CONDUCTIVE ELECTROSPUN SCAFFOLD FOR WOUND HEALING

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INTRODUCTION

Chronic wounds fail the normal healing process that restores tissue integrity after an injury and leads to a long-lasting inflammation [1]. In this field, three-dimensional (3D) biocompatible scaffolds represent the most outstanding innovations: they act as a physical support where cells can adhere, migrate, and proliferate [2]. To enhance the biological response, four-dimensional (4D) scaffolds, which are 3D platforms that react to external stimuli, have been proposed and in particular, electrical stimuli have attracted attention. Graphene is a conductive material that promotes the passage of the electrical current, and, upon electrical stimulation, it is reported as able to possess bioactive properties together with antibacterial features [3].

AIM

Given these premises, the aim of the present study is the design and the manufacturing of 4D scaffolds based on polycaprolactone (PCL) and collagen (COL) nanofibers, loaded with graphene (Gr), to promote skin wound healing.

METHODS

FIBERS PRODUCTION

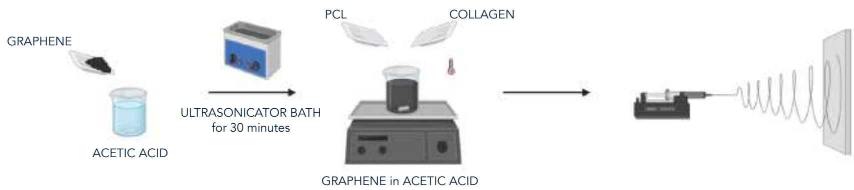

Table 1. Quali-quantitative composition of PCLCOL-Gr

Blend	COL:PCL	Graphene (%w/w)	Solvent
PCLCOL	1:10	0	Acetic acid
PCLCOL-Gr0.5		0.5	
PCLCOL-Gr1		1	
PCLCOL-Gr2		2	

FIBERS CHARACTERIZATION

- **Morphological and dimensional analysis** by means of scanning electron microscopy (**SEM**) on both dry and hydrated samples
- Atomic Force Microscopy (**AFM**) to investigate **scaffolds morphology and profilometry**
- Fourier transform infrared spectroscopy (**FTIR**) to assess **chemical surface characteristics**
- **Mechanical properties** by means of a **Texture Analyzer** on dry and hydrated samples
- Scaffolds **wettability** through **contact angle** evaluation
- **In-vitro cytotoxicity** using MTT assay on normal human dermal fibroblasts (NHDF) after 24 hours of contact with fibers extracts

RESULTS

MORPHOLOGY and DIMENSIONAL ANALYSIS

Fibers were characterized by smooth surface and regular dimensions of about 400 nm. The addition of the Gr to the composition did not cause a modification of the fibers dimensions (***Figure 2***). The presence of graphene into the fibers structure was confirmed by TEM analysis (***Figure 3***)

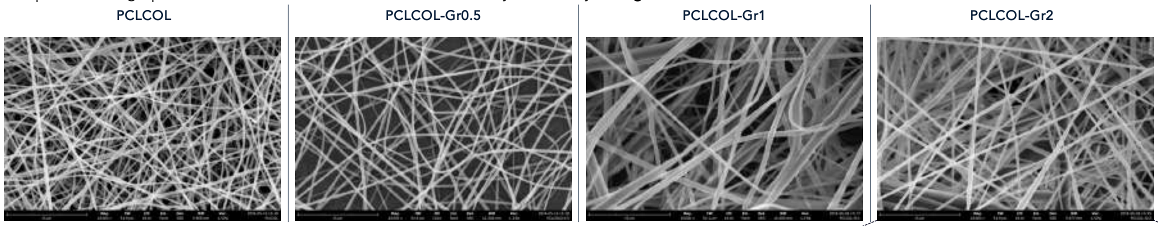

Figure 1. SEM micrographs of fibers at 10 kx ma g nifications (scale bar: 15 μm); dry and hydrated in deionized H_2O overnight samples

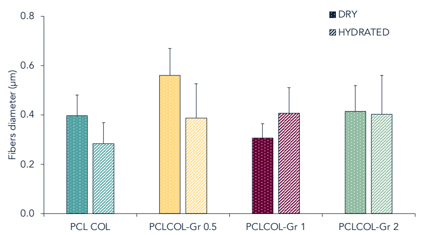

Figure 2. Comparison of fibers dimensions (right); dry and hydrated in deionized H_2O overnight samples

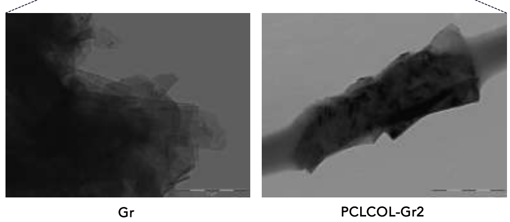

Figure 3. TEM micrographs of fibers

MECHANICAL PROPERTIES

Figure 4 shows the values of force at break point (Fmax) of PCLCOL-Gr nanofibers. The addition of Gr to the formulation induced a decrease in the values of force at break. On the contrary, the hydration process did not affect the scaffolds resistance.

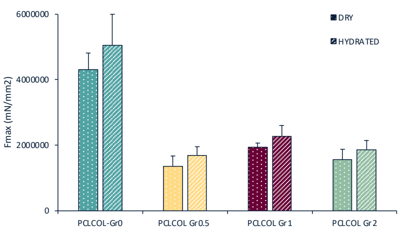

Figure 4. Values of maximum force (mN/mm^2) at break point; dry and overnight water hydrated scaffolds (mean values ± s.d.; n= 6)

FTIR

Figure 5 shows the FTIR spectra of PCLCOL and the scaffolds prepared with different Gr concentrations.

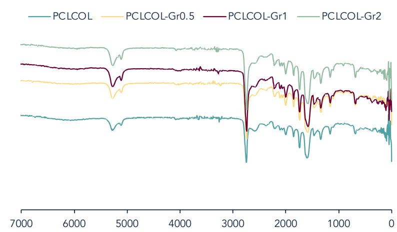

Figure 5. FTIR spectra of PCLCOL and PCLCOL-Gr

WETTABILITY

Figure 6 shows the contact angle values. A decrease in contact angles was observed overtime, especially for PCLCOL and PCLCOL-Gr0.5.

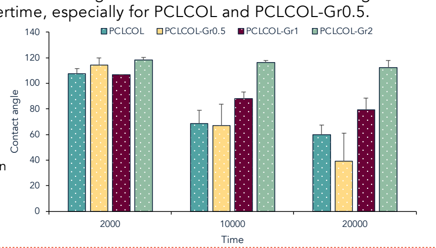

Figure 6. Comparison of wettability tests carried out in water and acquired over time on fibers (mean values ± s.d.; n=3)

IN-VITRO CYTOTOXICITY

The MTT assay performed on NHDF confirmed scaffolds biocompatibility even at higher concentrations. Moreover, nanofibers loaded with Gr were characterized by a higher biocompatibility than that of Gr as suspension which means the fibers were able to protect cells (***Figure 7***).

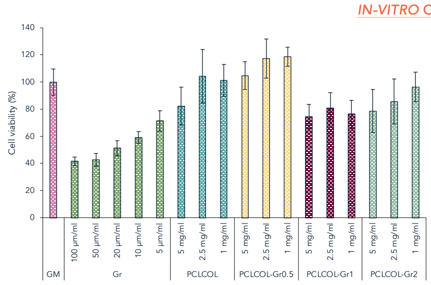

Figure 7. Viability of fibroblasts after 24 hours of contact with Gr as suspension and with PCLCOL-Gr0, PCL-COL-Gr0.5, PCLCOL-Gr1, PCLCOL-Gr2 in comparison with the positive control GM (growth medium, as standard growth conditions) (mean values ± s.d.; n=6)

CONCLUSION

In conclusion, the study allowed to successfully develop PCLCOL nanofibers doped with graphene via electrospinning. Preliminary evaluations on scaffolds electrical conductivity are on-going. Further studies assess *in-vitro* cell proliferation and adhesion with and without skin electrical stimulation.

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