A Novel Bioinspired Skin Substitute for Accelerated Wound Healing

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Acute, chronic, and surgical wounds affect millions of people with unmet critical needs. There is no effective way to stop traumatic wound bleeding and suturing involves a risk of infection. The current study led to the development of a skin substitute capable of sealing traumatic wounds, closing wounds like sutures, and adhering strongly to skin with skin-like elasticity. Nanoparticle-enforced dual-network hydrogels were synthesized by mixing alginate, n-isopropyl acrylamide (NIPAm), and cellulose nanocrystal (CNC) solutions with reagents. An isolation layer was made using spin-coated silicone, while an adhesive layer was synthesized using chitosan and coupling reagents. Gels were characterized using methods including uniaxial tensile testing, optical imaging, and cytotoxicity tests. A porcine skin wound model was created to demonstrate performance. The skin substitute displayed a Young's Modulus of 1.38 MPa and can be stretched to 280% of its original length. Strong adhesion withstanding > 23 N/m was observed. The dual-polymer network exhibited drastic mechanical contraction when warmed from room to skin temperature (~ 50% area reduction). When tested on simulated wounds on porcine skin, 30% wound contraction was observed. The skin substitute was able to stop bleeding even under pressure as high as the systolic pressure (16 kPa or 120 mmHg), which is seen in severe traumatic wounds such as gunshots. Ultimately, the skin substitute displayed skin-like elasticity, high-pressure-proof adhesion to stop bleeding, and drastic contraction to accelerate wound healing. Further improvements may include the addition of photo-responsive contraction, controlled release of antibiotics and growth factors, and adaptation to 3D printing.