


Nanotechnology in papermaking – future or present

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What is a nanomaterial?

„Nanomaterial“ means a natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50 % or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm-100 nm.

2011/696/EU – Commission Recommendation from 18.10.2011 on the definition of nanomaterial

What is a nanomaterial?

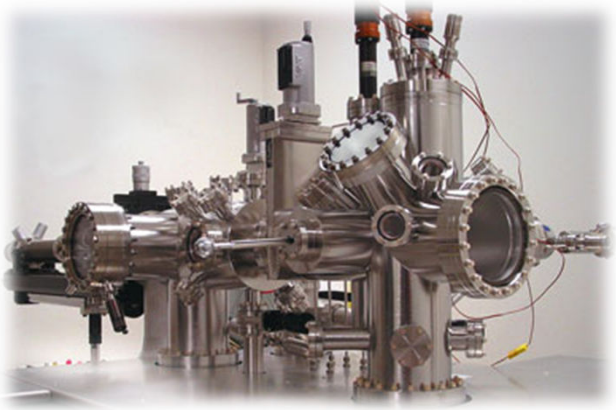
- Examples from nature

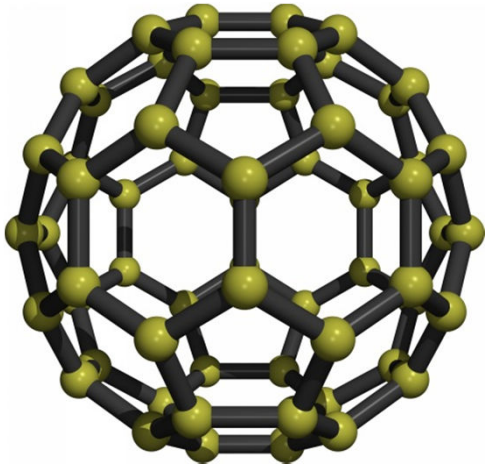
Synthetic nanomaterials

- In use for a long time
  - → colloidal gold
  - → soot in rubber industry
  - → magnetic tapes, magnetic discs

Synthetic nanomaterials

- The beginnings of nanotechnology
  - → 1981 – discovery of scanning tunneling microsope
  - → 1985 – discovery of fullerenes
- Until year 2000:
  - → basic research in field of nanoparticles
  - → production of nanomaterials on a laboratory scale





Synthetic nanomaterials

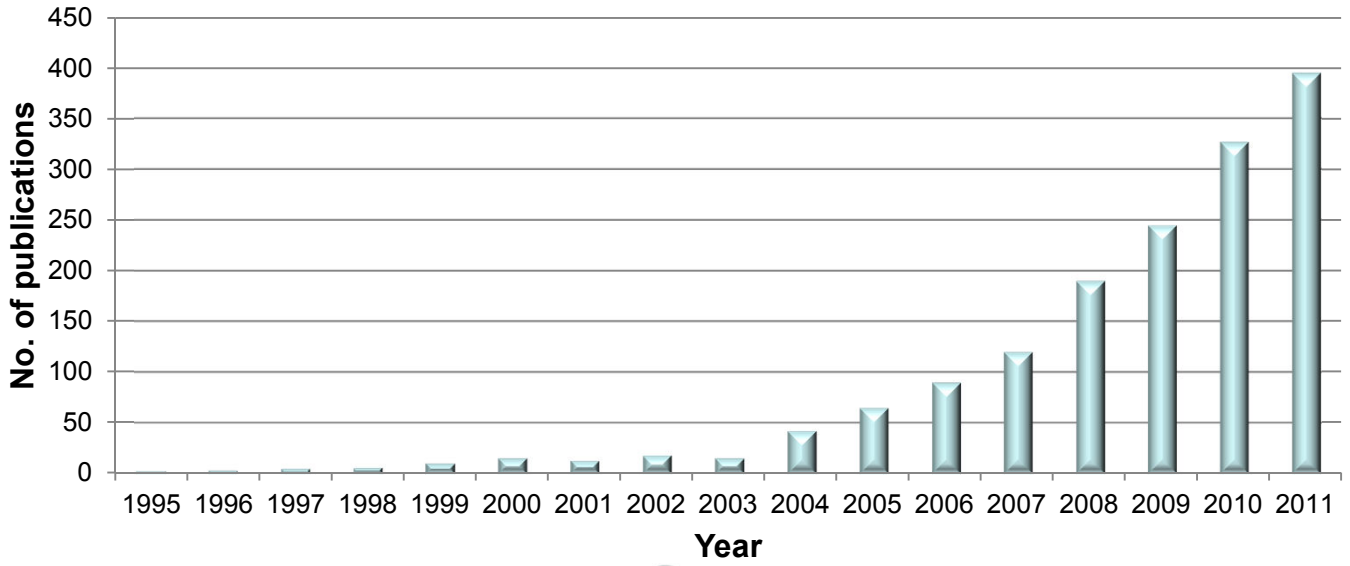
- After year 2000 – first commercial applications
  - → nanosilver – antibacterial additive
  - → titanium dioxide – cosmetics, self-cleaning glass
- Increasing applications in various areas:
  - → chemical industry – main source of nanomaterials, catalysts
  - → new materials with new properties – self-assembly, self-healing properties, improved strength

Nanomaterials in papermaking

- Already in use
  - → natural – e.g. clays
  - → synthetic – e.g. titanium dioxide
- New materials
  - → nanocellulose
  - → nanopigments
  - → polymeric nanomaterials
  - → composites

Nanocellulose

- Probably highest intensity in research
  - → nanocrystalline cellulose (NCC)
  - → nanofibrillated cellulose (NFC)
  - → nanocellulosic fibres (NCF)



Nanocellulose

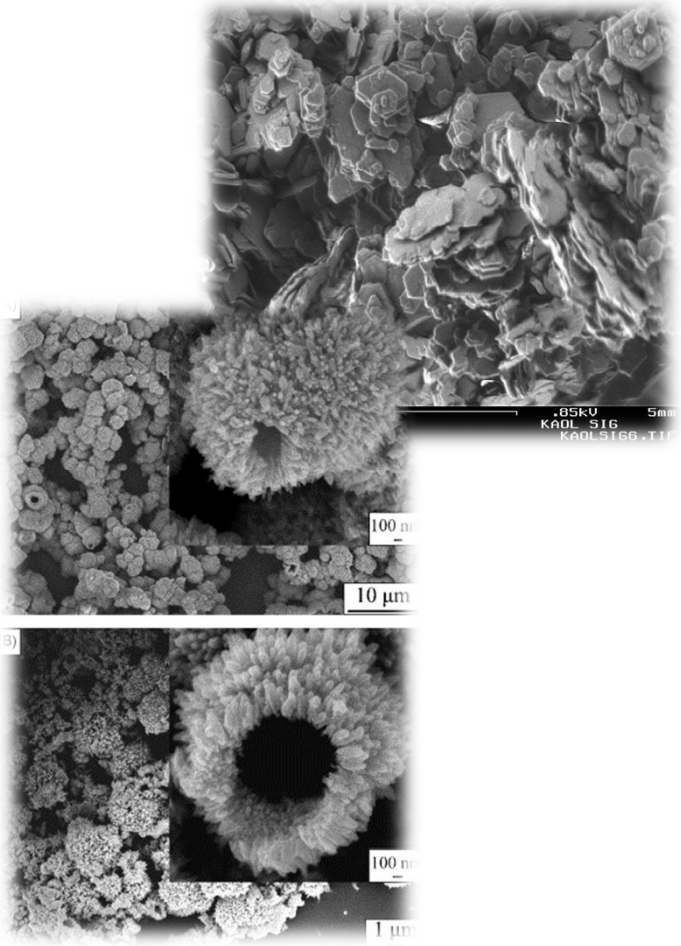
- Main properties
  - → fibre dimensions: d= 10-100 nm, L = 100 nm - 100 µm
  - → high strength
  - → very good thermal stability
  - → high specific surface
  - → transparency
  - → good water absorption
  - → available in various forms

Nanocellulose

- First semi-industrial plant in operation (Celluforce, Windsor, Kanada)
- Potential uses:
  - → improvement of mechanical properties,
  - → partial exchange of binders,
  - → barrier coatings,
  - → packaging materials,
  - → component in composites.

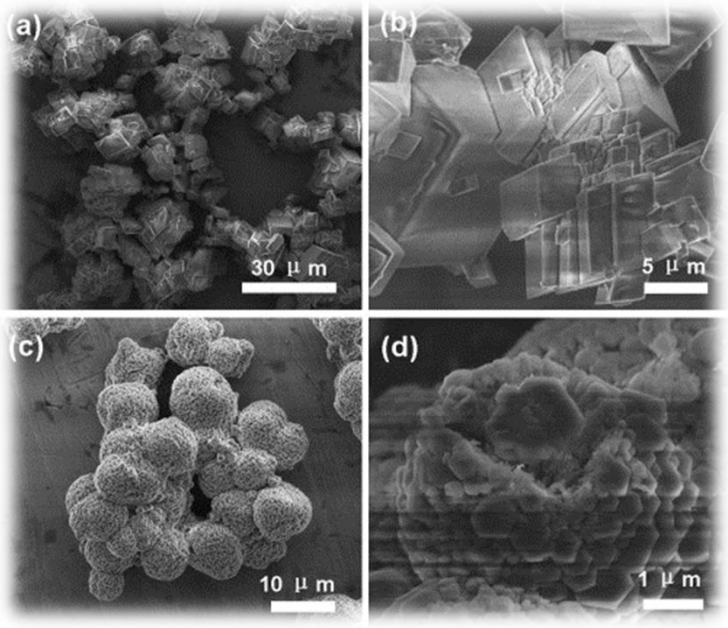
Nanopigments

- Clay
  - → natural clay is already a nanomaterial
  - → improved properties by further processing
- Titanium dioxide
  - → targeted processing for improved properties



Nanopigments

- Calcium carbonate
  - → nano PCC
  - → nanostructured GCC



Nanopigments

- Potential use
  - → as fillers ⇨ to significantly increase the portion of fillers in paper
  - → in coatings ⇨ improved barrier properties, controll of ink penetration
  - → most commonly used in composites

Polymeric nanomaterials

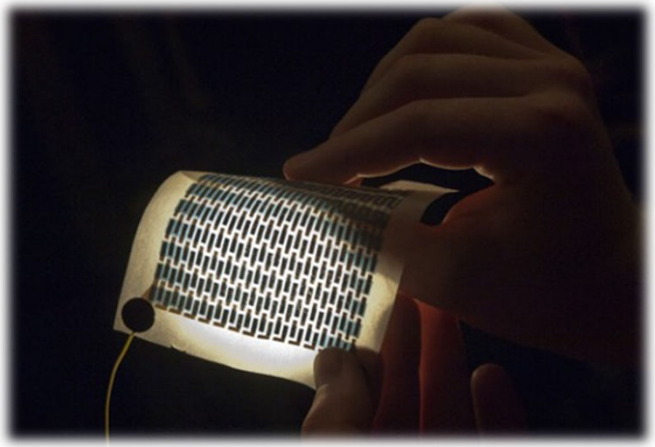
- Micro & nano capsules
  - → these are made of polymeric materials
- Polymeric nanoparticles
  - → self-assembly, self-healing properties
  - → active materials – responding on environmental changes
- Potential use
  - → most commonly in composites
  - → functional layers (barriers, biosensors, chemical sensors)

New properties

- Surfaces treated with nanoparticles
  - → coatings with nanoparticles (Ag, TiO_2)
    - ↳ *antibacterial properties*
    - ↳ *self-cleaning properties*
  - → mikroparticles treated with nanoparticles on surface
    - ↳ *pigment composites*

New properties

- Surfaces treated with nanoparticles
  - → direct application of nanoparticles
    - *barrier properties*
    - *superhydrophobic or superhydrophilic surfaces*
  - → printing with nanoparticles
    - *printed electronics*
    - *printed sensors*



New materials with new properties

- Nanocrystalline cellulose (NCC)
  - → varoius forms, crystals dimensions are in the nm range
  - → used as pure material, as coating or in composites
    - *high strength (stress at brake ~ 200 MPa)*
    - *high stiffness*
    - *good barrier properties against oxygen*

New materials with new properties

- Nanofibrillated cellulose (NFC)
  - → cellulose fibres < 1µm in length, 10 – 100nm in diameter
  - → used as pure material for coating or in composites
    - ↳ e.g. for improving the mechanical properties while increasing the portion of fillers in paper

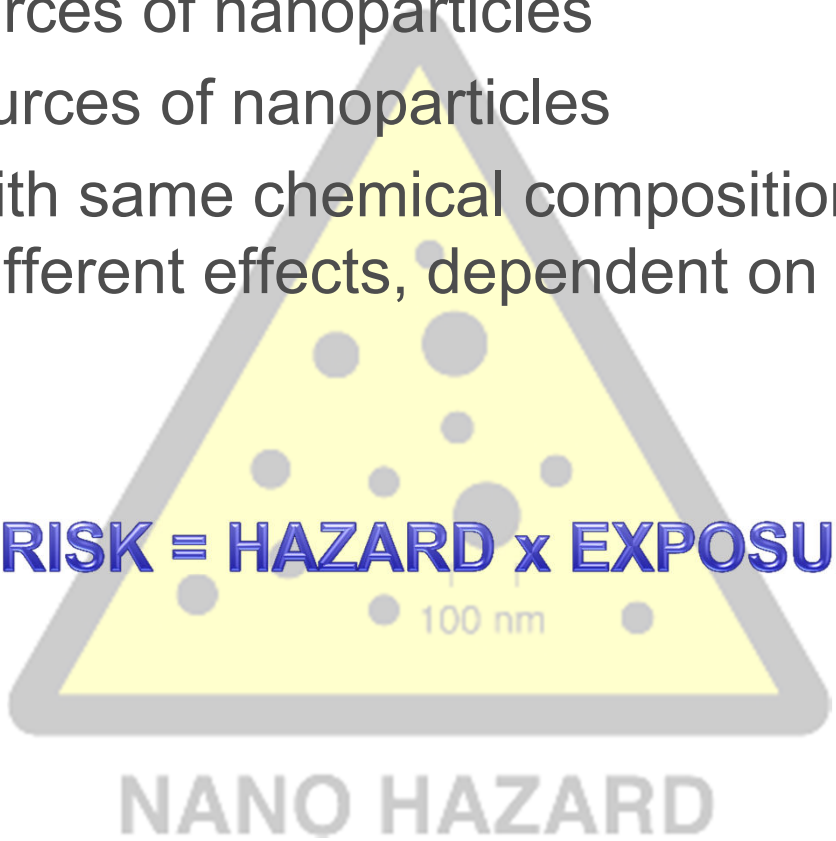
New materials with new properties

- Composites
  - → sinergy of properties of individual materials
  - → new properties can be even better – sinergy on microscopic scale
  - → products with high added value
  - → increased portion of renewable materials in final product

Safety of nanomaterials

- Natural sources of nanoparticles
- Artificial sources of nanoparticles
- Although with same chemical composition, the materials can have different effects, dependent on their size

RISK = HAZARD x EXPOSURE



Safety of nanomaterials

- Classical approach to risk assessment isn‘t sufficient
- Standards are not defined yet
- There is a need for comprehensive risk assessment in terms of:
  - → material itself
  - → converting steps
  - → material‘s intended use
  - → final treatment, disposal
- Combination of risk assessment and LCA

Conclusions

- Nanomaterials are present in nature.
- Synthetic nanomaterials are relatively new.
- The properties of nanomaterials are significantly different and are thus opening new fields of use.
- Nanomaterials are „multifunctional“ materials ⇨ can be used for various products.
- Because of their properties they can represent a potential risk ⇨ risk assessment.

Questions?

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