Encapsulated essential oils in Mesoporous silica nanoparticles to control Fusarium avenaceum and its production of enniatins

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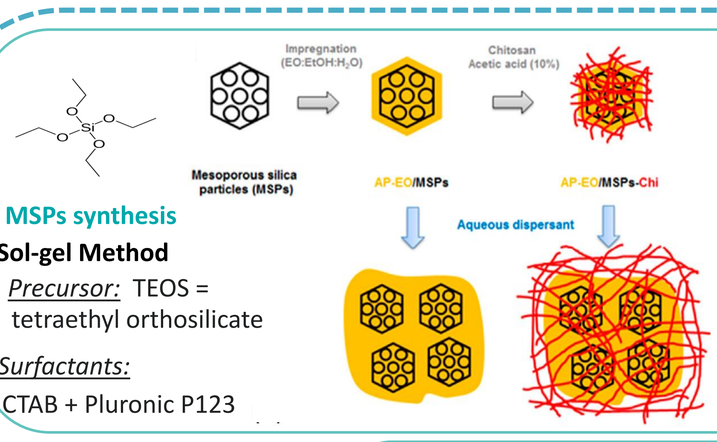
Despite the in vitro efficacy of various essential oils (EOs), their practical use to control toxigenic *Fusarium* spp is limited by their high volatility and sensitivity to UV and oxidation. Their nano-encapsulation can provide protection for the active volatile molecules and allow for a gradual release into the environment. Mesoporous silica nanoparticles (MSPs) are inert, mechanically stable, stable in suspension in an aqueous medium and their specific surface area is very suitable for functionalization. We used them for the encapsulation of *Ammoides pusilla* EO, which was proved to have antifungal and antimycotoxin activity (Chakroun et al, 2021), and further coating with chitosan.

Methods



MSPs synthesis

Sol-gel Method

Precursor: TEOS = tetraethyl orthosilicate

Surfactants:

CTAB + Pluronic P123

Impregnation of Essential oil

EOs : Hydrodistillation of *Ammoides pusilla* (AP) [aerial parts]

EOs dissolution in hydroalcoholic solution
Addition drop by drop to MSPs

Evaporation of the solvant at 25°C

Caracterisation of the nanoproducts

N2 physisorption measurements at 77K:

* Specific surface area: Brunauer-Emmett-Teller (BET)

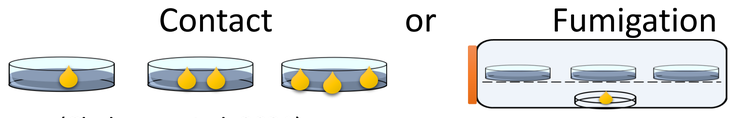
* Pore size distribution: Barrett-Jorner-Halenda (BJH)

DLS Characterization **Thermogravimetric Analyse**
XPS for surface chemical composition **SAXS pattern**
In vitro release of EO in liquid and evaporation

Evaluation of antifungal (*F. avenaceum*) and antimycotoxins (enniatines) activities

Cultures in FDM-Agar medium, 25°C, 10 d

Contact or Fumigation



(Chakroun et al. 2021)

=> Mycelial growth rate

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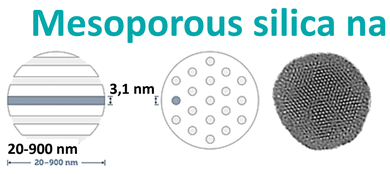
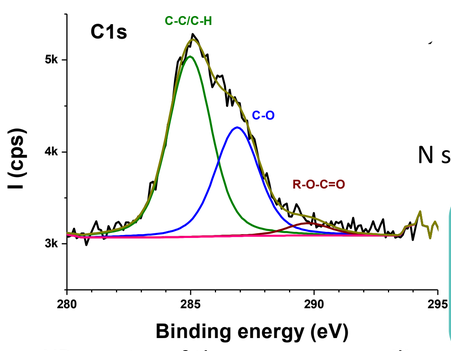
Enniatins B1+B2+B3 (ENNs) concentrations in Agar- [UPLC-DAD]

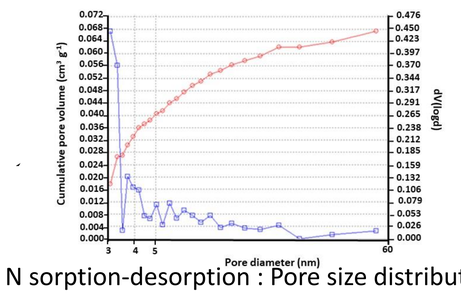
Results

Mesoporous silica nanoparticles characterization



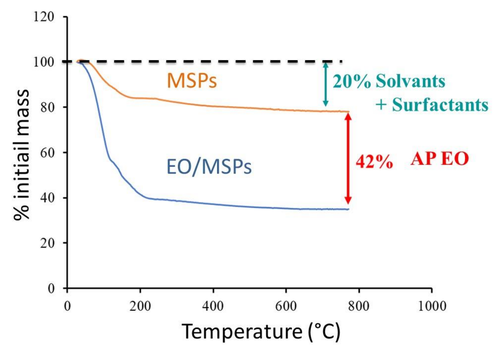


XP spectra of the mesoporous silica



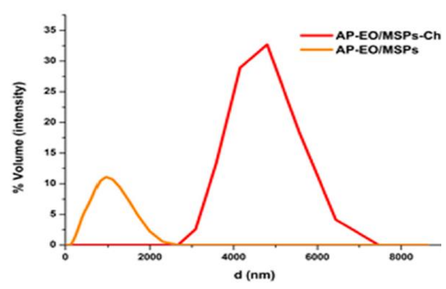
N sorption-desorption : Pore size distribution

- Specific surface area = 486.97 $m^2 g^{-1}$
- Mean pore size: 3,1 nm
- Particles 20-100 nm
- Quasi-neat silica = calcined mesoporous

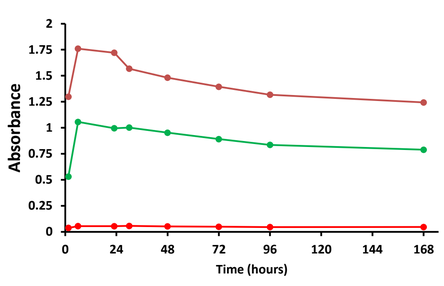


Thermogravimetric analysis of MSPs - AP

EOs' encapsulation



DLS characterization of the EO/MSPs

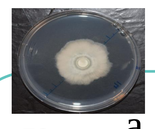


AP-EO release in PBS buffer

- Encapsulation yield = 42 %
- Large aggregates of single MSPs due to hydrophobicity of EO ; enlarged by capping with Chitosan
- Increased diffusion time of EO after encapsulation in MSPs + Protection against diffusion by Chitosan

Results

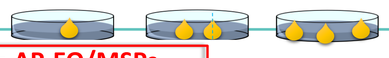
Antifungal and antimycotoxin activities

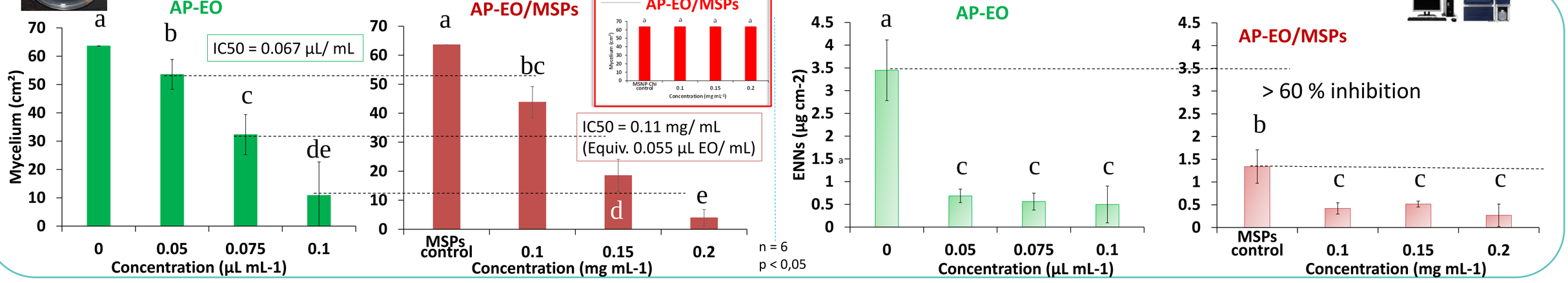


2 mg AP-EO/MSP ~ 1 µL AP-EO

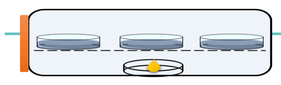
Enniatins B1+B2+B3

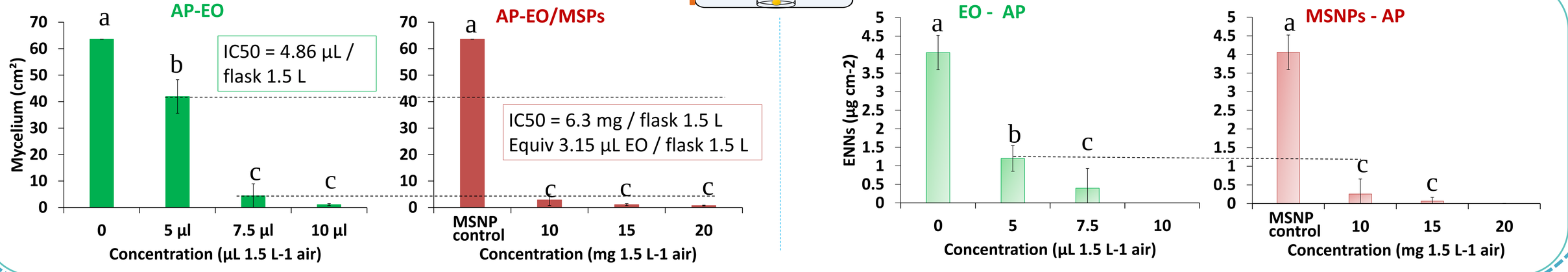
Contact





Fumigation





MSPs (without EO) in contact inhibited significantly the accumulation of enniatins by *Fusarium avenaceum*

Encapsulation in MSPs improved the antifungal and anti-enniatins activity of *Ammoides pusilla* essential oil on *Fusarium avenaceum*

Coating with chitosan improved the shelf life

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Chakroun Y. et al.. *Ammoides pusilla* essential oil: a potent inhibitor of the growth of *Fusarium avenaceum* and its enniatin production. *Molecules*. 2021; 26(22):6906.
Chakroun Y. et al. Encapsulation of *Ammoides pusila* essential oil into mesoporous silica particles for the enhancement of their activity against *Fusarium avenaceum* and its enniatins production. *Molecules*. 2023; 28, 3194.

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