ZnO-based nanofungicides: Synthesis, characterization and their effect on the coffee fungi Mycena citricolor and Colletotrichum sp.

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\textbf{ABSTRACT}

In this work we compare the antifungal capacity of zinc oxide nanoparticles (ZnO-NPs) synthesized by a chemical route and a ZnO-based nanohybrid obtained by green synthesis in an extract of garlic (Allium sativum). To find out the characteristics of the materials synthesized, X-ray diffraction (XRD), IR spectroscopy and absorption in UV–Vis were used, as well as both scanning (SEM) and transmission (TEM) electron microscopy. The results showed that the samples obtained were of nanometric size (< 100 nm), with a predominance of the wurtzite crystal phase of ZnO and little crystallization of the nanohybrids. Their antifungal capacity on two pathogenic fungi of coffee, Mycena citricolor (Berk and Curt) and Colletotrichum sp. was also evaluated. Both nanomaterials showed an efficient antifungal capacity, particularly the nanohybrids, with −97% inhibition in growth of M. citricolor, and −93% for Colletotrichum sp. The microstructural study with high resolution optical (HROM) and ultrastructural microscopy (using TEM) carried out on the fungi treated with the synthesized nanomaterials showed a strong nanofungicidal effect on the vegetative and reproductive structures and fungal cell wall, respectively. The inhibition of the growth of the fungi and micro and ultra-structural alterations were explained considering that the size of the nanomaterials allows them to pass easily through the cell membranes. This indicates that they can be absorbed easily by the fungi tested here, causing cellular dysfunction. Nanofungicide effects are also attributable to the unique properties of nanomaterials, such as the high surface-to-volume ratio of atoms and their surface physicochemical characteristics that could directly or indirectly produce reactive oxygen species (ROS), which affect the proteins of the cell wall.