Traditional paper and board products are based on sustainable production. They are made mainly from renewable materials and can be recycled several times before finally being used for energy production. In today’s high-quality products, however, oil-based additives and, in particular, binders in surface treatments are very commonly used. The general aim of the forest cluster is to direct the research at even more sustainable use of materials and production technologies. Scale-Up Nano Particles in Modern Papermaking (SUNPAP) is a new large-scale integrating project in the European Community’s 7th Framework Programme under the NMP programme. The three-year project started on 1 July 2009. It is co-ordinated by VTT Technical Research Centre of Finland (VTT), Finland.

The project focuses on scaling up the production of nano fibril cellulose. The project covers four research topics: sustainability evaluation of the whole value chain, scaling up production of native and functionalized nano fibrilcelluloses (NFCs), industrial product applications for different end uses and health and safety issues in nano fibril cellulose production, application and end products. The different research topics have a strong synergy and they are well integrated with each other.

The sustainability part deals with the whole value chain including market needs, sustainability assessments, and recyclability and biodegradability studies. The data collection is a critical part of the success, as it will feed data to the sustainability analysis conducted in the project. The sustainability analysis includes environmental, economic and social aspects.

The first aim of the research work into cellulose-based nano material production is to identify optimal pulp raw material and pre-treatment conditions for energy-efficient NFC preparation. The experimental trials with different chemical, enzymatic and mechanical pre-treatment processes are ongoing. The main target of the project is to scale up the technologies to produce natural or functionalized nano fibril cellulose. The quality of nano fibril cellulose is aimed at different current and novel industrial paper and board products. NFC can be produced on a laboratory scale using a high-pressure homogenizer at 150 to 200 MPa. This process is not suitable on a pilot scale, however, due to the low throughput and energy efficiency. PTS studies new processes, in co-operation with various research and industrial partners, in order to be able to demonstrate energy-efficient production on a pilot scale.

The paper and board applications in five different end-use areas will be studied using native or modified NFC in order to increase the strength of or give new
functional features to the end products. The NFC-based products now under
development lay the foundations for revolutionising existing papermaking
processes and developing new processes that will only be possible with NFC. The
use of NFC at the wet end is studied to determine whether its strength can be
increased in combination with a new product design and, if so, how this could be
done. Synthetic binders will be replaced by NFC in the coating of paper surfaces to
influence the traditional coating layer properties as required for specific purposes.
VTT in Finland is developing foam coating as a new surface application method for
fibre-based webs in the KCL’s pilot plant together with several SUNPAP partners.
The new application method uses special features of NFC, film-forming properties
and the high specific surface area. The foam coating under development will apply
a thin, uniform coating layer of special-purpose particles.

The health and safety issues of NFC production, application and end products will
be studied in cooperation with all the other research groups. At the same time, the
impacts of the products on recycling behaviour and occupational health and safety
must also be taken into consideration. Cellulose as such is considered a safe
natural material, but the characteristics of NFC differ slightly from those of
cellulose. In addition, nanocellulose has three properties that are associated, to
some extent, with pathogenicity in particles. First, the nano form of cellulose can
have a higher level of toxicity than larger-sized particles. Second, they are fibres
and may therefore behave like asbestos and other pathogenic fibres, which have
toxicity associated with their needle-like shape. As a third point, they are expected
to be bio-persistent in humans. The testing methodology suggested for the risk
assessment of NFC includes in vitro cytotoxicity and immunotoxicity tests to give
an indication of whether NFC will cause cellular damage and whether systemic
effects are likely. In addition, a nematode model-based test organism is used to
investigate potential systemic effects and neurotoxicity. As exposure to NFC is
likely to be through inhalation, an inhalatory toxicity study on animals is planned
for inclusion. This ensures that new packaging, and graphic and specialty papers
will be able to be produced in an even more sustainable way in the future in
Europe.

The research leading to these results has received funding from the European
Community’s Seventh Framework Programme under grant agreement n° 228802.
The EU will cover almost 70% of the 9.8 million € research costs. The collaborative
project will run until June 2012. Most of the project work will be carried out in
Finland, Germany and France at research centres committed to the regeneration of
forest industries (VTT, PTS and CTP). The industrial partners – and future
beneficiaries of project results on an industrial scale – are Stora Enso, Ahlstrom,
UPM-Kymmene, Felix Schoeller, Poyry and J. Rettenmaier & Sohne. The SUNPAP
project consortium consists of twenty-two partners from eight European countries:
Finland, Germany, France, Italy, Sweden, Portugal, Austria and the UK, and they
are all EU-member states. The partners include six research organizations, four
universities, four SMEs and eight large industrial companies.
SUNPAP-Scale-Up Nano Particles in Modern Papermaking

Ulla Forsström
VTT Technical Research Centre of Finland
Industry driven project which aims for new products with nano fibril cellulose (NFC)

Source: SUNPAP project, Description of Work
Research modules:
Strong synergy & well integrated with each other

The three year and 9.8 million € project will run until June 2012. Partners: 6 research organizations, 4 universities, 4 SMEs and 8 large industrial companies.
Value Chain: “Three pillars of sustainable development” - not only economic, but also environmental and social impacts

Value Chain - Life cycle thinking

Source: VTT
Value Chain/ Data collection

MANUFACTURING
Technical process

Fibers, kg
Chemicals & fuels, kg
Electricity, MWh
NFC, kg

EMISSIONS
to water kg
to air kg
solid waste kg

Product, 1000 kg
By-products, kg

Source: VTT
Value Chain: Data collection for sustainability assessments

Source: Pöyry, more information published in public SUNPAP Deliverable 2.1 Methodology for assessing nano enhanced new products available in http://sunpap.vtt.fi
NFC production: Intensive and innovative studies in small scale

• Laboratory NFC studies:
  • Optimal pulp raw material and pre-treatment conditions for energy-efficient NFC preparation
  • Hydrophobization of NFC by adsorption of polymers or other chemical modifications
  • Preparation of active NFC with organic molecules and inorganic nano particles

➤ The final target: scale up the technologies to produce natural and functionalized NFC.
NFC Production: SEM and TEM examination of NFC suspension

NFC Processing: Small molecules and nano materials move with water in dewatering

- 90% of the water removed with former roll and loadable blades. Target symmetric dewatering.

Source: Metso
NFC Processing: Coating colour consolidation – small molecules and nano materials move with water – > non-uniform surfaces

- Liquid phase movement in conventional coating due to pressure pulses and capillary absorption

NFC Processing: Applications using both conventional and novel coating methods

Foam applicator
Source: VTT

Curtain applicator
Source: PTS
Future structures with novel surface treatments

- The use of nanocellulose with nano pigments or functional polymers make novel structures possible!

Source: Hellén and Maloney, 2008
Source: Urscheler et al., 2005
Health and Safety: Monthly text mining sentiment comparison of nanotechnology

Health and Safety - Risk assessment

• Methodologies include in vitro and in vivo tests:
  ➢ indications from possible cytotoxicity or systemic effects as well as neurotoxicity.
• As exposure to NFC is likely to be through inhalation:
  ➢ inhalatory toxicity studies on animals

New functionalities and thinner, stronger structures are developed as part of the EUR 9.8 million programme on new nanomaterial-based applications. The project is designed to create new fibre-based and recyclable paper and packaging products which will reduce landfill waste and minimise the use of petroleum-based chemicals.

The SUNPAP (Scaling Up Nanoparticles in Modern Paper Making) project has received funding from the European Community's 7th Framework Programme under the NMP program. The project will address the strengthening of European paper industry competitiveness by means of nanocellulose based processes to provide radical product performance improvements, new efficient manufacturing methods and the introduction of new added value functionalities.

http://sunpap.vtt.fi
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• The research leading to these results has received funding from the European Community’s Seventh Framework Programme under grant agreement n° 228802.

• All SUNPAP partners

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Altogether 22 partners from eight European countries