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Strong, Lightweight and Shape-memory Bamboo-derived All-cellulose Aerogel for Versatile Scaffolds

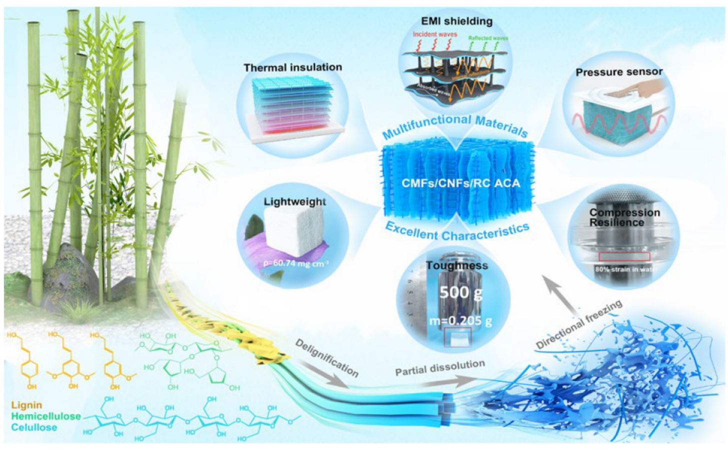
Hongping Dong, Xiazhen Li, Song Wei, Xianjun Li*, Yiqiang Wu*
Central South University of Forestry and Technology, Changsha, Hunan (P. R. China)

INTRODUCTION

Strong, lightweight, and shape-memory cellulose aerogels have great potential in multifunctional applications. However, achieving the integration of these features into a cellulose aerogel without harsh chemical modifications and the addition of mechanical enhancers remains challenging.

ABSTRACT

Graphical abstract



A strong, lightweight, and water-stimulated shape-memory all-cellulose aerogel (ACA) is created by methods of partial dissolution and unidirectional freezing from bamboo for multifunctional material applications.

METHOD

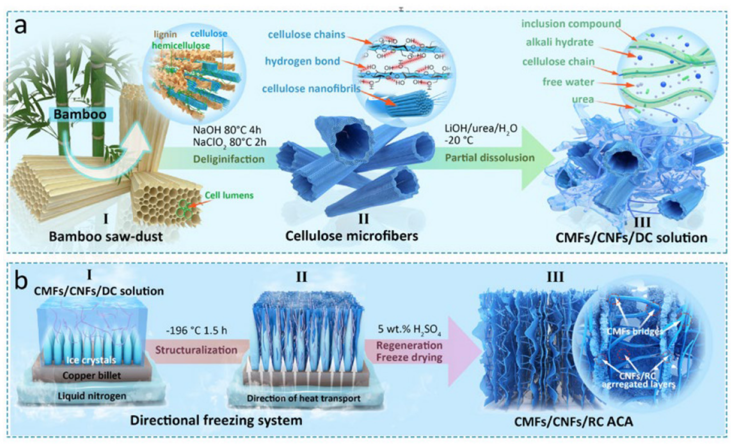


Fig. 1 Schematic illustration of fabricating ACA by partially dissolution(a) and unidirectional freezing(b).

CMFs were fabricated by delignification of bamboo sawdust with NaOH and $NaClO_2$ solution. Then CMFs were rapidly and partially dissolved in urine-alkali solution to obtain CMFs/CNFs/DC. Finaly, the CMFs/CNFs/RC ACAs were obtained by unidirectional freezing and regeneration processes.

RESULTS AND DISCUSSION

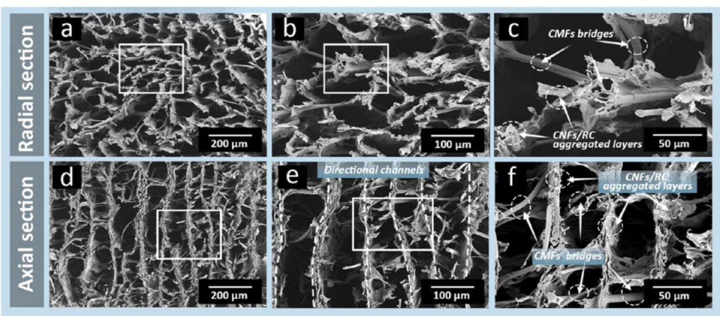


Fig. 2 SEM images of ACA on radial (a-c) and (d-f) axial sections.

ACA, composed of various phases and scales of cellulose, has a unique hierarchical anisotropic structure, in which CNFs/RC aggregated layers anchor mutually perpendicular CMFs bridges to form a firmly interconnected porous framework.

RESULTS AND DISCUSSION

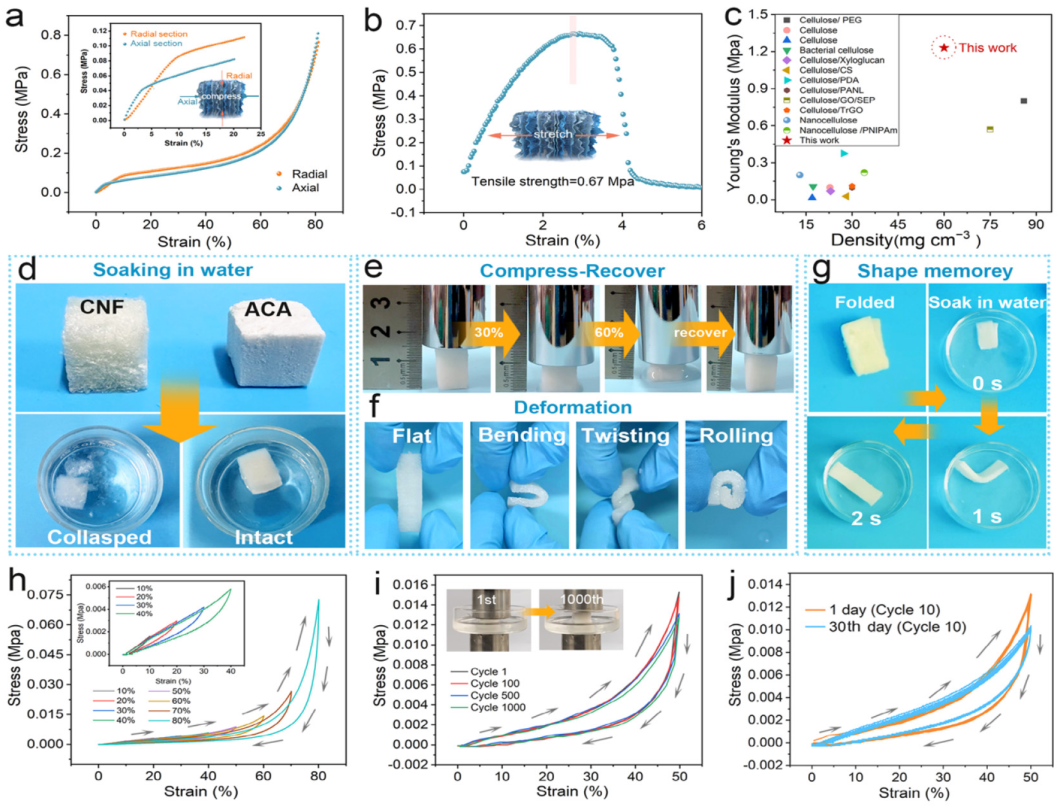


Fig. 4 Mechanical properties of ACA in dry state (a-c) and soaked in water (d-j).

ACA with a low density (60.7 mg/cm^3) exhibits high compressive modulus of 1.23 and 0.96 MPa in radial and axial section, respectively, and a high tensile strength of 0.67 Mpa. Moreover, ACA features excellent water adaptability, including high compressibility (80% strain) and fatigue resistance (1000 cycles compression), various elastic deformations, and shape-memory property.

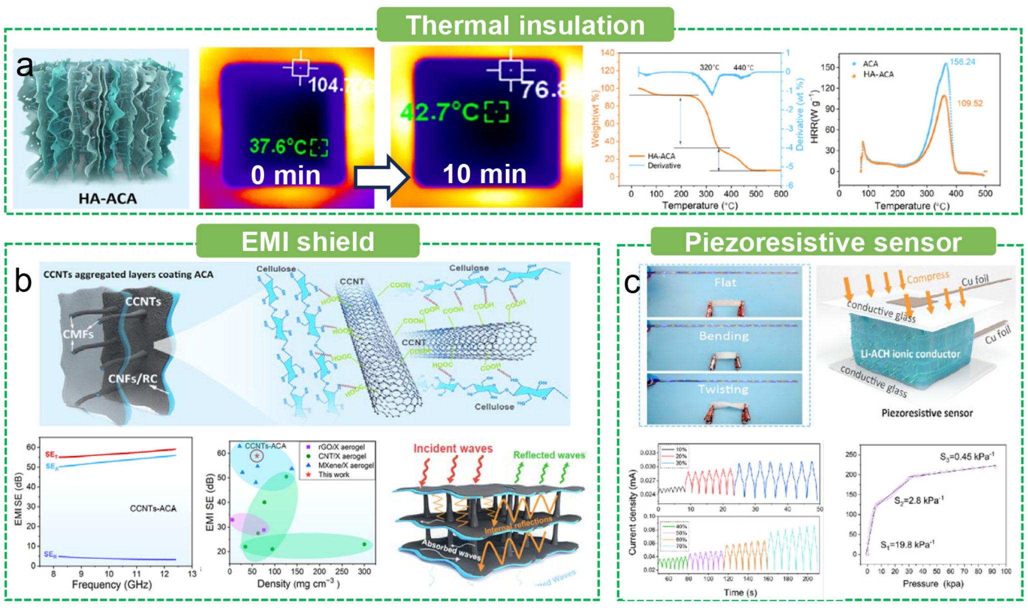


Fig. 5 ACA-based thermal insulation (a), EIM shield (b) and piezoresistive sensing (c) materials and their performances.

The ACA with fine micro/nanostructure and superb mechanical properties can be used as the versatile substrate to integrate hydroxyapatites, CNTs and metal ions to develop high-performance thermal insulation, EIM shield and piezoresistive sensing materials.

CONCLUSIONS

- A novel ACA was created using a combination strategy of partial dissolution and unidirectional freezing from bamboo.
- The ACA features integrated merits of lightweight, high compressive/tensile modulus, excellent water adaptability, and full biodegradability.
- The ACA is a low-cost and sustainable versatile scaffold for developing multifunctional materials in various applications.