Polyelectrolyte complexed nanoparticles loaded with eugenol-containing essential oils against *Staphylococcus aureus* and *Pseudomonas aeruginosa*

Joana Domingues[1], Maria Olívia Pereira[2], Helena P. Felgueiras[1], Joana C. Antunes[1]*

[1]Centre for Textile Science and Technology (2C2T), University of Minho, Portugal
[2]Centre of Biological Engineering (CEB), University of Minho, Portugal
*joana.antunes@2c2t.uminho.pt

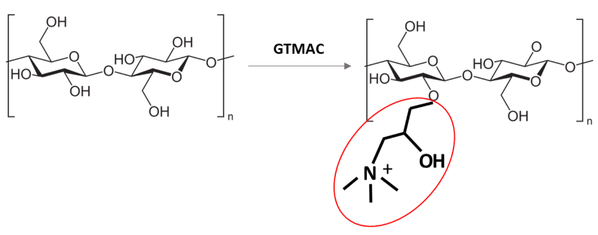
Infected Diabetic Foot Ulcers (DFU's)

Infected diabetic foot ulcers (DFUs) are a frequent and costly complication of diabetes, with limb amputation being highly prevalent worldwide. Persistent pathogens such as *Staphylococcus aureus* and *Pseudomonas aeruginosa* are the main pathogens of infected DFUs, often gaining antimicrobial-resistance to treatment.[1] Nanoparticle (NP)-mediated therapies may overcome this problem, as they are able to carry and protect loads from biodegradation, be internalized by the cell, and release the load(s) in a controlled manner. As payloads, plant-derived essential oils (EOs) exert quick and strong bactericidal action. This work proposes cinnamon leaf oil (CLO) and clove oil (CO)-encapsulation into polyelectrolyte complexed (PEC) NPs fabricated with natural, renewable, and bactericidal polymers [quaternized cellulose (QC) and carboxymethyl lignin (CML)].[2]

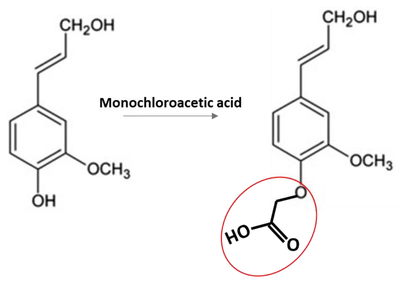
Polymer derivatives

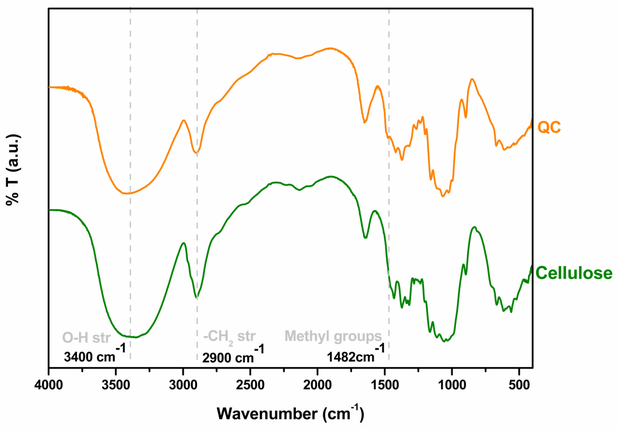
QC was obtained trough reaction with glycidyltrimethylammonium chloride (GTMAC), and the incorporation of the quaternized moieties was confirmed by the presence of a peak at **1482 cm^{-1}** in FTIR spectra which corresponds to the methyl groups of cationic quaternary amines grafted onto the cellulose chain. CML was obtained via reaction with monochloroacetic acid, with the FTIR spectra showing two absorption bands at **1710 cm^{-1}** and **1417 cm^{-1}** corresponding to the introduction of the negatively charged carboxyl groups.

Quaternized cellulose

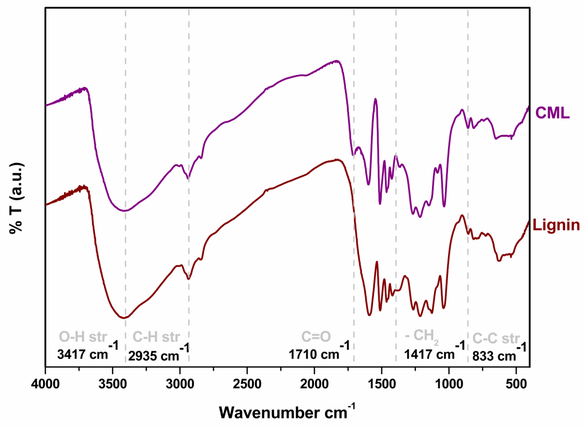


Carboxymethyl lignin





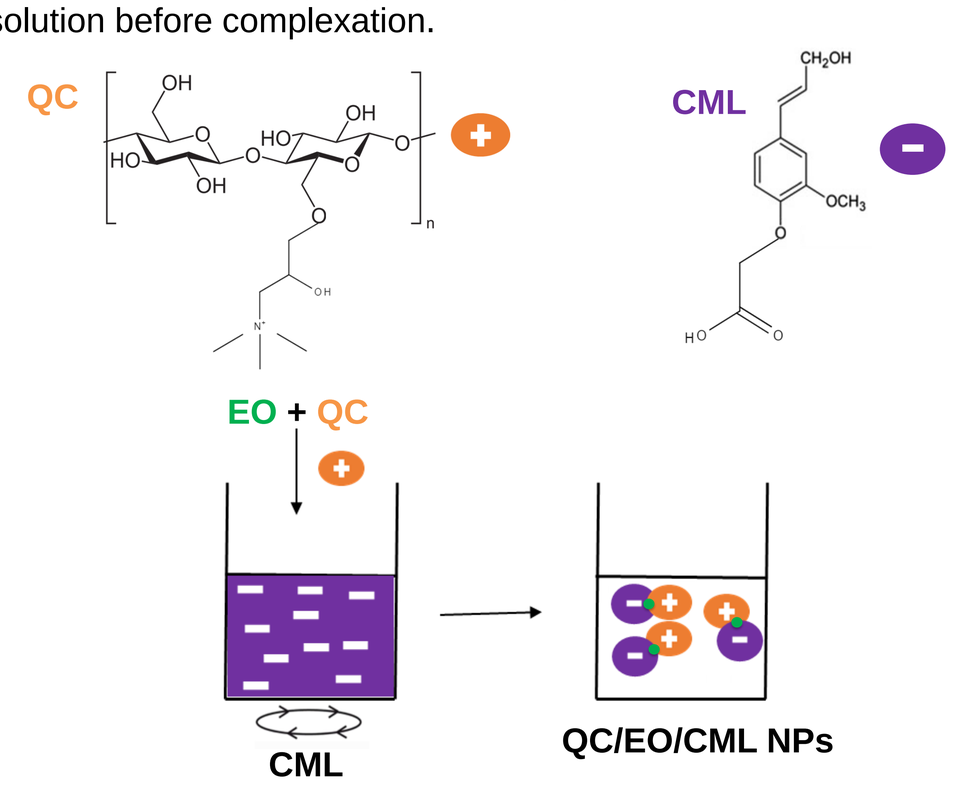
FTIR spectrum of QC



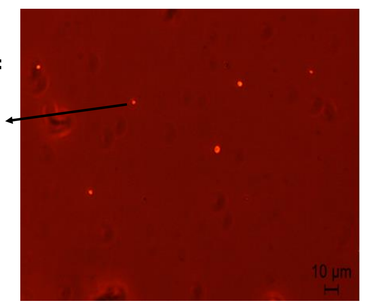
FTIR spectrum of CML

Polyelectrolyte complexes (PECs)

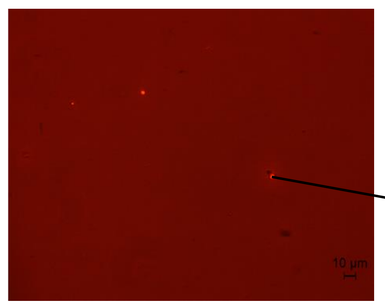
PECs were produced trough electrostatic interaction between the opposite electrical charges of the polymers' derivatives: QC is positively charged and CML is negatively charged. EOs were blended with CML solution before complexation.



1635,6 µg of CLO entrapped into NPs (83% loading efficiency)



Morphology of QC/CLO/CML NP's (40x)

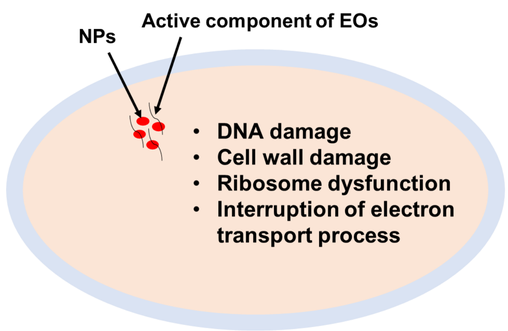


Morphology of QC/CO/CML NP's (40x)

234,2 µg of CO entrapped into NPs (12% loading efficiency)

Antibacterial potential

NPs functionalized with EOs have significant antibacterial potential against *S. aureus* and *P. aeruginosa.*[2]



Conclusions

It was possible to produce PEC NPs with QC and CML trough electrostatic interactions. CLO and CO were successfully encapsulated into QC/CML NPs.

References

[1]Antunes JC, Tavares TD, Teixeira MA, et al. Eugenol-Containing Essential Oils Loaded onto Chitosan/Polyvinyl Alcohol Blended Films and Their Ability to Eradicate Staphylococcus aureus or Pseudomonas aeruginosa from Infected Microenvironments. Pharmaceutics 13:195 (2021).

[2]Miranda, C. S., Antunes, J. C., Homem, N. C. & Felgueiras, H. P. Controlled Release of Cinnamon Leaf Oil from Chitosan Microcapsules Embedded within a Sodium Alginate/Gelatin Hydrogel-Like Film for *Pseudomonas aeruginosa* Elimination. Proceedings 69, 39 (2020).

Acknowledgements

Authors acknowledge FCT for supporting the projects with references PTDC/CTM-TEX/28074/2017(POCI-01-0145-FEDER-028074) and UID/CTM/00264/2021. Joana Domingues is also grateful for the FCT PhD grant 2020.07387.BD.