Multifunctional wound dressing for rapid hemostasis, bacterial infection monitoring and photodynamic antibacterial therapy

Hao Yanga, Yuehui Lianga, Jing Wanga, Qingyun Li , Qunliang Li , Aixing Tanga,
Youyan Liua, Hai-Bo Liu
Acta Biomaterialia 135 (2021) 179–190

Speaker : Shih Han Tang, Advisor : Cheng-I Lee, Date : 2022/11/04

1、 簡述論文的概要與重大發現

傷口管理是一個重大的全球性問題，因抗生素的抗藥性問題嚴重，開發更有效的止血敷料以控制出血和預防病原體感染的挑戰越來越大。在這項實驗中，作者們開發了一種多功能傷口敷料，能夠快速止血、細菌感染監測和光動力抗菌治療。光動力療法（PDT）是依靠光敏劑產生的單支態氧進行滅菌，無耐藥性、低毒、幾乎無副作用。止血層具有較大的表面積和對出血部位血小板的吸附孔徑，可快速止血。同時，檢測層可以監測細菌感染情況，並通過發射螢光響應反映細菌感染情況。發生感染時，可採用傷口敷料進行光動力抗菌治療。體外和體內實驗結果表明，該傷口敷料能有效殺滅病原菌，具有良好的生物相容性，且不會引起發炎反應。這種傷口敷料有望防止大量出血並降低致病菌相關感染的風險，並進一步促進傷口癒合。

2、 對論文內容的疑問

在 Fig.6B 中，在圖像顯示中比較像是紅血球吸附到 PSGC 上，但作者卻解釋是血小板吸附到上面?

3、 論文的缺點與評論

作者們經過本實驗提出了多功能傷口敷料，能在傷口還沒感染或感染後利用 PDT 都能進行傷口修復，而且還是一種具有生物相容性的多功能醫用材料，在未來有望應用於醫藥保健領域。

Acta Biomaterialia 135 (2021) 179–190

Contents lists available at ScienceDirect

Acta Biomaterialia

journal homepage: www.elsevier.com/locate/actbio

Full length article

Multifunctional wound dressing for rapid hemostasis, bacterial infection monitoring and photodynamic antibacterial therapy

Hao Yang[a], Yuehui Liang[a], Jing Wang[a], Qingyun Li[a,b], Qunliang Li[a,b], Aixing Tang[a,b], Youyan Liu[a,b], Hai-Bo Liu[a,b,*]

[a] School of Chemistry and Chemical Engineering, Guangxi University, Nanning, Guangxi Province, 530004, China
[b] Key Laboratory of Guangxi Biorefinery, Guangxi University, Nanning, Guangxi Province, 530004, China

ARTICLE INFO

Article history:
Received 10 February 2021
Revised 23 August 2021
Accepted 24 August 2021
Available online 29 August 2021

Keywords:
Rapid hemostasis
Bacterial infection
Photodynamic antibacterial therapy
Wound healing
Biocompatibility

ABSTRACT

Wound management is a major global issue, and there is a growing challenge to develop more effective hemostatic dressings to control bleeding and prevent pathogen infections. In this study, a multifunctional wound dressing was developed to meet the clinical need. The hemostatic layer of wound dressing can quickly stop the bleeding. Meanwhile, the detection layer is used for real-time fluorescence monitoring of the bacterial colonization. When infection occurs, wound dressing is further subjected to illumination for in-situ photodynamic antibacterial treatment. In the rabbit ear artery hemostasis model, the hemostasis time of the wound dressing was 1 s. The detection limit of the wound dressing was 1.4×10^5 CFU/cm^2 for *Escherichia coli*, 5.9×10^5 CFU/cm^2 for *Staphylococcus aureus*, and 3.8×10^6 CFU/cm^2 for *Pseudomonas aeruginosa*, respectively. Compared with the control group, an enhanced wound closure (up to 97.3%) were observed in mice treated with the wound dressing. *In vitro* and *in vivo* experiment results suggested that the wound dressing was effective in killing pathogenic bacterial and exhibited good biological compatibility, and induced no inflammatory reaction. The proposed design prevents massive bleeding and wound infection, and further promotes wound healing.

Statement of significance

In this work, we developed a multifunctional wound dressing, capable of rapid hemostasis, colorimetric monitoring of bacterial infection, and *in situ* photodynamic antibacterial. The hemostatic layer can quickly stop the bleeding due to its large specific surface area and adsorption pore size for platelet at bleeding site. Meanwhile, the detection layer can intelligently monitor the bacterial infection and respond to report bacterial infection by emitting fluorescence. When infection occurs, wound dressing can be used for in-situ photodynamic antibacterial treatment. *In vitro* and *in vivo* results showed that the wound dressing was biocompatible, prevented massive bleeding and wound infection, and further promoted wound healing.

1. Introduction

Uncontrolled hemorrhage is the main cause of death following severe trauma [1–3], and severe trauma is susceptible to infection, which can impair the natural healing process and cause complications [4,5]. Although many materials are currently used in wound healing [6–9], there is still a lack of ideal multifunctional materials to control bleeding and prevent bacterial infection simultaneously. Hence, there remains a need to develop more effective multifunctional materials to meet the intended applications [10].

Previous studies have reported several advanced hemostatic materials [11,12], among which biocompatible materials are attracting more and more attention in wound hemostatic therapy [13–15], such as starch, tannic acid (TA), and polyethylene glycol (PEG). Starch is a polysaccharide used in the treatment of wound bleeding due to its biocompatibility and biodegradability [16–18]. TA is a natural metabolite with anti-inflammatory, anti-microbial and antioxidant activities and it has been widely used [19–22]. PEG has been extensively used in many fields [23–25], especially in the medical field [26, 27], where it is used in wound healing materials and tissue engineering scaffolds [28–32]. In this work, PSGC is used

* Corresponding author.
E-mail address: lwllhb@gxu.edu.cn (H.-B. Liu).

https://doi.org/10.1016/j.actbio.2021.08.037