Wat is nanotechnologie en welke zijn de mogelijke gezondheidseffecten voor de werknemers

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Overview

• Introduction:
  – Definition: Nanomaterials – ultrafine particles?
  – Use of nanomaterials
  – Safe Nanomaterials

• Issues in NanoToxicology?
  – Role of size (nano versus larger)
    • Surface
    • Systemic delivery
  – Role of shape
    • One material different shapes
    • CNT ....

• Conclusions
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• Conclusions
Definition?

- European Academy at Bad Neuenahr: “Nanotechnology (therefore man-made) is dealing with functional systems based on the use of subunits with specific size dependent properties of the individual sub-units or of a system of those.”
  - very general; no exact size ≠ 100 nm
  - excludes non purpose made materials such as soot and dust.

- Nanoparticle: one dimension <100 nm (and larger than 1 nm)
  - Spherical
  - Rods & Tubes
  - Surfaces
Do we “need” nanotechnology
Do we “need” nanomaterials

- **Materials**: Light as plastic, strong as steel
- **Water**: Clean water any time, any place
- **Medicine**: Smart drugs that kill the disease, not the person
- **Energy**: “PowerPlastic™ that converts light to energy - anywhere”
Definition?

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- Nanomaterials: one dimension <100 nm (and larger than 1 nm)
  - Spherical
  - Rods & Tubes
  - Surfaces
≠ Nano materials
≠ Nano particles

**Origin**
- natural
- unintentionally released
- manufactured („old“, „new“)

**Chem. composition**
- metals/ metal oxides
- polymers, carbon
- semiconductors
- biomolecules
- compounds ...

**Dispersion in**
- gases (aerosols)
- liquids (e.g. gels, ferrofluids)
- solids (e.g. matrix materials)

**Nanoparticulate Materials**
- Nanocapsules
- Ultrafine Aerosols
- Quantum dots
- Nanoparticles
- Nanotubes

**Shape/Structure**
- spheres
- needles
- platelets
- tubes

**Aggregation state**
- single particles
- aggregates
- agglomerates

**Surface modification**
- untreated (as obtained in production process)
- coated (e.g. conjugates, polymeric films)
- core/shell particles (e.g. spheres, capsules)
Nanotechnology = fast evolving

1st: Passive nanostructures (1st generation products)
   a. Dispersed and contact nanostructures. Ex: aerosols, colloids
   b. Products incorporating nanostructures. Ex: coatings; nanoparticle reinforced composites; nanostructured metals, polymers, ceramics

2nd: Active nanostructures
   a. Bio-active, health effects. Ex: targeted drugs, biodevices
   b. Physico-chemical active. Ex: 3D transistors, amplifiers, actuators, adaptive structures

3rd: Systems of nanosystems
   Ex: guided assembling; 3D networking and new hierarchical architectures, robotics, evolutionary

4th: Molecular nanosystems
   Ex: molecular devices ‘by design’, atomic design, emerging functions

~ 2000
~ 2005
~ 2010
~ 2015-2020

Risk Governance Frame 1
Frame 2
USE: What is produced?

www.nanotechproject.org/inventories/consumer/analysis_draft/

Major Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Number of Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver</td>
<td>259</td>
</tr>
<tr>
<td>Carbon</td>
<td>82</td>
</tr>
<tr>
<td>Zinc</td>
<td>30</td>
</tr>
<tr>
<td>Silicon/Silica</td>
<td>35</td>
</tr>
<tr>
<td>Titanium</td>
<td>50</td>
</tr>
<tr>
<td>Gold</td>
<td>27</td>
</tr>
</tbody>
</table>
USE: Main applications?
www.nanotechproject.org/inventories/consumer/analysis_draft/

Product Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Mar 8, 2006</th>
<th>Aug 25, 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health and Fitness</td>
<td>605</td>
<td></td>
</tr>
<tr>
<td>Home and Garden</td>
<td>152</td>
<td></td>
</tr>
<tr>
<td>Electronics and Computers</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>Food and Beverage</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>Cross Cutting</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Automotive</td>
<td>68</td>
<td></td>
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<tr>
<td>Appliances</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>Goods for Children</td>
<td>19</td>
<td></td>
</tr>
</tbody>
</table>

23 Februari 2010  Nanotechnologie en gezondheid op de werkvloer
Safe nanomaterials?

Risk characterization

- Hazard Evaluation (toxicity)
- Dose response relation
- Exposure evaluation

Risk assessment

Systematic scientific characterisation of potential adverse health effects resulting from human exposure to hazardous agents (or situations).
Safe nanomaterials?

Risk characterization

Hazard Evaluation (toxicity)  Dose response relation  Exposure evaluation

Risk assessment

Does nano play a role in Hazard? Exposure?
Overview

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• **Conclusions**
Issues in NanoToxicology: SIZE

1 µM
= 0.000 001 m
= 0.001 mm
= 1 000 nm

diameter

0.01 µM = 10 nm diameter

0.1 µM = 100 nm diameter
Issues in NanoToxicology: SIZE

- Existing molecule e.g. TiO2
  - Known in microsize (low toxicity)
  - Now in nanosize ....?

New risk assessment?
Yes – No?

Why yes – Why no?
Nanotechnology and health on the workplace

Oberdörster et al. Environmental Health Perspectives, 113, 2005
Size plays a role!

Amorphous monodisperse silica: In press: Napierska et al Small 2008
<table>
<thead>
<tr>
<th>Diameter (µm)</th>
<th>Nº particles</th>
<th>Surface area (µm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>$19 \times 10^6$</td>
<td>$6 \times 10^6$</td>
</tr>
<tr>
<td>0.05</td>
<td>$153 \times 10^6$</td>
<td>$120 \times 10^6$</td>
</tr>
<tr>
<td>0.1</td>
<td>$19 \times 10^6$</td>
<td>$600 \times 10^6$</td>
</tr>
<tr>
<td>0.5</td>
<td>$153 \times 10^6$</td>
<td>$120 \times 10^6$</td>
</tr>
<tr>
<td>1.0</td>
<td>$19 \times 10^6$</td>
<td>$60 \times 10^6$</td>
</tr>
</tbody>
</table>
Issues in NanoToxicology: SIZE

- Existing molecule e.g. TiO2
  - Known in microsize
  - Now in nanosize

New risk assessment? Probably Yes

Why?
- Different (more) toxicity
  - Surface & reactivity!
- ?
Bioavailability: deposition in lung

Inhalation of particles ≠ deposition

Figure 6
Regional deposition of inhaled NP with diameters between 1 nm and 1000 nm for nose and for mouth breathing in the extrathoracic airways (ET), the bronchial airways (Bb) and the alveolar region (Al) during breathing at rest, as predicted by ICRP 66 model (ICRP, 1994).
Systemic uptake of nanomaterials after inhalation in humans

Inhalation of $^{99m}$Tc-carbon particles ("Technegas")

Issues in NanoToxicology: SIZE

- Existing molecule e.g. TiO2
  - Known in microsize
  - Now in nanosize

New risk assessment? Probably Yes
Why?
- Different (more) toxicity
  - Surface?
- Systemic delivery
  - Higher/different internal exposure/dose
Issues in NanoToxicology: SHAPE

Nano-ZnO: One chemistry, many shapes
Courtesy of Prof. Z.L. Wang, Georgia Tech

23 Februari 2010
Nanotechnologie en gezondheid op de werkvloer
SHAPE plays a role

- **Delivery**
  - Inhalation
  - Skin penetration

- **Mechanical damage**
  - Needle vs spheres

- **Time of exposure**
  - Excretion & Biopersistent
Carbon nanotubes introduced into the abdominal cavity of mice show asbestos-like pathogenicity in a pilot study

CRAIG A. POLAND¹, RODGER DUFFIN¹, IAN KINLOCH², ANDREW MAYNARD³, WILLIAM A. H. WALLACE¹, ANTHONY SEATON⁴, VICKI STONE⁵, SIMON BROWN¹, WILLIAM MACNEE¹ AND KEN DONALDSON¹*

Nature Nanotechnology May 20 2008
Nature Nanotechnology May 20 2008

[Graphs and data from the paper on inflammation and granuloma responses to nanofibers]
Absence of Carcinogenic Response to Multiwall Carbon Nanotubes in a 2-Year Bioassay in the Peritoneal Cavity of the Rat

Julie Muller,* Monique Delos,† Nadtha Panin,* Virginie Rabolli,* François Huaux,* and Dominique Lison*†

*Industrial Toxicology and Occupational Medicine Unit, Catholic University of Louvain, 1200 Brussels, Belgium; and †Laboratory of Pathology, University Hospital of Mont-Godinne, Catholic University of Louvain, 5530 Yvoir, Belgium

Received April 8, 2009; accepted April 30, 2009

- Crocidolite (positive controls) → expected carcinogenic response
- No clear evidence of a similar activity for MWCNT

- The negative response to MWCNT in the study → critically interpretation + and calls for further studies
  - Different nanotube preparations
  - Different dosing regimens
  - Other bioassays
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Conclusion: Safe nanomaterials

Risk characterization

| Hazard Evaluation (toxicity) | Dose response relation | Exposure evaluation |

Risk assessment

Each chemical entity ➔ more than one evaluation!
There is no universal “nanoparticle” to fit all the cases

Physico-chemical characteristics
Crystal structure, Size, aggregation, dissolution, …

Exposure & delivery micro vs nano
+ (Correct) test conditions
Thank You For Your Attention