High Internal Phase Pickering Emulsions Stabilized with Solid Particles for Encapsulation of Lipophilic Drugs and Oxygen Generation via Calcium Peroxide

Chronic skin conditions such as diabetic ulcers, pressure sores, and postoperative wounds represent a serious challenge for modern medicine and healthcare systems. Despite the use of advanced dressings, antibiotics, and local therapies, many wounds fail to heal properly and develop into chronic, painful lesions. One of the key factors responsible for this condition is the presence of bacterial biofilm, which is a structured community of microorganisms surrounded by a protective matrix that adheres to the wound surface and shields bacteria from drugs and the immune system. Biofilm leads to persistent inflammation, blocks epidermal regeneration, and supports the growth of drug-resistant bacteria. It is estimated that biofilm is present in up to eighty percent of chronic wounds, contributing to prolonged treatment, high healthcare costs, and the risk of serious complications such as amputation.

The aim of this research project is to develop innovative therapeutic systems based on High Internal Phase Pickering Emulsions, known as HIPPEs. These emulsions are stabilized with biodegradable solid nanoparticles that form a physical barrier at the oil–water interface. The goal is to create stable formulations containing lidocaine, a lipophilic drug with analgesic and antiseptic properties, and calcium peroxide, which generates molecular oxygen upon contact with the wound and supports the healing process. A key element of the study will be the simultaneous stabilization of oil droplets containing these active substances and the control of their performance in a model chronic wound environment.

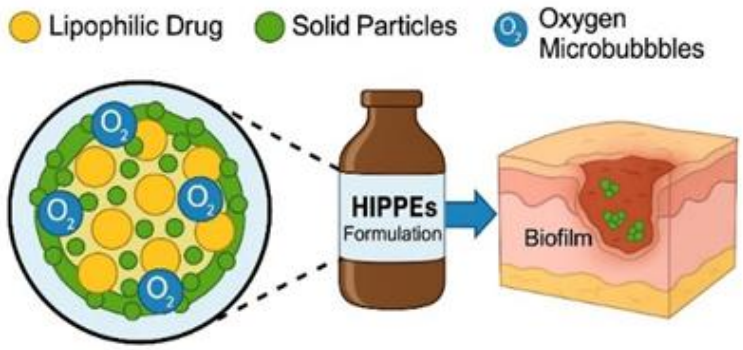

Fig. 1 HIPPE Emulsion Formulations with Lipophilic Drugs for Analgesic and Antiseptic Action in Chronic Wounds with Biofilm.

The project will include research on the synthesis of nanoparticles, the development of emulsion formulations, and their physicochemical characterization, including rheological properties, surface tension, stability, and active compound release capacity. Particular attention will be paid to the cytotoxicity and biocompatibility assessment of the developed materials under in vitro conditions, in collaboration with an expert in cell biology. The stabilization mechanisms of HIPPE-type emulsions will also be investigated.

The novel aspect of this project is the combination of lipophilic drug delivery and oxygen generation in a single emulsion-based system. This will enable integrated antibacterial, analgesic, and healing-promoting action at the site of application, reducing the need for antibiotic use. The project responds to the current demand for the development of safe and effective therapeutic materials that support chronic wound treatment without increasing the risk of bacterial resistance.

The result of the project will be a new therapeutic solution based on biocompatible ingredients, which may be applied in the treatment of hard-to-heal wounds, especially in elderly populations and patients with chronic diseases. The project also has strong potential for further research in the fields of biomaterials engineering and regenerative medicine.