Insights into the Material World - What is going on?

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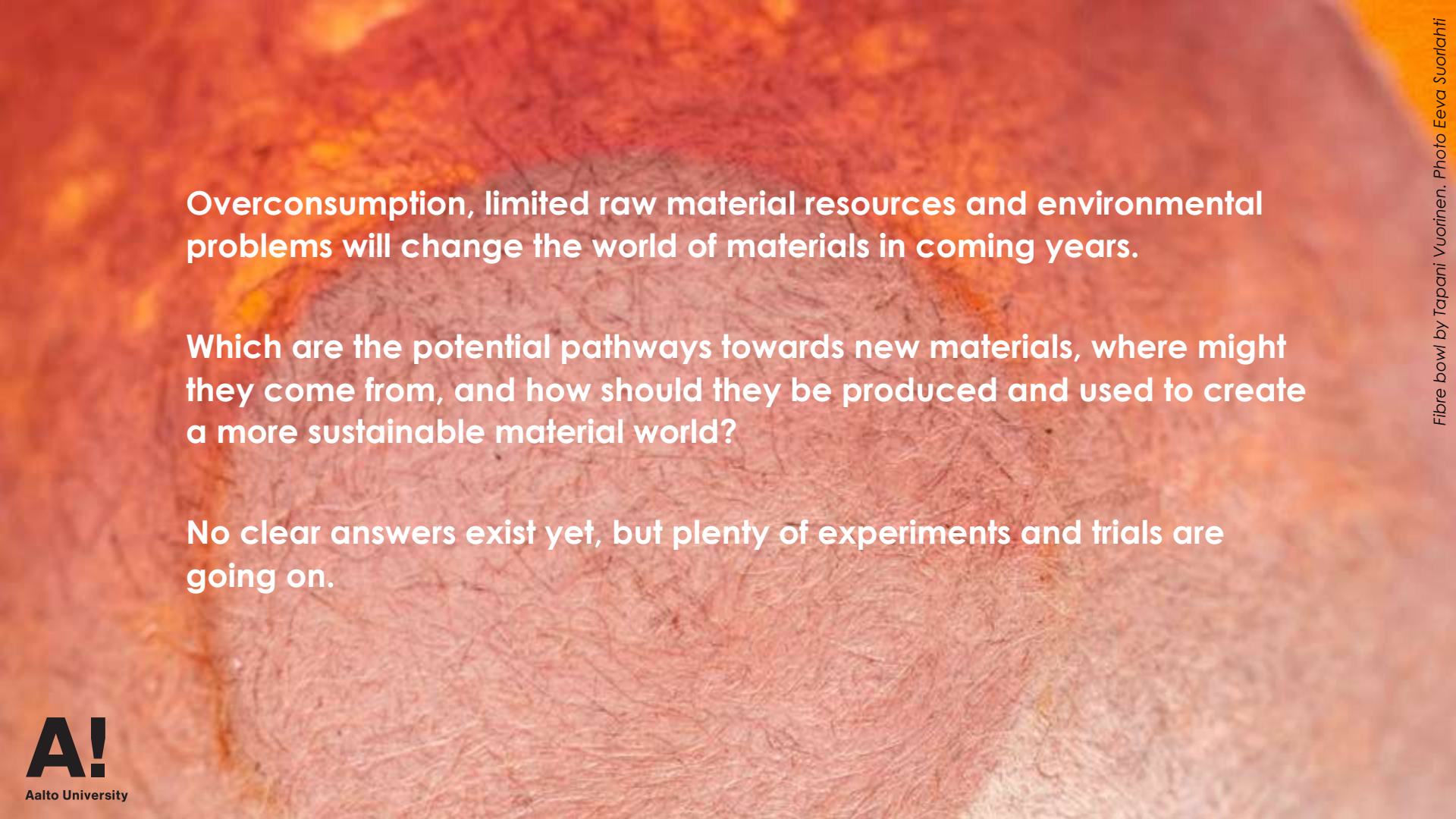
Carbon Capturing Images by Aman Asif &Valentina Guccini CHEMARTS 2020 Photo Esa Kapila



Overconsumption, limited raw material resources and environmental problems will change the world of materials in coming years.

Which are the potential pathways towards new materials, where might they come from, and how should they be produced and used to create a more sustainable material world?

No clear answers exist yet, but plenty of experiments and trials are going on.

Fibre bowl by Tapani Vuorinen. Photo Eeva Suorlahti

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Materials are part of United Nation Sustainable Development Goals

Four phenomenas changing the world of materials

1. **Innovative use of regular, novel or traditional raw materials**
2. **Reuse, recycling**
3. **Biofabricating** materials with **biological processes**
4. **Designing new materials for example with synthetic biology**

Alder bowl by Saara Kantele 2019 Photo Eeva Suorlahti

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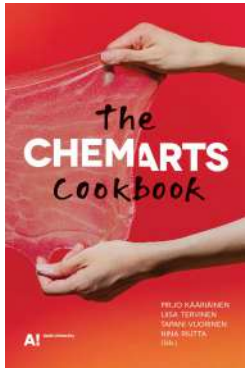
Photo Petri Anttila



Photos Eeva Suorlahti

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LONG FIBRES FROM NATURE

25 BAST FIBRES FROM WILLOW BARK

Tapani Vuorinen & Jesse Das, CHEMARTS 2017

Willow is the common name for trees and shrubs of the Salix genus. Fast-growing willow hybrids have been developed for bioenergy crops. This recipe processes natural materials from willow inner bark for craft experiments. Willow bark peels easily, especially in late spring when the active growth season has started. Different willow species and hybrids may have different fibre properties and produce different colours, varying from pink to almost black.

INGREDIENTS

Willow stem or branch
Baking soda (sodium bicarbonate)
Water

EQUIPMENT

Knife
Large pan and stove

METHOD

1. Cut the stem or branch to the desired length.
2. Remove the dark outer bark by scraping it off with a knife. Leave the inner bark intact.
3. Make a longitudinal cut on the inner bark along its whole length using a knife, and pull it apart. If the bark does not separate, heat the stems in hot water for 15–30 min (80–100 °C).
4. Weigh the separated inner bark.
5. Place the bark into a large pan and add enough water to cover it. Add baking soda, at least one tenth of the weight of the bark.
6. Heat to boiling and cook for an hour. Beware, the mixture boils over easily.
7. Add cold water to cool, and wash the bark. For soft and flexible fibres, rub and separate the material into thin bast fibres by hand in the water. Keep the material moist or wet until you have completed the fibre separation. Separating the fibres by hand requires time and patience.
8. Dry the fibres on newspaper or other water-absorbing material. Avoid staining your clothes with the wet fibres.

TIP While cooking, various small-sized molecules such as sugars and aromatic substances dissolve, forming an intensive, typically reddish colour. This natural dye from willow can be used to colour textiles or other materials into red brown tones.

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Aalto University CHEMARTS for bio-based material experimentations since 2011

1. Innovative use of regular, novel or traditional raw materials

Algae from Baltic Sea, Laura Rusanen Chemarts 2020, photo Esa Kapila

Rice straw

Photos: Eeva Suoranta

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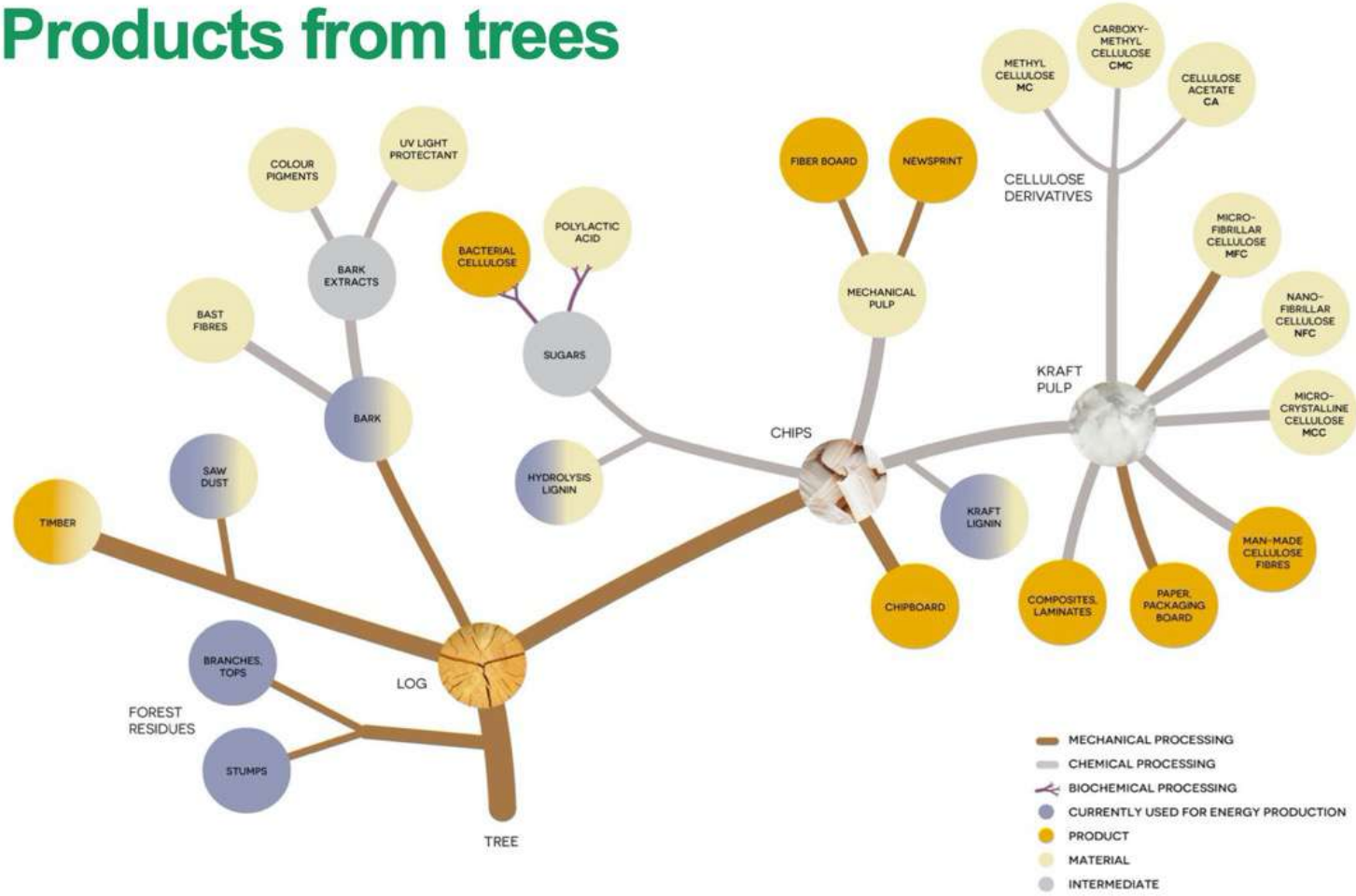
Products from trees



Nina Riutta & Tapani Vuorinen, The CHEMARTS Cookbook

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New ligno-cellulosic materials for circular economy

Cellulose is the most abundant organic polymer in the earth - it is in wood, plants, algae.

Trees and plants contain also lignin, hemicellulose, bark, long bast fibres, extractives for colours and natural ‘chemicals’…

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Wood-based materials

Wood pulp

Thermoformable packaging material by Huhtamäki

Sulapac packaging material

Timberfill
3D printing filament

Ioncell textile fibres
@Marimekko

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Photos Eeva Suorlahti

Cellulose-based materials can be soft, hard, transparent… In most cases these materials react with moisture and biodegrade.

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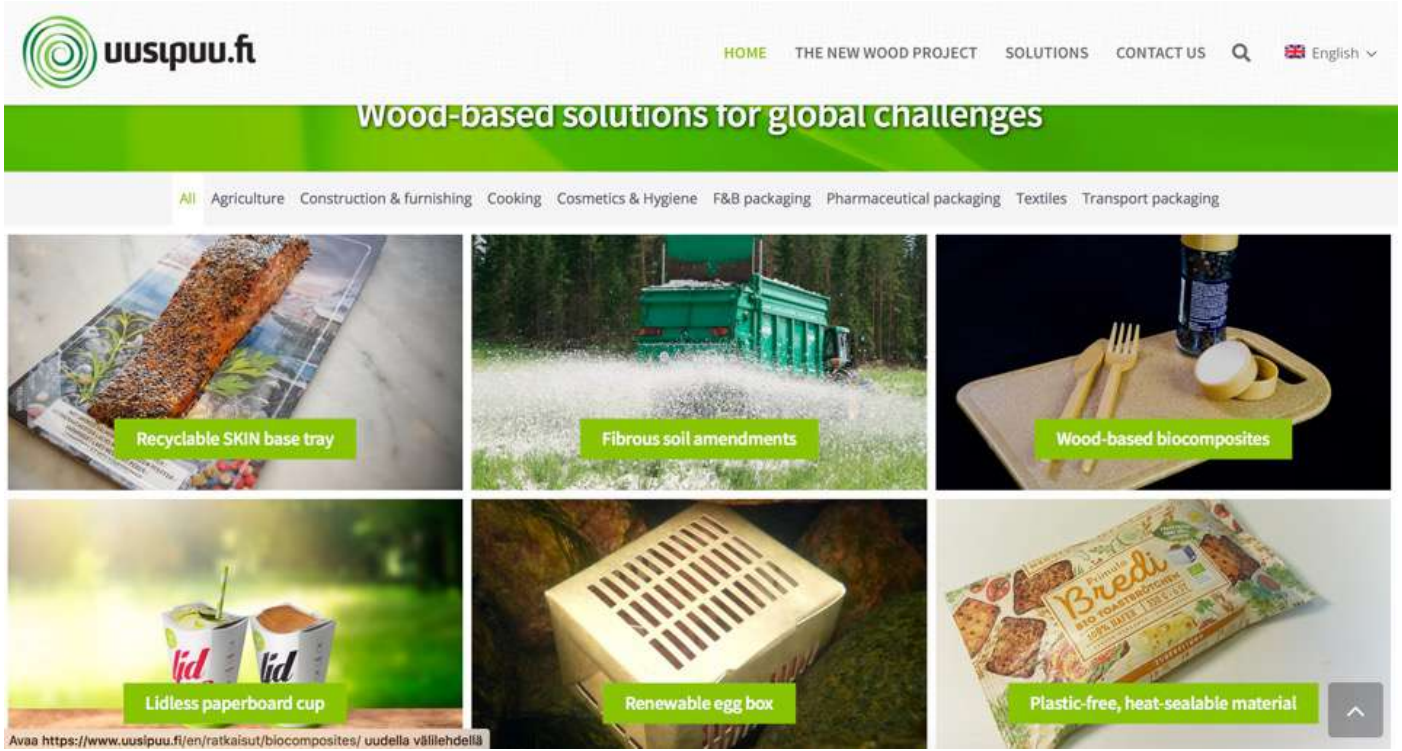
Examples of commercialized material development



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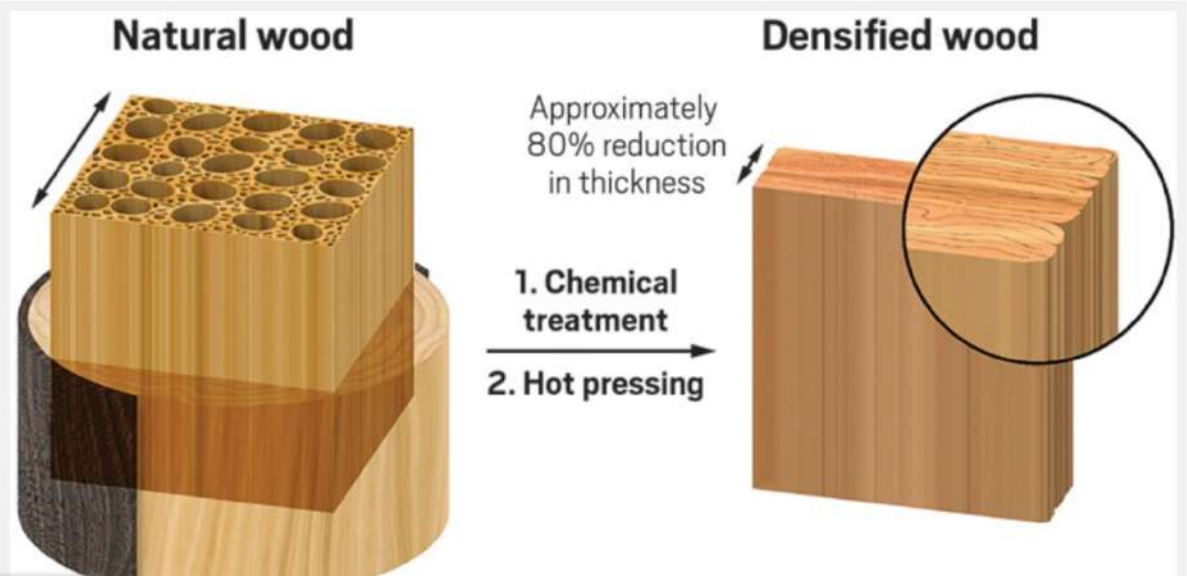
Process makes wood stronger than steel

Alkaline boiling and hot pressing collapse wood's pores, maximizing its density

By ***Stu Borman***

[+]Enlarge



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Wood-based structural colour

Shimmering Wood – Sructural colour from nanocellulose by Noora Yau & Konrad Klockars and Prof. Orlando Rojas's team at Aalto CHEM

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How wisely are we using our precious raw materials today?

or

Light and durable nanocellulose tubes by Tiina Härkäsalmi. Bicycle by Kim-Niklas Antin & team. DWoC project 2017, photo Eeva Suorlahti

New/old raw materials for textile fibres

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Nettle experiments Henna Salminen Aalto CHEMARTS 2020. Photo Esa Kapila

Julie-Anne Gandier 2020, Department of Bioproducts and Biosystems, Aalto University. Photo Valeria Azovskaya

Dyers Woad - Natural indigo Finland & Marimekko Photo Mikko Raskinen

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Replacing leather – but what about durability?

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2. Reuse, recycling

Ioncell, new sustainable technology to produce high quality textile fibres from wood or cellulosic waste (cotton, cardboard, paper waste) by Prof. Sixta's team.

Ioncell yarns from recycled cotton, paper and cardboard

ioncell.fi

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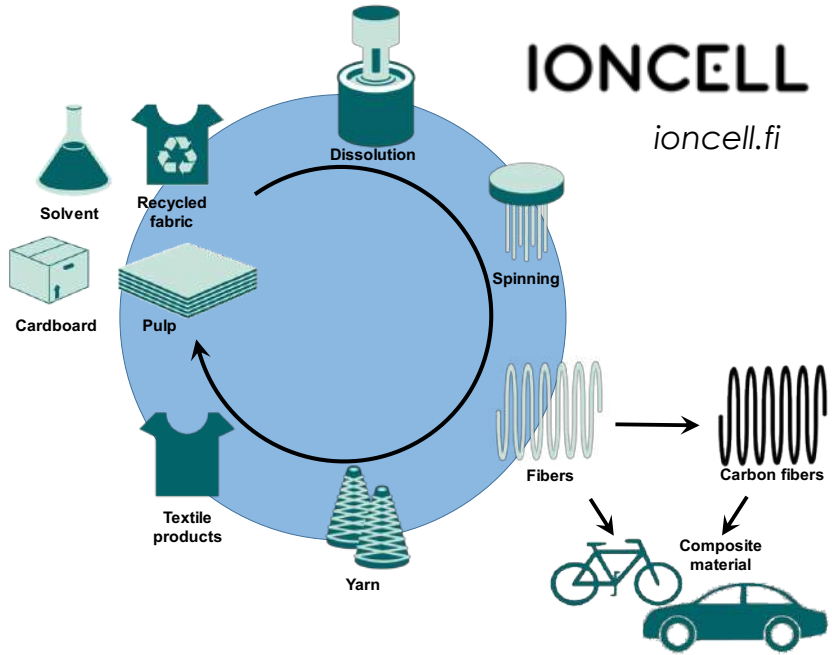
Circular material processes enabling circular economy



Recycling material and colour with Ioncell technology
by Eugenia Smirnova & Ioncell team CHEMARTS 2015

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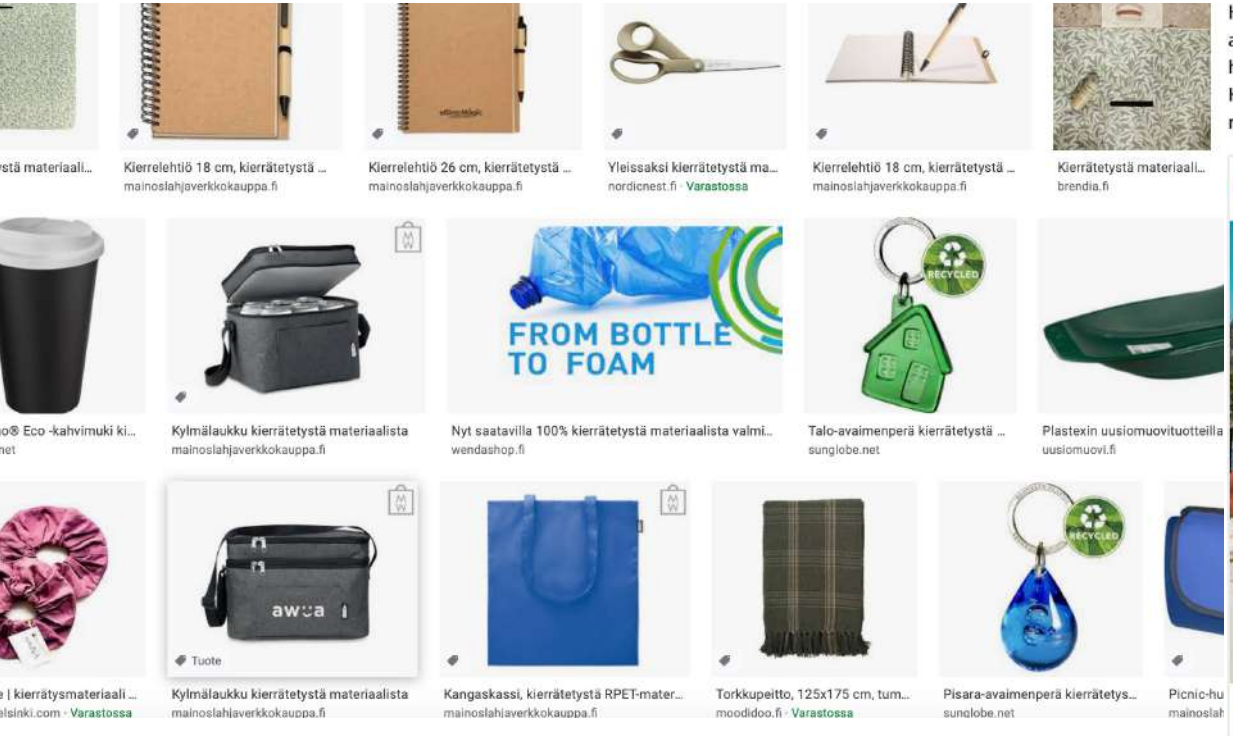

Halla Hallan pirteät bikinit ja uikkarit ovat olleet pinnalla jo muutaman vuoden ajan. Perustajat Salla Valkonen ja Hanna Chalvet saivat idean uikkarimerkkiin huomatessaan matkoillaan, miten paljon meressä kelluu muovijätettä. Halla Hallan uima-asut tehdäänkin merten jätteistä valmistetusta Econyl-kankaasta, ja myös nämä uikkarit ommellaan Balilla.

Upcycling waste
– but we also need to solve the original problem

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New design strategies

'In circular economy materials are not only reused or recycled; they are merely stored in products, and used again and again'- Prof. Mark Hughes Aalto CHEM

Adidas Futurecraft shoes made of monomaterial to enable recycling

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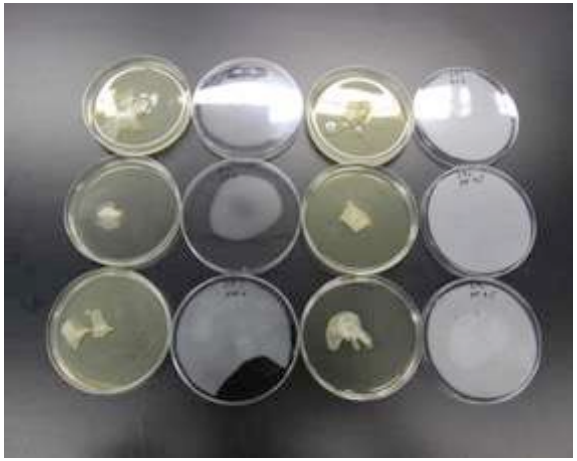
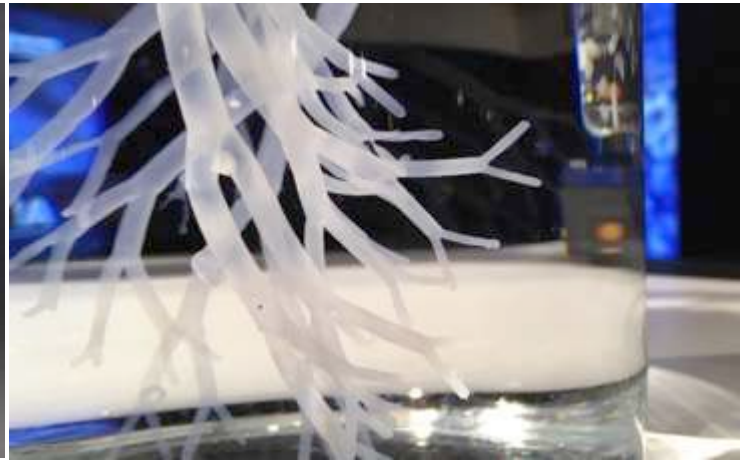
3. Biofabricating materials with biological processes (with the help of microbe, yeast or fungi)





Complex structures of microbial cellulose grown by Prof. Orlando Rojas's team 2018, Aalto University

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A bio-design studio has grown the material in their home kitchen for a protective mask made of xylinum. Photo: Elizabeth Bridges and Garrett Benisch, Sum Studio.

Textile-like materials from microbial cellulose and other bio-based materials. Julia Strandman, Aalto University CHEMARTS 2018. Photo Esa Eeva Suorlahti

Experimental mycelium jacket By Aniela Hoitnik https://neffa.nl/portfolio/

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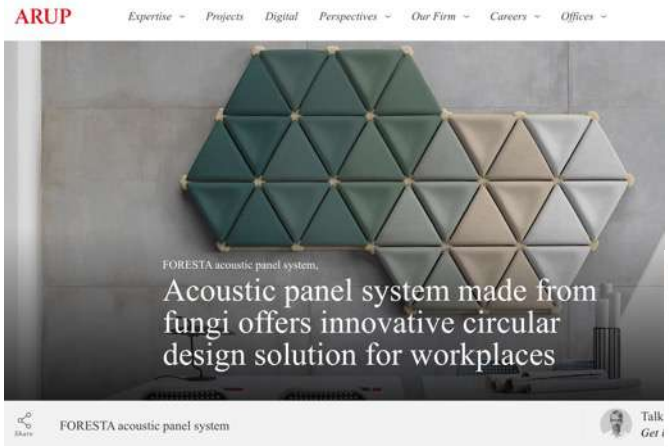
Mycelium structures

Mycelium pavillion at Dutch Design Week Eindhoven 2019
thegrowingpavilion.com



FORESTA acoustic panel system

Scaling up bio-composites: towards industrial production

Mycelium is the name given to the fine root network of fungi, consisting of so-called hyphae. It grows rapidly with the supply of moisture and nutrients – in this case organic waste such as hemp chives as well as textile residues – and colonises the substrate. A subsequent drying process stops the growth, hardens the composite and makes it robust. Since only the hyphae are used, the final bio-composite material contains no spores, aligning with health and safety requirements.

arup.com

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Why future homes could be made of living fungus

14 January 2021

by *Caleb Davies*

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Scientists are exploring the possibilities of turning mycelium, the fungus that produces mushrooms, into a new type of building material. Image credit - Rob Hille/Wikimedia, licensed under CC SA3.0

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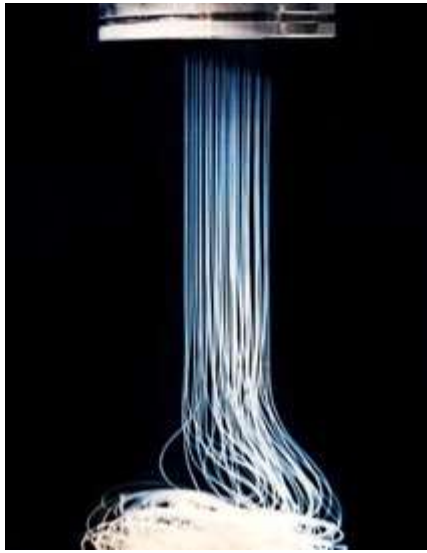
4. Designing totally new materials for example with synthetic biology

Combining artificial silk-like proteins with cellulose, NewSilk project

Transgenic glowing silk. Fantasma by Another Farm et al. Japan.



Microsilk by Bolt Threads. U.S

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Pigments of Microorganisms
Master's thesis on microbial colour
by Eveliina Juuri, Aalto-yliopisto 2020

Colours through photosynthetis
by Aman Asif, Aalto CHEMARTS 2020

Colours by microbi or photosynthesis

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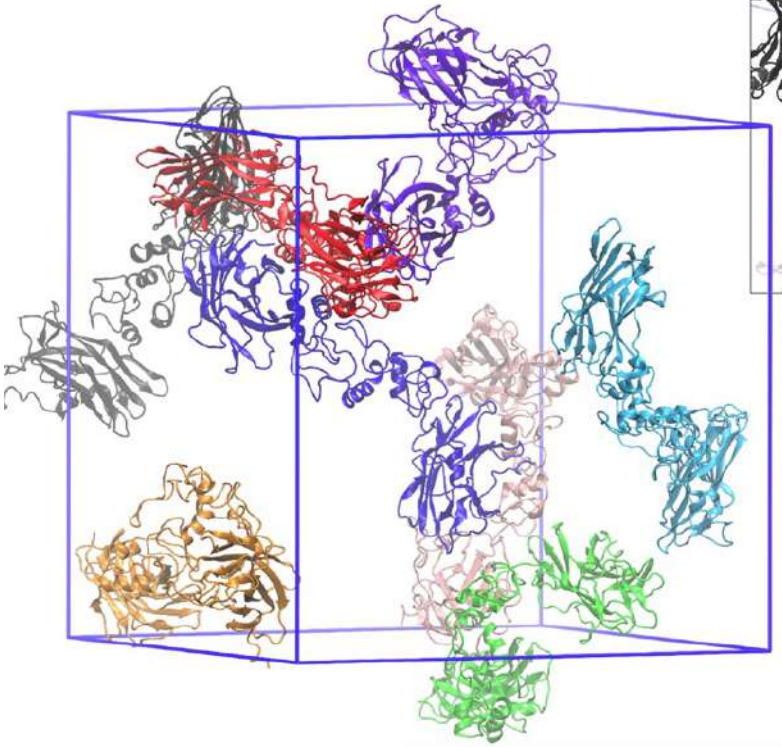
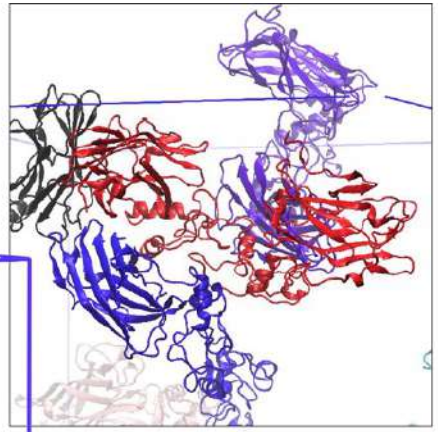
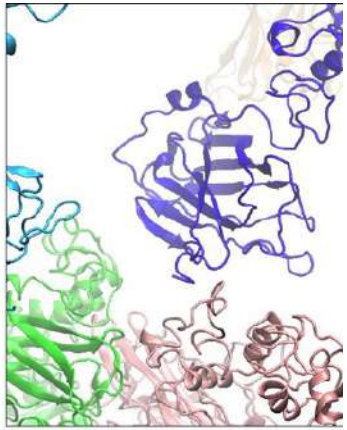
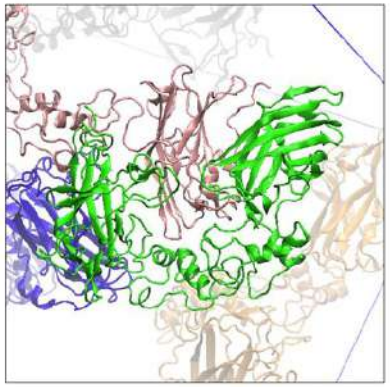
Examples of proteins in salt solution



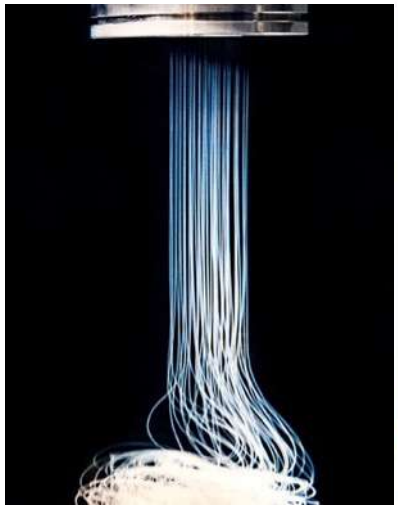






Closer look at the intermolecular connections

'Let's brew for a pullover!'



Microsilk by Bolt Threads, U.S

Stella Mc Cartney x Bolt Threads

Brewed Protein by Spiber

New kind of textile factory: Brewed Protein by Spiber

Source: 'Understanding 'Bio'material Innovations' report 2020, https://www.biofabricate.co

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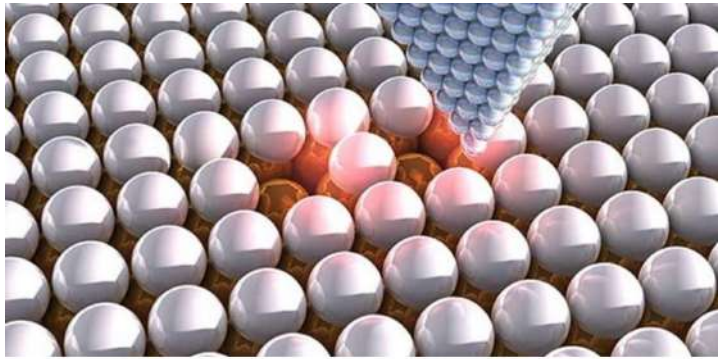

Researchers at Aalto University have manufactured artificial materials with engineered electronic properties. By moving individual atoms under their microscope, the scientists were able to create atomic lattices with a predetermined electrical response. These results bring 'designer quantum materials' one step closer to reality.

News

Researchers create artificial materials atom-by-atom

Published: 27.3.2017

Possibility to arrange the atoms precisely bring designer quantum materials closer to reality.

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Some future insights:

Traditional and new materials in new ways:
No bad or good materials as such, right materials in right place, ecodesign approach in design for closing the loops

Production: non-toxic chemicals and reducing use of water and energy in processes, transparency of production chains, locality

Renewing consumption habits: against overconsumption, better quality, repairing, recycling (products, materials)

New business opportunities and models will emerge

Photo: Eeva Suorlahti

Aalto University

Long journey from idea to innovation and products: material development takes 5-15 years

Fibre bowl by Tapani Vuorinen. Photo Eeva Suorlahti

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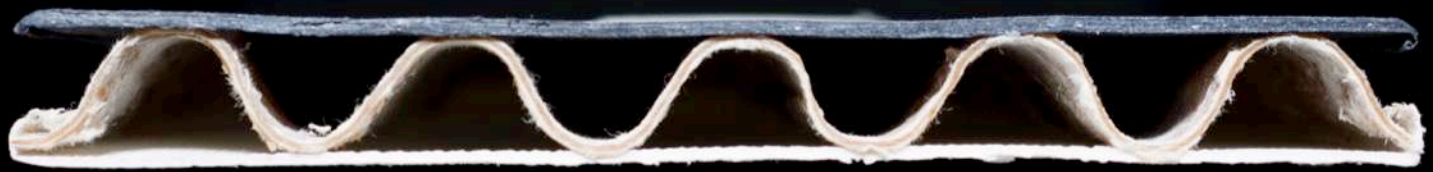
‘The challenges to our planet are so complex that they cannot be solved by one discipline. Design is a bridge. It translates scientific ideas and discoveries into real-world applications.’

– *Matilda McQuaid, Curator at Cooper-Hewitt Smithsonian Design Museum, NYC in the exhibition catalogue: ‘Nature: Collaborations in Design’, 2019*



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Multilayered nanocellulose sheet / Maker Tiina Härkäsalmi, DWoC project 2017, photo Eeva Suorlahti