Lignin nanocapsules for bioactive compound delivery to plants

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Nanotechnology applications are increasingly involved to make sustainable agricultural practices. Environmental concerns about the wide use of pesticides and fertilizers have driven researchers to find new sustainable techniques to avoid their undesired distribution in the soil causing strong ecotoxicity. The need to find sustainable solutions is becoming urgent if it is considered that the world population is expected to increase to 9.3 billion in 2050. Moreover, pesticide reduction is one of the Sustainable Development Goal (SDG 2) in the Agenda 2030 which aims to guarantee food to all people especially to the disadvantaged. In this context, nanotechnology shows several advantages among which a relevant one is delivering more efficiently agrochemicals to plants, reducing the overall amount of chemicals needed. In particular, polymer nanocarriers have been demonstrated to improve the aqueous availability of hydrophobic bioactive compounds, reducing their loss in the environment. Moreover, polymer-based nanovectors increase also the adhesion and the uptake especially in foliar administration protecting the active ingredients from degradation. For example, nanocarriers based on biocompatible polymers, like zein, chitosan, or poly(ε-caprolactone) (PCL), have been shown to enhance the photostability of active compounds such as geraniol, essential oils, or R-citronellal with respect to unentrapped molecules. Several studies report the successful delivery of hormones into polymer nanovectors for plant growth. Other applications concern herbicide, insecticide and fungicide delivery. For example, PCL nanocapsules were used to deliver herbicide, like atrazine, causing higher mortality of weeds at a lower dose compared to the commercial formulation. On the other hand, carboxymethyl chitosan nanocapsules delivering methomyl showed higher armyworm larvicidal activity compared to the active ingredient. Among different polymers, lignin is one of the most promising since it is biodegradable and a renewable compound. New studies developed lignin nanocapsules to deliver hormone like Gibberelic Acid in seeds improving germination. Other applications of lignin nanostructures concern the transport of natural active substances with antiparasitic activity, such as neem oil and capsaicin, to improve their efficacy with respect to the active ingredients alone.