Evaluation of semiconductor nanocrystals and superparamagnetic nanoparticles for the
development of new diagnostic and control methods of plant and human fungal pathogen

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Abstract

Recent developments in nanotechnology have demonstrated the usefulness of nanoparticles (NPs) for
a wide range of application in biological systems [1,2,3]. All these applications make NPs promising
tools for the development of novel strategies for the detection and control of plant and human diseases.
However, before the design of such strategies, it is crucial to elucidate their interactions with target cells,
cellular uptake and/or eventual excretion from cells, and the possible induction of toxic biological
responses. Thus, we evaluated the interaction of two types of NPs, semiconductor nanocrystals (QDs)
and superparamagnetic NPs (SiO2/MgO-magnetite) with fungal cells, as essential step to achieve the
eyarly detection of fungal pathogens and to address the feasibility of new NP-based smart delivery
systems for its control. QDs were chosen because of their high sensitivity for detection in optical
microscopy while the superparamagnetic NPs are biocompatible magnetic labels for magnetic
detection.

NPs were tested with Fusarium oxysporum, an important plant fungal pathogen responsible for
economically devastating vascular wilts of most crops [4] and an opportunistic pathogen of immune-
compromised patients [5]. No completely efficient control methods are available so far. Thus, an early
diagnostic of the pathogen is crucial for its control.

Our results indicated a differential trend in NP internalization and toxicity depending on the NPs.
Imaging of the F. oxysporum-NP interaction by means of confocal microscopy indicated that both types
of NP showed high affinity for the pathogen and were quickly attracted by the fungal cells (Fig.
1).However, while the QDs readily penetrated the fungal hyphae, most of the SiO2/MgO-magnetite NPs
remained attached to the fungal cell wall surface (Figs. 1).Toxicological assessment by evaluation of
fungal germination and growth, production and accumulation of ROS, and cell viability indicated no or
mild toxicity of both types of NPs at biological concentration. Altogether, the internalization and toxicity
studies showed that the QDs and SiO2/MgO-magnetite NPs might be applied for the rapid and sensitive
detection of F. oxysporum. After adequate functionalization, they may also be useful for the control of
this devastating pathogen. In both cases, in combination with a biomolecule able to target a desired
formae specialis, the NPs could act as inner-(in the case of QDs) or -surface (in the case of magnetic
NPs) fungal labels. To this purposes, antibodies directed against a highly specific pathogenicity-related
protein of the fungus have been obtained and used to functionalize both types of NPs. The preliminary
results on their functionalization and detection of the functionalized forms are also presented.
References


Figures

Fig. 1. Detection of QDs and SiO$_2$/MgO-magnetite NPs in a cell culture of *F. oxysporum*. Pictures represent visible and confocal micrographs and their corresponding transverse optical sections. Lower case letters indicate the orientation of the images. The green hurdle in the overview images marks the plane of the 3D section. *F. oxysporum* was incubated with MPA-QDs (A) or SiO$_2$/MgO-magnetite NPs (B) for 16 h at 28°C.