

Nanosilver in Consumer Products

Dr. Andrea Haase
Experimental Research (FG73)

Fields of Competence

Biological Safety

Safety of Substances & Preparations

Food Safety

Safety in the Food Chain

Safety of Consumer Products

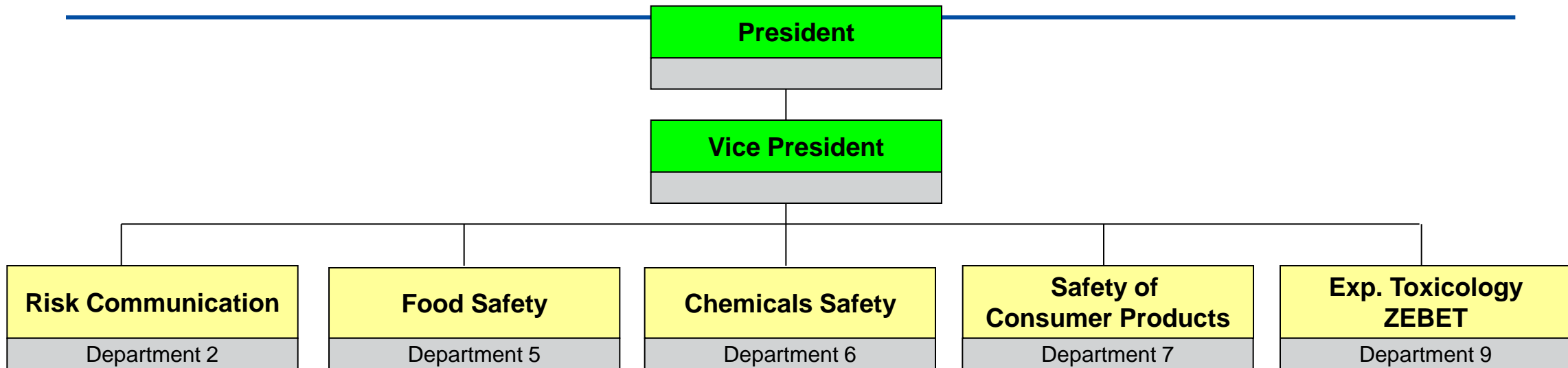
Experimental Toxicology & ZEBET



Risk Communication



BfR Departments involved in „nano activities“



➤ Risk Assessment

(expert reports, opinions according to internationally recognized scientific criteria)

➤ Work in National & International Bodies

(committees & panels, working groups)

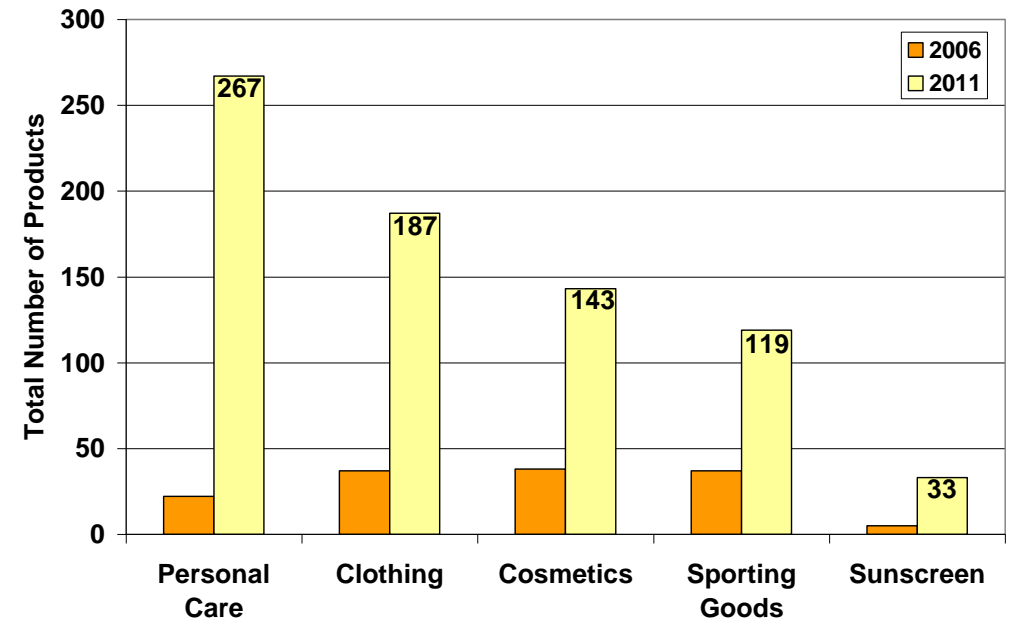
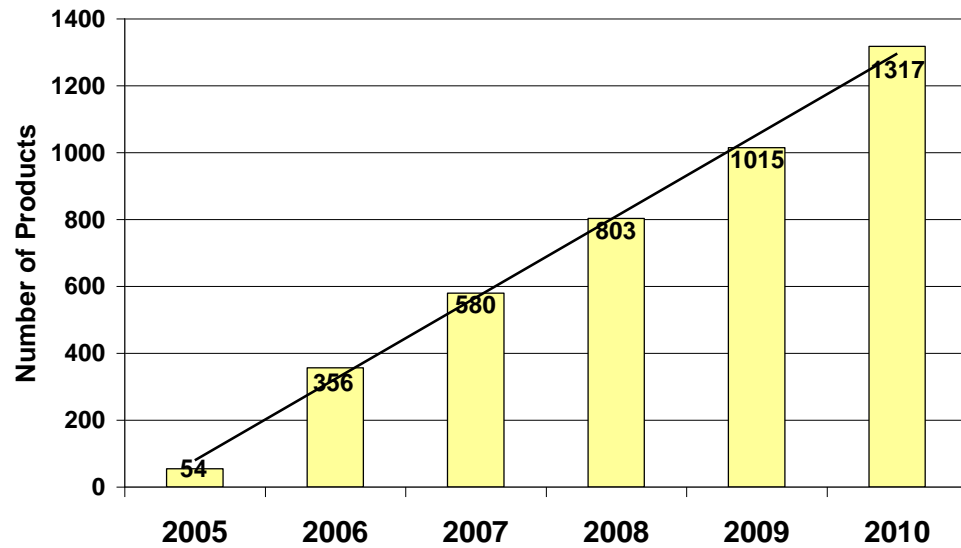
➤ Research Activities & Cooperations

(primarily to strengthen risk assessment processes)

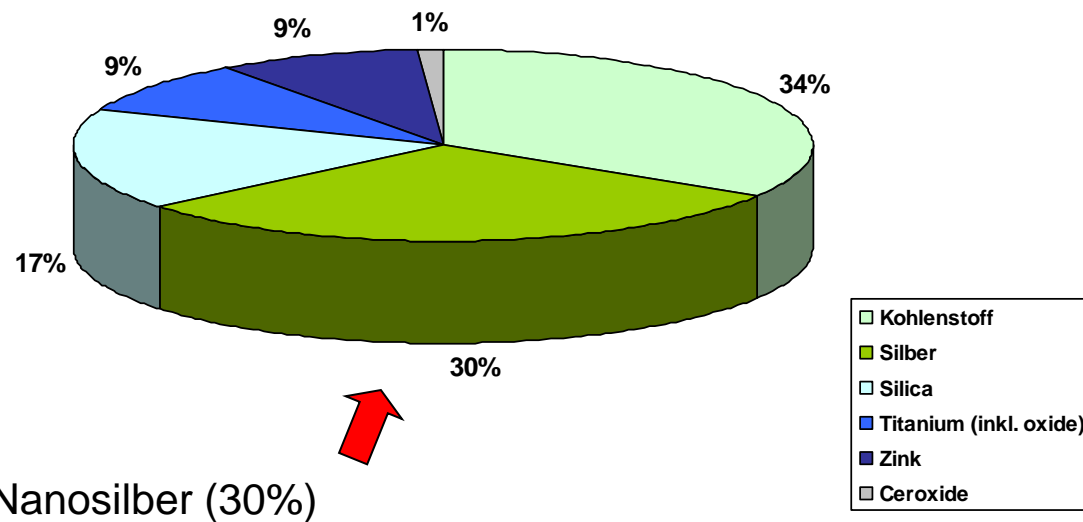
➤ Risk Communication

(informing the public in a transparent, comprehensive way)

Total number of products claiming to contain “nano”



Woodrow Wilson Inventory



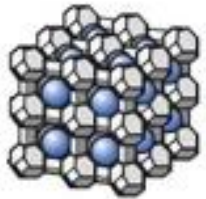
Silver used in Consumer Products and Food: Different Usage Forms



Bulk Material



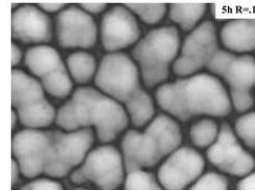
Silver wires
Different thicknesses



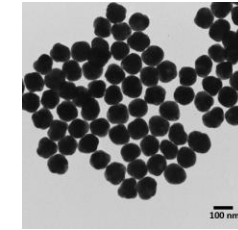
Zeolite A with Silver Ions
Embedded in Polymers



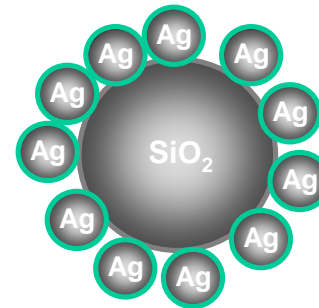
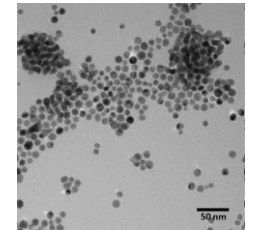
Silver Ions
Silver Nitrate
ACS Grade
Silver Nitrate



Surface with Silver Coating
Metalized **finishings of different thickness**



Silver Nanoparticles:
OECD silver:
a) 75 nm Citrate Capped,
b) 10 nm PVP Capped



Nanosilver composite



Colloidal Silver
Solution of elemental **silver in the size of 1 - 1000 nm**

Product categories

Cosmetic Products



Personal Care



Food Contact Materials



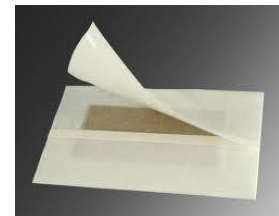
Food Additives/ “Supplements”



Textiles



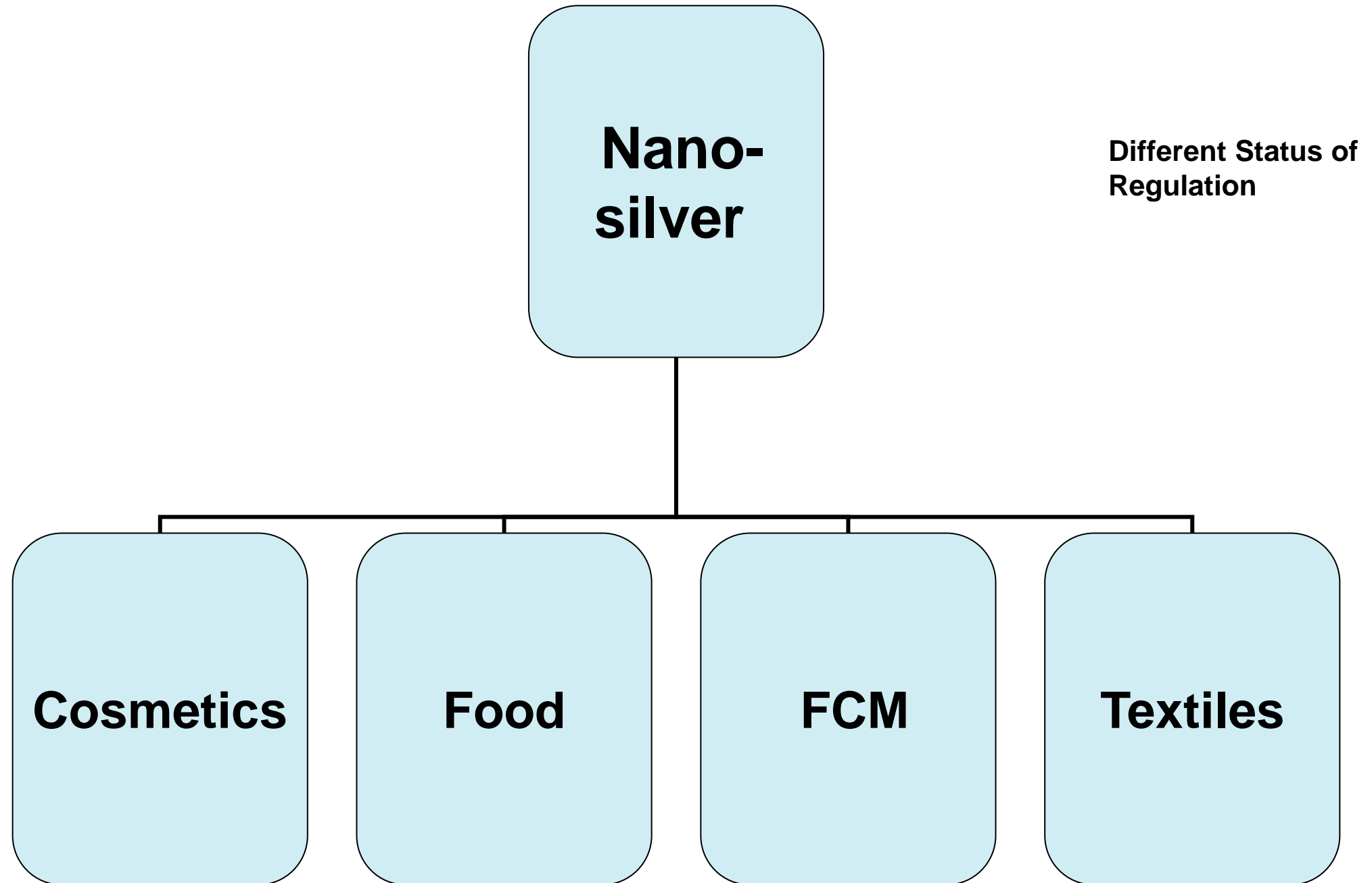
Medical



Machines

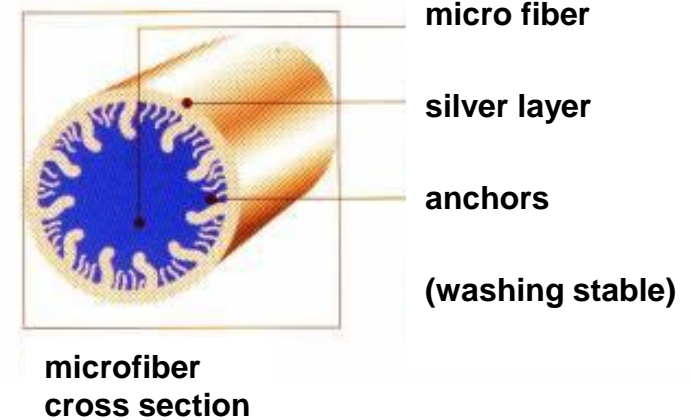


Main application areas of “nanosilver”

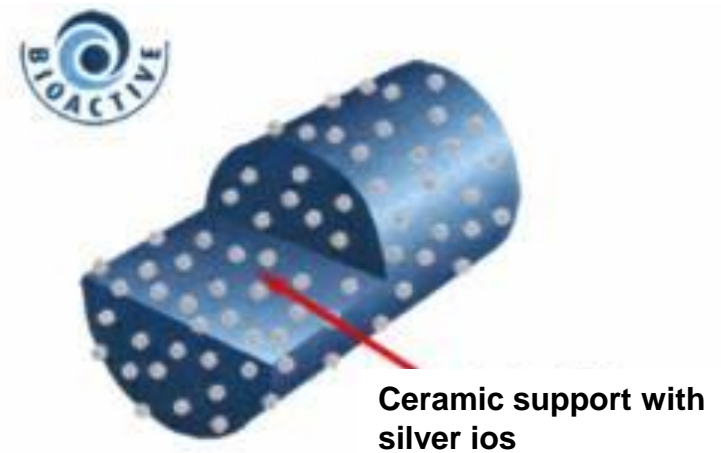


Textiles

- **Silver coated Fibres**



- **Fibres with embedded silver**



Source: Lauffenmühle)

Nanomaterials in Textiles – (No) Regulation

- Textiles: No EU wide accepted definition, only a academic – industry consortium created definition
- Textiles: No Regulation – neither EU nor National (exception: biocides such as silver regulated via Biocidal Directive)

Situation:

- no register existing
- no approval necessary (exception silver due to biocidal activity)
- no labelling necessary (exception silver due to biocidal directive)

Cosmetic Products

Examples for Nanosilver containing cosmetics

- ❖ **Cremes**
- ❖ **Shampoo**
- ❖ **Soap**
- ❖ **Tooth paste**
- ❖ **Antiperspirants**

Regulation in Cosmetic Sector

➤ Cosmetic products:

Definition for Nanomaterials: existing

'nanomaterial' means an **insoluble or biopersistent** and intentionally manufactured material with **one or more external dimensions**, or an **internal structure**, on the scale from **1 to 100 nm**;

➤ Cosmetic products:

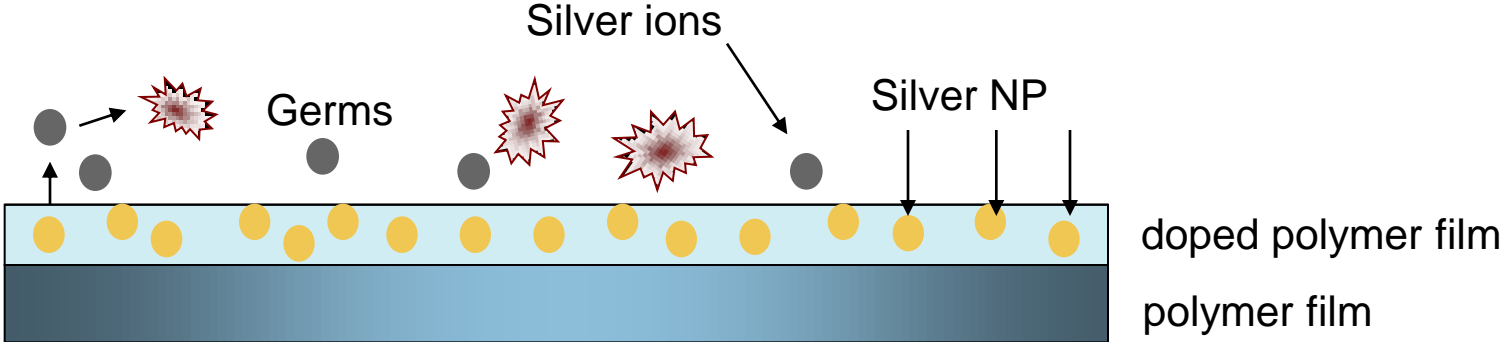
Regulation (EC) No 1223/2009
(**Article 16**; applicable 2013)

Situation:

- ❖ Information on ingredients
- ❖ Data on exposure on the individual compounds
- ❖ *In-vitro* Tests on formulations
- ❖ Data for humans (if available)
- ❖ **Risk assessment dossier**
- ❖ Product Labelling (beginning 2013)

Duty of the manufacturer!

Food Contact Material – Anti-microbial coating



without
nanosilver

with
nanosilver



Sources: Langowski, 2010;
Bellucci, Nanodialog, 2008

Food Contact Material – Self sterilizing polymer

- Generation of NP:
 - plasma flame reaction:

$\text{Ca}_3(\text{PO}_4)_2$ NP, 20-50 nm



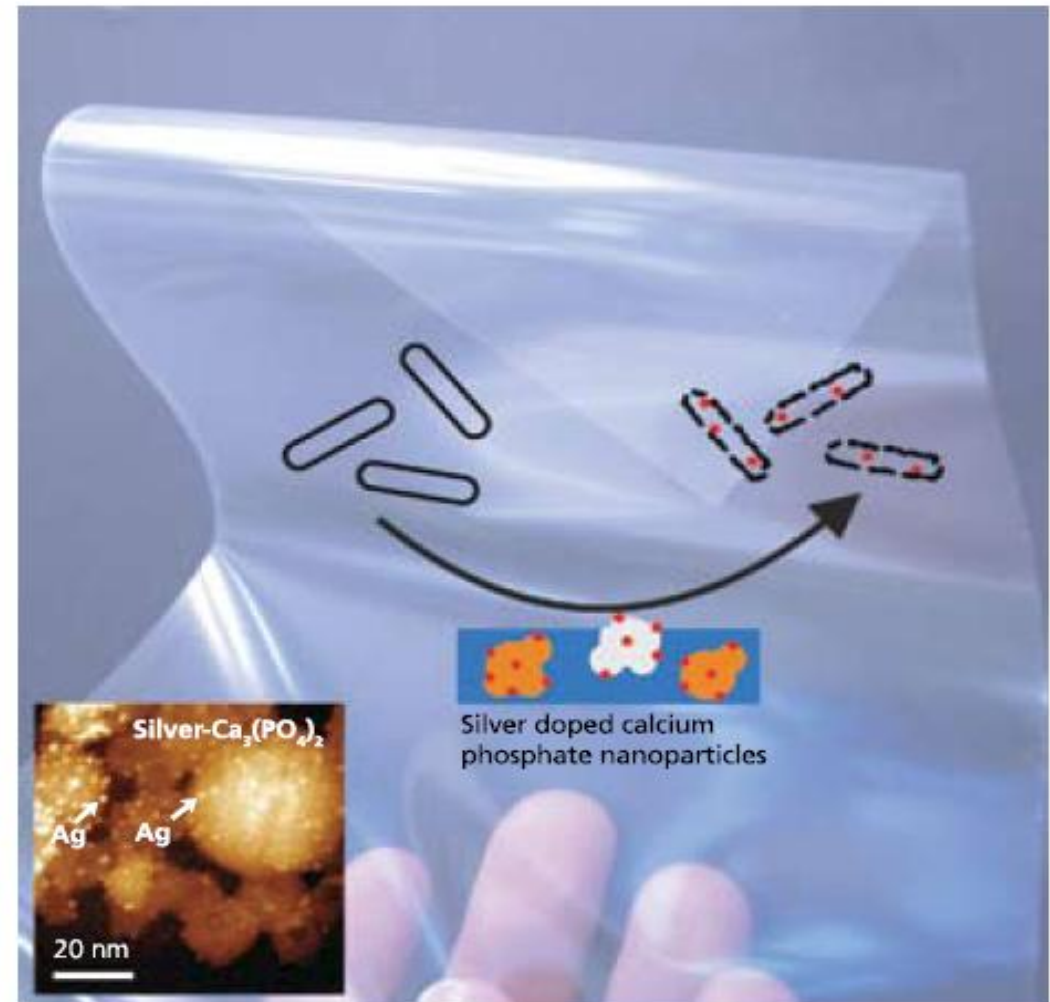
Nanosilver particles, 1-2 nm

Metal salt complexes embedded in plastic film

1000 x more effective against *E. coli* as conventional films using Ag as antimicrobial agent

Proposed mode of action:

E. coli: ingestion of $\text{Ca}_3(\text{PO}_4)_2$ during growth period, consumption of $\text{Ca}_3(\text{PO}_4)_2$, release of Ag NP



Loher et al. (2008) Microorganism-triggered release of silver nanoparticles from biodegradable oxide carriers allows preparation of self-sterilizing polymer surfaces. *Small* 4, 824 - 832

Regulation for Food Contact Materials

- FCM: **Regulation (EC) No 1935/2004**
(**Article 3**; Article 11, **Article 2**)

Definition for Nanomaterial: not existing

“Article 2. Substances in **nanofom** shall only be used **if explicitly authorized and mentioned** in the specifications in Annex I.”

Regulation (EC) 10/2011 (“PIM”),
(replaces 2002/72/EC), applicable 01.05.2011

Definition for Nanomaterial: not existing
but, mentions Nanoparticle and importance of particle size

Situation:

- no register existing
- approval only in certain cases
- no labelling necessary

FCM: **Not** Assessed by EFSA

Silver – nanoscale

- Use: Surface biocide or antimicrobial active component
- Activity: „Nanosilver“ particle on the surface, release of silver ions
- Assessment:
 - ⇒ **No** EFSA-Assessment for silver nanoparticles and silver nanoparticle composites
 - ⇒ **Not** included in national lists for substances intended to come into contact with food

SOME Silver compounds – **bulk form**, macro scale are **assessed**

- Use: Surface biocide in plastic materials intended for the food contact
- Activity: Release of silver ions
- Assessment: The EFSA Journal (2004) 65, 1-17 & (2005) 201, 1-28

Food

- Approved food colour for sweets (silver coating) E 174 silver shining effect, **not nano** (Colour!)
- Migration from food contact materials
- Colloidal silver (“food supplement”)



Regulation for Food

- Food: Additives: Definition for Nanomaterial: not existing but, mentions nanoparticles and importance of particle size
- “Novel Food”: Definition for Nanomaterial: existing

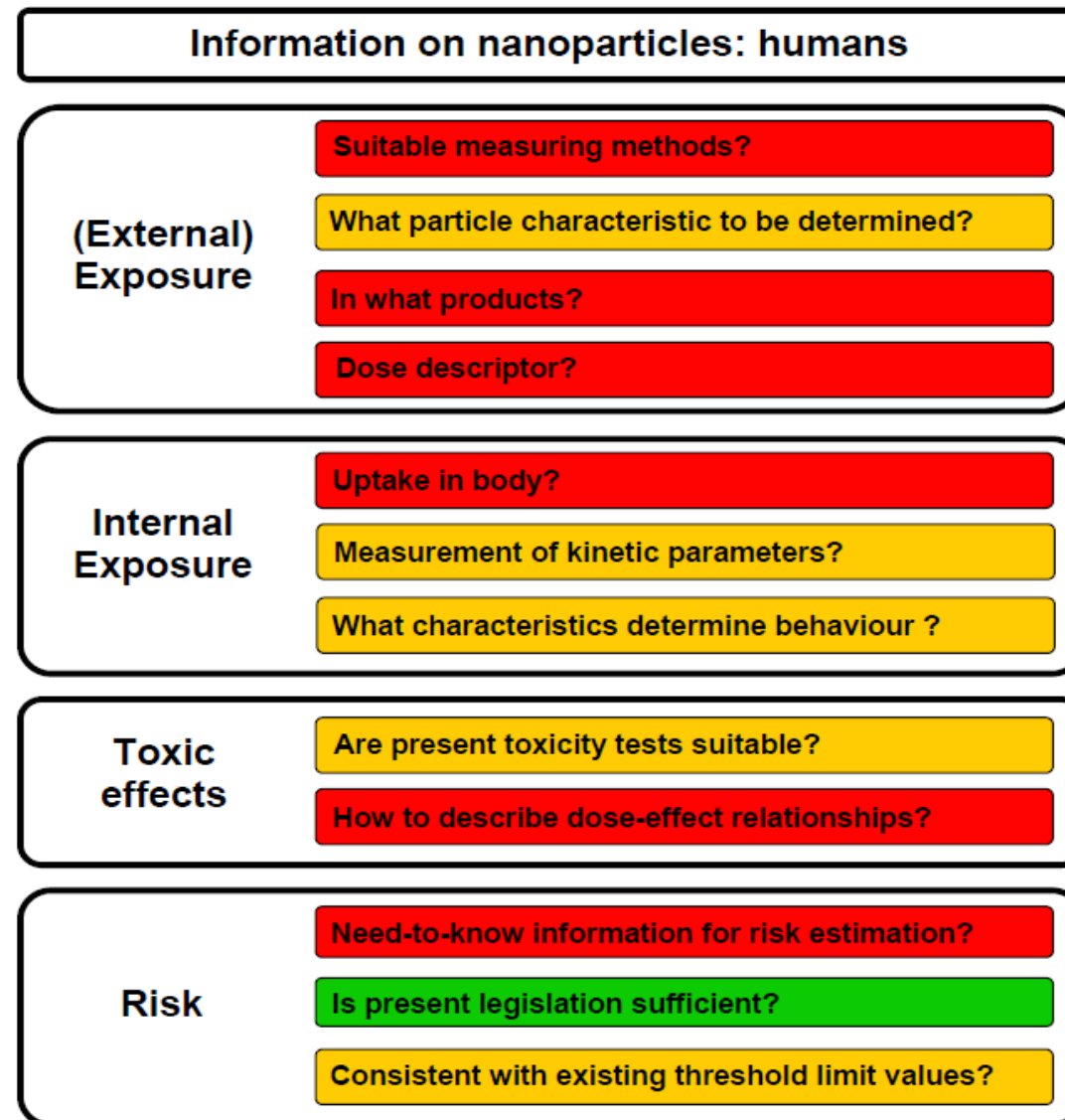
"engineered nanomaterial" means any intentionally produced material that has **one or more dimensions** of the **order of 100 nm** or less or that is composed of discrete functional parts, either internally or at the surface

- Food: Additives: Regulation (EC) No 1333/2008 (**Article 12** & 14)
- “Novel Food”: Regulation (EC) No 258/97 (3. Reading 1 Q 2011)

Risk Assessment:

Hazard x Exposition

Most significant knowledge gaps



Exposure dependents on:

Free nano-particles

- Example: DIY Surface treatment, e.g. nano-silver (cleaning products, also in possible contact with food)
- **In which form: Spray, Creme etc.**

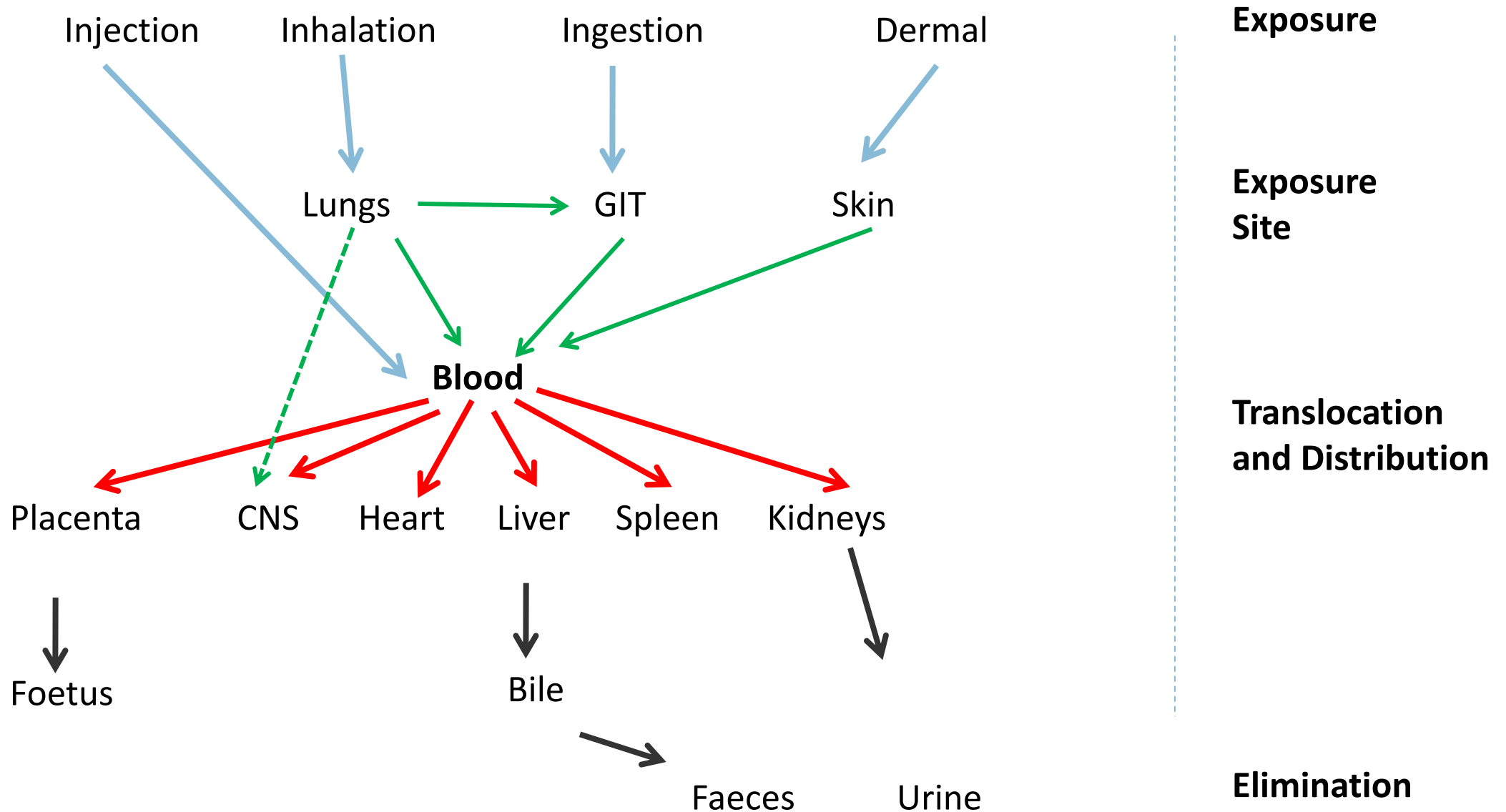
Surface bound nano-particles

- Example: Surface coating of polypropylene (storage) boxes

Matrix embedded nano-particles

- Example: Nano-clay incorporated in polymer layer, middle layer of multilayer foils

Nanosilver: different ways of Exposure



Adapted from Oberdoerster 2005

Hazard dependents on:

Particle Size (1- 100 nm) (primary/ agglomerate size)

- *in vitro* studies: silver causes size dependent effects (viability, ROS)
(Hussain et al. 2005. *Toxicol In Vitro* 19:975-983), (Carlson et al., 2008. *J Phys Chem B*, 112 (43).13608-13619)
- *in vivo* studies: no size dep difference in some studies (10 vs 25 nm, 15 vs 60 nm)
(oral **28d**: Kim et al. 2008 *Inhal. Tox.* 20, 575-83; **90d**: Kim et al. 2010 *Part & Fibre Tox* 20, 7)
(inhalation, acute: Sung et al. 2010, **28d**: Ji et al. 2007 *Inhal. Tox* 19, 857-871; **90d**: Sung et al. *Inhal. Tox.* 20, 567-74)
- *in vivo* studies: size dep uptake in other studies (oral) (10 vs 75 vs 110 nm)
(FDA pharmacokinetic study i.v. and oral; FDA ADME study oral: size dep. uptake)

Particle Surface/ Coating (e.g. Citrate, polymers, polysaccharides)

- *in vitro* studies: bioavailability (dissolution) & stability depends on coating
(Braydich-Stolle et al. 2010 *Toxicol. Sci.*, 116 (2), 577-589)
- *in vivo* study: no difference (Citrate vs no coating), (Ju and coworker)

Shape (e.g. spheres, rods, wires, plates)

Charge (depend. on coating)

How meaningful are nanotoxicological studies?

TOXICOLOGICAL HIGHLIGHT

How Meaningful are the Results of Nanotoxicity Studies in the Absence of Adequate Material Characterization?

David B. Warheit¹

DuPont Haskell Global Centers for Health and Environmental Sciences, Newark, Delaware

Received November 6, 2007; accepted November 6, 2007

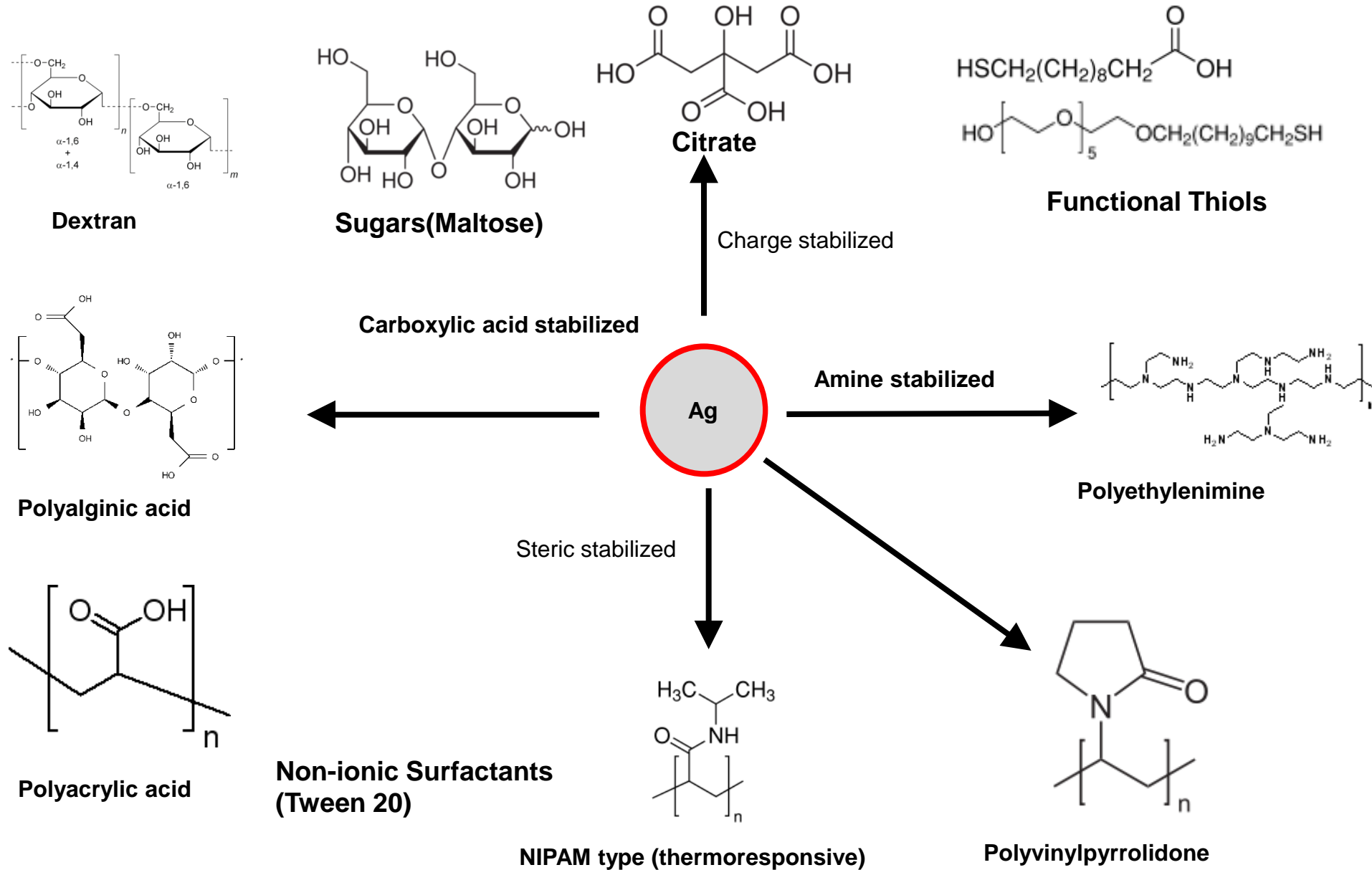
Do nanoparticle properties change under exposure situation?

Size: Agglomeration? Dissolution?

Surface: Stability of coating? Adhesion of biomolecules?

Need for appropriate in situ characterization techniques!

Coatings used for nanosilver:



BfR Opinion on Nanosilver

Uncertainties:

- To what extent are consumers exposed to nanoscaled silver particles? Release, Uptake?
- What kind of effects of nanosilver in the human body?
- How great is the potential to develop resistance toward silver and the spread of resistance toward silver or antibiotics?

BfR recommends that nano-silver is not used in foods and everyday products

BfR Opinion Nr. 024/2010, 28 December 2009

Manufacturers of foods, cosmetics or everyday products have long been taking advantage of the antimicrobial properties of silver ions. Lotions may contain silver salts as preservatives and refrigerators or athletic socks and other textiles are equipped with silver compounds in order to inhibit the growth of germs or avoid the development of odours. In recent times, nanoscale silver compounds have also increasingly been used for these purposes. The Federal Institute for Risk Assessment (BfR) finds that a conclusive assessment of health risks associated with the widespread use of nano-silver is not possible at this time.

BfR Opinion # 024/2010

„BfR recommends manufacturers to avoid the use of nanoscaled silver or nanoscaled silver compounds in foods and everyday products until data are comprehensive enough to allow for conclusive risk assessment ensuring that products are safe for consumer health.“

Thank you for your attention

Dr. Andrea Haase

Federal Institute for Risk Assessment

Max- Dohrn Strasse 8-10 • D-10589 Berlin

Tel. +49 30 - 184 12 – 3423

andrea.haase@bfr.bund.de • www.bfr.bund.de

Overview on literature and data on nanosilver

Nano-silver- a review of available data and knowledge gaps in human and environmental risk assessment (2009) Wijnhoven et al., *Nanotoxicol.*

Nanomaterials under REACH- Nanosilver as a case study (2009) Pronk et al, *RIVM report 60178003/2009*

Aschberger et al, (2011) Analysis of currently available data for characterising the risks to environment and human health. Four case studies. *Environment International*

Christensen et al, (2010) Nano-silver, feasibility and challenges for human health risk assessment based on open literature, *Nanotoxicology*

Johnston et al, (2010) A review of the in vivo and in vitro toxicity of silver and gold particulates *Critical reviews in Toxicology*

EPA Nanomaterial case study (2010): Nanosilver in disinfectant spray

Food Contact Materials: Assessed by EFSA

* Group restriction: 0.05 mg Ag/kg food, based on the human NOAEL of about 10 g of silver for a total lifetime oral intake allocated by WHO (WHO, 2004) for drinking water.

Name of the substance:	Ref. No.	EFSA Opinion
Silver chloride (20% w/w) coated onto titanium dioxide (80% w/w)	86430	16 th list of substances for FCM Group restriction of 0.05 mg Ag/kg food * http://www.efsa.europa.eu/en/efsajournal/pub/555.htm
Silver-containing glass (Silver-magnesium-calcium-phosphate-borate)	86432	4 th list of substances for FCM Group restriction of 0.05 mg Ag/kg food * http://www.efsa.europa.eu/en/efsajournal/pub/65a.htm
Silver containing glass (silver-magnesium-aluminiumphosphate-silicate), silver content less than 2%	86432/ 20,	12 th list of substances for FCM Group restriction of 0.05 mg Ag/kg food * http://www.efsa.europa.eu/en/efsajournal/pub/395.htm
Silver containing glass (silver-magnesium-aluminiumsodium-phosphate-silicate-borate), silver content less than 0.5%	86432/ 40	12 th list of substances for FCM Group restriction of 0.05 mg Ag/kg food * In accordance with other boron compounds the biocide Ref No86432/40 will be subject to a group SML of 6 mg B/kg food http://www.efsa.europa.eu/en/efsajournal/pub/395.htm
Silver containing glass (silver-magnesium-sodiumphosphate), silver content less than 3 %	86432/ 60	12 th list of substances for FCM Group restriction of 0.05 mg Ag/kg food * http://www.efsa.europa.eu/en/efsajournal/pub/395.htm

Food Contact Materials: Assessed by EFSA

* Group restriction: 0.05 mg Ag/kg food, based on the human NOAEL of about 10 g of silver for a total lifetime oral intake allocated by WHO (WHO, 2004) for drinking water.

Name of the substance:	Ref. No.	EFSA Opinion
Silver Zeolite A (Silver zinc sodium ammonium alumino silicate), silver content	86437	7 th list of substances for FCM Group restriction of 0.05 mg Ag/kg food * Maximum content in polymer: 10% (w/w) of silver zeolite A containing ≤ 5% silver. Only for repeated use articles made from polyolefins (up to 40°C for contact times below 1 day) and for poly(alkylene terephthalate) based polymers (up to 99°C for contact times below 2 hours) http://www.efsa.europa.eu/en/efsajournal/pub/201a.htm
Silver-zinc- aluminium – boron – phosphate glass, mixed with 5-20% barium sulphate, silver content 0.35 – 0.6 %	86437/50	7 th list of substances for FCM Group restriction of 0.05 mg Ag/kg food * Group restriction: 1 mg Ba/kg food Group restriction: 6 mg B/kg food Maximum content in plastic: 1% (w/w) http://www.efsa.europa.eu/en/efsajournal/pub/201a.htm
Silver zinc zeolite A (silver-zinc sodium alumino silicate calcium metaphosphate), silver content 1 - 1.6 %	86438	7 th list of substances for FCM Group restriction of 0.05 mg Ag/kg food * http://www.efsa.europa.eu/en/efsajournal/pub/201a.htm
Silver zinc zeolite A (silver-zinc sodium magnesium alumino silicate calcium phosphate), silver content 0.34 - 0.54 %	86438/50	7 th list of substances for FCM Group restriction of 0.05 mg Ag/kg food * http://www.efsa.europa.eu/en/efsajournal/pub/201a.htm