Electrospun Nanofibers as advanced materials for bio-devices

Giulia Massaglia[1,2], Eve Verpoorten[1,2], Marzia Quaglio[2],

[1]*DISAT, Politecnico di Torino, Turin, Italy*

[2] *Center for Sustainable Future Technologies, Istituto Italiano di Tecnologia@Polito, Turin, Italy*
Email:giulia.massaglia@polito.it, web site: https://areeweb.polito.it/ricerca/micronanotech/main-page/

Electrospun nanofibers can be defined as the conjunction point between the nanoscale world and the macroscopic one, thanks to their diameters, in the range of some tens of nanometers, and their length, which can reach up to some kilometers. Electrospinning is an electrohydrodynamic technique that leads nanofibers formation by providing the electrostatic forces, obtained by applying an electrostatic field between two electrodes. The first one is the tip of needle of the syringe where the polymeric solution is loaded, while the second one is a grounded substrate (or collector). Strong repulsive electrical forces can overcome the surface tension in a charged polymeric jet. In contrast to the fibers obtained with conventional spinning methods, the electrospun nanofibers show interesting morphological characteristics, like high surface area to volume ratio and small size pores, guaranteeing high porosity. One of the most important advantage of electrospinning technique is the possibility to obtain a wide class of nanomaterials. Starting from a polymeric solution of both natural and synthetic polymers and through a proper chemical or thermal post-treatment, the final nanofibers can be based on metals, metal oxides, ceramics, and different classes of (bio)-composites. Among all composite nanofibers based on the combination of a conductive filler and a polymeric matrix, bio-composite nanomaterials represent one of the most interesting class of materials [1]. In particular, we developed bio-composite nanofiber mats, based on bacteria embedded into Polyethylene-oxide (PEO) nanofibers, as represented in Figure 1. We selected a specific species of bacteria, named exo-electrogenic microorganisms, which are normally present into the environment, thanks to their ability to release electrons directly to an electrode surface, and then to be employed as a sensitive element in some bio-electrochemical devices. The aim of this study was to demonstrate the capability of nanofibers as storage scaffold, where the bacteria, encapsulated into nanofibers, preserved their metabolic activity. To this purpose, the bio-composite nanomaterials were developed as anodic electrode applied into Microbial fuel Cells, demonstrating thus the bacteria vitality and the consequent correct functionality of these devices. Another important class of functional materials are the intrinsically conductive polymers (ICPs), which combine unique properties, such as good chemical resistance, low weight and low production cost, good mechanical, optical and electrical characteristics [2-4]. Among all the conductive polymers, poly (3,4-ethylenedioxythiophene) doped with poly (styrene sulfonate) (PEDOT:PSS) results to be the most attractive ICPs, due to its high stability, high electrical conductivity and wide processability [4]. We studied electrospun nanofiber mats, as 1D nanomaterials, enhancing the intrinsic properties of this kind of ICPs. All the properties shown by nanostructured samples obtained by electrospinning, such as high surface area, high porosity, and their ability to offer a preferential pathway for electrons flow, play a crucial role to enhance the overall performances of ICPs materials in electrochemical applications. For example, the sensitivity of (bio) sensors can be deeply improved by enhancing the surface area of samples. In particular, we developed PEDOT: PSS nanofibers, starting from a polymeric blend solution, where a dopant compound was added to enhance the electrical ionic conductivity, and simultaneously ensured the nanofiber formation. PEO results to be extremely effective to ensure the nanofibers formation and to enhance their electrical conductivity. The combination between the intrinsic properties of ICPs and the features of the nanofibers, opens the door to the production of a high performing sensitive elements in bio-electrochemical devices.

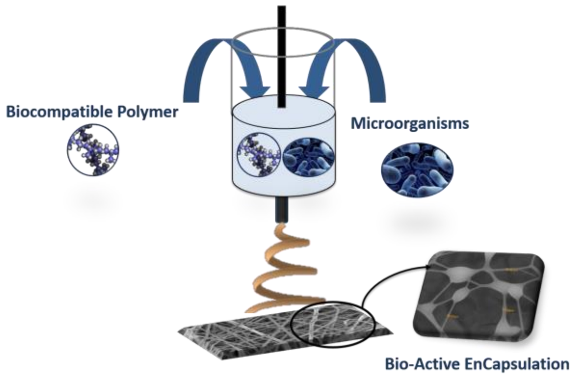

Fig1. Schematic representation of bacteria embedded into nanofibers

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