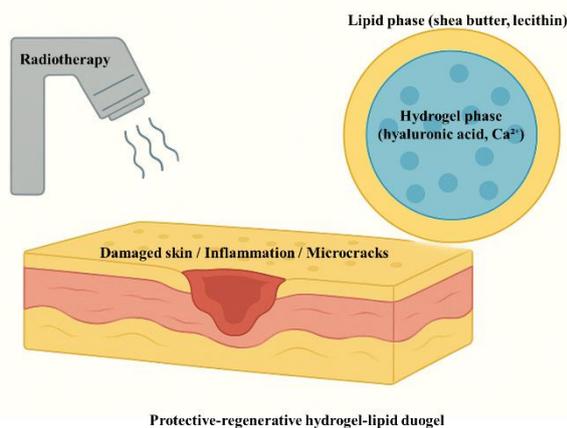


Structural and Biocompatibility Aspects of Duo-gels: Fundamental Research on the Integration of Hydrophobic and Hydrophilic Phases in the Context of Biological Barriers

Modern oncology effectively extends patients' lives, but often at the cost of treatment-related complications that significantly impact daily functioning. One of the most frequent and distressing side effects of radio- and chemotherapy is damage to the skin and mucous membranes—particularly in sensitive areas such as the mouth, groin, vulva, and perianal region. Patients commonly report burning, pain, microcracks, and inflammation that interfere with basic activities. Currently available protective preparations often contain alcohol, preservatives, or strong emulsifiers that can further irritate delicate tissues. There remains a clear need for solutions that are simultaneously gentle, biocompatible, structurally stable, and effective.

The aim of my three-year research project is to develop an innovative, semi-solid protective and regenerative preparation in the form of a duogel—a gel structure composed of two interacting phases: a hydrophilic (hydrogel) phase and a lipophilic (fat-based) phase. This system combines the moisturizing, soothing, and regenerative functions of the aqueous phase with the protective and occlusive properties of the lipid matrix. The innovation lies in the unique method of forming the duogel: the hydrogel phase, based on sodium alginate and hyaluronic acid, will be crosslinked using calcium ions directly within the lipid matrix (composed of natural ingredients such as shea butter and coconut oil). The entire structure will be stabilized by lecithin, a natural biosurfactant. This approach eliminates the need for traditional emulsifiers or preservatives, offering high biocompatibility with sensitive skin and mucosal surfaces.

This novel method of in situ hydrogel crosslinking within a lipid structure allows for the creation of a stable, elastic system that adapts to physiological surface conditions. As such, the duogel may serve as a protective barrier, promote the regeneration of damaged epithelium, and support the controlled release of active ingredients such as hyaluronic acid. All components used are safe, gentle, and well-known for their soothing properties, making them especially promising in the context of supportive care during cancer therapy.



The research will be conducted in four stages: development of the lipophilic phase, synthesis and crosslinking of the hydrogel phase, integration of both into a single duogel system, and detailed analysis of its properties. Parameters such as viscosity, structural stability, adhesion to biological surfaces, morphology, biocompatibility with skin cells (keratinocytes and fibroblasts), and controlled release of hyaluronic acid will be evaluated. The work will be carried out in a laboratory setting using advanced techniques, including SEM microscopy, FT-IR spectroscopy, rheometry, and in vitro cytotoxicity tests.

Responding to the side effects of cancer treatment must go beyond addressing the disease itself—equally important is supporting patients in coping with the complications of therapy. Cutaneous and mucosal damage is among the most common adverse effects of oncology treatment and has a direct impact on patients' quality of life, sometimes even necessitating treatment interruptions due to ulceration or pain. The development of biocompatible, gentle, and effective topical systems for regeneration support is therefore an important area of research in supportive oncology. Although the proposed duogel is not yet a therapeutic product, it has the potential to serve as a foundation for such solutions in the future.

This project fits within the current scope of fundamental research at the intersection of physical chemistry, bioengineering, and biomedical materials science. While not application-driven, the project's results will provide a valuable step toward the development of gentle, biocompatible protective systems for oncology patients. The duogel developed here will serve as a model system for studying the behavior of semi-solid materials at biological interfaces—especially where conventional preparations fail and regenerative support is critically needed.