Host Institution: University of Angers, FRANCE
Micro and Nanomedecines Translationnelles Laboratory
(UMR INSERM U1066 // UMR CNRS 6021) http:// mint.univ-angers.fr
Address : IBIS IRIS CHU Angers
4 rue Larrey
49933 ANGERS Cedex 9
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MASTER 2 INTERNSHIP (polymer chemistry, nanomedicines) - MINT – Angers

Project: Engineering Targeted Polyoxazoline-Based Lipid Nanocapsules for Precision Drug Delivery and Diagnostics

Description

Lipid nanocapsules (LNCs) are highly promising nanocarriers in pharmaceutical applications due to their unique combination of advantages: high encapsulation efficiency (EE) [1], long-term physical stability [2], biodegradability, biocompatibility, and scalability [3]. These nanocarriers are capable of co-encapsulating multiple drugs [4] and enabling their sustained release, making them particularly suited for complex therapeutic strategies.

Classically, LNCs consist of a triglyceride-based oily core surrounded by a shell of PEGylated surfactants and phospholipids. One of their key advantages: in their solvent-free formulation *via* the Phase Inversion Temperature (PIT) low-energy method [5], which avoids the use of organic solvents—an essential consideration for green and sustainable chemistry. Their size typically ranges from 20 to 100 nm, allowing efficient passive accumulation in tumor tissues *via* the enhanced permeability and retention (EPR) effect. Importantly, LNCs are versatile platforms capable of encapsulating both hydrophilic [6] and hydrophobic [7,8] drug molecules, further extending their applicability. LNCs have advantages such as prevention of drug aggregation, enhancement of controlled and localized drug delivery, and minimization of systemic side effects—making them an attractive alternative to conventional drug carriers. We have recently demonstrated their capacity to load photosensitizers for photodynamic therapy [9].

Polyoxazoline will be used as alternative PEG based surfactant for LNCs formulation. Functionalization of lipid nanocapsules with targeting ligands such as biotin and folic acid will significantly enhances their specificity and efficacy for drug delivery. Both biotin and folic acid receptors are overexpressed on the surface of various cancer cells, allowing targeted nanocapsules to preferentially accumulate in tumor tissues while minimizing off-target effects. This active targeting strategy improves cellular uptake and therapeutic outcomes by promoting receptor-mediated endocytosis. Moreover, these ligands can enhance the diagnostic potential of the nanocapsules by enabling selective imaging of pathological sites. Incorporating biotin and folic acid on the surface of polyoxazoline-modified LNCs provides dual functionality, combining biocompatibility with precise targeting capabilities.

Methodology

Lipid Nanocapsules Formulation using the PIT low-energy method to avoid organic solvents, optimizing temperature and composition parameters.

Characterization of LNCs for size, polydispersity index (PDI), zeta potential, and morphology using Dynamic Light Scattering (DLS), Transmission Electron Microscopy (TEM).

Drug Loading and Encapsulation Efficiency. Incorporation of model drugs (both hydrophilic and hydrophobic) into the LNCs core during formulation.

In Vitro Stability and Release Studies.

Cellular Uptake and Targeting Efficiency.

Cytotoxicity and Biocompatibility Assays.

This project aligns with SDG 3 (Good Health and Well-being) by advancing targeted, more effective, and less toxic drug delivery systems, contributing to improved treatment outcomes and patient safety. Moreover, the use of biodegradable and solvent-free nanocarriers supports the EU Green Deal vision by promoting environmentally sustainable pharmaceutical technologies and reducing chemical waste in medical manufacturing.

Mission of the student correspond to the methodology of the project.

The student will gain practical experience in formulating LNCs, learning the key physicochemical principles involved. She/he will perform advanced characterization techniques such as DLS and TEM to analyze nanoparticle size, morphology. Additionally, the student will learn to load drugs into nanocapsules and evaluate their release using analytical methods like HPLC and UV-Vis spectroscopy. Finally, the internship offers training in *in vitro* biological assays, data analysis, and scientific communication.

Candidate profile

Curious and motivated student of M2, looking to contribute to the research.

Experience in formulation and characterization techniques of nanocarriers will be felicitate.

Supervisor: Prof. Oksana Krupka

Oksana Krupka, E-mail: oksana.krupka@univ-angers.fr

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