BIO-INSPIRED MATERIALS
NATIONAL CENTER OF COMPETENCE IN RESEARCH

Bioinspiration - wenn die Natur die Forschung inspiriert

Dr. Eliav Haskal
Innovation Manager, NCCR Bio-Inspired Materials
Université de Fribourg / Universität Freiburg

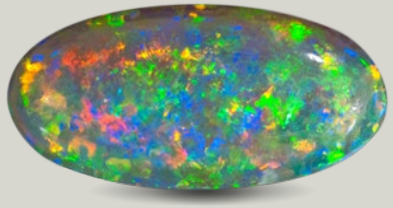
Swiss National Science Foundation

Bio-Inspiration: Learning from Nature

Bio-inspiration is the systematic study of nature's structures, designs, processes, and functions, to design innovative materials and develop breakthrough technologies.

Unlike direct biomimicry, bio-inspiration strategically adapts nature's underlying principles to solve complex human engineering challenges.

Nature’s 3.8 billion years of evolutionary optimization holds the blueprint for revolutionary materials that could transform technology, medicine, and sustainability.



The Value of Bio-Inspired Design

Efficiency: Biological systems are optimized for performance.

Innovation: Nature offers unique mechanisms not yet or fully explored in engineering.

Sustainability: Nature-inspired designs could reduce environmental impact.

Cheese Marks and the Problem for Swiss Cheese Makers

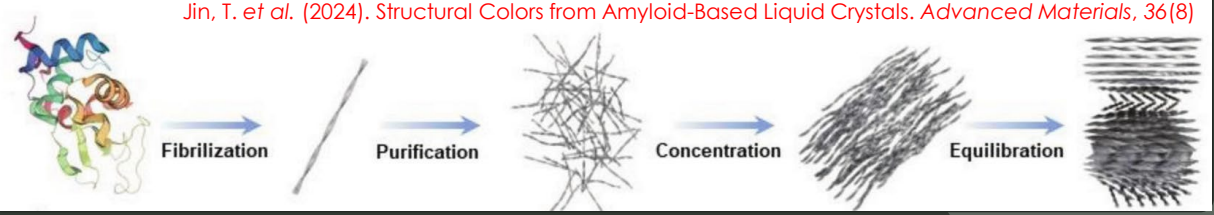
Definition

1. Casein-based disc
2. ID card of a cheese
   a. Dairy
   b. Storage location

Technology

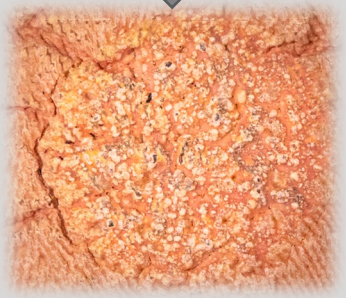
Crystalline, asymmetric amyloids are extracted from waste whey, and subsequently aligned to create an optical effect, similar to liquid crystal technology

Jin, T. *et al.* (2024). Structural Colors from Amyloid-Based Liquid Crystals. *Advanced Materials*, 36(8)



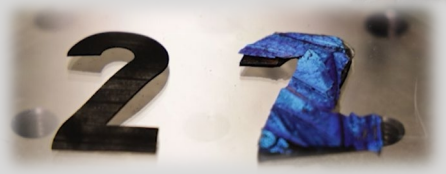
The Problems

1. Monopoly of cheese mark producer outside Switzerland
2. Food fraud of Gruyère cheese
3. Fading colors in cheese marks



Project Goals

1. Swiss whey-based cheese marks in white and black
2. Holographic, butterfly-inspired structures to create a security label



adolphe merkle institute
excellence in pure and applied nanoscience

Praveen Kumar, Viola Vogler-Neuling, Raffaele Mezzenga, Ullrich Steiner
and Interprofession du Gruyère

LE GRUYÈRE® SWITZERLAND AOP

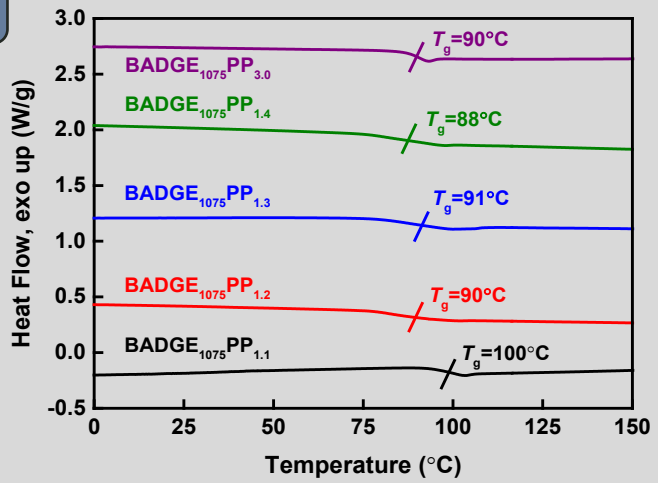
Debondable-on-Demand Epoxy as a Shellac Mimic

Shellac

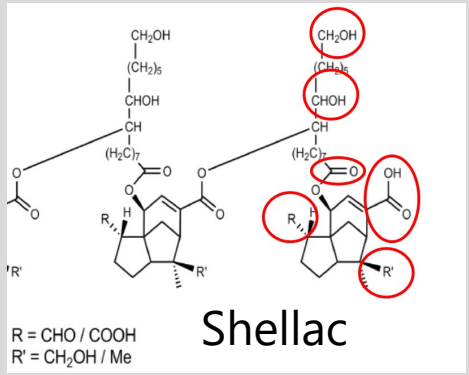
Shellac is a resin secreted by the female lac bug on trees in the forests of India and Thailand.

Debondable/Mendable

Flows at ~100C, and rebonds at original strength

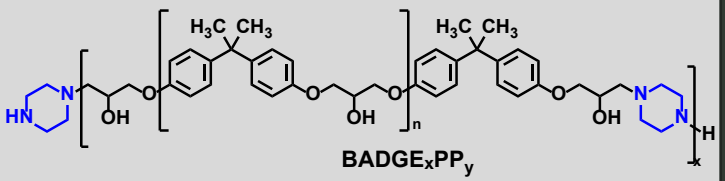


Modified Epoxy



Shellac

One-step, modified linear epoxy from two commercial products, DoD



BADGE$_x$PP$_y$

Results

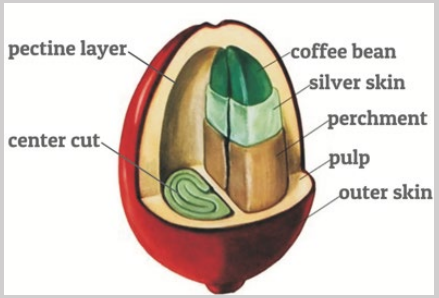
1cm2 lap joint

adolphe merkle institute
excellence in pure and applied nanoscience

Skandalis, Ayer, Weder *ACS Macro Letters* **2025**, *14*, 420. Patent application filed.

Valorization of coffee waste into functional materials for food packaging

Objective



Extraction of lignin and pectin from spent ground coffee and coffee husks to develop new coatings for packaging industry

Research Team

Dr. Manon Guivier

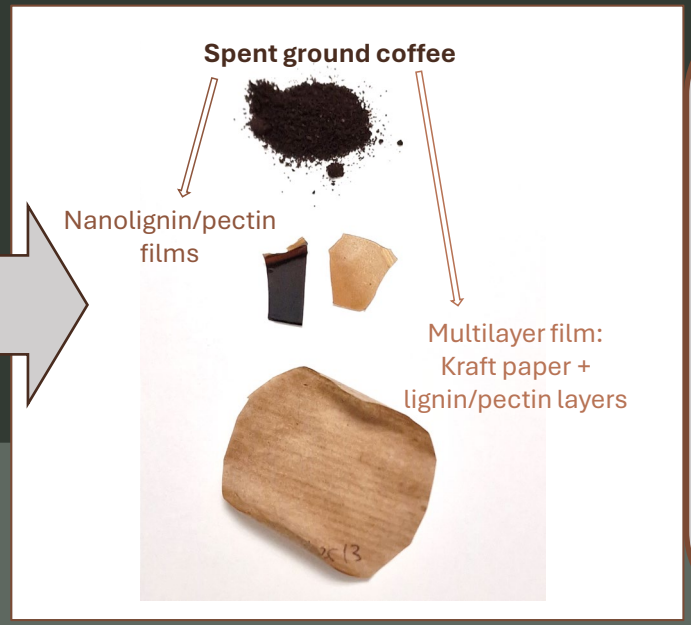
adolphe merkle institute
excellence in pure and applied nanoscience

UNI FR

Benjamin Ladet

Technology

1. Collection of by-products
2. Extraction using green and reusable solvents
3. Processing of pectin and nanolignin into multilayer films
4. Evaluation of packaging efficiency

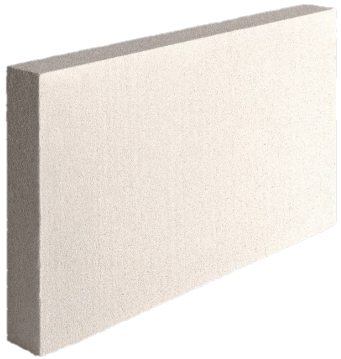


Our collaborator: Torpedo Coffee

Collection of coffee waste
+
Organoleptic tests of coffee beans packed with our packaging solution

TORPEDO
L'Art du Café

Building Insulation Reborn from Mineral Waste



Mineral foam technology, manufactured with low energy, forms ultra-stable bubbles, enabling maximized performance and sustainability at competitive cost

Particle-stabilized foams using sustainable materials

Spinoff ETH zürich

FenX

Mineral Waste

Grounded/Filtered to fine powder

Sustainable Building Material from Mineral Foam

Ultra-stable foaming with FenX additives

Future Directions

Revolutionary advances in nanotechnology and biotechnology now enable precise replication of nature's most complex and sophisticated architectural designs at multiple scales.

Further academic research is needed, to enable applications in robotics, medicine, and more, with startup creation and industrial collaborations

Challenges:

- Financing for research
- Scalability
- Cost

About us

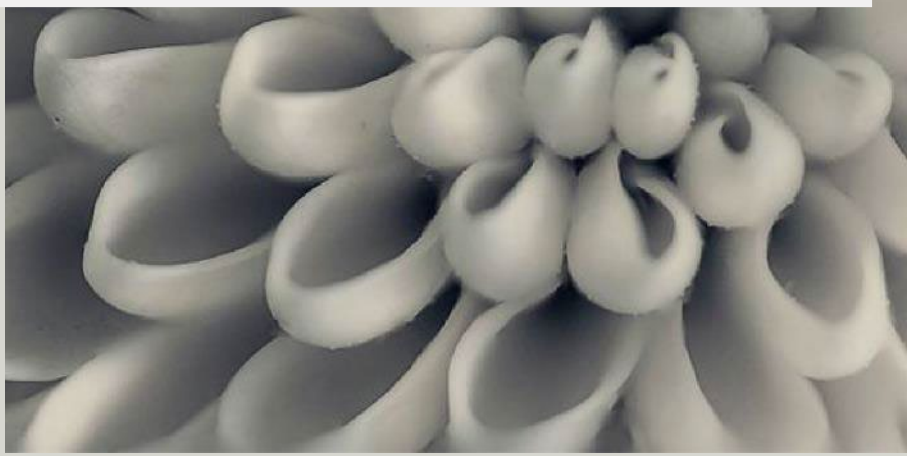
BIO-INSPIRED MATERIALS
NATIONAL CENTER OF COMPETENCE IN RESEARCH

Swiss National Science Foundation

eliav.haskal@unifr.ch

Summary

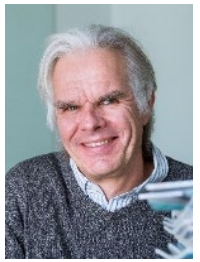
Nature is truly sustainable and forms its own circular «economy».



Key figures

BIO-INSPIRED MATERIALS
NATIONAL CENTER OF COMPETENCE IN RESEARCH

- ***Funding:*** 85 Mio over 12 years (SNSF + UNIFR + 3rd Party)
- ***Members:*** ca. 120 (including 25 Professors)
- ***Partners:*** EPFL, ETHZ, Empa, CSEM, TU Darmstadt, UniSalzburg, Cornell, KU Leuven, UniTurku
- ***Headquarters:*** Adolphe Merkle Institute (AMI, Fribourg)



Ulli Steiner (UniFr) Director

Esther Amstad (EPFL) Deputy

Network

eliav.haskal@unifr.ch

Swiss National Science Foundation

BIO-INSPIRED MATERIALS
NATIONAL CENTER OF COMPETENCE IN RESEARCH

19 Full PIs and 8 Associate PIs from 10 research institutions