Cellulose Nanocrystal-Indium Tin Oxide NPs nanohybrid for Targeted Photothermal Cancer Therapy

Francesca Mancusi[1], Elisa Bianchi[1], Alessio Gabbani[2] , Beatrice Muzzi[3], Francesco Pineider[2], Costanza Montis[1], Barbara Richichi[1], Stefano Cicchi[1]

[1] Department of Chemistry "Ugo Schiff", University of Florence, Sesto Fiorentino (FI), ITALY
[2] Department of Chemistry and Industrial Chemistry, University of Pisa, Pisa (PI), ITALY
[3]CNR-ICCOM – Istituto di Chimica dei Composti Organometallici, Sesto Fiorentino (FI), ITALY

* Email: francesca.mancusi@unifi.it

Keywords: nanocellulose, nanoparticles, photothermal therapy, cancer

Objective
Cellulose nanocrystals (CNCs) are emerging as highly versatile nanomaterials due to their distinctive combination of chemical and physical properties. [1] The aim of this work was to design and characterize a nanohybrid platform for cancer therapy that integrates the biocompatibility and sustainability of CNCs with the optical properties of Indium Tin Oxide nanoparticles (ITO NPs). These nanoparticles exhibit a pronounced absorption band in the near-infrared (NIR) region, specifically within the range of 1700 to 1800 nm, which corresponds to the biological transparency window of tissues, facilitating deep tissue light penetration. Upon absorption, ITO NPs convert NIR light into heat, enabling localized photothermal effects. [2] Their combination provides an opportunity to develop a selective delivery system for targeted photothermal tumor therapy.

Methods
CNCs were chemically modified through the introduction of carboxyl groups, creating reactive sites for ITO NPs conjugation. To selectively direct the platform toward tumor cells, a sugar unit was incorporated as a selector ligand. The resulting CNCs–ITO nanohybrid was purified and characterized by multiple analytical techniques to confirm successful functionalization and nanoparticle anchoring.

Results
The functionalization strategy effectively enabled stable attachment of ITO NPs onto the CNCs backbone. Biological evaluations demonstrated that CNCs–ITO nanohybrid achieved more efficient nanoparticle delivery into tumor cells compared to free ITO NPs. Furthermore, the nanohybrid can reduce cancer cell viability, confirming its potential for therapeutic use.

Conclusions
CNCs provide a sustainable and modifiable carrier, while ITO NPs enable efficient heat generation upon NIR irradiation. The integration of CNCs with ITO NPs establishes a promising platform for selective tumor therapy. Further in-depth biological studies will be conducted to validate their therapeutic potential.

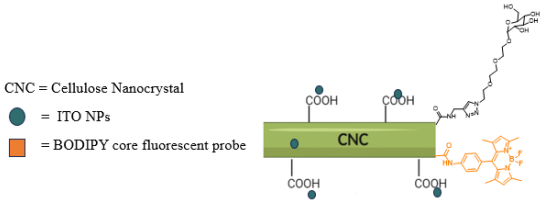

Figure 1. Cellulose Nanocrystal-Indium Tin Oxide NPs Nanohybrid

ACKNOWLEDGMENTS

This research has been funded by the Italian National Recovery and Resilience Plan (PNRR).

REFERENCES

[1] N. Lin, A. Dufresne, Nanocellulose in biomedicine: Current status and future prospect. European Polymer Journal, 59 (2014), 302-325.

[2] A. Mazzotta, A. Gabbani, M. Carlotti, M. Ruggeri, E. Fantechi, A. Ottomaniello, F. Pineider, A. Pucci, V. Mattioli. Invisible Thermoplasmonic Indium Tin Oxide Nanoparticle Ink for Anti-counterfeiting Applications. ACS Applied Materials & Interfaces, 14 (2022), 35276–35286.