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# Preparation of Nanocellulose-Based Biomaterials for Biomedical Applications

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## Extended Abstract

Sustainable and eco-friendly biomaterials based on natural sources have increased dramatically, due to their recyclability, biodegradability, and biocompatibility. Cellulose is one of the most abundant natural biopolymers that can be produced from plants and microorganisms [1]. Nanofibrillated cellulose (nanocellulose, NFC), the extracted form of the native cellulose, is composed of nanoscaled fibrils with a few micrometers in length and less than 100 nm in diameter [2]. Owing to its biodegradability, biocompatibility, unique chemical binding capacity, and superior mechanical properties, NFC has attracted significant interest as an excellent alternative to petroleum-based polymer material for biomedical applications. In the current studies, we report the preparation of a biocompatible NFC-based surgery thread for dermal wound drug delivery application and the development of a low-cost and fully recyclable biocomposite for 3-D bioprinting manufacture, respectively.

We prepared NFC surgery thread (nanothread) by extruding TEMPO-NFC (treated by 2,2,6,6-tetramethylpiperidine-1-oxyl radical) hydrogel in an ethanol bath, followed by an air-drying process. Scanning electron microscopy (SEM) image showed that the as-fabricated nanothread has a mean diameter of ~120 μm and consists of well-aligned nanofibrils. The tensile strength test demonstrates the superior mechanical performance of the nanothread with a strength of 331 MPa and Young's modulus of 13.52 GPa, respectively. Due to its good water absorption capability, nanothread can absorb the physiological fluid and re-swell slowly. The capability to re-swelling provides an opportunity to release pre-loaded medicines in the nanothread, which can promote wound healing and prevent bacterial infection. We further incorporated fluorescent dye rhodamine 6G (R6G) to monitor the releasing profile. Our preliminary results showed that a non-linear releasing profile and the release of R6G can last for one week. The nanothread was loaded with gentamicin that showed very good antibacterial properties. Our previous studies showed that NFC based devices have good biocompatibility [3]. We anticipate that the cell culture study will prove that the NFC thread can sustain cell growth as well and that the drug-loaded nanothread can be an effective strategy to promote skin wound healing.

The abundant carboxylic groups and hydroxyl groups of the TEMPO-NFC nanofibril offer unique binding capacity with polysaccharides, proteins, surfactants, and plasticizers, which make the TEMPO-NFC an ideal adhesive material for 3-D bioprinting application [4]. We are able to produce a novel low-cost, biodegradable and recyclable 3-D printing biocomposite that consists of NFC and brewer's spent grain (BSG). BSG is the major by-product waste from the brewing industry, consisting of 30% of non-cellulose polysaccharides [5]. In a typical process, we blended NFC hydrogel with fine-grinded BSG particles. Our preliminary results show that the biocomposite is a sticky gel-like material and can further be stabilized by using glutaraldehyde, the rheology of which can be affected by BSG particle size and NFC ratio. A thermal stability test and tensile test will be conducted to evaluate the rheology and mechanical resistance. 3-D printing of prototypes were demonstrated, including as an intelligent packaging indicator. We anticipate the biocomposite will be a low-cost, recyclable, and sustainable material that can be used for 3-D bioprinting manufacture.

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