Electrodeposition of nanocellulose for multiscale structuring

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Abstract

The orientation and multiscale structuring of nanoscale component is an important technology for achieving sophisticated functional materials. Herein, a simple and flexible technique for multiscale of nanocellulose by electrodeposition is reported. Cellulose nanofibers (CNFs) are deposited on an anode in a CNF/water dispersion and seamlessly oriented from horizontal to vertical relatively to the electrode by changing the applied voltage between the electrodes. The oriented CNF hydrogels exhibit anisotropic mechanical properties, and it is possible to form complex orientations and hierarchical structures in response to electrode shape and applied voltage. This technique is expected to be applicable to various materials and contribute to a wide range of fields that include biomimicry, functional nanomaterials, and sustainable and functional moldings.

Background & Results

Orientation and hierarchical structure control techniques for nanomaterials have been attracted considerable research interest with the aim of achieving particular functions, such as those of biological tissue. However, it is still difficult to simultaneously achieve multiaxial orientation control, multiscale structuring, and molding using a simple process. In this study, a simple electrophoretic and electrochemical deposition method was developed for controlling and fixing CNF orientation, and its potential applications were investigated. CNFs were fixed in horizontal, random, and vertical orientations with respect to the anode surface by changing the applied voltage. Hierarchical structures, comprising CNFs with different layer-by-layer orientations, were formed in one-pot processes, forming complex structures.

Significance of the research and Future perspective

The technique is simple and flexible and it can be applied to various applications such as patterning, biomimicry, and CNF molding. However, further research on the orientation mechanism is required. Clarifying the mechanism responsible for electrophoretic- and electrochemical-deposition-induced orientational control and additional optimization is expected to assist in the development of nanomaterial composites that mimic biological tissue and the design of highly functional materials.

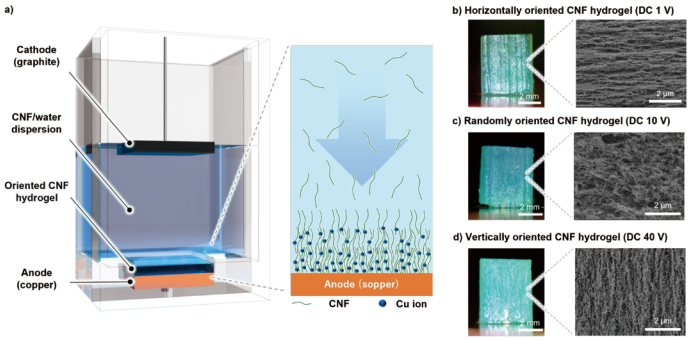

Figure 1

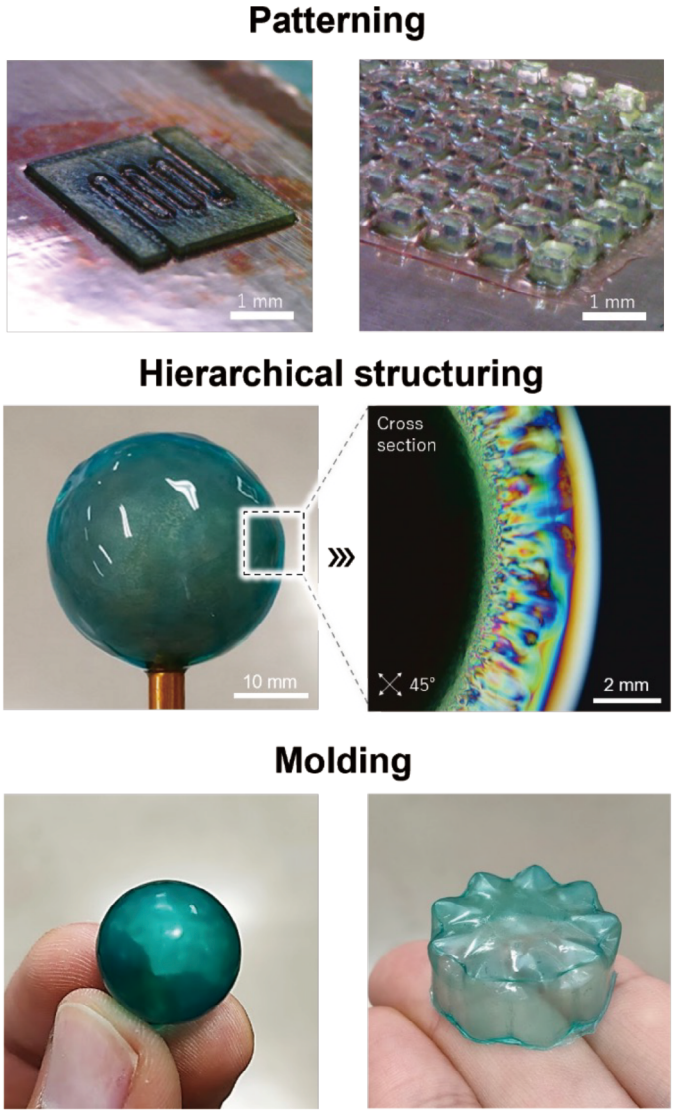

Figure 2

Patent Japanese Unexamined Patent Publication No.2021-195443, Japanese Patent Application No. 2021-154644, 2022-073615

Treatise Kasuga, Takaaki et al. One-pot hierarchical structuring of nanocellulose by electrophoretic deposition. ACS Nano. 2023, 16 (11), 18390-18397. doi: 10.1021/acsnano.2c06392

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Keyword nanocellulose, orientation control, biomimetics