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LCA of Nanotechnological Products

What's the issue?

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LCA of nanotechnological products

-What's the issues?

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Nanotechnology

An enabling technology –
 Meaning it provides the possibilities to see
 and manipulate nanosized structures

Great potential for “smart” multifunctional
 and high-performance products for
 innumerable commercial and
 industrial applications.

Sector/Application	Chemical	Environmental
Automotive	Lightweight construction, Catalysts, Painting, Tires; Sensors; Windshield and body coatings	Environmental monitoring; Soil and groundwater remediation; Toxic exposure sensors; Fuel changing catalysts; Green chemistry
Construction	Materials; Insulation; Flame retardants; Surface coatings; Membranes	Household
Electronics	Displays; Data memory; Laser diodes; Fiber optics; Optical switches; Filters; Conductive, antistatic coatings	Sports
Engineering	Protective coatings for tools, machines; Lubricant-free bearings	Warfare
Food and Drink	Packaging; Storage life sensors; Additives; Juice clarifiers	Textiles
Medicine	Drug delivery systems; Contrast medium; Rapid testing systems; Prostheses and implants; Antimicrobial agents; In-body diagnostic systems	
Textiles	Surface coatings; “Smart” clothes (antiviral, stain resistant, temperature controlled)	

(Lekas, 2005)

Improved functionality of materials
 Improved efficiency of energy production and use
 Remediation and sensing
 Health sciences improvements
 Reducing use of chemicals
 Improved information and communication

Toxicological risks
 Use of scarce resources
 Waste in top down production
 Energy demand in production
 High requirement to materials and chemicals
 Rebound effects
 Disassembly and recycling

How to find the balance for environmental benefits?

Production processes

Ultra clean room requirements?
 Material specification, e.g.
 •high purity chemicals
 •high quality and purity bulk materials
 Data estimation routines necessary (initially)
 Anticipated high energy usage, and
 large waste production (in top down production)
 Inclusion of capital equipment?

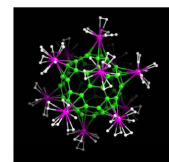
- PVD
- CVD
- Sol gel
- Flame assisted deposition
- Flame hydrolysis
- Molecular imprinting
- Lithography
- Spin coating
- Etc.

Data is missing!

Uncertainties!

Nano products

New functionalities
 Additional benefits to technical function
 Definition of functional unit
 Rebound effects?



Three-dimensional Scandium (pink) C₆₀ (green) complex. Dillon et al., 2006. Mater. Res. Soc. Symp. Proc. Vol. 895

Raw materials

Increased usage of rare elements
 Depletion of scarce resources?
 Impact assessment of resources required
 Data for Mining!

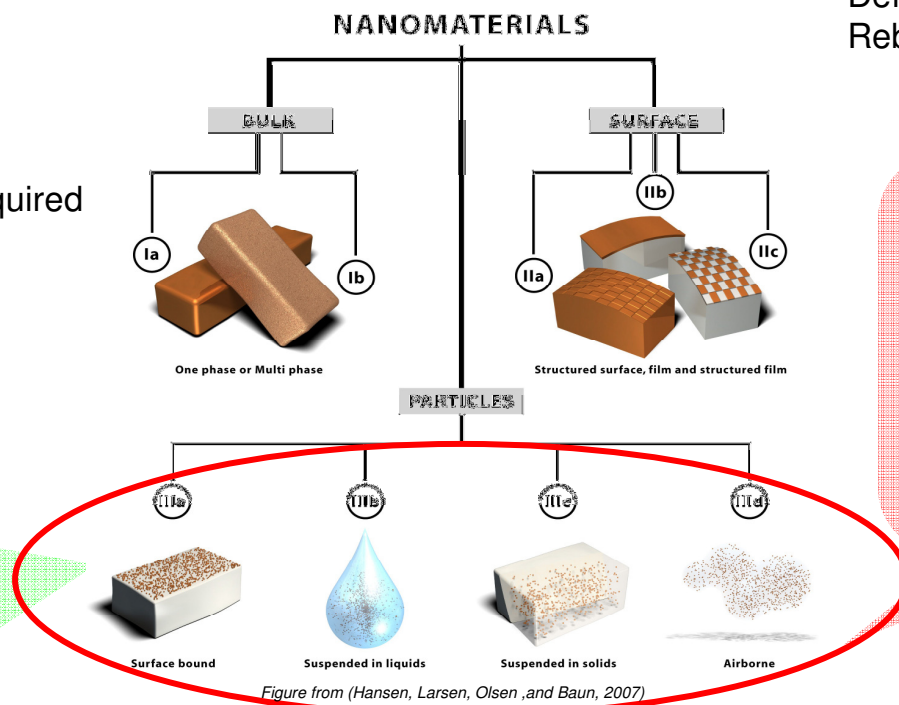


Figure from (Hansen, Larsen, Olsen, and Baun, 2007)

Inventory issues for Nanoparticles

Definition, nomenclature and classification
 Emission paths and volume
 Measurement and characterisation techniques

Disposal

Difficulties in disassembly and recycling
 Waste related problems with nanoparticles
 Knowledge about behaviour of “nano” waste

Life Cycle Impact Assessment of nanoparticles

Fate and transport?
 Uptake and mobility in organisms
 Toxicological mechanisms?
 Dose-response relationship?

Need for simplified sensitivity assessments or worst case scenarios?

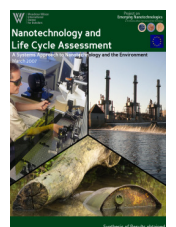
- Determining parameters?
- Size (surface area, size distribution)
 - Chemical composition (purity, crystallinity, electronic properties etc.)
 - Surface structure (surface reactivity, surface groups, coating etc.)
 - Solubility
 - Shape
 - Aggregation

Information flow and cooperation with risk assessment community needed!

Stig Irving Olsen

Case studies needed!

A joint US –EU workshop identified a number of LCA and nanotechnology related issues and came up with recommendations for the further work (Klöpper et al., 2007)



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