

# ***Enzyme-responsive nanofertilizers for controlled phosphorus delivery***

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One of the main challenges imposed by the rapid growth of the global population is the increase in food production, and therefore in crop yields. Traditionally, this has been addressed by applying more agrochemicals to our fields, while a smarter and more sustainable solution is to enhance the efficiency of agricultural technologies. Currently crops absorb only a minor fraction of the nitrogen and phosphorus added to soil (around 50% of nitrogen and 15% of phosphorus), while the rest is lost through run-off, leaching, and volatilization. This is not only a massive waste of resources, but also has terrible effects on the environment, such as water eutrophication and other forms of ecosystem pollution.

Nanotechnology offers a promising approach to improve the effectiveness of fertilization. However, most of the nanomaterials developed so far for agriculture are simple nanosized formulations of the plant nutrient, while much greater efforts can be made to optimize the release of the active ingredient. Herein, lignin-based nanoparticles were developed for targeted phosphorus delivery to plants. Lignin was chemically modified and crosslinked with a phosphorus-containing compound to create 200 nm particles. These particles were designed to be degraded by an enzyme produced by the plant roots, so that they can release the nutrients mainly in the plant proximity.

The nanofertilizer showed excellent control over phosphorus release both in laboratory experiments in aqueous solution and in pot tests on *Arabidopsis thaliana*. These nanoparticles are promising tools for supplying phosphorous to crops in a smart and controlled way, avoiding nutrient losses in the environment and enriching the soil organic matter with lignin.