CHEMICAL ENGINEERING

MUR DM 118 - Development of innovative Antimicrobial bionanocomposites from natural macromolecules for the wounds treatment

Funded By	MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [P.iva/CF:97429780584] Politecnico di TORINO [P.iva/CF:00518460019]
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Context of the research activity	The research activity is focussed on antimicrobial nanosystems for wound healing and, more generally, on innovative strategies in the treatment of antibiotic resistance. The activity concerns the PNRR missions "Emerging infectious diseases", "Diagnostics and innovative therapies in precision medicine" and "Consequences and challenges of aging". Progetto finanziato nell'ambito del PNRR - DM 118/2023 - CUP E14D23001680006
	Chronic wounds are a large global health issue affecting 2% of the population in western countries, with mortality rates becoming as high as 52% in some cases. Chronic wounds can be caused by – or cause – infections, as pathogens do not encounter the natural barrier represented by the skin and can interfere with the normal healing process. It has been estimated that these infections are responsible for 75% of postoperative deaths. In parallel, treating infections is becoming more difficult, due to antimicrobial resistance (AMR), i.e., the tendency of microorganism to adapt and develop resistance against the drugs that are used to eradicate them. Without further action, AMR is predicted to cause around 10 million deaths per year by 2050. Chronic wounds are a silent epidemic that is set to become larger and larger as our median age and the incidence of the related comorbidities keep increasing. This demands for urgent solutions, including new types of wound dressings. The research project is aimed at the formulation, engineering and investigation of antimicrobial nanosystems based on biomacromolecules for the treatment of wounds and chronic dermatological pathologies in the context of innovative strategies for the treatment of antibiotic resistance.

Objectives	In particular, novel bionanocomposites made by biomacromolecule-based matrixes filled with nanostructured materials will be developed. Biomacromolecules primarily bring high biocompatibility and biodegradability. Bionanocomposites can also possess many other beneficial features, such as anti-inflammatory, hemostatic, cellular proliferation and tissue regeneration properties. Common biomacromolecules include polysaccharides like chitosan, cellulose, alginate and starch, to proteins like collagen, gelatin and chitin. As far as nanostructured materials are concerned, zinc oxide and calcium oxide nanoparticles will be used to obtain the antimicrobial activity. Nanostructured zinc oxide (nZnO) is extremely effective in terms of antibacterial properties, and showed lower toxicity compared to metal nanoparticles. Plus, zinc is an essential element for the human body, and is involved in wound healing and the immune system. The bionanocomposites will be prepared in the form of both films and aerogels. The complete physico-chemical characterization the films and aerogels will be carried out by means of several techniques (XRD, FESEM, TEM, UV-Vis, IR, XPS, EDS). Then, the antimicrobial activity will be studied in vitro in terms of the minimum inhibitory concentration (MIC) and the minimum bactericidal concentration (MBC) applying the EUCAST disk diffusion method. The tested bacteria will be the gram-positive Staphylococcus epidermidis and the gram-negative Escherichia coli. Moreover, biopharmaceutical characterization will be carried out in collaboration with the University of Pavia. Wettability, swelling properties, mechanical behaviour in different conditions will be investigated, as well as the degradation in time and in different fisiological conditions. In-vitro tests will be carried out on human dermal fibroblasts to study the cytocompatibility of bionanocomposites. Finally, in-vivo wound healing tests will be carried out carried on rats.

Skills and competencies for the development of the activity	Graduate related to the following areas: Pharmacy, Chemistry, Materials Science, Chemical Engineering, Material Engineering, Biomedical Engineering