Abstract

This PhD is an “Industrial-PhD”, carried out in collaboration between University of Basilicata and LUCART S.p.A (Porcari, Lucca, Italy), in that case with the plant located at Avigliano (Potenza, Italy). The scholarship was financed by “Regione Basilicata” and the working time was shared between the company and the University.

The goal of the thesis was the development of eco-sustainable methodologies for the production of innovative materials based on cellulose fibers.

As a matter of fact, the aim of the work was to produce cross-linked electrospun hybrid scaffolds composed of gelatin/poly(D,L-lactic) acid (PDLLA), gelatin/PDLLA/cellulose nanocrystals (CNCs), and gelatin/PDLLA/cellulose nanocrystals/elastin as wound dressing materials. Fourier transform infrared spectroscopy, X-ray diffraction, and high-performance liquid chromatography demonstrated the complete embedding of each component in the hybrid scaffolds. The degree of cross-linking was quantified by the 2,4,6-trinitrobenzenesulfonic acid assay, and attenuated total reflectance spectroscopy revealed the effectiveness of the cross-linking reaction. Notably, the interconnected porous structure revealed in un-cross-linked scaffolds persisted even after cross-linking. Scaffolds were characterized in water through their contact angle showing total wettability. We investigated their mechanical properties by uniaxial tensile testing, which showed that even in the dry state, nanocellulose- and elastin-containing scaffolds exhibit higher elongation at rupture compared to those with pure gelatin/PDLLA. Therefore, we succeeded in tuning the toughness of the scaffolds by modulating the composition. In order to use scaffolds as medical devices, we assayed fibroblasts on scaffold extraction media, indicating that they were noncytotoxic. Finally, the attachment and proliferation of fibroblasts on the surface of different scaffolds were evaluated.

During the six months spent at *Centre inter universitaire des matériaux* (CIRIMAT) of Université Paul Sabatier-Toulouse (France), electrospun scaffolds at different CNCs percentage (w/w) were produced and thermal stability, physical structure and their mechanical behavior were studied. The results suggested that the electrospun scaffolds are characterized by improved thermal and mechanical properties in comparison with bulk materials. We found that the scaffolds containing 3% (w/w) of CNCs showed best hydrophilic and thermo-mechanical properties.

The aim of the collaboration with Lucart SpA was the research of biopolymers and substances of natural origin suitable to be used in the airlaid process in the Avigliano Plant, as cross-linkers in

blends or in substitution of the standard vinyl binder. A laboratory-scale binder distribution simulation method was developed. First research efforts were directed to block the development of formaldehyde during the binder crosslinking reaction by adding urea to the standard binder dispersion. A clear decrease in the production of formaldehyde upon the addition of urea was observed. Therefore, an industrial trial was carried out. Although the results were not confirmed in the industrial test. The second path was to collaborate with the Company in the Research and Development of alternative sustainable binders, trying to substitute, partially or totally, the vinyl binder with substances of natural origin, without compromising the final product properties. A laboratory test was performed on an innovative XBS Binder, formaldehyde free, added with a polyamidoamine-epichlorohydrin based wet strength agent. The results were encouraging because the paper sample with only XBS Binder showed an important absorbency decrease due to a higher hydrophobicity of the polymer. The study of different poly(vinyl alcohol) dispersions grades was carried out through many laboratory tests. However, they demonstrated that, due to high viscosity values, the stand-alone PVA use is not possible. Finally, a biodegradable and compostable engineered polysaccharide was tested with the aim of increasing the final product compostability. The industrial trial was performed confirming the reduction of wet tensile anticipated by laboratory test.