Packaging Materials of the 21st Century
"Sustainable Nano-Marterials - Benefits to the industry"

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Agenda 2020

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Packaging at Point of Sale
Packaging Materials of the 21st Century

- Appearance
- Low Cost
- High Strength
- Lighter weight
- Sustainable materials
Profound Changes will Drive Innovation

2010 Per Capita Consumption & GDP
Size is Population


W Europe & N America
15% population of world / 50% consumption world resources
Demand in Asia accelerates: Commodity prices will explode
Forest Based, Materials of 21st Century

PJ 2012
The consumption potential of China becomes very large
With substantial implications on demand for and cost of materials

Source: London Times 2011
Oil price and refinery balances are re-setting the opportunities for paper-based materials

Source: G Thornton 2011
Waves of Innovation

Adapted from L Hunter Lovins 2008

Iron
Water Power
Mechanization
Textiles
Commerce

Steam Power
Railroad
Steel
Cotton

Electricity
Chemicals
Internal Combustion Engine

Digital Networks
Biotechnology
Software
Information Technology

Petrochemicals
Plastics
Electronics
Aviation
Space

Sustainability
Radical Resource
Productivity
Whole system design
Wisdom
Biomimicry
Green Chemistry
Industrial ecology
Renewable energy
Green Nanotechnology

Source: Natural Edge
Waves of Innovation

Source: Natural Edge

1st Wave
Iron
Water Power
Mechanization
Textiles
Commerce

2nd Wave
Steam Power
Railroad
Steel
Cotton

3rd Wave
Electricity
Chemicals
Internal Combustion Engine

4th Wave
Digital Networks
Biotechnology
Software
Information Technology

5th Wave
Petrochemicals
Plastics
Electronics
Aviation
Space

6th Wave
Sustainability
Radical Resource
Productivity
Whole system design
Wisdom
Blomimicry
Green Chemistry
Industrial ecology
Renewable energy
Green Nanotechnology

Tree based
Cellulose
Minerals

INNOVATION
1785  1845  1900  1950  1990  2020

Adapted from L Hunter Lovins 2008

www.nanotechforest.org
Motivations

Layer 4: Aluminium foil
www.longflat.com.au

Multi-layer packaging

Source Thao: EMPA 2011
Needs

Replace non-renewable & Non compostable packaging

Reduce food wastage

Source: Conservation, Summer 2012
Bio-mimetic Processes Leveraging Bio-Technology

Hierarchical structures of nanocellulose in wood provides strength.

Photonics developing new materials to interact with light in precise ways.

Nature constructs valuable materials from low cost low materials assemble with low energy.

Sources:
- D Grey 2003, Canada
- Sambles 2001, UK
- Yano 2007, Japan
Towards novel nanocellulose materials

Cellulose nanomaterials

- nanofibrillated cellulose, NFC
- nanowhiskers
- nanospheres

Upper TEM-image: TKK, Nykänen, 2007

Tailored properties

- functionalization
- self-assembly
- multicomponent systems

Cellulose nanomaterials in applications

- low grammage, high strength products
- new cellulose structures
- coatings, films, foams
- composites
- adhesives

Source: Qvintas et al VTT, Finland, 2010
CNC / Clay Composite

Source Thao: EMPA, Switzerland, 2011
Porous Materials & Fiber Web Structures

- Paper & Board Strength Enhancement

- Wood fiber web structures – Paper as a porous nanocomposite
  (e.g. Gardner et. al, J. Adhesion Sci. and Tech. (2008) 545–567,

NFC increased both:
binding area and binding strength ($S_{tot} \sim A_B \cdot S_B$)

- Applications:
  High strength / high bulk / high filler content paper & board

- Hans-Peter Hentze, VTT - 'From Nanocellulose Science towards Applications' - 2nd of June 2010
Composite & Construction Materials

- Concrete and Cementicious Materials
  - Strength enhancement of cellular concrete (e.g. Nanocrete Technologies')
  - Foamed, cellular NFC-concrete hybrid materials
  - Dense, silica-polymer hybrid materials

- Application: - Light-weight, foamed, cellular concrete structures
  - Crack reduction, combining toughness & strength

- Hans-Peter Hentze, VTT - 'From Nanocellulose Science towards Applications' - 2nd of June 2010
Nano-fibrillated Cellulose with Kaolin
Next Generation Composites
Packaging at Point of Sale
Packaging Materials of the 21st Century

• Abundant resources
• Renewable resources
• Sustainable Packaging

Source: Conservation, Summer 2012