PhD in MATERIAL SCIENCE AND TECHNOLOGY

Research Title: Biobased Composite Nanofibrous Membranes for Smart Packaging

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Context of the research activity	Membranes made of polymer-based nanofibers are attractive for many applications due to their intrinsically high porosities and large surface areas. Electrospinning is the most versatile and promising technology for the mass production of these materials: although the setup is extremely simple, the spinning mechanism and related phisico-chemical phenomena are rather complicated. This is challenging, but means that one is allowed to have an extraordinary control over the fiber structure (size, morphology, etc) and properties. Parameters that can be changed during the process are several: spinning conditions (e.g, voltage applied, gap distance between the electrodes, polymeric solution dispensing flow rate), but also environment conditions (e.g., humidity, temperature, and atmosphere), the polymer to spin, the solvent of the spinnable solution, the solution concentration. Designing and tailoring the nanofibers open the way to many applications: materials fabricated through electrospinning have already found their way into tissue engineering, wound dressing, protective clothing, high efficiency filtration and also food packaging. The use of electrospun fibers as packaging material is mainly targeted at keeping the freshness of the food for a longer duration. In fact small pore size between the interconnected fibers acts as an efficient physical barrier and may even prevent against the entry of bacteria. The polymer forming the fibers can even be accurately selected to impart special properties to the membrane, such as antimicrobial or antibacterial activity. Moreover active agents can be encapsulated within the fibers: many different performances can be expected by the packaging depending on the additives present in the nanofibers, for example antifouling behavior.

	The nanostructures may also be employed in nanosensor development: in the field of food packaging it is very relevant the detection and monitoring of food conditions during transport and storage. Including sensing materials in a nanostructured membrane having high surface area allows quick response to its surrounding conditions.

Objectives	This research work aims at the fabrication of nanostructured functional membranes, with unique properties, including optimized chemical and mechanical resistance, sensing and recyclability. The nanofibrous membranes will be preferable based on natural polymers (e.g. chitosan and other cellulose derivatives); carbon nanofillers such as graphene, properly modified and functionalized, will be added to the spinnable solutions and used in view of imparting sensing properties. In the first part of the project the fabrication process and the final properties of the nanofibrous materials will be optimized in order to obtain the desired fiber diameter, filler concentration, mechanical, thermal and sensing properties and to meet the demands of end application. In the second part of the project improvements of the performances of the membranes will be studied. In fact, biobased electrospun materials can have limited performances in terms of chemical resistance, also thermal and mechanical properties may be unsuitable for applications. In packaging there is also a certain concern concerning the use of electrospun fibers as loose fiber strands may be present and contaminate the content (the issue is especially important for food packaging). These problems can be solved by a proper covalent crosslinking of the membranes. Therefore in the project membrane fabrication will be accomplished coupling electrospinning and photoinduced crosslinking processes. Photoinitiated processes are a wide range of fast and eco-friendly processes that use light to induce chemical reactions: throughout the project, UV radiation will be used for crosslinking the nanofibers, tuning their mechanical properties and their stability. Reversible crosslinking reactions will be preferred in view of depolymerizing and thus recycling the material.

Skills and competencies for the development of the activity	Applicant is requested to have a background in polymer science and experience of chemical lab work, to know techniques such as optical and electron microscopy, thermal and mechanical analysis, IR spectroscopy, permeability and conductivity tests. Experience of work in the field of electrospinning and/or biopolymers is assessed positively.