus* ATCC 11778, Gram-negative bacteria *Escherichia coli* ATCC 25922, *Salmonella typhimurium* ATCC 14028, and *Pseudomonas aeruginosa* ATCC 27853, as well as the yeast species *Candida albicans* ATCC 18804 and *Saccharomyces cerevisiae* CCY 21-6-3. As illustrated in the figures below, both Si/Cu nanocomposites exhibited significant antibacterial activity, with their minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) values determined against the seven microorganism. The tested nanomaterials had similar antimicrobial effects on different microorganisms. The small difference was proved for low concentrations of 0.25 mg/mL, but at higher concentrations there was no significant difference between the heated and gel materials.



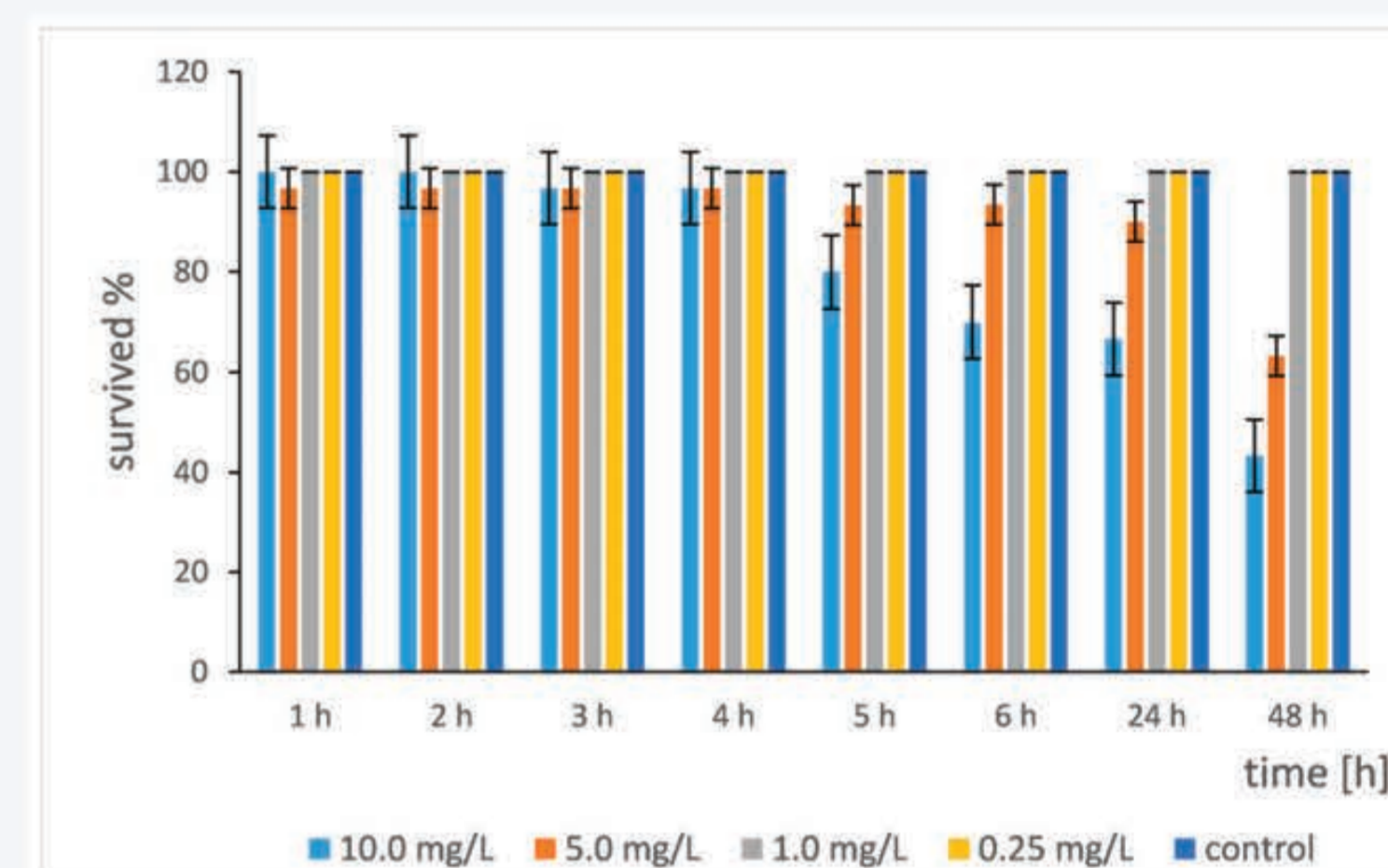
Chemiluminescent Oxidation Tests:

The newly synthesized nanomaterials demonstrated inhibition of the free radical and ROS oxidation in all model chemical systems. Thus, the effect of these hybrids is more accurately characterized as inhibitory towards the free radical-driven oxidation, rather than traditionally antioxidant, with respect to the electronic interactions of silicon and copper within the composite matrix. In summary, the chemiluminescent assay results demonstrate that the tested newly synthesized nanocomposites exert a pronounced general inhibitory effect on the ROS generation and oxidation across the tested model systems. These findings emphasize the necessity of carefully tailoring the nanostructure with respect to the medium and intended application. The synthesized nanohybrids can be potentially applied as modulators or inhibitors of free radical processes and generation within biological systems.

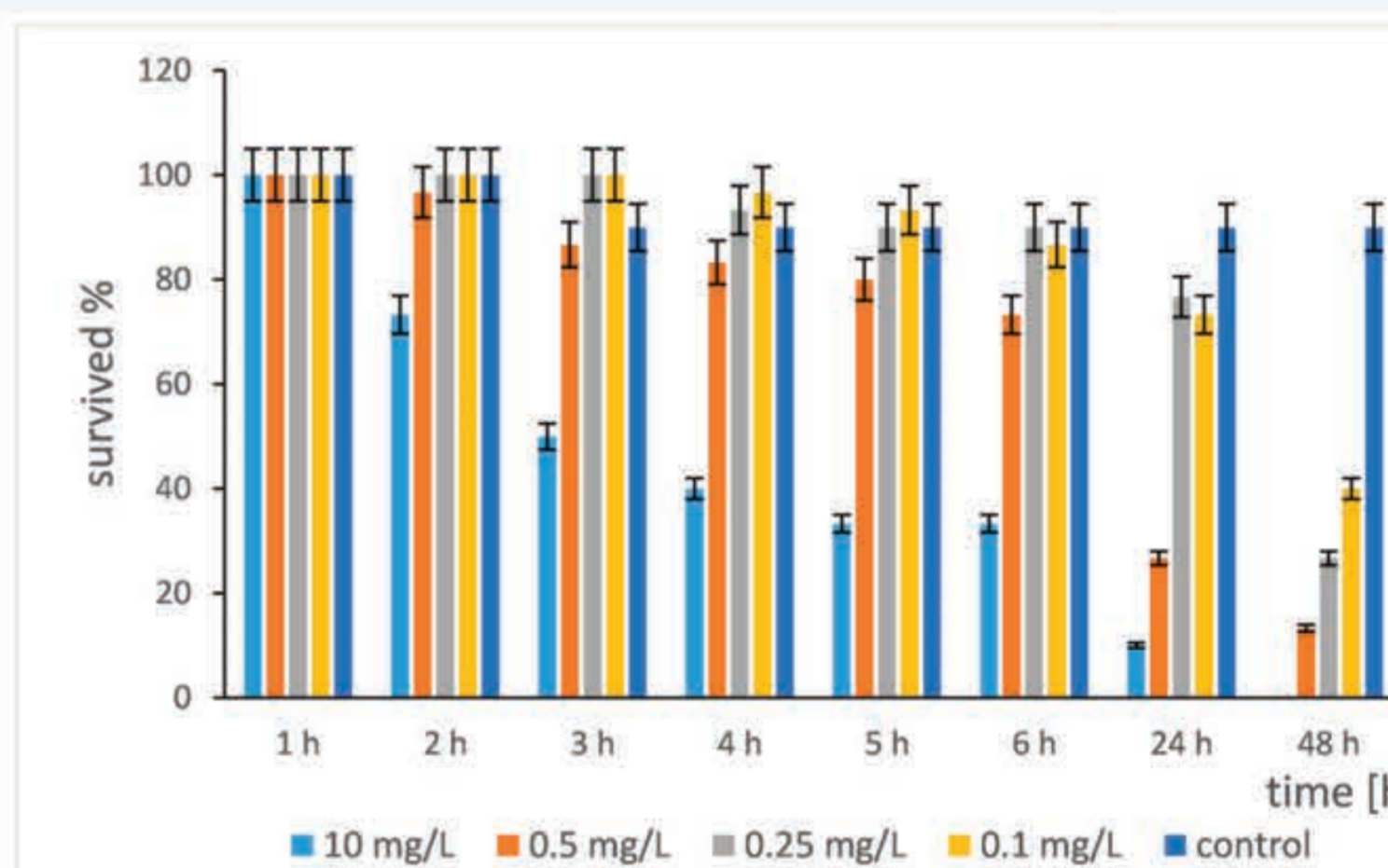


Daphnia magna Tests

The first toxicological test was conducted with daphnia (*Daphnia magna*) exposed to different concentrations of Si/Cu (gel) for a period of 48 h. The figure presents the survival rate of *Daphnia magna* for 48 h upon exposure to different concentrations of Si/Cu (gel) nanocomposites. The results showed a clearly expressed "concentration-effect" relationship: the higher the concentration, the faster and more serious the survival rate decreased. The results obtained for Si/Cu/500 show a significantly lower acute toxicity to *Daphnia magna* compared to classical copper nanoparticles, which is consistent with the data in the literature. While in the present study, the LC_{50} (48 h) is approximately 8.84 mg/L, most studies on CuO or Cu nanoparticles report much higher acute toxicity. For example, Santos-Rasera et al. (2019) found an LC_{50} (48 h) of around 0.1 mg/L for CuO nanoparticles, which is over 80 times lower than that observed for Si/Cu/500. Similar values were also reported by Kien et al. (2017), who measured LC_{50} in the range of 0.05–0.2 mg/L, indicating an extremely high bioavailability of free copper nanoparticles.



Daphnia magna survival rate after treatment with Si/Cu (gel) nanocomposites.



Daphnia magna survival rate after treatment with Si/Cu/500 nanocomposites.

Conclusions:

1. When comparing treatments with intermediate concentrations, Si/Cu/500 (calcined at 500 °C) consistently demonstrated a stronger antimicrobial effect compared to the gel form nanomaterial (Si/Cu (gel)).
2. The presented nanohybrids could act as regulators and inhibitors of free radical processes in biological systems, including living eukaryotic systems.
3. Si/Cu (gel) was toxic to daphnia even at relatively low concentrations.