New Materials for the Forest Products Industry

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S curves in music

Performance

LPs

Time

CDs

Internet based?

?
S curves in joint replacement
• The nanocrystals are made up of ~25 chains of 13000 glucose units

• Whisker shaped particles 100-200 nm x 5-10 nm

• Highly crystalline cellulose I can be used to prepare flat model surfaces

• Average nanocrystal anionic charge of ~0.5 e/nm² (and hydrophilic)

• Optically birefringent

TEM image of dilute suspension on carbon grid

Carbon Fiber Reinforced Plastics rule!
### Various Life Cycle and Maturation Stages

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▲ Technology Readiness  
▲ Application Readiness  
▲ Production Readiness

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Toyota and Ford have made public commitments to the use of sustainable materials and there are several initiatives in Canada such as BioCar and Auto21 aimed at developing cost effective bioproducts for automobiles.

“Monozukuri” and the Cycle of Nature ... Toyota’s World View and Our Mission

“Cycles of Nature”
All people and communities are subject to the natural cycles of the earth. Toyota is committed to undertaking “monozukuri” (manufacturing) that strikes a harmonious balance with nature in order to carefully sustain the global environment.

“Cycles of Industry”
An industry creates new value, while spawning the birth of a new industry—such is the way of the cycles of industry. Toyota endeavors to be a driving force behind the development of sustainable industries.

Toyota’s mission as it heads toward the year 2020 is to reexamine the relationship between nature and industry and to help promote efforts toward finding a harmonious balance between the cycles of nature and the cycles of industry.
New photonic bandgap pigments

Applications in:
- camouflage
- IR reflection
- cosmetics
- novel coatings

Courtesy, Peter Alberius, YKI
Biological porous materials – Q-membranes

Silica template from wing scales

Porous membranes in Amoeba

Plankton biostructures

Courtesy of Robert Corkery, YKI
Surfactants used for templating

Surfactants are used as templates for synthesis of porous particles.

Display many mesophases e.g. hexagonal and lamellar.

Bicontinuous cubic – used in Exxon/Mobil MCM-48

Courtesy of Robert Corkery, YKI
Self-assembly is one of the most important concepts for building nanostructured material templates e.g. Zeolites and mesoporous silica.
Use of DNA as template for mesoporous silica

Chenyu Jin, Lu Han, and Shunai Che, Angew. Chem. Int. Ed. 2009, 48, 9268 – 9272
Micellar templating at YKI

Solvent evap.

LLC intermediate

Tube furnace

N₂

Solution

Filter

Dry mesostructured hybrid

Micr. Mesop. Mater. 2004, 72, 175
Uncoated: Coated

TEM pictures

9 nm thick film
Application Projects

• Fragrance delivery
• Flavour delivery
• Biocide delivery in paints and coatings
• Drug delivery
• Immobilization of sensor liquids
• Carriers in ink jet inks
• Pigment coating for high quality ink jet paper
Metal-organic frameworks (MOFs)

Advantages:
- Ordered structures
- Large surface areas
- High thermal stability
- Adjustable chemical functionality
- Permanent porosity
- Flexible structures
- Diverse topologies

MOFs offer a surface area equivalent to a football field in a 1 g sample. Their versatility allows for limitless applications from storage of small molecules for gas storage or purification to catalysis.

Emulsion templating of nanoporous polymers

Controlling the shape of nanoparticles with surfactants

12nm iron oxide nanocubes (Scale bar is 20nm)

13 nm iron oxide nanospheres (Scale bar is 20nm)

Courtesy of Anwar Ahniyaz, YKI
Newly developed ceria nanoparticle-based clear coat

Commercial clear coat with organic UV absorber
Nanoparticle Sensors

- Charge tunneling through the thin insulating layer between nanoparticles.
- Gas adsorption in the tunnel barrier affects the electrical conductivity dramatically.

Schematic representation of a sensor based on the sensed molecules (e.g. moisture) affecting the tunneling current in the nanoparticle assembly

Linear sensors for packaging surveillance
Nano Surface Design in Nature

- Lotus leaf effect
Superhydrophobic coatings

- One-step coating procedure to produce required hydrophobicity and roughness to achieve a contact angle of 150°
- Both macro and microscale roughness important (scale bar 20 μm)

Courtesy of Agne Swerin, YKI
Superhydrophobic surfaces

Water repellency and self-cleaning via patented self assembly coatings

Next step is oil repellency through advanced surface chemistry – avoiding the use of fluorocarbons.
• Nanocelullosics and Nanocomposites
• Biorefinery Concept in Nanocellulose Manufacturing
• Nanotech Coatings and New Nano-enabled Functionalities
• Organized Structures, Thin Films and Interfacial Assemblies
• Computer Modeling
• Wood Products and Nanotechnology
• Market Opportunities for Forest Based Nanomaterials
• Consumer Perception/Governmental Regulations and Nanotechnology