Tailoring of nanocellulose structures for industrial applications (NASEVA)

A public cross disciplinary project

Partners: Aalto and VTT

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From cellulose (wood) fibres to nanofibrillated cellulose

Fibres
- Width 30-40 μm
- Length 1-3 mm

Fibrils
- Width 5-30 nm
- Length over 1 μm
Industrial Potential of NFC

- Strong gels \( \rightarrow \) Concrete, paints, food
- Strong and light composites
- Ultrathin films for coatings
- Transparent films
- Magnetic materials
- Conductive materials
- Photocatalytically active materials
- Self-cleaning materials

Paper, board, car industry, construction materials
Insulation, filtering, membranes

Electronics, Solar cells, Diagnostic, Sensors
From fibres to nanomaterials

Preparation and **modification** of nanofibrils

Novel processes for new materials

Nanocellulose has to be surface **modified** in several applications!

Yano et al. (2005) and Nogi et al. (2008)
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Objectives

- To tailor the properties of nanocellulose for optimal functionality in different applications
- Find novel applications of nanocellulose

Added value from nanocellulose

- Increased functionality, improved mechanical properties, novel optical and conductivity properties, light weight high performance structures
Nanofibrillar cellulose – Application areas

**Rheology modifiers**
- Cosmetics, pharma, food
- Paints, emulsions, foams

**Reinforcement additive**
- Construction, vehicles, custom products, furnitures

**Functional additives**
- Water-treatment
- New material for electronics
- Antimicrobial material

**Nanocomposites/films**
- Transparent polymer-NFC
- Renewable and biodegradable composites
- O₂ barrier films

**Coatings and functional surfaces**
- Printing papers
- Food packaging
- New material for electronics

**Functional membranes/foams**
- Insulation
- Packaging
- Bioactive membranes, filters
- Tissue engineering
- Water treatment

*TKK, Pääkkö, 2005
TKK, Ikkala, 2005
Ahola et al, Biomacromol. 9(2008)1273*
General allocation of resources and milestones

- **Applications**
  - Understanding of interactions between NFC and polymers
  - Applications identified
  - Methods to functionalize NFC using proteins, enzymes, nanoparticles,..
  - Demonstrators for novel functional materials using NFC

- **Fundamentals**
  - Understanding of interactions between NFC and polymers
Achievements of fundamental research

- A large fundamental knowledge of the NFC behaviour
- Comprehensive characterization of different NFC grades
- Hydrophobized NFC
  - direct chemical reactions, in-situ polymerization, well controlled grafting, biochemical modification, adsorption, click chemistry
- Charged NFC (+/-)
- Reactive NFC
- Inorganic modifications
- Biochemical modification via fusion proteins
- Modification via adsorption and specific functions via “double-click” modification

Virtually any functionality can be achieved!
Different modified NFC

Ready made products

Counter-part is determined by customer

Tailor-made properties
Highlighted properties

- Multifunctional nanocellulose
- Strong mechanical properties
- Barrier properties (O₂, oil, water)
- Rheological properties
- Transparency
- Utilization of nanostructure in final materials (e.g. in films, coatings, fibres)
Examples of NFC Demonstrator Materials:

1) Novel high strength materials
   - Nanocellulose as matrix
   - Nanocellulose as additive

2) Large scale self-supported NFC films
   - Dynamic film forming process and means to adjust functionality
   - NFC film for diagnostics, sensors

3) NFC effects in coatings
   - Stabilization of added nanoparticles and coating functionality

4) NFC in Fibre Foams
   - NFC stabilizes fibre foam
   - For evaluation as soundproofing and air filtration material
Naseva Outcome in Numbers

- Invention disclosures: 22
- Patent applications: 10
- Scientific Articles and Manuscripts: > 70
- Presentation/posters: > 70
- Several M.Sc and PhD theses
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Thank You!

and

Welcome to see Naseva Posters and demomaterials, Area 15