



LIVING LAYERS

Designing Modular E-Skin with Bacterial Cellulose

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E-Skin with Bacterial Cellulose

We introduce a multi-layered, biodegradable electronic skin (e-skin) using bacterial cellulose. This modular and repairable system draws inspiration from human skin, offering a scalable approach to sensor integration. Our design advances sustainable solutions in Human-Computer Interaction, robotics, and smart materials.

Material & Design

Our e-skin mimics human skin using bacterial cellulose biofilms, which replicate the epidermis, dermis, and subcutaneous layers. Bacterial cellulose is a natural polymer produced through microbial fermentation. It is flexible, mechanically robust, and self-adhesive, allowing sensors to be added or replaced without any extra adhesives. The material is fully biodegradable, and the electronic components can be removed, repaired, and reused. The e-skin integrates touch, temperature, and humidity sensors within its structure.

Fabrication

Our e-skin is assembled using a bottom-up layering approach, where wet bacterial cellulose biofilms self-adhere without adhesives. Sensors are embedded between these layers: conductive yarn for touch sensing, copper wires for temperature detection, and aluminum electrodes for humidity measurement. Two workflows enable customization: (1) sequential layering, where each sensor is added individually and dried before the next, or (2) simultaneous stacking, embedding multiple sensors at once for faster fabrication. Damaged layers can be rehydrated and replaced, ensuring easy repairs and modularity.

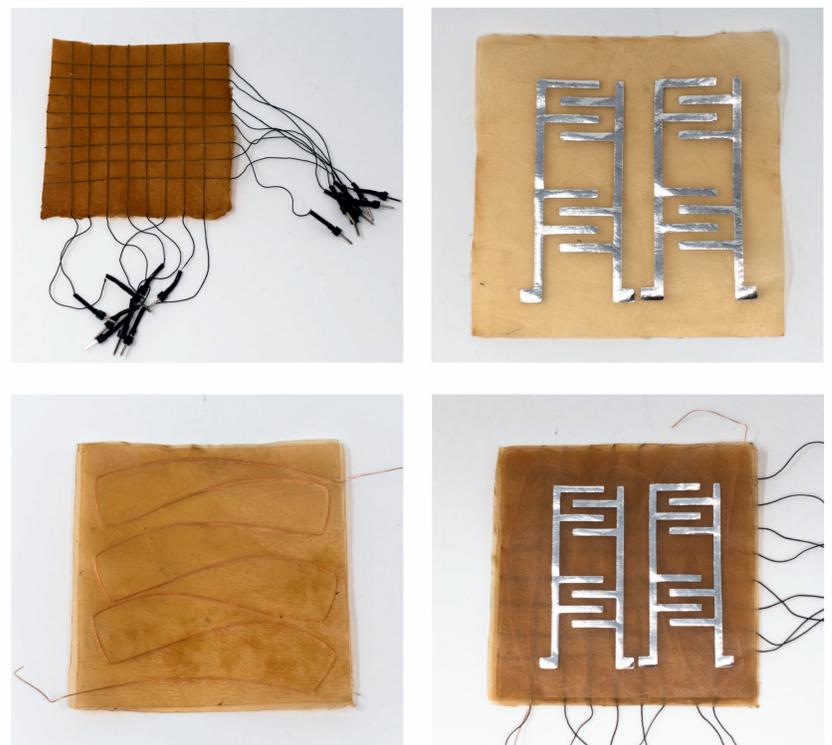
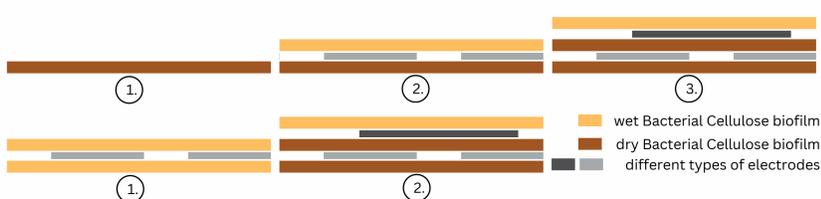


Figure: Individual layers and a three layer prototype.

Use Cases

Imagine buildings that sense and respond to their surroundings—e-skin could enable adaptive architecture, with bacterial cellulose membranes reacting to temperature and humidity. In animatronics, it creates lifelike, touch-sensitive surfaces for enhanced human interaction, adapting to environmental conditions and user input, blending technology with organic materials.



Takeaway

Our e-skin reduces e-waste with its biodegradable design, offering a sustainable alternative for soft electronics. However, its susceptibility to drying, molding, and limited stretchability poses challenges for long-term durability, leaving room for further exploration into enhancing its stability and adaptability. Additionally, maintaining its mechanical integrity requires regular hydration or protective treatments, adding complexity to its upkeep. The material's low elongation at break also limits its application in highly dynamic environments, necessitating further advancements to improve its flexibility.