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MAT-DAY 2026

17.09.2026

BOKU Tulln - Dipl.-Ing. Dr. Claudia Frey,
NDU - Univ.-Prof. Mag. Dr. Sandra Dittenberger &
Univ.-Prof. Mag. Stefan Moritsch

ALL-WOOD: BIO-INSPIRED COLOUR OBTAINED FROM WOOD TO COLOUR WOOD

Grundlagenforschungsprojekt
Laufzeit: 10/2023 – 09/2026



GEFÖRDERT IM RAHMEN DER FTI-STRATEGIE NIEDERÖSTERREICH 2027

Projektleitung und -koordination: Universität für Bodenkultur Tulln, Institut für Holztechnologie und Nachwachsende Rohstoffe

Dipl.-Ing. Dr. Claudia Frey

Projektteam:

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Konsortialpartner - New Design University:

Projektleitung: Univ.-Prof. Mag. Dr. Sandra Dittenberger & Univ.-Prof. Mag. Stefan Moritsch

Wissenschaftliche Projektmitarbeiterin NDU: Agnes Raschauer, MA

Studienassistentz: Hanna Huber – Lena Schuller

Kooperationspartner:

Max-Planck-Institut für Kolloid- und Grenzflächenforschung

Dr. Thomas Parton, Prof. Silvia Vignolini



PROJEKTIDEE – CIRCULAR DESIGN

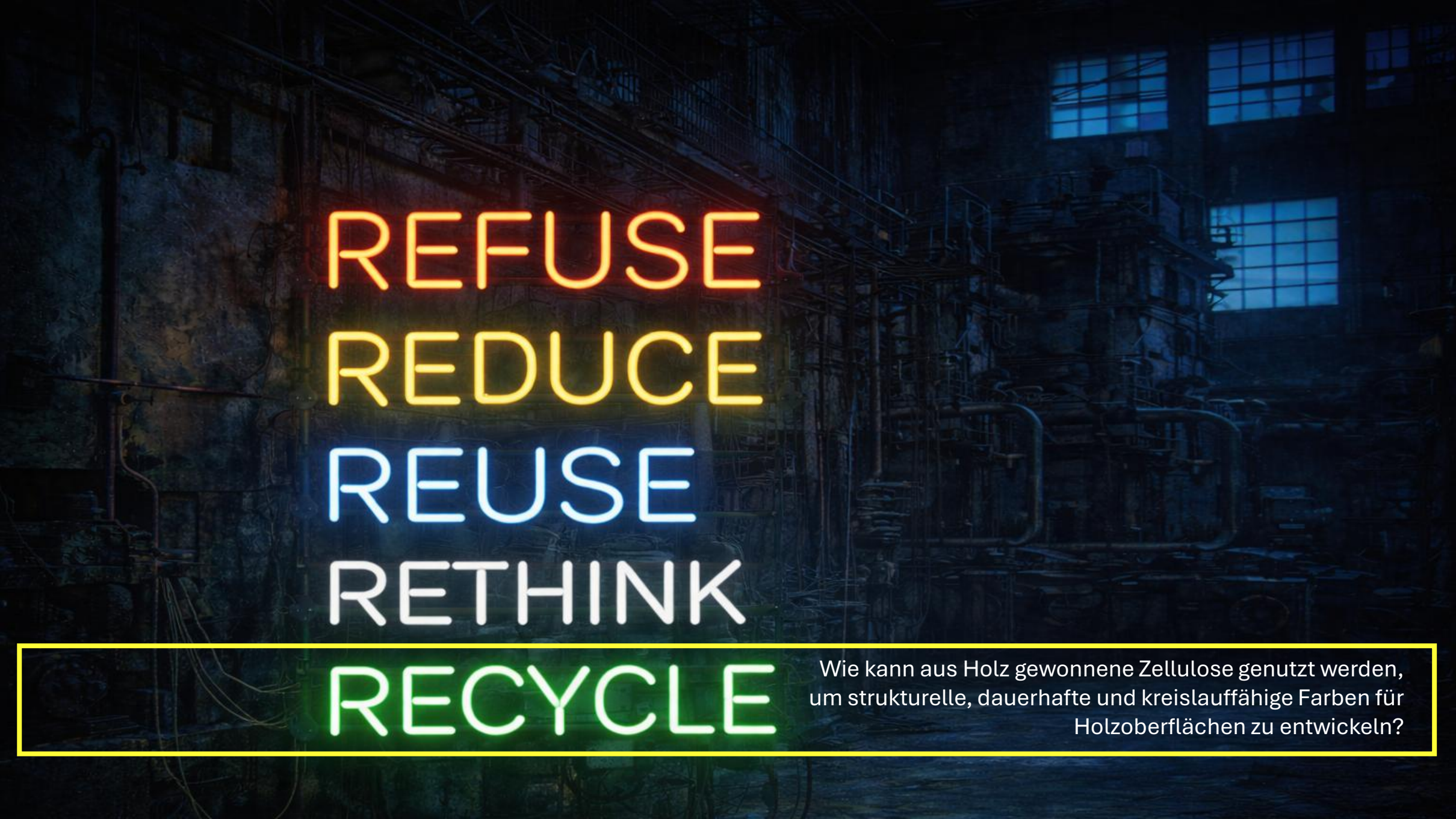
Polia condensata Pflanze

= Die Zellulosestruktur der Früchte erzeugt durch strukturelle Farbe eine blaue Erscheinung.

= Ideengeber für das Projekt All-Wood

Lässt sich dieses Prinzip mit aus Holz gewonnener Zellulose auf Holzoberflächen als biobasierte und zirkuläre Farblösung übertragen?





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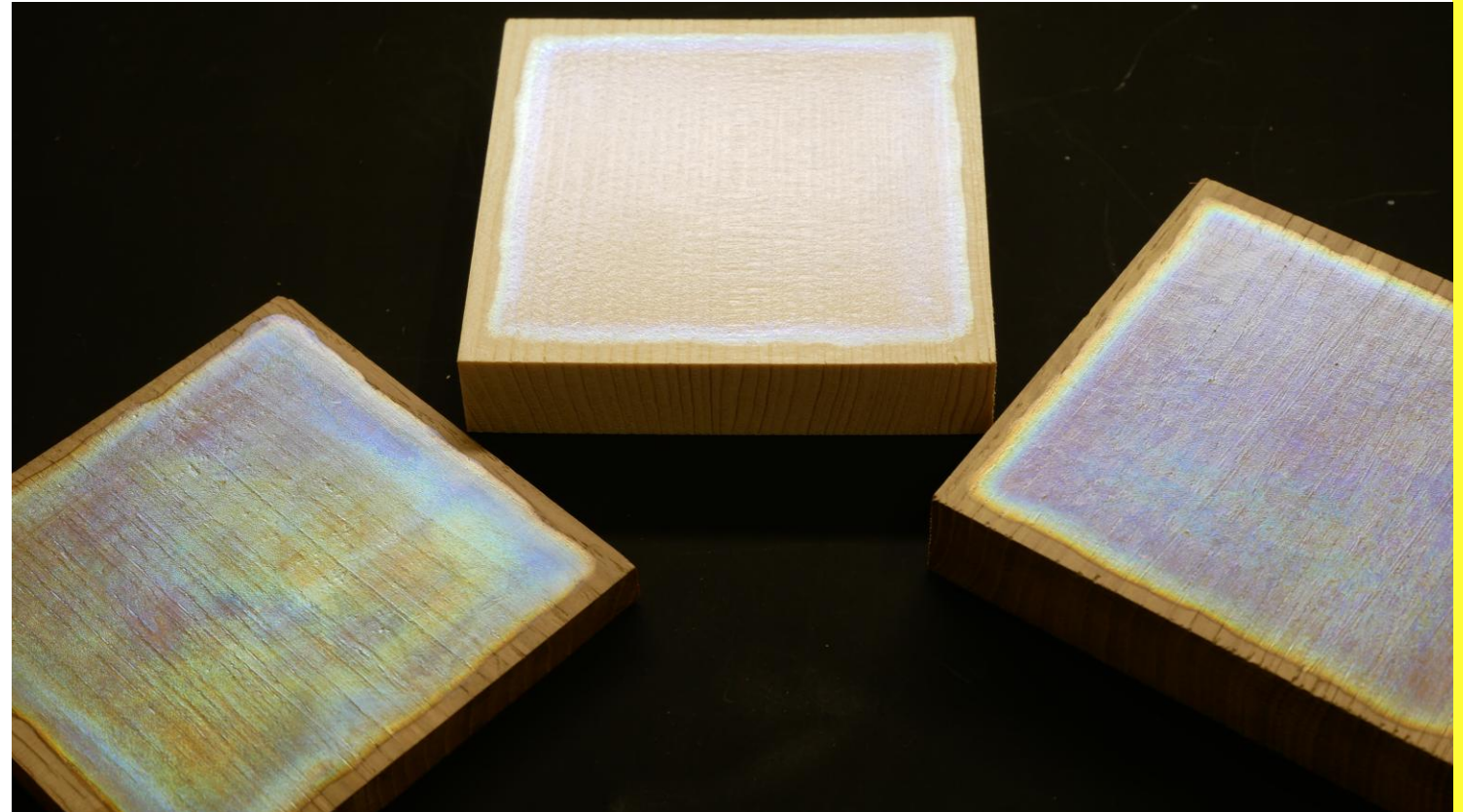
RETHINK

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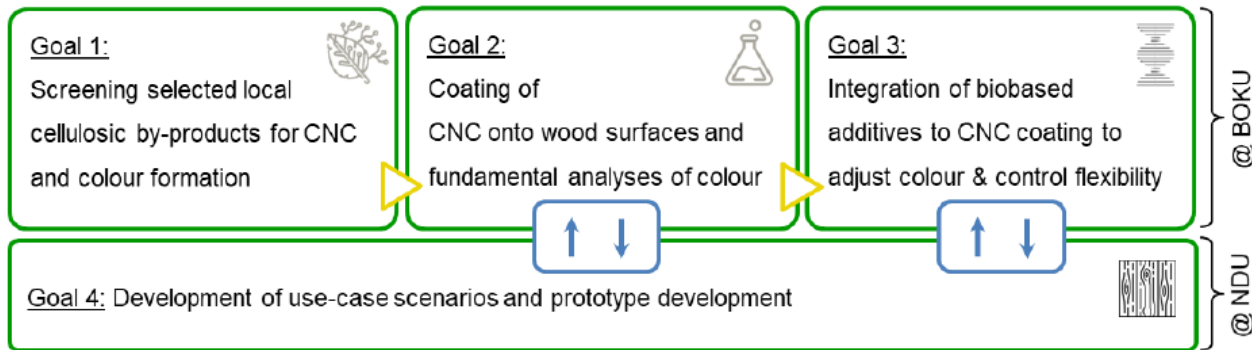
Wie kann aus Holz gewonnene Zellulose genutzt werden, um strukturelle, dauerhafte und kreislauffähige Farben für Holzoberflächen zu entwickeln?

ALL-WOOD: BIO-INSPIRED COLOUR OBTAINED FROM WOOD TO COLOUR WOOD

Wie kann aus Holz gewonnene Zellulose **genutzt werden**, um strukturelle, dauerhafte und kreislauffähige Farben für Holzoberflächen zu entwickeln?



ALL-WOOD: PROJEKTZIELE & HYPOTHESEN

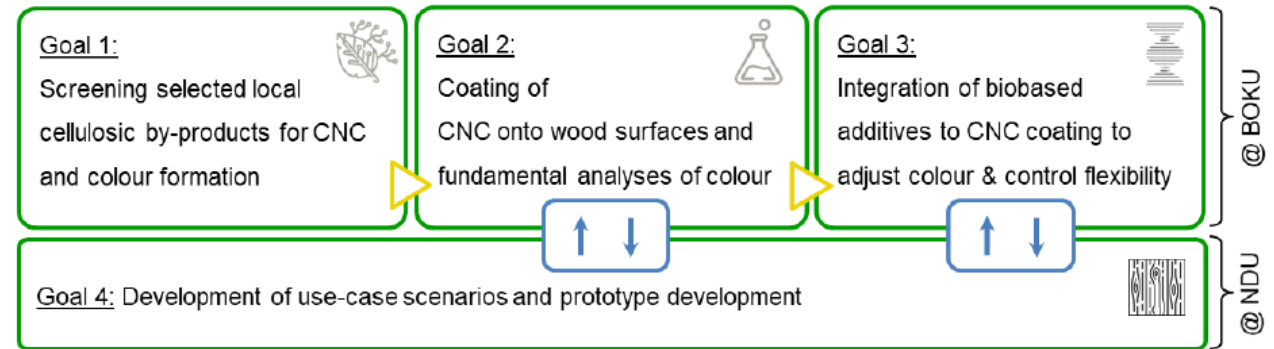


Hypothese 1: Nanomaterialien, die aus verschiedenen Holz- und landwirtschaftlichen Nebenprodukten gewonnen werden, entwickeln unterschiedliche Strukturfarben.

Hypothese 2: Lebendige und homogene Strukturfarben erzeugen eine stabile und gut definierte Holzfärbung.

Hypothese 3: Strukturell gefärbtes Holz eignet sich für eine Reihe von Anwendungsfällen und führt zu vollständig recycelbaren Prototypen.

PROJEKTZIELE



Projektziel NDU in All-Wood: angewandte Forschung

Im Hinblick auf die Untersuchung der **Hypothese 2** werden **Zellulose-Nanokristalle auf Holzoberflächen** verschiedener Holzarten (Hart- und Weichholz), Schnittrichtungen (tangential, radial, längs), vorbehandelten Oberflächen (geschliffen, karbonisiert, plasmabehandelt) und Beschichtungsmethoden (gewalzt, getaucht, gespritzt) aufgebracht. Im Anschluss wird die **ästhetische Wirkung** der einzelnen generierten Materialproben mit Bezug auf den späteren Einsatz im Produktdesign untersucht.

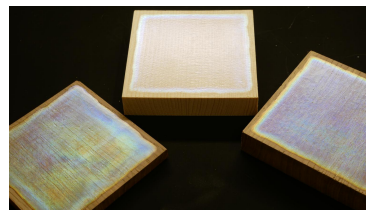
Um die Umsetzung der einzelnen Ergebnisse pro Projektabschnitt des zellulosebeschichteten Holzwerkstoffs zu überprüfen, werden unter der Bearbeitung der **Hypothese 3** zunächst Fallbeispiele und Szenarien definiert, die die spätere Entwicklung von **Prototypen** zu möglichen **Anwendungsbeispielen** der neuen Holzfärbetechnik bei Holzprodukten darstellen.

CO-CREATION/DESIGN WORKSHOP BOKU-NDU

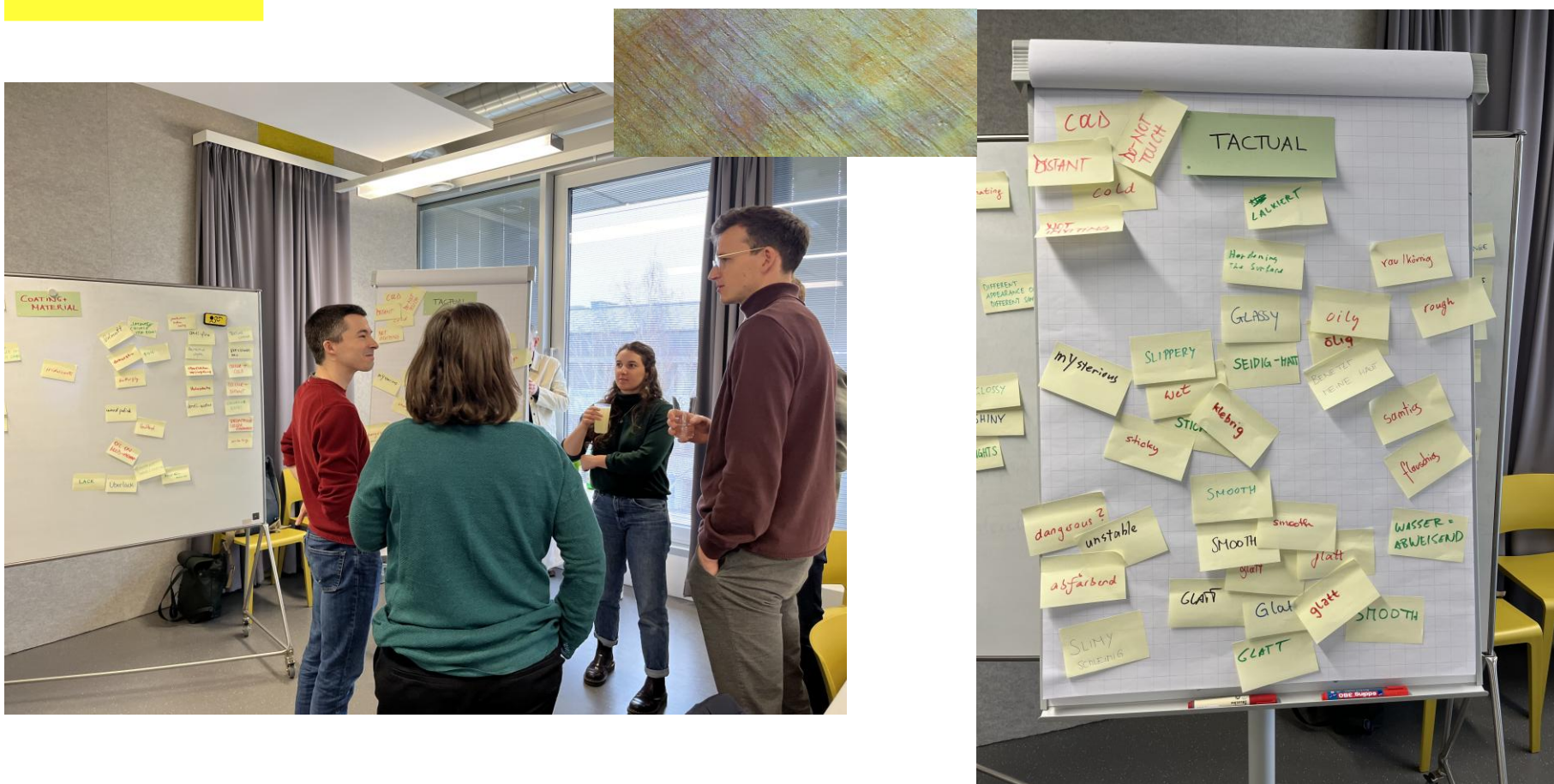
Hypothese 3: ästhetische Wirkung des strukturell gefärbten Holzes eignet sich für eine Reihe von Anwendungsfällen und führt zu vollständig recycelbaren Prototypen.

Co-Creation/Design Workshop BOKU-NDU

Freies Assoziieren: Die Teilnehmer:innen wurden gebeten, bei den folgenden vier Impulsen frei zu assoziieren. Sie schrieben ihre Assoziationen (hauptsächlich Ein-Wort-Antworten) auf Post-its, die auf Flipchart-Papier aufgeklebt wurden. Nach der Sammlung der Assoziationen wurden die Antworten geclustert und diskutiert.



CO-CREATION/DESIGN WORKSHOP BOKU-NDU



MATERIALPROBEN

Ästhetische Wirkung von Zellulose-Nanokristalle auf Holzoberflächen verschiedener Holzarten:

Hart- und Weichholz,
Schnittrichtungen (tangential, radial, längs),
vorbehandelter Oberflächen (geschliffen, karbonisiert, plasmabehandelt),
verschiedener Beschichtungsmethoden (gewalzt, getaucht, gespritzt)

	Nuss/Nut	Zwetschke/Plum	Erie/Alder	Eiche/Oak	Kiefer/Pine	Fichte/Spruce	Ahorn/Maple
roh, beträufelt / raw, dribbled							
geschliffen, beträufelt / sanded, dribbled							
getunkt / dipped							
bepinselt / coated							
gestemmt, beträufelt / stemmed, dribbled							
Sonstiges							
	1. hineingestemmt- tes Muster, be- träufelt 2. aufgepinselte Streifen	1. aufgeraspelte Oberfläche und auf der rechten Seite eingeritzt, beträu- felt 2. gestemmt, be- träufelt	1. hineingestemmt- tes Muster, be- träufelt 2. aufgepinselte Streifen			1. gestemmt und aufgeriebene Holz- fasern, beträufelt	1. hineingestemmt- tes Muster, be- träufelt

AUSSTELLUNG „TWISTED NANOCRYSTALS“

Design Days Schloss Hollenegg

Exponate:

- 8 gedrechselte Holzproben aus Eiche, Lärche, Hainbuche, Kreuzdorn und Fichte
- 12 flache Holzmuster aus Pflaume, Nussbaum, Lärche, Fichte, Erle, Eiche und Ahorn



AUSSTELLUNG „TWISTED NANOCRYSTALS“



AUSSTELLUNG „TWISTED NANOCRYSTALS“

All-wood: Bio-inspired colour obtained from wood to colour wood

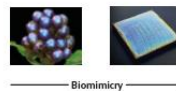
What is the project about?

Cellulose-based structural colors in nature are able to reflect light at a specific wavelength, giving them an intense, permanent and non-fading appearance, such as the African tropical plant *Pennisetum glaucum*. This principle can be imitated using cellulose obtained from wood to enable sustainable and safe dyeing. This new type of dyeing is particularly interesting for wood materials, which are also the raw material for dyeing, in order to improve their color stability and durability. The coatings and pigments currently used for this purpose are largely synthetic, often hazardous to health and complicate recycling processes due to the combination of materials of different chemical origins and properties.

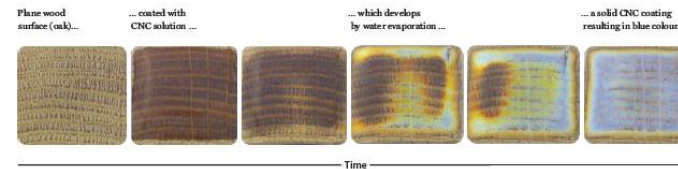
Cellulose nanocrystals isolated from wood are able to generate the required photonic structure for structural pigments and are being investigated as part of the project as a bio-based alternative to synthetic pigments and varnishes for coating wooden surfaces. The material and surface thus consist uniformly of one material origin and are therefore easy to reuse. Production follows the principles of the circular economy in order to contribute to a more sustainable future. By-products of the wood industry such as wood dust are used to obtain the cellulose nanocrystals and their potential for the development of structural color is being investigated. On the one hand, the expected improved durability, color and UV stability will be analyzed, and on the other hand, bio-based additives will be tested to produce a wider range of colors.

In a cooperation involving BOKU (Tulln), New Design University (St. Pölten) and other international partners, the aim is to lay the foundation for the development of fully recyclable wood products.

Some plants and animals in nature exhibit particularly vibrant and iridescent colors. Unlike with conventional dyes, these structural colors arise from a specific nanostructure of the material. By generating such a structure on wood, iridescent, non-toxic and fully biodegradable wood coatings can be obtained.

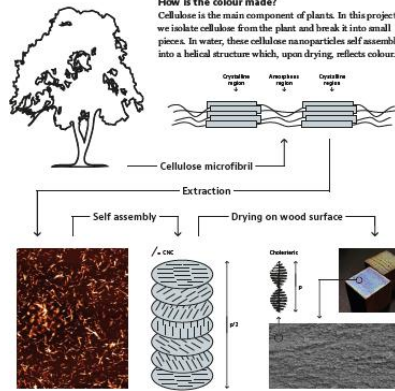


Development of structural colour on wood surface

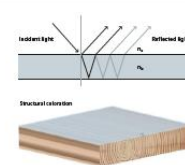


C. Lointier¹, S. Veigel¹, C. Gusenbauer¹, J. Konnerth¹, S. Dittenberger¹, S. Moritsch¹, A. Raschauer¹, H. Huber²
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FINANCED AS PART OF THE 101-STRATEGY LEADERS AUSTRIA 2021



What is the science behind?
 When light hits a thin layer of material, the waves reflected from the top and bottom of the layer travel different distances resulting in a phase difference. At specific angles, the waves are one or more full wavelengths apart and add up which results in a strong reflection of a particular colour. Each wavelength is reflected at specific angles and the perceived colour thus depends on the viewing angle.



Twisted Nanocrystals



S. Moritsch, H. Huber, P. Stemmerberger, S. Dittenberger, A. Ljubas
 Form Material & Material Culture, New Design University, St. Pölten, Austria

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What is the project about?

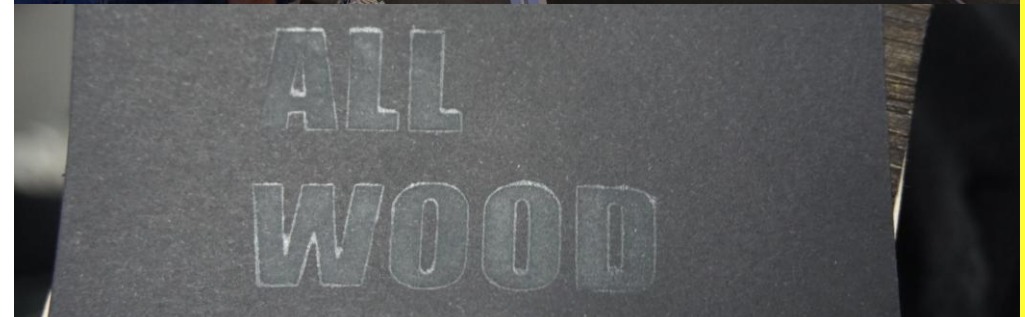
Twisted Nanocrystals is a research project linking craftsmanship and science, aiming to apply non-pigment colour to wood, in form of a coating. Cellulose-based structural colours in nature are able to reflect light at a specific wavelength and therefore have an intense, durable and non-fading appearance. Cellulose nanocrystals isolated from wood create the required photonic structure for structural colours. Hand-turned artefacts serve as samples for this new dyeing process, which is being explored as part of an ongoing basic research project by BOKU's Institute of Wood Technology and Renewable Resources and NDU's Material & Material Culture study programme.

SPECULATIVE DESIGN WORKSHOP

Erarbeitung erster Ansätze für eine mögliche Umsetzung in der Projektphase „Demonstrate possibilities“

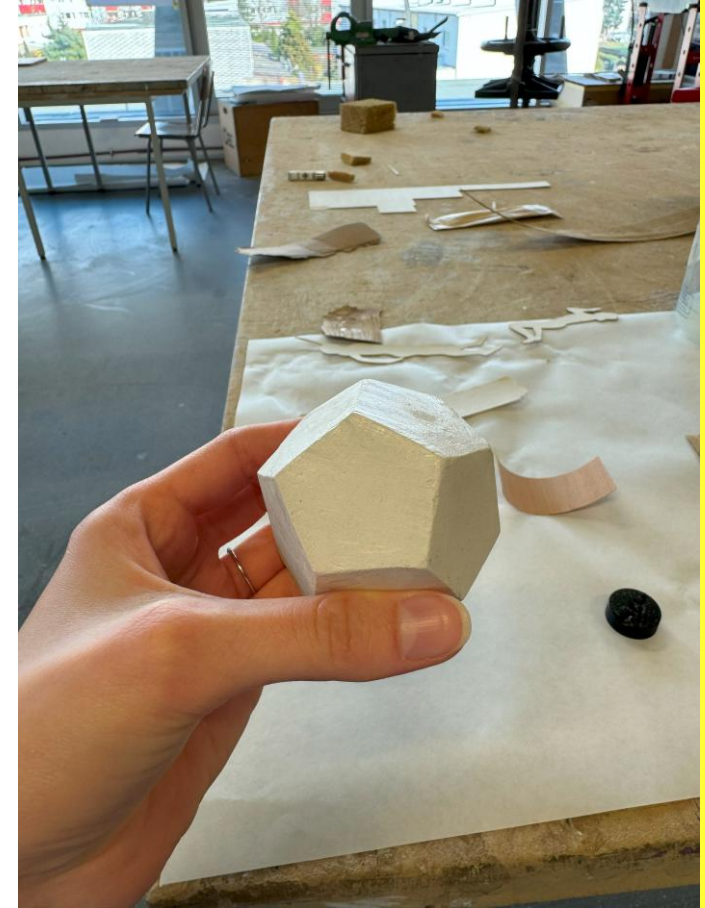
Ziel:

Ideen und Konzepte entwickeln wie das CNC gefärbte Holz in Produkten eingesetzt werden könnte.



SPECULATIVE DESIGN

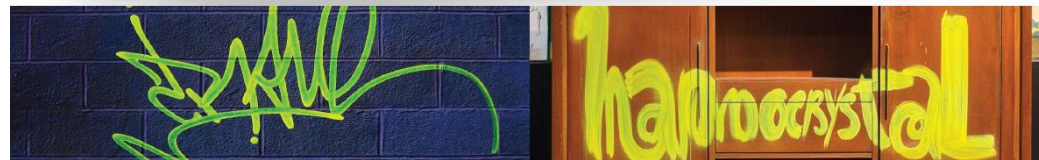
Design-Team der Studierenden entwickeln Modelle für die ersten Entwürfe der Demonstratoren.



SPECULATIVE DESIGN



SPECULATIVE DESIGN



SPECULATIVE DESIGN



Präsentation entwickelter
Designkonzepte



DISKUSSION

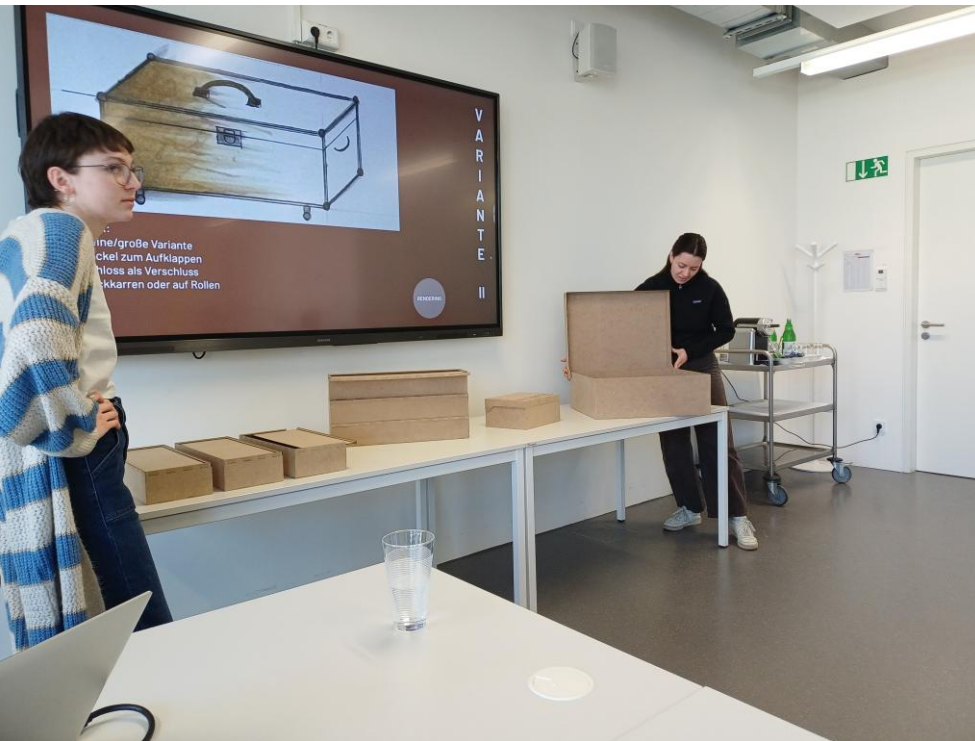


„SAMPLE-BOX ZUR WISSENSCHAFTS-KOMMUNIKATION“

Präsentation der Entwürfe



„SAMPLE-BOX ZUR WISSENSCHAFTS-KOMMUNIKATION“



„SAMPLE-BOX ZUR WISSENSCHAFTS-KOMMUNIKATION“



„SAMPLE-BOX ZUR WISSENSCHAFTS-KOMMUNIKATION“

Präsentation des Prototyps



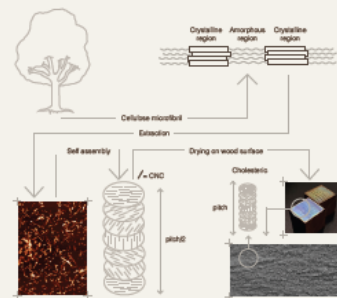
„SAMPLE-BOX ZUR WISSENSCHAFTS- KOMMUNIKATION“



„SAMPLE-BOX ZUR WISSENSCHAFTS-KOMMUNIKATION“

Allwood

Bio-inspired colour obtained from wood to colour wood



How is the colour made?

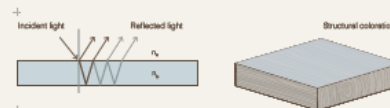
In cellulose nanocrystal films, structural colour is produced when incident light interacts with the self-assembled helical structure. This regular spiral arrangement selectively reflects specific wavelengths of the incoming light, while the reflected light depends on its pitch and the viewing angle.

What is the science behind?

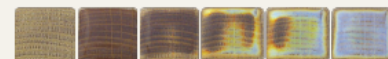
When light hits a thin layer of material, the waves reflected from the top and bottom of the layer travel different distances resulting in a phase difference. At specific angles, the waves are one or more full wavelength(s) apart and add up which results in a strong reflection of a particular colour. Each wavelength is reflected at specific angles and the perceived colour thus depends on the viewing angle.

$$k = n_{\text{avg}} \cdot \text{pitch} \cdot \sin(\alpha)$$

k : Reflected wavelength of light
 n_{avg} : Average refractive index of ONO film
 p : Pitch
 α : Observation angle

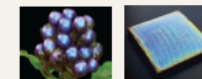


Development of structural colour on a wood surface: a plain oak substrate is coated with a ONO solution, which forms a solid ONO film upon water evaporation, resulting in blue coloration.



Time

Some plants and animals in nature exhibit particularly vibrant and iridescent colours. Unlike with conventional dyes, these structural colours arise from light interactions within hierarchical nano- and microstructures. By mimicking such a structure on wood, iridescent, non-toxic and fully biodegradable wood coatings can be obtained.



Reproduced by J. Zhou, 2014

Biomimicry

What is the project about?

Cellulose-based structural colours in nature are able to reflect light at a specific wavelength, giving them an intense, permanent and non-fading appearance, such as the African tropical plant *Pollia condensata*. This principle can be imitated using cellulose nanocrystals obtained from wood to enable sustainable coloration. This new type of dyeing is particularly interesting for wood materials, which are also the raw material of the colour. In order to improve their colour stability and durability. The coatings and pigments currently used are largely synthetic, often hazardous to health and complicate recycling processes due to the combination of materials of different chemical origins and properties. The material and surface thus consist uniformly of one material origin and are therefore easy to reuse. Production follows the principles of the circular economy in order to contribute to a more sustainable future. This project investigates novel cellulose nanocrystal sources, including water plants, for structural colour formation on

wood. The nano- and microstructure of ONO coatings, their interaction with wood, and the influence of application techniques on pitch and colour are analysed.

In a cooperation involving BOKU (Tulln), New Design University (St. Pölten) and other international partners, the aim is to lay the foundations for the development of fully recyclable wood products.

C. Lointier¹, S. Velgel¹, C. Frey¹, J. Konnerth¹, S. Dittenberger¹, S. Moritsch¹, A. Raschauer¹, H. Huber²

¹ Institute of Wood Technology and Renewable Materials, Department of Material Sciences and Process Engineering, BOKU – University of Applied Sciences, Austria
² Team Material & Material Culture, New Design University, St. Pölten, Austria

A dark, industrial interior, possibly a factory or warehouse, with a complex network of pipes, wires, and structural elements. In the background, several large windows are visible, some of which are illuminated from within, casting a blue glow. The overall atmosphere is gritty and somber.

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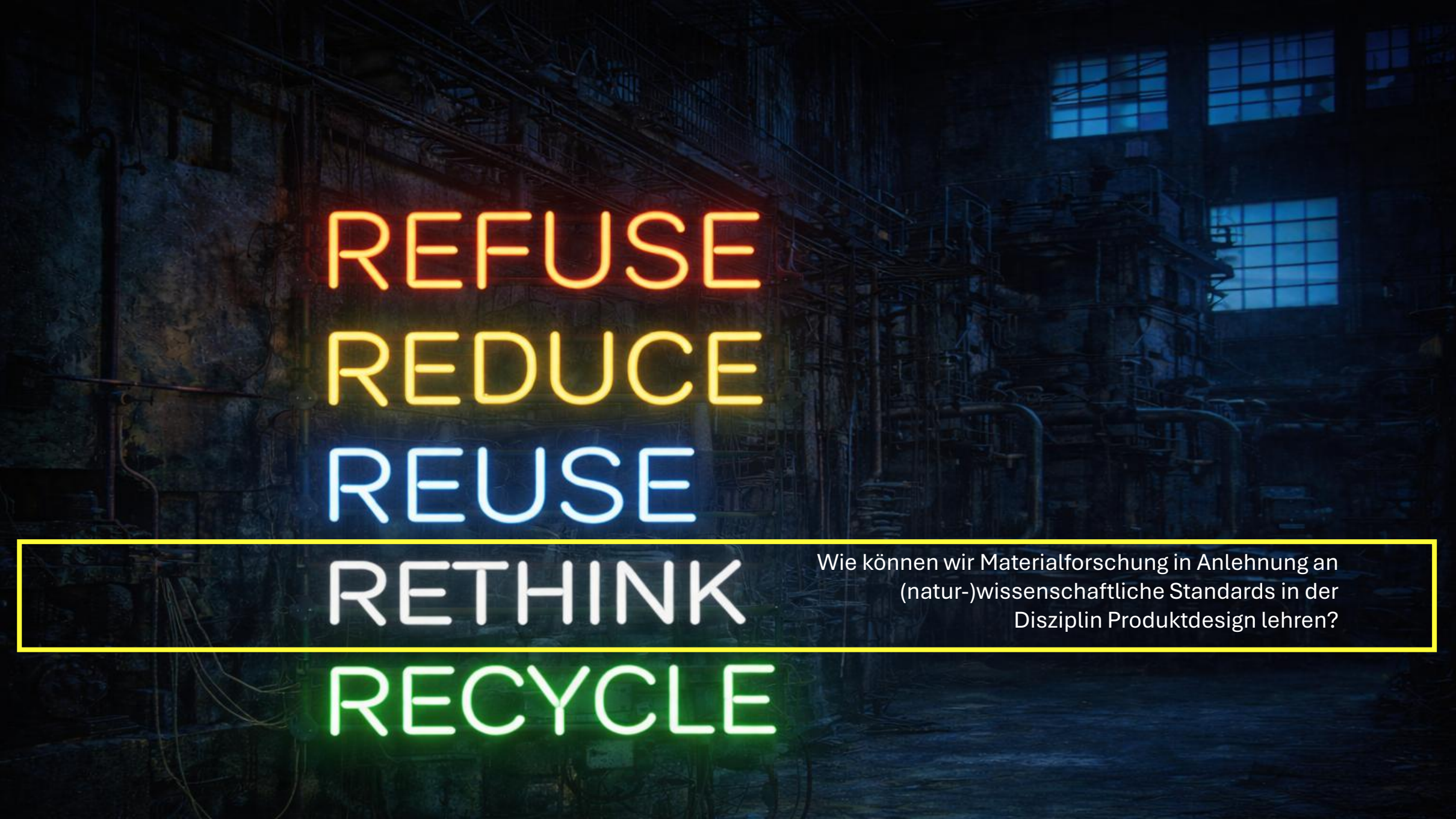
RECYCLE

FORSCHUNGSLÜCKE

... Zusammenarbeit der beiden
Projektteams (Materialforschung
im Design – in den
Naturwissenschaften)

... unterschiedliche “Wissenschaftssprache”
... unterschiedliche Forschungsmethodologie





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Wie können wir Materialforschung in Anlehnung an
(natur-)wissenschaftliche Standards in der
Disziplin Produktdesign lehren?

UNTERSUCHUNG DER ANSCHLUSSFÄHIGKEIT ...

	Materialforschung in den Naturwissenschaften	Materialforschung im Produktdesign
Ziel	Hypothese und Zielsetzung = grundlegende Materialeigenschaften verstehen	Materialanwendung für spezifische Kontexte
Methodik	Kontrollierte Bedingungen und Variablen, Methoden der Charakterisierung = systematisch, kontrolliert, quantitativ	Explorativ, iterativ, qualitativ
Ergebnisse	Dokumentation und Reproduzierbarkeit, Datenanalyse und Interpretation = verallgemeinbar, reproduzierbar	Kontext- und anwendungsspezifisch

MATERIALFORSCHUNG IM PRODUKTDESIGN



Um den **Ist-Stand von Prozessabläufen im Produktdesign bei Materialforschungsprojekten zu erheben**, wurde eine Beobachtungsstudie im Wintersemester 2023-24 mit den Studierenden des 3. Semesters im Studiengang DHMK durchgeführt, die unter der Leitung von Ulrike Haele und der Themenstellung „Plastic or not Plastic ... Crafting Materials“ Materialien beforschen und entwickeln sollten.

Die Beobachtung und spätere Analyse wurde entlang des “Experiential learning cycle” nach Kolb & Fry (1975) anhand der Schritte : 1 – applying (active experimentation), 2 – experiencing (concrete experience), 3 – reflecting (reflective observation) und 4 – generalizing (abstract conceptualization) durchgeführt.

Fazit:

Mit Bezug auf den „Experiential learning cycle” lässt sich beschreiben, dass die Studierenden bei ihren Abschlusspräsentationen auf die Elemente „1 - active experimentation“ und „2 - concrete experience“ eingingen, die Schritte „3 - reflective observation“ sowie „4 - abstract conceptualization“ bei den Schilderungen keine Rolle spielten. **Das Ergebnis der Beobachtung legt die weitere Bearbeitung der nach Kolb und Fry’s (1975) definierten Phasen (3) Reflexion und (4) Generalisierbarkeit nahe.** Dies deckt sich mit Romani, Rognoli und Levi’s (2023) Ruf nach einer Transferierbarkeit bzw. Generalisierung der gewonnenen Erkenntnisse aus Materialexperimenten, welche sie anhand von Materialproben, die durch Kategorisierung in Material-Bibliotheken eingepflegt wurden, untersucht haben.

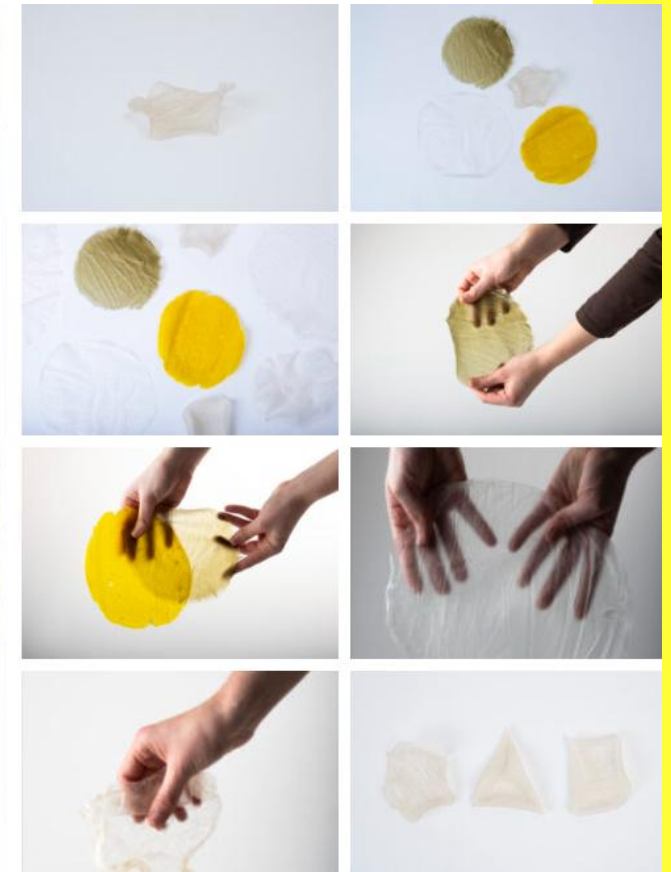
MATERIALFORSCHUNG IM PRODUKTDESIGN



Ouschan Laura – corn experiment



Michalak Sofie – potato starch experiment



Materials experiments in product design

Material selection + background research (origin, material properties, main uses)

Material tinkering – in three phases:

- + **tinkering with the formula:** experimenting with the composition of the components of the material,
- + **tinkering with the process:** how does the material react to different treatments (pressing, vaporizing, etc.)?
- + **tinkering in relation to the material effect:** testing and changing the visual-tactile properties of the material.

Research question, hypothesis and objectives:

which variables will I be focusing on? what is the aim of my research?,
what question am I asking or what do I want to find out?

Conduction of literature review

Definition of a research approach and experiment setup:

conditions and variables: how can I create controlled conditions and define variables for the conduction of my experiment?,
methods: which methods are most helpful for answering my question?,
data analysis and interpretation: how do I plan to evaluate the pre-defined variables of my experiment?

Conduction of experiments + creation of a demonstrator for the results gained

Description and reflection on results

LEARNXDESIGN 2025

Präsentation des Papers auf der
LearnXDesign 2025 Konferenz
an der Universität Aveiro/Portugal.



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in design education
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22-24 sep.'25
university of aveiro · portugal

Design
Research
Society

DRS

Teaching materials experiments in product design

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Abstract: Ecological challenges have moved the engagement with materials to the forefront in product design as well as in design education. Apart from the focus on materials experience, increased attention is being placed upon the development of (new) materials in the process of designing. While there is no shortage of diverse approaches and methods for conducting materials experiments, the handling of the knowledge gained in the course does not yet approach scientific standards. The increasingly transdisciplinary context in which designers collaborate with other disciplines generates a growing need to prove the effectiveness and possible impact of the results gained. Thus, product design teaching has to take up this challenge and find new ways of closing the gap between the practice of material tinkering to conducting materials experiments in alignment to scientific standards. Educators need to devise expanded concepts and process models to equip students for this next stage. In this paper, a summary of how materials experiments are practiced in product design and its teaching is contrasted with characteristics of materials experiments in the field of natural sciences, denoting main differences. Building on this, preliminary results from a multi-method study with students in a product design BA-programme are presented, investigating how teaching a new generation of product designers might be improved to better prepare them for handling materials experiments in a systematic way that is compatible with other disciplines.

MATERIALFORSCHUNG IM PRODUKTDESIGN

	Materials research in the natural sciences
Objective	Hypothesis and objective = Understand basic material properties
Methodology	Controlled conditions and variables, Methods of characterization = systematic, controlled, quantitative
Results	Documentation and reproducibility, Data analysis and interpretation = generalisable, reproducible

Experiment 1 : Icing Method	
Objective	create an object using standard recipe to imitate bowl shape
Materials/Measurements	- Potato Starch - 14 grams - Glycerin - 7 grams - Vinegar - 7 grams - Water - 60 mL
Cooking process	- combine ingredients into a saucepan and place onto stovetop - over medium heat (level 6 on my stove) stir the mixture consistently with a rubber spatula. It will begin looking milky, and become increasingly gooey and gelatinous. Once it is transparent and bubbly, remove from heat.
Moulding method	pour over the outside of a parchment paper-lined heat-safe bowl, and ice mixture with the spatula like a cake. Allow to cool.
Tools used	- rubber spatula - metal bowl - stove - parchment paper - metal saucepan - scale
Process time	2 minutes 55 seconds cooking time - drying time - approximately 1 week
Description of results	- a little wrinkly and uneven appearance - thickness varies - rather sturdy material, difficult to tear at thicker points - can be bent easily but maintains bowl shape
Reflection	the bowl does not resemble a conventional bowl by any means, with its uneven consistency, and rough and wrinkly appearance. The stickiness of the material makes it quite difficult to evenly "ice" the bowl, so each bowl made via this method will be unique. However, this also reminds the user of the DIY process behind it. For the next experiment, I will try to make it have a more even consistency.



Images 15-20: icing method process from start to finish, own source.

Experiment 2 : Press Method

Objective	• make a bowl with a more even consistency
Materials/Measurements	• Potato Starch - 14 grams • Glycerin - 7 grams • Vinegar - 7 grams • Water - 60 mL
Cooking process	• combine ingredients into a saucepan and place onto stovetop • over medium heat (level 6 on my stove) stir the mixture consistently with a rubber spatula. It will begin looking milky, and become increasingly gooey and gelatinous. Once it is transparent and bubbly, remove from heat.
Moulding method	• pour mixture onto a piece of parchment paper. Place another piece of parchment paper on top and press down evenly with a flat object, such as a cutting board. Take both sheets and wrap around outside of metal bowl. Allow to cool.
Tools used	• rubber spatula • metal bowl • stove • parchment paper • metal saucepan • scale
Process time	• 2 minutes 55 seconds cooking time • drying time - approximately 1 week
Description of results	• thinner result from pressing it rather than "icing" but consistent thickness • brittle around the edges, wrinkly appearance from moulding to parchment paper • not as sturdy because of thinness, more easily folded
Reflection	• While I achieved my goal in making the bowl have a more even consistency, the material is quite thin and brittle, making it less likely that it will function as a bowl compared to the first experiment. For the next experiment I will try to make the material stronger.



Images 21-26: press method process from start to finish, own source.

Water Test 2: Testing bowl's ability to hold room temperature water

Objective	Unlike in test 1, where I only tested <i>material</i>, I will test one of my <i>bowl's</i> ability to hold room temperature water to see whether it can function as a bowl.
Sample used	Bowl made via icing method
Process time	25 seconds
Water volume used	approximately 170 mL
Performance observations per temperature	Very shortly after pouring in the water, the bottom of the bowl began to feel slippery, indicating that the water was penetrating through the material. After approximately 25 seconds water was beginning to drip from the bottom of the bowl.
Reflection	After conducting this test, I realized that it would be quite difficult to use this bowl for dishes that are both cold and have a high water content, so it would be difficult to serve cold soups, for instance. While this bowl was relatively thin to begin with, the fact that the water penetrated through within 30 seconds suggests that even a bowl with 5 times the thickness would most likely not hold water for more than a couple of minutes. However, I will test a thicker bowl's reaction to water next.



Images 73-75: from L to R - bowl's reaction to being filled with water, own source.

DERZEIT

Special Issue

Regenerative Craft and Circular Practice: Material, Technological, and Socio-Cultural Dimensions of Sustainable Making

Message from the Guest Editors

This Special Issue invites contributions that advance our understanding of sustainable making through craft-based practices, with a focus on the following themes:

- Material Innovation
- Technological Integration
- Socio-Cultural Dynamics
- Systems Thinking and Frameworks
- Case Studies and Interventions

We particularly welcome interdisciplinary collaborations that bridge craft studies, design, materials science, sustainability studies, anthropology, and related fields. Submissions may include original research, empirically grounded case studies, methodological explorations, or critical reviews.

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