Novel nanocarriers and antibacterials from compost-extracted humic substances

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Abstract

Compost-derived Humic Substances (HS) are well known plant biostimulants. However, technologically advanced uses of HS could be imagined, like in the synthesis of novel nanoparticles (NP). They were synthesized by adding HS to a chitosan solution, and NP formation was based on ionotropic gelation, whereby the oxygen-containing functions of HS react with the positively-charged chitosan amine functions. These electrostatic interactions decrease the chitosan surface charges, thus reducing the solubility of the newly formed humic-chitosan complexes, which ultimately results in the spontaneous formation of nanoparticles. The different physical-chemical features of the NP (z-average, zeta potential, thermal stability) were related to the molecular structure and conformational stability of the original humic substances. The obtained NP displayed a relevant bioactivity against the development of bacteria responsible for human diseases, such as *Staphylococcus aureus*, *Enterococcus faecalis*, *Acinetobacter*, and *Escherichia coli*.

We furthermore selected one nanoproduct to explore its potential as carrier of double-stranded RNA (dsRNA) molecules, which can be used in RNAi-mediated insect pest control strategies. The rationale of the experiment is based on the sensitivity of dsRNA to several environmental biotic and abiotic factors. Therefore, its encapsulation was expected to preserve its structure and functionality. We focused on dsRNA molecules able to silence an immune gene of *Spodoptera littoralis* larvae, a well-known phytophagous of tomato. Interestingly, our results showed an encapsulation efficiency > 90%. Also, the dsRNA was successfully released in the gut of *S. littoralis* larvae, hence silencing the target gene similarly to naked dsRNA. We inferred that the dsRNA release might be related to the high gut pH, at which values the dsRNA was fast released, as observed in *in vitro* trials.

Due to the promising results and the easiness of production of humic-chitosan NP, further investigations are encouraged to explore their potential as drug carriers or agrochemicals.