Evolution of thermal properties and secondary structure of collagen with atmospheric plasma jet treatment

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Collagen type I is the most abundant extracellular matrix protein in the animal kingdom and it is widely used as a biomaterial for tissue regeneration and implantation [1]. To improve strength and durability, collagen may be cross-linked by chemical (glutaraldehyde) or physical methods (gamma rays, UV irradiation). Chemical cross-linkers are potentially cytotoxic and lead to calcification of fibers, decreasing the durability of the bioprostheses. UV treatments have been investigated to cross-link collagen although irradiation can cause both stabilization and destabilization of the collagen structure.
In this study, we have investigated the effects of non thermal atmospheric pressure plasmas as they are not yet used for the treatment of collagen fibers, but already successfully used in various other biomedical applications. We used a low temperature plasma jet generated in ambient air [2] and producing various active species (excited species, free radicals, charged particles and photons covering a large spectrum from UV up to visible) that are in contact with type I collagen fibers under both freeze-dried and hydrated states.
To quantify the effect of the plasma treatment on the thermal properties and secondary structure of type I collagen, samples have been characterized by Differential Scanning Calorimetry (DSC) and Fourier Transform Infra-Red (FTIR) Spectroscopy.

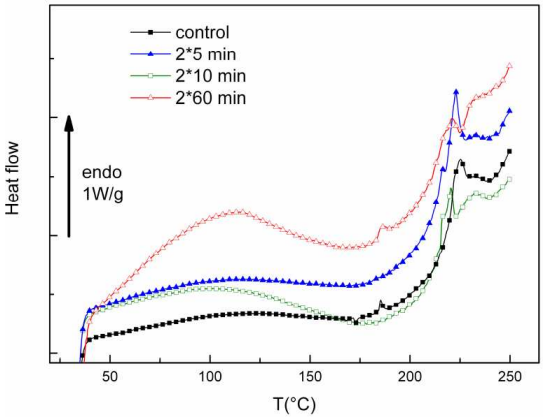

Figure 1 : *DSC first scan (20 °C/min) of freeze-dried collagens*

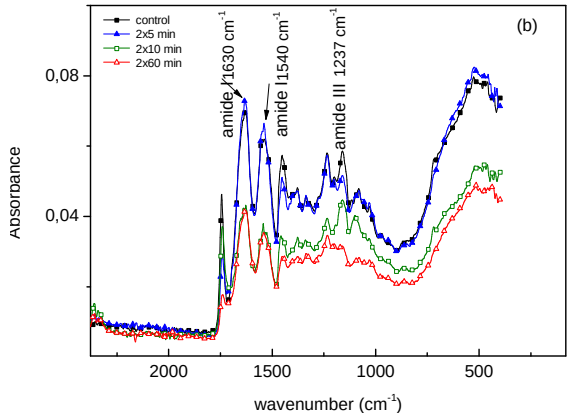

Figure 2 : *FTIR spectra of control and plasma treated collagen.*

Our studies show that the destabilization of the triple helical structure is the main event for the longest exposure times in the freeze-dried state. For hydrated samples, the cross-linking phenomenon becomes predominant for the longest exposure times. It is shown from FTIR analysis, slight modifications in absorption band synonymous of the preservation of the integrity of the triple helical structure of collagen[3].

[1] Bradshy B., Werkmeister J.A., Ramshaw J.A.M. Biopolymers (2003), 119-153, ed. A Steinbüchel, Weiley, Weinheim
[2] N. Merbahi, Yousfi M., Eichwald O., N° the patent: WO 2011/00170 A1, 6/01/2011
[3] Samouillan V.,Merbahi N., Delaunay F., Yousfi M., Dandurand J., Gardou J.P., Lacabanne C., IEEE Trans. Plasm. Sc. (2012)