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The Hypatia Project: Calcium orthophosphate nanoparticles as smart fertilizer for sustainable agriculture

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Abstract: The world population is growing, and it is estimated to be over 9 billion by 2050, demanding a significant increase of food production. The application of fertilizers in agriculture provides the macronutrients (N, P and K) necessary for plants development; however, increasing the crop yields by intensifying the use of conventional fertilisers is not sustainable because of their low efficiency, their significant contribution to environmental pollution and the depletion of non-renewable resources. On these bases, nanotechnology can offer a valuable contribution to a more efficient and sustainable agriculture, besides a smart use of non-renewable resources as phosphorous ores. Within this project, amorphous calcium phosphate nanoparticles and hydroxylapatite-based nanocomposites were synthesized. These bio-inspired types of nanoparticles, intrinsically rich in P, were designed to incorporate N-based macronutrients. The in-depth characterization of these materials in term of crystallinity degree, crystal structure, morphology and aggregation degree, chemical composition and stability allows us to correlate the physico-chemical properties of nanoparticles with their effectiveness as smart nanofertilizers. In fact, modulating the size, structure and composition of nanoparticles is possible to provide a slow and controlled release of macronutrients by their progressive dissolution, avoiding the massive leaching caused by rainwater for conventional and more soluble fertilizer. Moreover, the biocompatible nature, the low-cost and easy scalability at industrial level of calcium phosphate nanoparticles make these materials a promising smart fertilizer for future exploitation.

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