LUMINESCENT NANOSTRUCTURED MATERIALS FOR BIOLOGICAL APPLICATIONS AND SENSING

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Luminescent nanostructured materials are attracting growing interest as multifunctional platforms for theranostics and sensing, thanks to their ability to integrate diagnostic, therapeutic, and monitoring functions within a single nanosystem. Their unique optical features — including tunable emission, high photostability, and sensitivity to environmental changes — enable advanced bioimaging and real-time detection of biomarkers, pH fluctuations, and redox states in complex biological environments. When combined with therapeutic agents, these materials offer a synergistic approach that couples targeted treatment with on-demand monitoring of therapeutic efficacy.

This presentation will showcase representative examples, such as dye-doped and rare-earth-doped silica nanoparticles with enhanced photostability and optical efficiency for human papilloma virus (HPV) detection [1], as well as porous silica and porous silicon nanoparticles engineered with multiple functionalities — including luminescence, magnetism, drug transport, and pH-controlled release — for integrated theranostic applications [2, 3]. Additional luminescent porous systems, including rare-earth-doped and Ag-ion-exchanged zeolites, will also be discussed.

As a frontier direction, the integration of artificial intelligence, specifically Physics-Informed Neural Networks (PINNs), into the rational design and growth of nanoparticles will be highlighted. This emerging approach holds promise for creating next-generation luminescent nanostructured platforms that seamlessly combine imaging, sensing, and therapy, paving the way toward precision medicine and personalized healthcare.

Figures

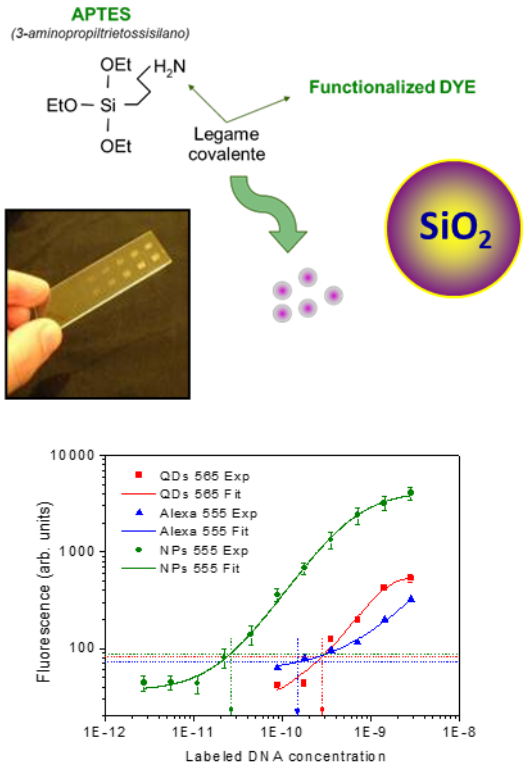

Figure 1. Example of luminescent dye-doped silica NPs for enhanced DNA-microarray detection of HPV.

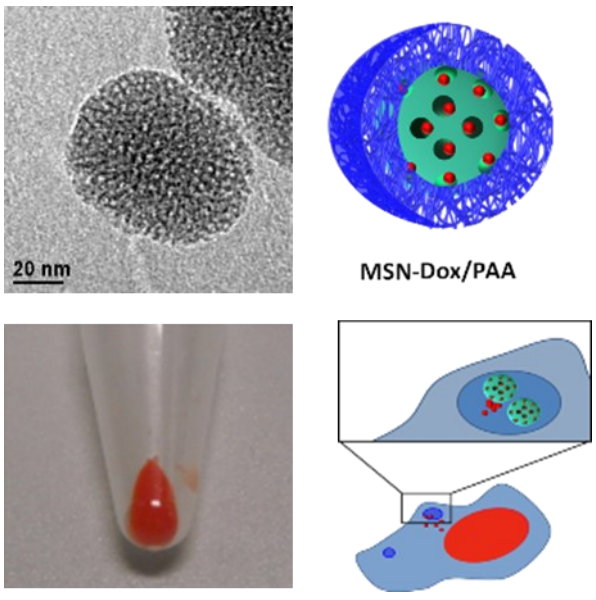

Figure 2. Example of pH-controlled drug release from doxorubicin-doped mesoporous silica nanoparticles.

References

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