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Preparation of Dissolving Microneedle with a Backing Layer of Electrospun Nanofibers for Accelerating Wound Healing

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ABSTRACT

Introduction: Wound healing is a complicated physiological process requiring an appropriate environment to encourage healing. Herein, we develop a novel dissolving microneedle (MN) patch with an electrospun nanofiber backing layer to perform transdermal delivery and combination therapy for wound healing. A nanofibrous scaffold with poly (vinyl alcohol) and gelatin loaded with taurine and Bi2S3 nanoparticles was prepared using the electrospinning method, PGTBi. The needle of the MN, called PHA, was composed of poly methyl vinyl ether-alt-maleic acid, hyaluronic acid, and allantoin.

Methods and Materials: The PGTBi-PHA MN patches were fabricated via a molding method in a two-step casting process. All characterization assays, including size and photothermal performance of the Bi2S3 nanoparticles, morphology and mechanical properties of the fibers, and ex vivo and in vitro, insertion of the needle in the skin and parafilm, were performed to ensure the fabricated device meets desirable properties for effective wound healing.

Results: TEM image, zeta potential, and elemental analysis indicated successful synthesis of Bi2S3 NPs. The temperature of Bi2S3 NPs increased by about 50.4 °C at a concentration of 200 µg/mL after irradiation for 10 min, which is the temperature required to kill bacteria, indicating the excellent photothermal performance of Bi2S3 NPs. Investigation of tensile tests showed that Young's modulus of the nanofiber mats was 168.4 MPa, which was in the skin range. Parafilm and skin insertion tests show that the PGTBi-PHA MN patches have sufficient strength to penetrate the skin and release their contents after dissolution.

Conclusion and Discussion: In this study, an electrospun patch with photothermal properties was successfully incorporated into the backing layer of MNs for wound healing application. This technology can combine different therapeutic modalities to enhance the overall healing process of wounds on the skin.

Keywords: Nanofibers, Tissue engineering, Wound healing