A Flexible Electronic/Smart Hydrogel Integrated System for Real-Time Infection Monitoring and Dynamic Treatment

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Statement of Purpose: Wound management is a major clinical challenge in healthcare area. For current wound care strategies, the ‘‘Black Box’’ state of wound caused by the coverage of dressings makes it difficult to know infection in time, which may miss the best time for treatment [1]. Therefore, the ability to detect pathogenic infection in early stage and give proper treatment is of great importance to wound healing process [2]. Here, we fabricated a flexible electronic/smart hydrogel integrated system (Figure 1). This system includes two layers: the upper layer is a flexible electronic device with a temperature sensor and four LED 365nm lights, and the lower layer is a UV-responsive antibacterial hydrogel-based dressing. As temperature is an obvious marker of wound infection and may be used as an early predictor of infection before any other obvious changes. Therefore, we used a real-time temperature sensor to monitor the wound temperature and then the UV-responsive antibacterial hydrogel can be used to controllably release antibiotic under UV irradiation when the temperature was abnormal.

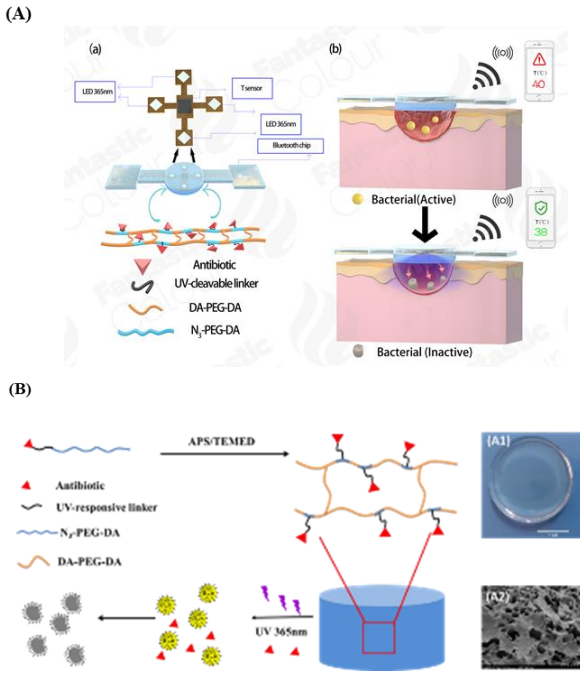

Figure 1 . Scheme of the integrated system (A) and UV-responsive antibacterial smart hydrogel (B).

Methods: The upper flexible electronic device layer containing temperature sensor and LED365nm lights were made on the PI substrate, then encapsulated by PDMS, the UV-responsive antibacterial dressing was then integrated with the upper layer. SEM was used to characterize the microstructure of dressing. Universal mechanical testing machine was used to analyze mechanical properties of the integrated system; UV responsive antibacterial effect was studied in vitro by plate counting and inhibition zone test; MTT was used to analyze the compatibility of system; HE and Gram stain were studied to assess antibacterial effects in vivo.

Results: In the UV-responsive antibacterial hydrogel, antibiotic was released by UV irradiation. The in vitro UV-responsive antibacterial results showed that bacterial viability decreased with the prolonged UV irradiation time, which meant more antibiotic was released from the hydrogel; Cell viability analysis showed the double layer smart dressing system had good compatibility; In vivo, miniature pig was injected MRSA to create a wound infection in the back of pig (Figure 2), the local wound temperature was monitored in real-time and displayed on the smart phone, anal temperature was used as a reference. From temperature data, the local wound temperature increased much higher and earlier than the anal temperature after injecting MASA, which can be used as an early predictor to warn infection. After UV irradiation for 20 min, the wound T decreased while anal T was still in a high level. The decrease of bacterial quantity in the results of HE and Gram stain also proved a good antibacterial effect.

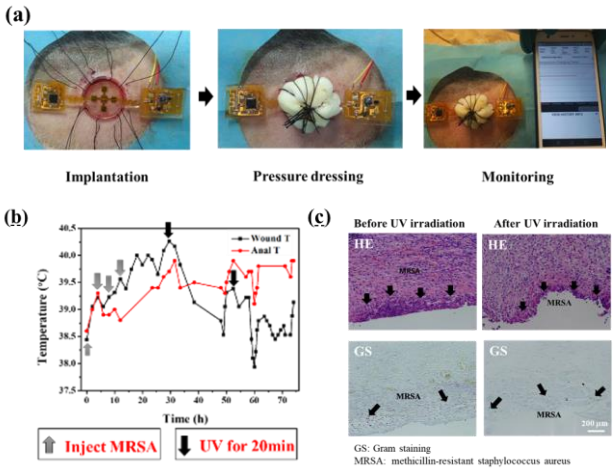

Figure 2. In vivo wound temperature monitoring (b) and biological analysis of bacterial quantity before and after UV treatment (c) (HE and Gram stain).

Conclusion: We successfully fabricated a smart dressing system, the temperature sensor has been proved to be an effective tool to detect and predict wound infection. And the release of antibiotic can be easily controlled by UV irradiation based on the need of wound. Moreover, this smart system showed good compatibility and holds a great promise in treating chronic and acute injuries.

References:

[1] B. Mirani, ADV HEALTHC MATER, 6 (2017) 1700718.

[2] Mostafalu P, Small, 2018: e1703509.