Two-phase flow analysis for electrospinning processes applications

Sintesi del progetto di ricerca & Piano attività

Nanofibers are the optimal tools for increasing efficiency of the vehicle, but also to prevent degradations, improve performance, increase safety and add functionalities. In particular, biphasic rubber based nanofibers offer a wide potential to introduce localized toughening and damping properties, which would increase the safety coefficient of vehicle components, thus also helping weight reduction and fuel savings.

In this frame, the optimal process for obtaining rubber-containing nanofiber is the electrospinning, where often rubber needs to be paired with a second component for attaining a stable and handable morphology without the need for rubber crosslinking. In the electrospinning, the application of an electrostatic field onto a polymeric solution jet is exploited. Under the action of the electrostatic field, the jet is deformed and stretched until the solvent evaporates and nanosized fibers are obtained. The ability to manage the electrospinning process in order to finely tailor the final nanofibers properties and morphology is thus a required step in order to fully develop this technology toward industrial application.

The project is aimed at contributing to the improvement of the industrial production of nanofibers by the development and application of experimental and computational methods for the fluid dynamics characterization of polymeric solution jets adopted in the electrospinning process.

The effect of the operative conditions of the process on the biphasic solutions characteristics will be assessed, considering the behavior in the complex environment (interplay of electrostatic field, ambient conditions and solvent evaporation rate, among the others).

The activity will be organized in two steps:

- the mixing and the local fluid dynamics characteristics of multiphase mixtures of different composition before the injection in the electrospinning chamber will be investigated by experiment and numerical simulations. The experiments will be performed in channels of size larger than that of the nozzles typically adopted in the electrospinning and the data will be adopted for the validation of models based on Computational Fluid Dynamics methods. The actual size of the needle will be finally considered by numerical simulations based on validated models and robust numerical solution strategies;
- the shape and the trajectory of the jet in the chamber from the injection nozzle to the collector will be characterized experimentally as a function of the operative conditions, namely the solution flow rate, the composition, the voltage and the distance between the nozzle and the collector.

The results obtained in the two steps will be finally combined in order to obtain guidelines for improving the management of the electrospinning process by relating the fluid dynamics and electric field parameters on the jet shape during the electrospinning and ultimately on the final fiber properties.