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Cefuroxime and Streptomycin Organic salts & Ionic Systems for Transdermal Nanomaterials

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Transdermal delivery represents a valuable route for antibiotic administration, offering an alternative to conventional dosage forms through the development of sophisticated delivery systems such as lipid nanoparticles and dissolving microneedles. However, most antibiotics exhibit poor permeability due to their high polarity and limited lipophilicity. To address this challenge, the combination of Active Pharmaceutical Ingredients (APIs) with Organic Salts and Ionic Liquids (OSILs) has emerged as a promising chemical strategy to modulate drug solubility, lipophilicity, and membrane interaction while maintaining biological activity.

In this work, two representative antibiotics, cefuroxime and streptomycin, were selected as model systems to explore the potential of ionic modification for enhancing transdermal delivery. A series of anionic cefuroxime OSILs (CFX-OSILs) were synthesized via buffer-assisted neutralization with pyridinium and imidazolium cations, while cationic streptomycin OSILs (STP-OSILs) were obtained by direct protonation with sulfonic and carboxylic acids. The resulting compounds were isolated as stable solids and extensively characterized by spectroscopic and analytical techniques.

Physicochemical and biological evaluations demonstrated that ionic modification effectively increased solubility, up to 200-fold in the case of cefuroxime, while allowing controlled tuning of lipophilicity and preserving antimicrobial activity. Cytotoxicity assays confirmed good biocompatibility for most derivatives, validating OSILs as a viable route for antibiotic optimization.

More details here: **https://laqv.requimte.pt/gazette/**

Building upon these findings, selected cefuroxime and streptomycin OSILs are currently being incorporated into solid lipid nanoparticles (SLNs) and dissolving microneedle array patches (MAPs) to assess their compatibility with advanced transdermal delivery systems. These platforms aim to evaluate how the intrinsic physicochemical modulation conferred by ionic pairing translates into improved formulation performance, controlled release, and enhanced skin permeability.

Overall, this work establishes antibiotic-based OSILs as a versatile chemical platform capable of bridging molecular design and formulation strategy, advancing the development of next-generation transdermal therapies.

Short Bio

Francisco Faísca is a PhD candidate in Sustainable Chemistry at NOVA University Lisbon, working within the LAQV/REQUIMTE research unit under the supervision of Professor Luís C. Branco. His research focuses on the development of organic salts and ionic liquids of active pharmaceutical ingredients (API- OSILs) as chemical platforms to enhance the transdermal delivery of antibiotics.

He holds a Bachelor's degree in Biochemistry and a Master's in Bioorganic Chemistry, both from NOVA University Lisbon, where he worked on synthetic chemistry projects involving peptidoglycan and cellulose derivatives. These early experiences in organic synthesis and biomaterial modification lead to the current focus on the intersection between chemistry, pharmaceutical formulation, and drug delivery.

His doctoral work integrates green chemistry, medicinal chemistry, and nanostructured biomaterials, exploring how ionic modification can modulate solubility, lipophilicity, and permeability in conventional antibiotics. He has presented his research at several international conferences, including the EuChemS Chemistry Congress and the Conference on Green and Sustainable Chemistry, and completed an internship at Queen's University Belfast, where he worked on microneedle-based transdermal systems under Professor Ryan Donnelly.

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