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News and Views

Photoresponsive hydrogel dressings for controlled drug release in wounds

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ABSTRACT

This work presents the design and development of photoresponsive hydrogels for controlled drug release in wound management. The fabrication of photoresponsive hydrogels incorporate photothermal-responsive ingredients which can facilitate the precise, stimuli-on-demand, and NIR-activated release of therapeutic formulations consisting of anti-inflammatory and anti-infective drugs. The localized heating of the hydrogels caused by the NIR irradiation will increase the diffusion of the therapeutic agents; address inflammation, infection, and tissue regeneration; and accomplish more effective wound management with self-regulatory behavior. Overall, these multifunctional hydrogel dressings deliver spatiotemporally controlled therapeutics, represent a promising alternative therapy to medically treat chronic wounds and infected wounds through minimally invasive on-demand therapy.

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Photoresponsive hydrogel dressings represent a promising alternative to controlled drug delivery in wound healing [1, 2]. The application of photothermal agents can provide stimuli-responsive properties via external light, particularly near-infrared (NIR) light to provide spatiotemporally controlled drug release at the wound application site. A typical photoresponsive hydrogel is comprised of photo-responsive compounds such as polydopamine (PDA), sodium alginate (SA), black phosphorus quantum dots (BPQDs), or reduced graphene oxide (rGO) which shares notable thermal properties including notable NIR light absorption and conversion into localized heat. The localized heating will trigger the release of drug formulations to soften and/or swell the hydrogel matrix, improve adhesion, and enhance antioxidant properties within the dressing. For example, PDA/SA hydrogels have shown prolonged drug release, radical scavenging, and application and removal can be performed as a dressing and is a key feature [3]. These hydrogels allow for a controllable release of bioactive agents such as anti-inflammatory drugs (e.g., ibuprofen), growth factors, and antibiotics [4]. The kinetics of the drug release can be controlled by light intensity and exposure time, allowing for on-demand dosing for each stage of healing wound. Some patches also can have a proof of concept for color changes that are indicative of structural changes for real-time release monitoring [5].

Recently we have been able to include visible photothermal responsive microspheres of methacrylated hyaluronic acid, silk-fibroin, and BPQDs [6]. After NIR irradiation the microspheres change stiffness to further promote adhesion to skin, and to trigger the release of co-loaded therapeutics, such as melittin and vascular endothelial growth factor (VEGF). This multifunctionality allows for wound healing in one device by treating infection and promoting tissue regeneration. Additionally, many of these photo-responsive hydrogels have self-healing, biocompatibility, and reversible sol-gel responses, which enable painless device removal without damaging any newly formed tissue. Also, their antioxidant and anti-inflammatory effects further takes away oxidative stress and localized inflammatory response, which is especially and extremely beneficial in chronic wounds like diabetic ulcers [7-9].

Some photoresponsive hydrogels have shown acceleration in the healing process via the promotion of collagen deposition, angiogenesis, and tissue remodeling [10-13]. In summary, these hydrogels could combine the photothermal-responsive release of drugs, photothermal antibacterial abilities, and regenerative support in one system [14, 15]. Their minimally invasive, tunable, and multifunctional design makes them well suited for treating both acute and chronic wounds, which offers effective, customized treatments.

Author Contributions

Naimeh Mahheidari: Conceptualization, Writing – original draft, Writing – review & editing. The author read and approved the final version of manuscript.

Declaration of competing interest

The author declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data Availability

No data is available.

Ethical issues

The author confirms full adherence to all ethical guidelines, including the prevention of plagiarism, data fabrication, and double publication.

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