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Photoactive type I (atelo) collagen as building block of advanced wound dressings

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The trends in diabetic occurrence and aging populations impose a heavy economic burden on healthcare providers worldwide [1]. Diabetic wounds suffer from delayed healing, and can soon become infected, chronic ulcers. If not treated timely, they can lead to gangrene, haemorrhage and lower-extremity amputations, potentially resulting in permanent disabilities and pain for patients. Advanced wound dressings have been commercialized to respond to the pressing needs of an increasing diabetic population. However, control of the wound microenvironment and matrix metalloproteinase (MMP) activity is still only partially accomplished, resulting in economically unaffordable healing times. Here, type I photoactive (atelo)collagen was synthesized and explored as a building block of factor-free advanced wound dressings with customisable macroscopic properties and integrated wound-regulating functionalities. Covalent functionalization of rat tail collagen with photoactive compounds, e.g. 4-vinylbenzyl chloride, was initially confirmed (by ^{1}H-NMR, TNBS colorimetric assay, and circular dichroism) to prompt the synthesis of UV-induced networks of collagen triple helices [2, 3]. The type and degree of collagen functionalization governed the structure-property relationships, whereby the averaged swelling ratios (*SR*: 707-1600 wt.%), bulk compressive (*Ec*: 15-129 kPa) and atomic force microscopy (AFM) elastic moduli (E_{AFM}: 16-387 kPa) could be adjusted [4]. Obtained network configurations proved key to control the activity of MMP-9 *in vitro*, with respect to a leading dressing product. This synthetic route was successfully transferred to minimally-antigenic, telopeptide-free type I collagen [5], resulting in comparable water-swollen atelocollagen networks. Preclinical investigations in a full-thickness wound model in diabetic mice proved the accelerated healing capability of this collagen system with respect to a commercial polyurethane dressing [6].

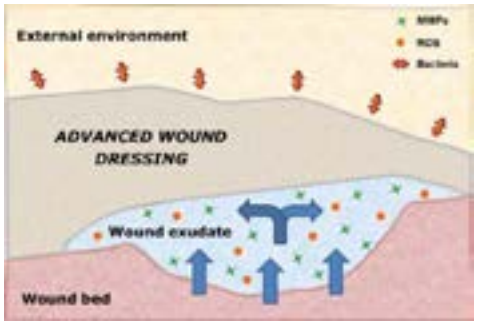

Figure 1: Design concept of an advanced wound dressing regulating wound exudate levels at the macroscopic scale, as well as pH and overexpressed MMPs and ROS at the biochemical level.

Recent publications

1. Vowden P, Vowden K (2016) The economic impact of hard-toheal wounds: promoting practice change to address passivity in wound management. Wounds International 7:10.
2. Tronci G, Russell SJ, Wood DJ (2013) Photo-active collagen systems with controlled triple helix architecture. Journal of Materials Chemistry B 1: 3705.
3. Holmes R, Yang X, Dunne A, Florea L, Wood D, wt al. (2017) Thiol-ene photo-click collagen-PEG hydrogels: impact of water-soluble photoinitiators on cell viability, gelation kinetics and rheological properties. Polymers 9 (6): 226.
4. Tronci G, Grant C A, Thomson N H, Russell S J and Wood D J (2015) Multi-scale mechanical characterization of highly swollen photo-activated collagen hydrogels. Journal of the Royal Society Interface 12:102.

5. Holmes R, Kirk S, Tronci G, Yang X, Wood D (2017) Influence of telopeptides on the structural and physical properties of polymeric and monomeric acid-soluble type I collagen. Materials Science and Engineering C 77: 823.
6. Tronci G, Yin J, Holmes R, Liang H, Russell S J, et al. (2016) Protease-sensitive atelocollagen hydrogels promote healing in a diabetic wound model. Journal of Materials Chemistry B 4:7249

Biography

Giuseppe Tronci is a Lecturer in Healthcare Materials at the University of Leeds with leading expertise in the chemistry of biopolymers, design of integrated biomimetic systems, and high-value manufacture of medical devices. He has established a bespoke platform for the fabrication of customised collagen materials with retained triple helix conformation and multiple integrated biofunctionalities. This work has led to the development of a University of Leeds patent-pending technology, whose applicability in wound healing has been successfully confirmed in diabetic mice.

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