SCIENZE A SISTEMA PER LA SOSTENIBILITÀ
La ricerca al Dipartimento di Biologia Ambientale
ROMA, 5 GIUGNO 2024

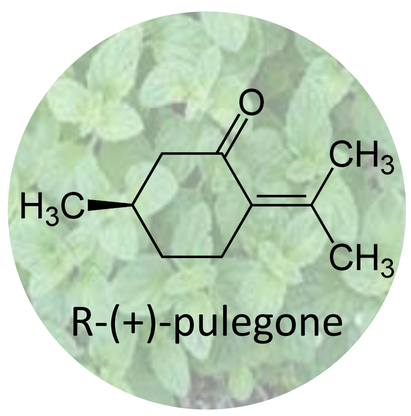
Development of eco-friendly biocides based on chitosan nanoparticles loaded with R-(+)-pulegone for the conservation of wooden materials

C. Genova, A. Ciccola, M. Beccaccioli, D. De Vita and G. Favero

Department of Environmental biology, Sapienza University of Rome, P.le Aldo Moro 5, 00185 Roma

1 Background

Fungal decay is one of the main cause of deterioration of wooden cultural heritage. Several products have been employed to prevent biodeterioration, but many of them are toxic for humans and the environment. In this perspective, the attention of scientists is focusing on new natural based products with intrinsic biocidal properties as an alternative to classical biocides. This is the case of the materials selected in this research, or Chitosan (Ch), Essential Oils (EOs) and their Major active chemical Components (MCs).

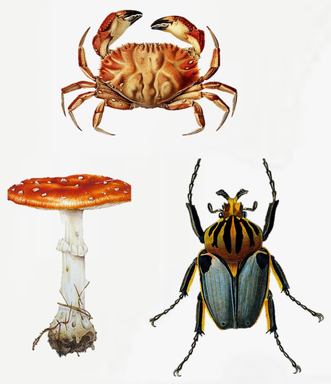


2 Aims

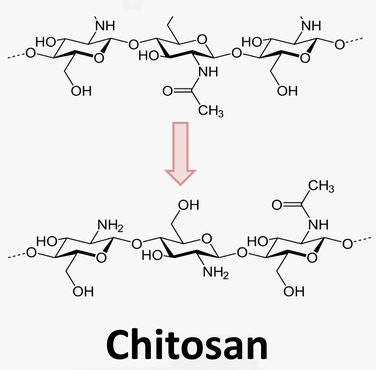
Here we propose the synthesis of a natural-based and sustainable system with the twofold function of biocide and consolidant for wooden materials.
R-(+)-pulegone, a major active component of several EOs with assessed biocidal properties, was selected to be encapsulated in chitosan nanoparticles (Ch-NPs), through ionic gelation, an easy and sustainable synthesis method.

3 Methods

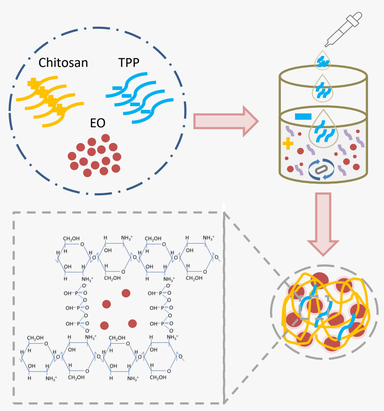
Chitin sources



Chitin



Ionic gelation

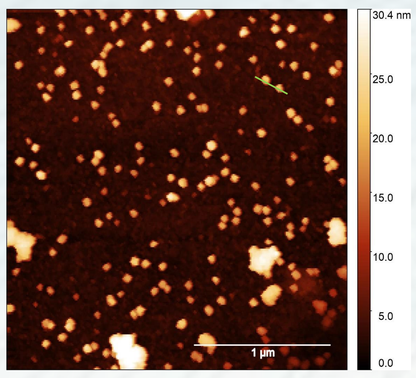


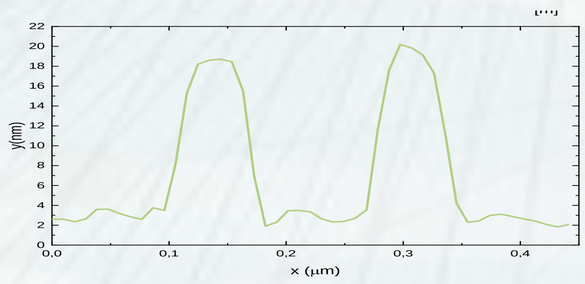
Chitosan is a natural cationic polysaccharide derived from the deacetylation of chitin, capable of forming nanoparticles (NPs) in aqueous solutions in the presence of polyanions, such as pentasodium tripolyphosphate (TPP). Hydrophobic substances, such as EOs and MCs, can be loaded into Ch-NPs, offering several advantages, including enhanced vehiculation of EOs, improved release performance, increased solubility and physical stability, and reduced volatility of EOs.
Nanoparticles loaded with a concentration ratios of 1:0.25 chitosan to R-(+)-pulegone were synthesized and applied on beech samples inoculated with *A. niger,* responsible of soft-rot disease. The NPs were also chemically and morphologically characterized

4 Results

1. The NPs show a spherical shape, with an average size of 66 nm. In some cases, some aggregates can be observed;
2. By comparing the FT-IR spectra of NPs loaded and unloaded with Pul, characteristic peaks belonging to this compounds can be observed in the loaded-NPs, confirming the success of the encapsulation;
3. The comparison between the beech samples highlight that the ones treated with the NPs show a reduced degree of fungal colonization.

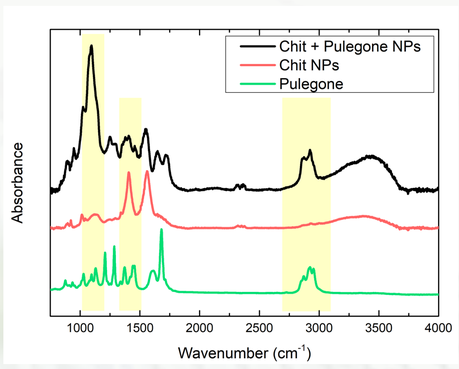
1 AFM observations





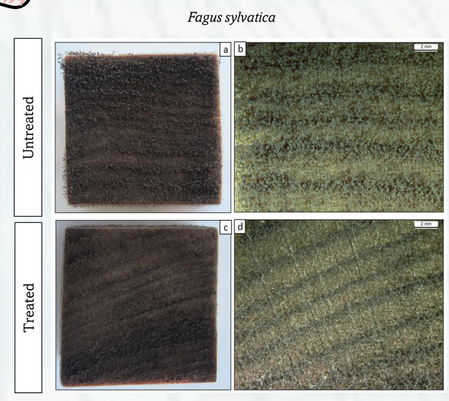
Resolution 512x512 pixels
AVG size D = 66 ± 5 nm

2 FT-IR characterization



3250-3500 cm^{-1}	Stretching -OH, $-NH_2$	**Chitosan**
~1025 cm^{-1}	Stretching C-O-C of the glucose ring	**Chitosan**
Increased intensity of the signals **2866-2955 cm^{-1}**	Stretching -CH, $-CH_3$	**R(+)-pulegone**
Increased intensity of the signals **1000 e 1150 cm^{-1}**	C-O-C group of the glucose ring	**Interactions Ch-Pu**

3



Beech samples inoculated with *Aspergillus niger:* Application via spray of aqueous solution of CHNPs, CH:Pu 1:0.25 a 0.75 [mg/ml]

5 Conclusions

R-(+)-pulegone was successfully loaded in chitosan nanoparticles.
A preliminary application of Pul-Ch-Nps on inoculated samples of *F. Sylvatica* showed the potentialities of these systems to be used as preservatives for wood material

WHAT NEXT?

- Evaluation of the biocidal properties of Pul-Ch-NPs against other microorganisms;
- Encapsulation of other natural biocides (EOs and MCs);
- Application on archeological and waterlogged wooden materials;
- Evaluation of the consolidant properties of chitosan on wood.

DBA Dipartimento di Eccellenza MUR 2023-2027

SAPIENZA UNIVERSITÀ DI ROMA