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

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Abstract (300 word limit)

The trends in diabetic occurrence and aging populations impose a heavy economic burden on the NHS and healthcare providers worldwide. 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 commercialised 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 synthesised and explored as building block of factor-free advanced wound dressings with customisable format (e.g. wound-contacting film, photocurable liquid, fibrous structure) and integrated wound-regulating functionalities (e.g. exudate management capability, control of proteolytic activity and enhanced proteolytic stability) [1-3]. Covalent functionalisation 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. The type and degree of collagen functionalisation governed the structure-property relationships. An averaged swelling ratios (*SR*: 707–1996 wt.%), bulk compressive (E_c: 50–129 kPa) and atomic force microscopy (AFM) elastic moduli (E_{AFM}: 16–387 kPa), as well as the network-induced control of MMP-9, were readily adjusted and enhanced compared to a leading dressing product. This synthetic route was successfully transferred to minimally-antigenic, telopeptide-free type I collagen [4], 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.

Image

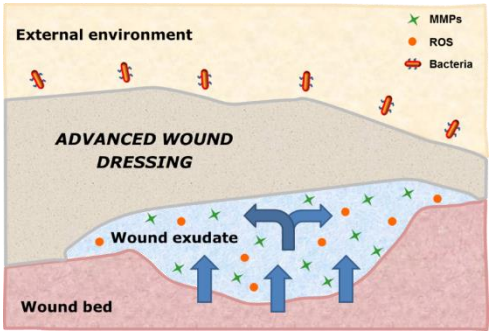


Figure 1. Design concept of an advanced wound dressing regulating wound exudate levels at the macroscopic scale, as well as pH and overexpressed MMPs and ROS at the biochemical level.

Recent Publications (minimum 5)

1. Tronci G, Grant CA, Thomson NH, Russell SJ, Wood DJ (2015) Multi-scale Mechanical Characterization of Highly Swollen Photo-activated Collagen Hydrogels. Journal of the Royal Society Interface 12:102.
2. Arafat MT, Tronci G, Yin J, Wood DJ, Russell SJ (2015) Biomimetic wet-stable fibres via wet spinning and diacid-based crosslinking of collagen triple helices. Polymer 77: 102.
3. Holmes R, Yang XB, Dunne A, Florea L, Wood DJ, Tronci G (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, Yin J, Holmes R, Liang H, Russell SJ, Wood DJ (2016) Protease-sensitive atelocollagen hydrogels promote healing in a diabetic wound model. Journal of Materials Chemistry B 4: 7249.



Biography (150 word limit)

Dr. Tronci is a Lecturer in Healthcare Materials with leading expertise in biopolymers chemistry, design of integrated biomimetic systems, in the form of e.g. water-swollen matrices and fibrous assemblies, and on-demand activation of antimicrobial devices. At Leeds, he has established a bespoke platform for the fabrication of customised collagen materials with retained triple helix conformation and tunable material format. 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 and will soon be evaluated in humans.

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Notes/Comments: The author gratefully acknowledges financial support from the Clothworkers' Centre for Textile Materials Innovation for Healthcare (CCTMIH), the EPSRC-University of Leeds Impact Acceleration Account (IAA), and the EPSRC Centre for Innovative Manufacturing in Medical Devices (MeDe Innovation Fresh Ideas Fund).