Hybrid polymer nanocomposites for dye absorption in wastewater treatment

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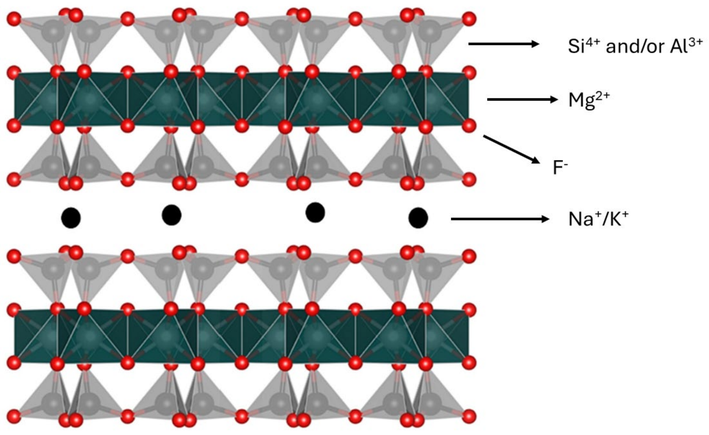
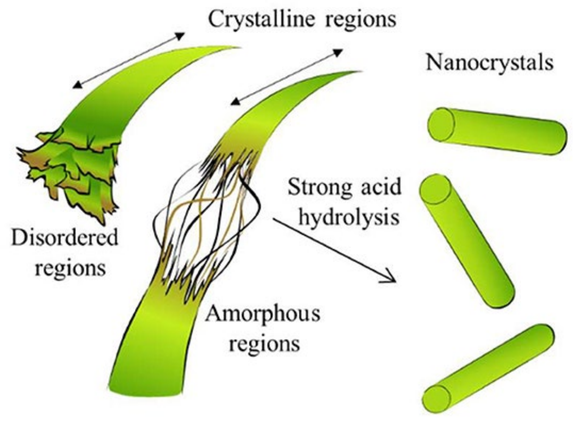
MICAS



Fluophlogopite micas are a type of phyllosilicate mineral characterized by their layered structure. They possess a high degree of cleavage due to the weak interlayer forces between the silicate sheets. These micas are composed by alternating layers of tetrahedral silica sheets and octahedral sheets containing magnesium and fluorine. This unique composition imparts them with properties such as low density, high thermal conductivity, and good dielectric properties. Fluophlogopite micas are widely used in various industries, including electronics, aerospace, and insulation materials. Their excellent thermal and electrical properties make them ideal for applications requiring high-performance materials.

CELLULOSE NANO-CRYSTALS

Cellulose nanocrystals (CNCs) are rod-shaped nanomaterials derived from the crystalline regions of cellulose, a major component of plant cell walls. CNCs exhibit exceptional mechanical properties, including high tensile strength, modulus, and stiffness, attributed to their highly ordered structure and strong intermolecular hydrogen bonding. Their biodegradability, biocompatibility, and sustainability make them attractive for various applications. CNCs are being explored as reinforcing agents in polymer composites, enhancing their mechanical properties and improving barrier properties. Additionally, their antimicrobial properties and controlled release capabilities make them promising for food packaging and drug delivery systems. CNCs offer a sustainable and versatile platform for developing advanced materials with tailored properties.



OBJECTIVES

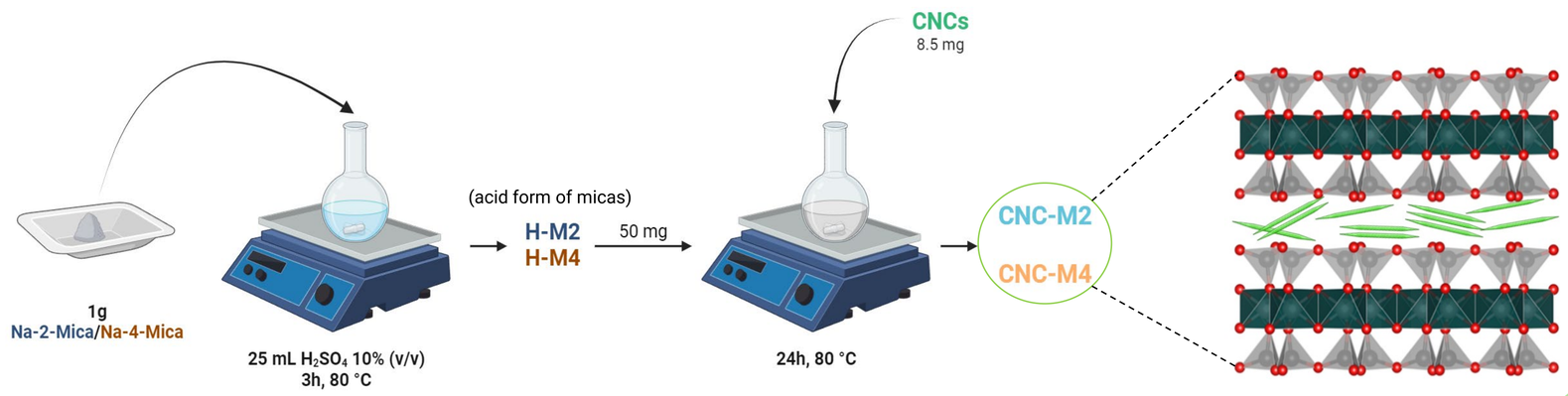
Intercalation of cellulose nano-crystals in synthetic micas

Absorption of water-soluble dyes

INTERCALATION OF SYNTHETIC MICAS WITH CNCS

The intercalation process consists in:

1. Activation of the micas through strong acid treatment;
2. Inserption of CNC between the layer of the micas with a thermal treatment.

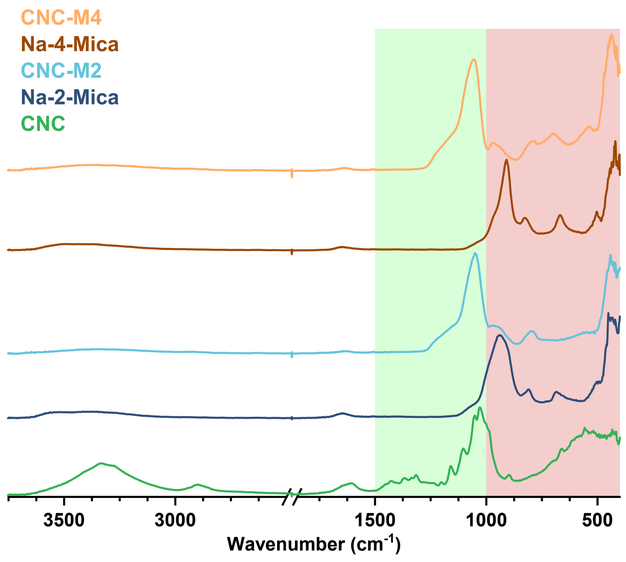


CHARACTERIZATION OF THE COMPOSITE MATERIALS

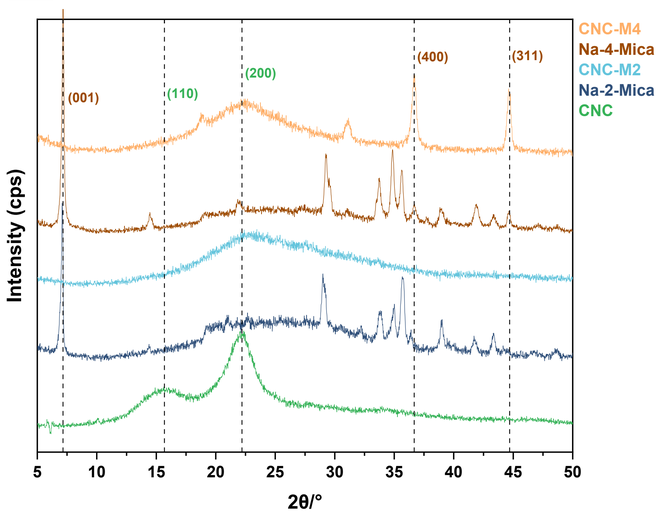
FT-IR Spectroscopy

: characteristic bands of layered aluminosilicates

: characteristic bands related to the pyranose ring of cellulose



XRD analysis

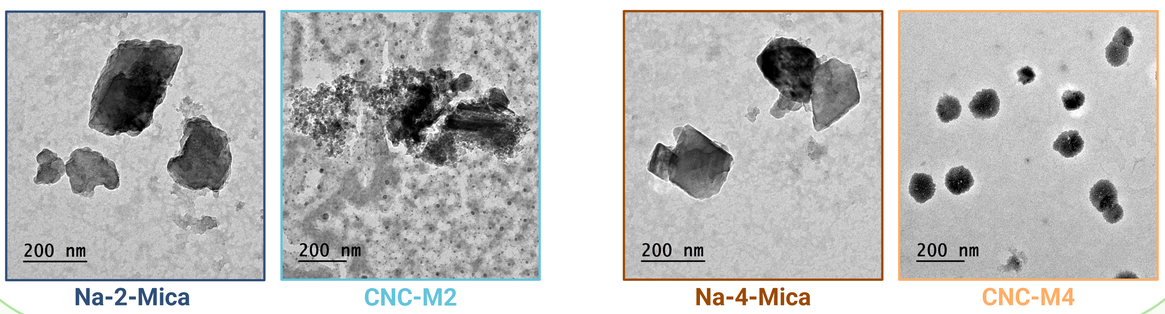


CNC diffraction pattern showed main peaks at 15.8° (110) and 22.2° (200), typical of the cellulose I crystal structure.

Na-2-Mica XRD pattern exhibits one family of reflections, characteristic of a mica-type layered structure consisting in an intense basal (001)b reflection at 2θ = 7.2° (*d* = 1.2 nm), associated to Na^+ cations accommodated in the hexagonal cavities of the tetrahedral sheet and a pseudo-monolayer of water between the silicate layers. Additionally, a few low-intensity peaks have been assigned to a magnesium silicate phase, forsterite (Mg_2SiO_4, JCPDS file no. 34-0189).

Na-4-Mica XRD pattern exhibits the same family of peaks corresponding to a mica-phase structure, like the Na-2-Mica, and the diffraction peaks of $MgAl_2O_4$ (ICDD card 5-672).

TEM images

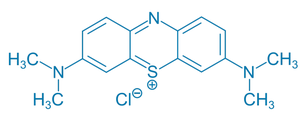


Na-2-Mica | CNC-M2 | Na-4-Mica | CNC-M4

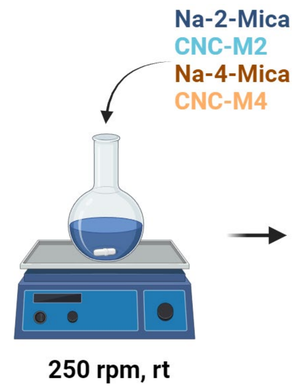
ABSORPTION OF DYES

Test the absorption capacity with water-soluble dye

Model molecule:



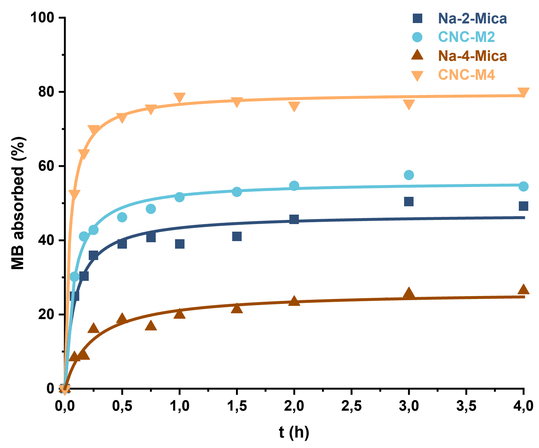
METHYLENE BLUE (MB)

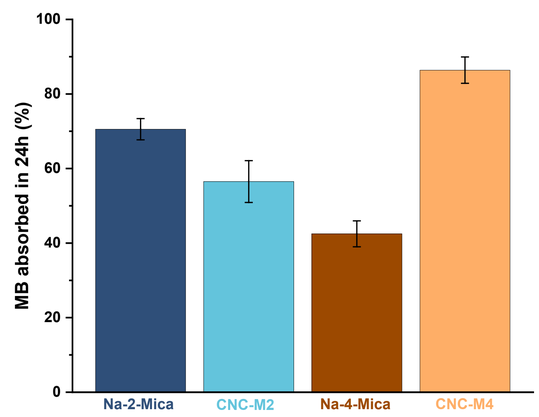


Uv-Vis spectroscopy

Check of the absorbance at **665 nm**

Results





CONCLUSIONS

The intercalation process succeded with **Na-4-Mica**, as demonstrated with XRD analysis and TEM imaging, but led to the disruption of the layered structure of Na-2-Mica. This result is probably related to the different interlayer distances among the two studied micas.

Absorption tests showed that **CNC-M4** possesses the highest capability of removing the methylene blue from water. On the contrary, CNC-M2 showed lower absorption capacity compared to the pristine mica, probably due to the disruption of the initial crystal structure.

REFERENCES

[1] Toro, R. G., Diab, M., de Caro, T., Al-Shemy, M., Adel, A., & Caschera, D. (2020). Study of the effect of titanium dioxide hydrosol on the photocatalytic and mechanical properties of paper sheets. *Materials*, *13*(6), 1326.
[2] Adel, A., El-Shafei, A., Ibrahim, A., & Al-Shemy, M. (2018). Extraction of oxidized nanocellulose from date palm (Phoenix Dactylifera L.) sheath fibers: Influence of CI and CII polymorphs on the properties of chitosan/bionanocomposite films. *Industrial Crops and Products*, *124*, 155-165.
[3] Martín-Rodríguez, R., Aguado, F., Alba, M. D., Valiente, R., Pavón, E., & Perdigón, A. C. (2022). Exploring the local environment of the engineered nanoclay Mica-4 under hydrothermal conditions using Eu3+ as a luminescent probe. *Journal of Alloys and Compounds*, *921*, 166086.

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