Holy Spirit University of Kaslik
College of Doctoral Studies
Doctoral Studies Rules and Regulations/ Article 2

PhD Thesis Proposal (PTP)[1]

General Information		
PhD Thesis Title	***Innovative Encapsulation Strategies for Essential Oils: Enhancing Stability, Bioavailability, and Antimicrobial Efficacy for Cosmetic and Food Applications***	
USEK Doctoral Program	***Chemistry***	
Joint Guardianship/Cotutelle	☐ Yes	Partnership university's doctoral program:
	☒ No	
Research Center		
Research Group		
Research Axis	**Science and Technology**	
PhD Supervisor	Name & Title: Nancy Zgheib – Associate Professor Email:nancyzgheib@usek.edu.lb	University Address: Holy Spirit University of Kaslik - USEK
Co-supervisor (if applicable)	Name & Title: Youssef El Rayess Email:youssefrayess@usek.edu.lb Name & Title: Philip Riyachi Email: philipriachy@usek.edu.lb	University Address: Holy Spirit University of Kaslik - USEK
Location (s)	Location 1: USEK	Work shift calendar /per year (%):
	Location 2: (if applicable)	Work shift calendar /per year (%):
Potential funding and scholarship		

Applicant's Name and Profile	
Comps Exam Language **(to be check-marked by the PhD Supervisor)**	X Oral Assessment ☐ Written Assessment ☐ Arabic ☐ French × English

Subject's national or worldwide context, objectives & research lines
Encapsulation technologies for essential oils (EOs) have gained significant attention worldwide due to their ability to enhance the stability, bioavailability, and efficacy of EOs in cosmetics, pharmaceuticals, and food industries. Essential oils, renowned for their antimicrobial, antifungal, and anti-inflammatory properties, face significant challenges, including volatility, instability, and sensitivity to environmental conditions. Addressing these challenges is vital to unlocking their full potential in combating pathogens, preventing spoilage, and delivering therapeutic benefits.

[1] The PhD Thesis Proposal should not exceed three pages. It shall be approved by the School/Faculty.

The primary objective of this research is to explore innovative encapsulation methods for essential oils and evaluate their antimicrobial potency, focusing on applications in cosmetics and food. Three encapsulation strategies will be investigated:

1. Liposomal Encapsulation: This approach utilizes liposomes as biocompatible carriers to enhance the stability and delivery of essential oils. The specific goal is to investigate the encapsulation effectiveness of essential oil and to formulate a liposomal gel. Parameters such as vesicle size, entrapment efficiency, and formulation stability will be thoroughly evaluated to ensure optimal delivery and performance[2].
2. Incorporation into Hybrid Materials: The combination of EOs with clay-based materials, such as mica and mesoporous silica (SBA-15), will be explored. These hybrid systems are designed to achieve sustained release and enhanced antimicrobial action. The immobilization of essential oils in montmorillonite-based materials will also be studied, leveraging their synergistic properties for applications in antibacterial and antifungal.
3. Nanoemulsion Development: Stable nanoemulsions containing EO mixtures and surfactant blends (Tween and Span 80) will be developed. The study will focus on optimizing the hydrophilic-lipophilic balance (HLB) and surfactant-to-oil ratios to achieve desirable physicochemical properties, including mean particle size (z-average) and polydispersity index (PDI). Response Surface Methodology (RSM) and Central Composite Design (CCD) will guide the formulation process, ensuring cosmetic grade nanoemulsion with excellent stability and antimicrobial efficacy.

The antimicrobial potential of these formulations will be assessed against key spoilage bacteria and foodborne pathogens and fungi. Additionally, the physicochemical properties, encapsulation efficiency and stability of these different entities under various environmental conditions ensuring prolonged shelf life will be analyzed.

This research aligns with global efforts to develop sustainable and innovative solutions for improving product preservation, safety, and functionality, particularly in the cosmetic and food sectors. By overcoming the challenges associated with essential oil formulations, this study aims to promote their broader adoption as natural, eco-friendly alternatives to synthetic chemical preservatives, contributing to advancements in environmental sustainability and public health.

Outcomes (OCs): What do we wish to achieve?	
OC1:	**Optimized Encapsulation Methods**: Development of efficient encapsulation techniques for essential oils, including liposomal systems, hybrid materials (e.g., SBA-15 and mica), and nanoemulsions.
OC2:	**Enhanced Stability and Bioavailability**: Improved stability of essential oils under various environmental conditions, including temperature and storage duration, ensuring prolonged shelf life.
OC3:	**Improved Antimicrobial and Antifungal Efficacy**: Effective inhibition of spoilage bacteria, foodborne pathogens, and fungi, particularly in applications related to cosmetics and food preservation.

[2] Wang et al., “Lecithin/Cholesterol/Tween 80 Liposomes for Co-Encapsulation of Vitamin C and Xanthoxylin.”

OC4	**Tailored Physicochemical Properties**: Achieving desirable particle sizes, narrow polydispersity index (PDI), and high entrapment efficiency through formulation optimization.
OC5	**Sustainable and Natural Solutions**: Promotion of essential oils as eco-friendly alternatives to synthetic preservatives, aligning with global sustainability goals.

References (R) (5 most recent peer-reviewed publications in the field)	
R1:	Mahmud, Jumana, Peter Muranyi, Shiv Shankar, Elham Sarmast, Stephane Salmieri, and Monique Lacroix. “Physiological and Antimicrobial Properties of a Novel Nanoemulsion Formulation Containing Mixed Surfactant and Essential Oils: Optimization Modeling by Response Surface Methodology.” *Colloids and Surfaces A: Physicochemical and Engineering Aspects* 686 (April 2024): 133405. https://doi.org/10.1016/j.colsurfa.2024.133405.
R2:	Sherry, Mirna, Catherine Charcosset, Hatem Fessi, and Hélène Greige-Gerges. “Essential Oils Encapsulated in Liposomes: A Review.” *Journal of Liposome Research* 23, no. 4 (December 2013): 268–75. https://doi.org/10.3109/08982104.2013.819888.
R3:	Sousa, Vânia Isabel, Joana Filipa Parente, Juliana Filipa Marques, Marta Adriana Forte, and Carlos José Tavares. “Microencapsulation of Essential Oils: A Review.” *Polymers* 14, no. 9 (April 23, 2022): 1730. https://doi.org/10.3390/polym14091730.
R4	Wang, Ruijuan, Chunliu Ma, Haitao Yan, Hailiang Zhao, Pu Wang, Shoubing Zhang, Jianwei Ju, Shuyan Yu, and Zhigang Yin. “Lecithin/Cholesterol/Tween 80 Liposomes for Co-Encapsulation of Vitamin C and Xanthoxylin.” *ACS Applied Nano Materials* 7, no. 6 (March 22, 2024): 5982–95. https://doi.org/10.1021/acsanm.3c05884.
R5	Weisany, Weria, Shima Yousefi, Solmaz Pourbarghi Soufiani, Danial Pashang, David Julian McClements, and Mehran Ghasemlou. “Mesoporous Silica Nanoparticles: A Versatile Platform for Encapsulation and Delivery of Essential Oils for Food Applications.” *Advances in Colloid and Interface Science* 325 (March 2024): 103116. https://doi.org/10.1016/j.cis.2024.103116.