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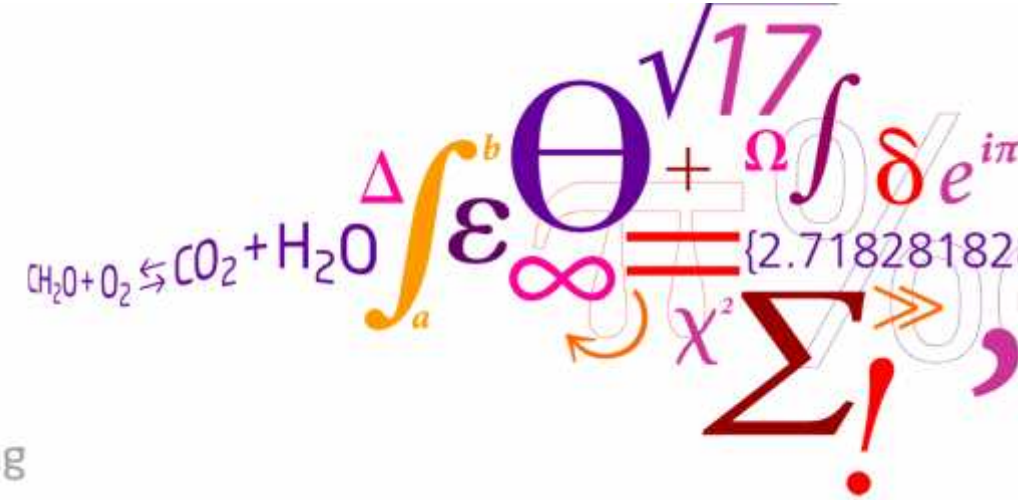
Technical University of Denmark DTU

Current state of knowledge when it comes to consumer exposure to nanomaterials embedded in a solid matrix

Aiga Mackevica & Steffen Foss Hansen



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Outline

- ENMs in consumer products & their potential release
- Consumer exposure estimation according to EU guidelines (ECHA R.15)
- Focus of the study
- Literature review
- Consumer exposure assessment
- Challenges & perspectives

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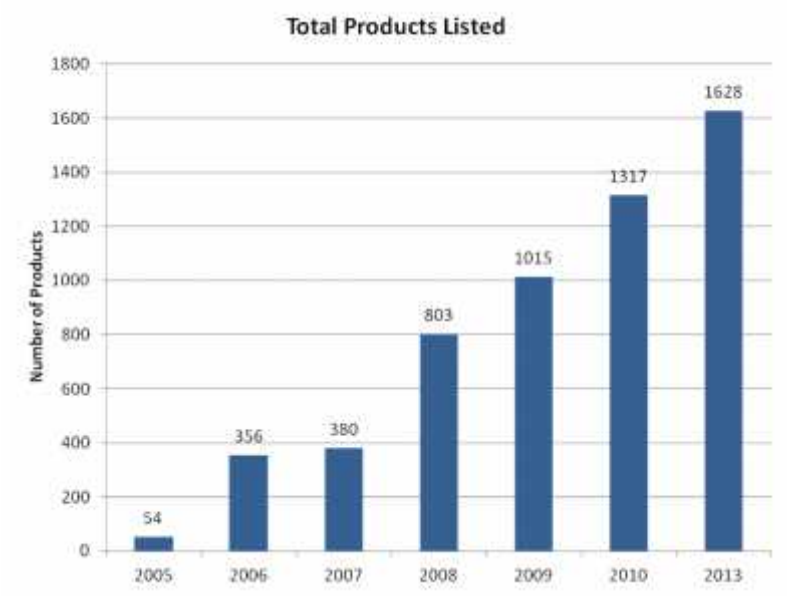
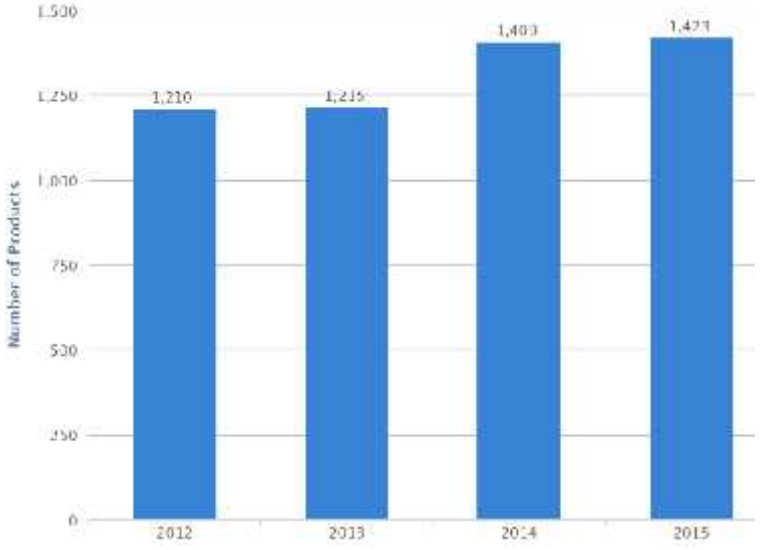
ENMs in consumer products

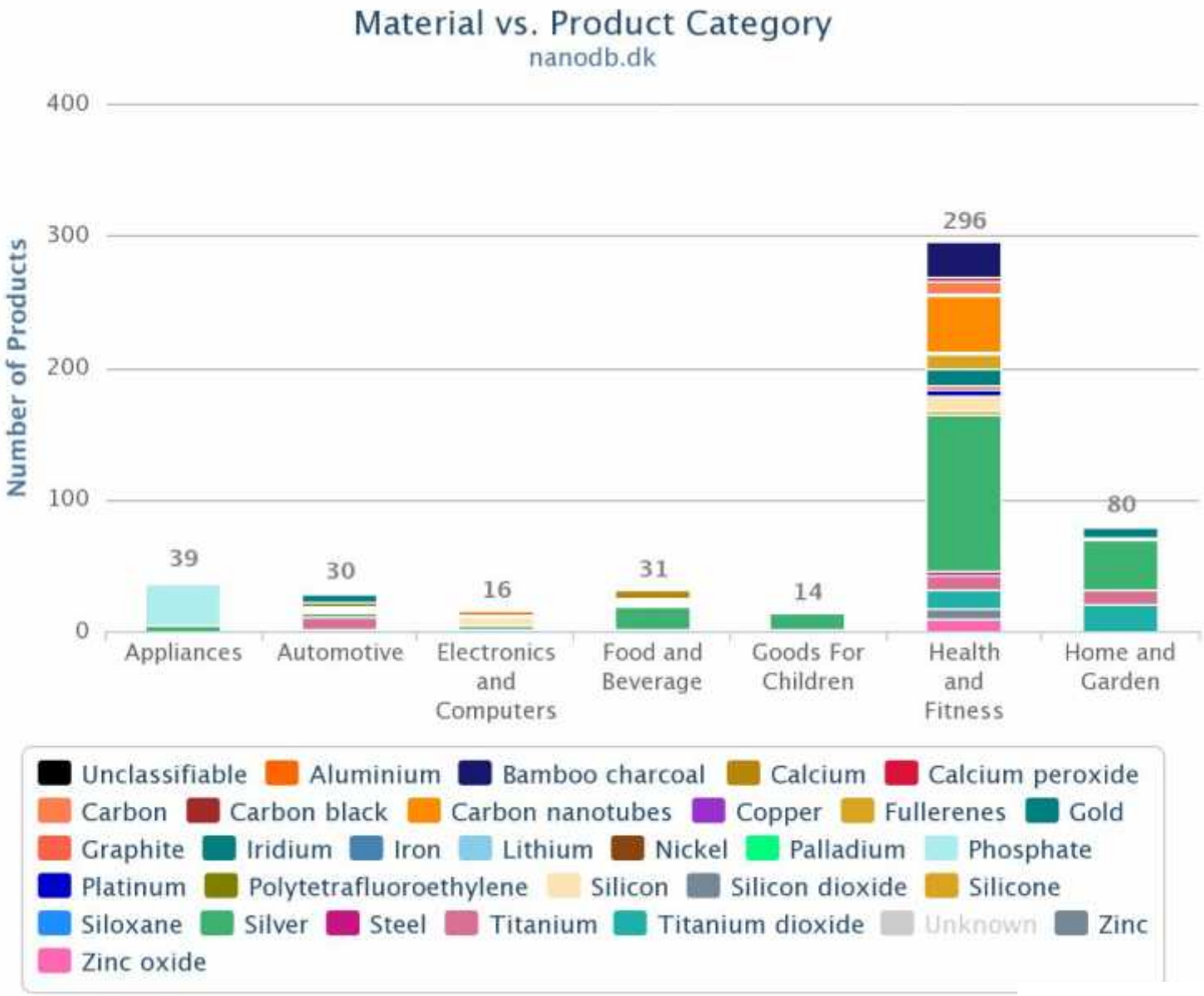
- Many nano-enabled consumer products on the market (nanodb.dk, Woodrow Wilson)



www.nanotechproject.org



www.nanodb.dk

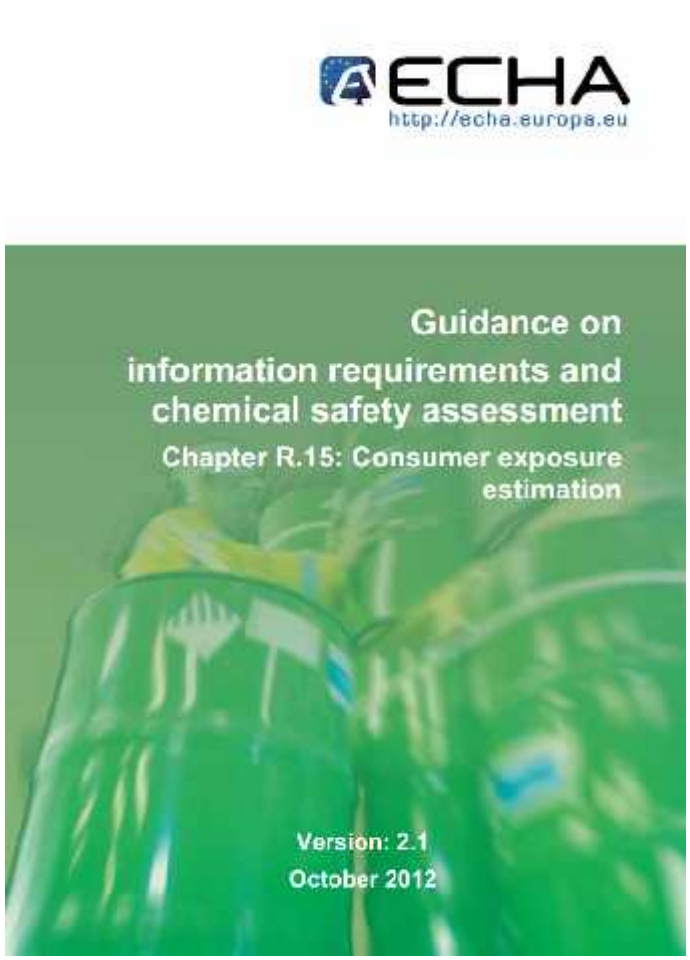


www.nanodb.dk


Element Location vs. Product
nanodb.dk
Number of Products
1,000
800
600
400
200
0
Airborne
Film
Multiphase
Powder
Structured film
Surface bound
Suspended in liquid
Suspended in solid
Unknown

ECHA Guidance document: R.15

- Describes information requirements with regard to substance properties, exposure, use and risk management measures, and the chemical safety assessment
- Stepwise procedure for consumer exposure assessment estimation for chemicals on their own, in mixtures, or in articles
- Provides models for consumer inhalation, dermal and oral exposure assessment



http://echa.europa.eu/

The problem

- A lot of work is focusing on effects of ENMs, but very little is known about actual exposure
- Many consumer products may lead to potential release from the product matrix - that can cause environmental and human exposure
- Data on quantified release are lacking

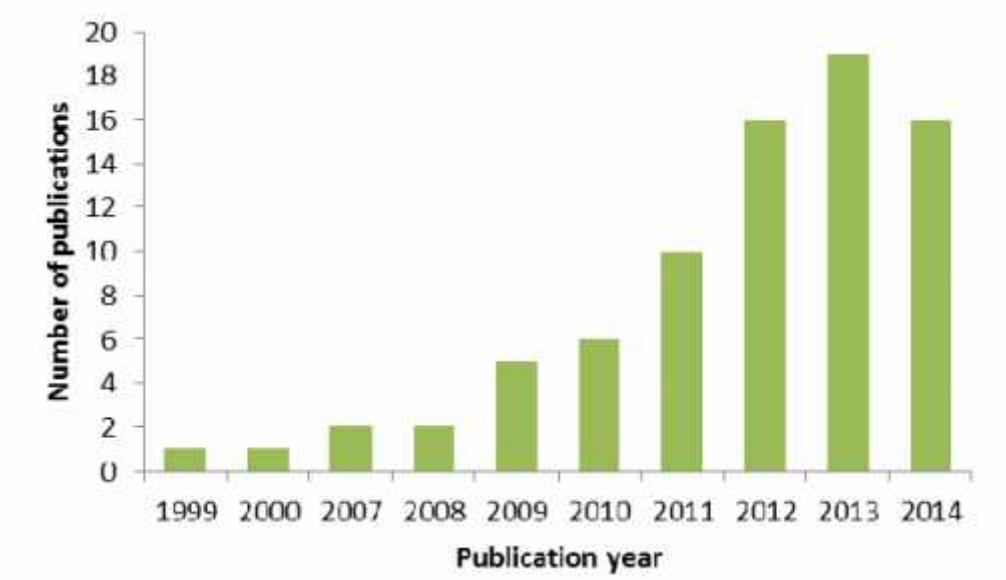
Focus of the study

- To investigate whether the experimental data in the literature can be used to fulfill the ECHA requirements for consumer exposure estimation

- To identify and discuss key data needs

Literature review

- Studies investigating release from materials that contain nanoparticles in a solid matrix
- ISI Web of Knowledge and cross-referencing
- 78 studies identified (as of Dec.2014)



Literature review

Studies were sorted according to:

- ENM
- Product group
- Experimental setup
- Relevant exposure route
- Results (ENMs in products and released)
- ENM characterization & quantification tools

ENM	Product	Release setup	Potential exposure	Analysis	Total content in product	ENM in product	Quantified total release	ENM released	Reference
Ag	Paint, façade panel	Leaching	Env.	ICP-MS TEM XRD	1.5mg m^{-2} (wet paint 6.2mgAg kg^{-1})	NR	0.5mg m^{-2} y^{-1} 30% loss	Single particles < 15 nm attached to the organic binder, some aggregates	**(Kaegi *et al.*, 2010)**
Ag	Fabrics	Leaching in sweat (AATCC pH 4.3)	Dermal	GF-AAS SEM-EDS TEM-EDS	36.12 ± 22.42 mg kg^{-1}	Not measured	21.01 ± 4.13 mg kg^{-1} 24h at 37° C	Not measured	**(Kulthong *et al.*, 2010)**
		Leaching in sweat (ISO pH 5.5)					15.53 ± 3.62 mg kg^{-1} 24h at 37° C	Not measured	
		Leaching in sweat (ISO pH 8.0)					34.27 ± 2.88 mg kg^{-1} 24h at 37° C	Not measured	
	Fabrics (lab A2)	Leaching in sweat (AATCC pH 4.3)			56.57 ± 34.28 mg kg^{-1}	Not measured	33.39 ± 15.80 mg kg^{-1} 24h at 37° C	Not measured	
		Leaching in sweat (ISO pH 5.5)					28.81 ± 10.34 mg kg^{-1}	Not measured	
		Leaching in sweat (ISO pH 8.0)					66.54 ± 46.29 mg kg^{-1}	Not measured	

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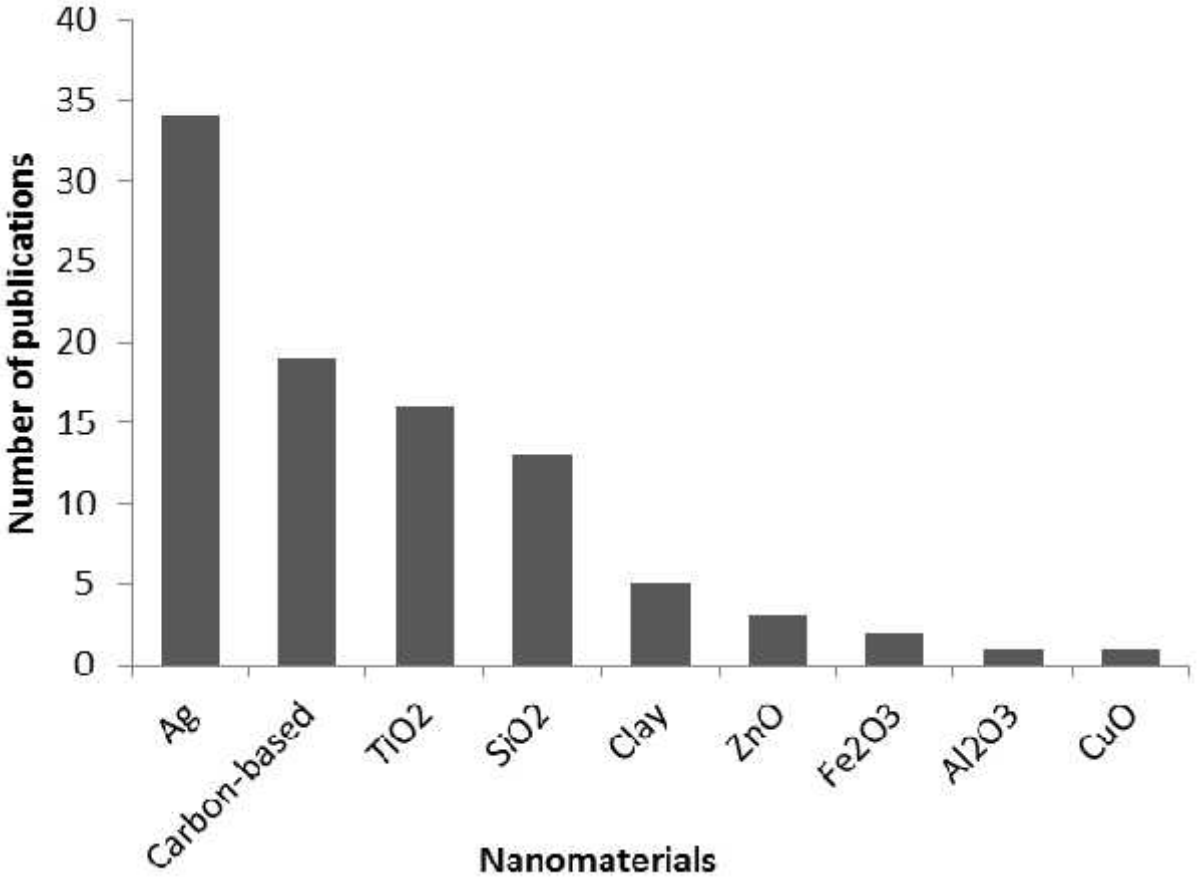
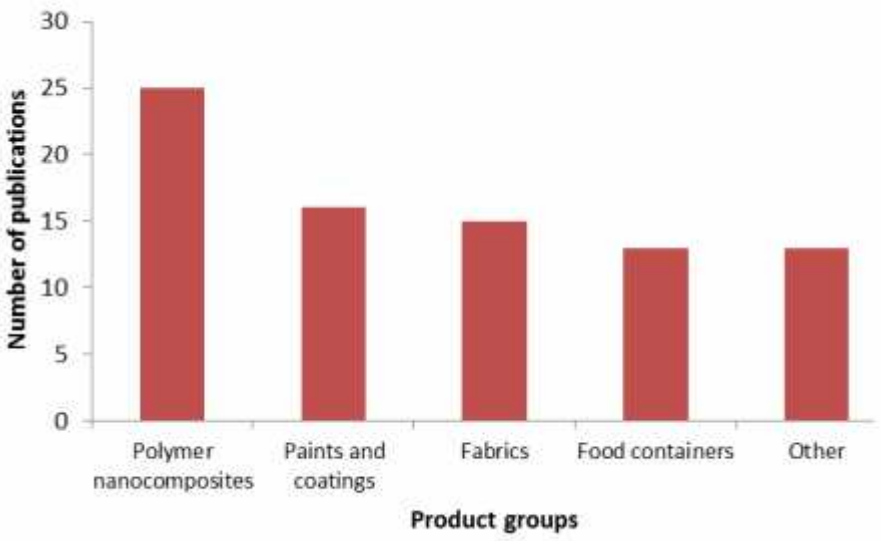
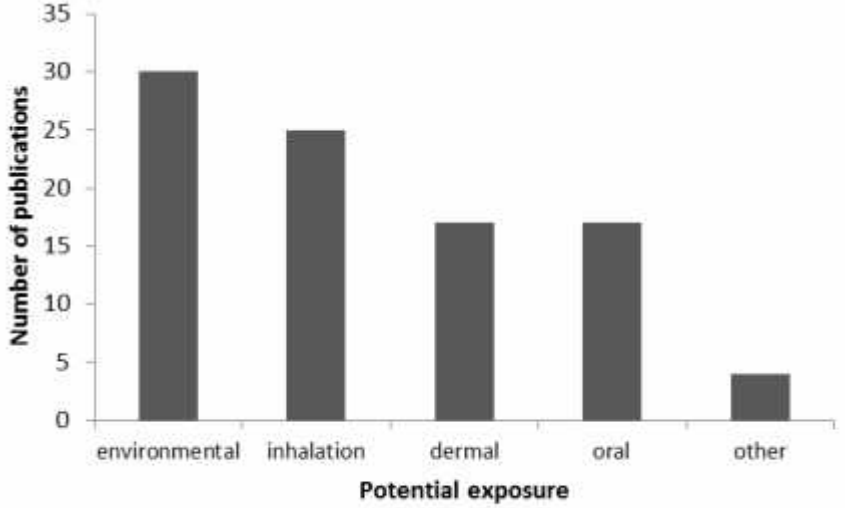

Number of publications
40
35
30
25
20
15
10
5
0
Ag
Carbon-based
TiO2
SiO2
Clay
ZnO
Fe2O3
Al2O3
CuO
Nanomaterials

Products & potential exposure





R.15 Consumer exposure estimation

- Inhalation

$$D_{inh} = \frac{F_{resp} \cdot C_{inh} \cdot IH_{air} \cdot T_{contact}}{BW} \cdot n$$

D_{inh} – Inhalatory dose (intake) of substance per day and body weight [$mg \cdot kg_{bw}^{-1} \cdot d^{-1}$]
F_{resp} – Respirable fraction of inhaled substance (default =1) [-];
C_{inh} – Concentration of substance in air of room [$mg \cdot m^{-3}$];
IH_{air} – Ventilation rate of person [$m^3 \cdot d^{-1}$];
$T_{contact}$ – Duration of contact per event (default 1 day) [d];
BW – Body weight [kg]

R.15 Consumer exposure estimation

- Dermal

$$D_{der} = \frac{L_{der} \cdot A_{skin}}{BW} \cdot n$$

D_{der} – Dermal dose, amount of substance (external dose) that can potentially be taken up [$mg \cdot kg_{bw}^{-1} \cdot d^{-1}$];
L_{der} – Dermal load, amount of substance on skin area per event [$mg \cdot cm^{-2}$];
A_{skin} - Surface area of the exposed skin [cm^2];
BW – Body weight [kg]

R.15 Consumer exposure estimation

- Oral

$$D_{oral} = \frac{Q_{prod} \cdot Fc_{prod} \cdot n \cdot 1000}{BW}$$

D_{oral} - Intake per day and body weight [$mg \cdot kg_{bw}^{-1} \cdot d^{-1}$];
Q_{prod} – Amount of product used [g];
Fc_{prod} – Weight fraction of substance in product [$g \cdot g_{prod}^{-1}$];
BW – Body weight [kg]

ENVIRONMENTAL Science & Technology

Article

pubs.acs.org/est

Release of Silver from Nanotechnology-Based Consumer Products for Children

Marina E. Quadros,*[,†,∥] Raymond Pierson, IV,[†] Nicolle S. Tulve,[‡] Robert Willis,[‡] Kim Rogers,[‡] Treye A. Thomas,[§] and Linsey C. Marr[†]

Table 3. Amount of Silver in Each Product and Amount Leached into Relevant Liquid Media (Mean ± Standard Error)

product	silver content (mg Ag/kg product)[a]	liquid media	amount of silver leached	
			mg Ag/kg product	percent
plush toy: interior foam	48.2 ± 5.0	tap water	0.24 ± 0.02	0.5 ± 0.0
		saliva	1.77 ± 0.03	3.7 ± 0.1
		sweat	18.5 ± 1.1	38.3 ± 2.4
		urine	17.4 ± 0.8	36.1 ± 1.6
plush toy: exterior fur	0.6 ± 0.1	tap water	ND[b]	
		saliva	0.03 ± 0.001	5.6 ± 0.2
		sweat	0.14 ± 0.002	2.6 ± 0.6
		urine	ND	
baby blanket	109.8 ± 4.1	tap water	1.6 ± 0.3	1.5 ± 0.3
		saliva	1.2 ± 0.1	1.1 ± 0.1
		sweat	4.8 ± 0.3	4.4 ± 0.3
		urine	3.7 ± 0.3	3.4 ± 0.3
		HCl	4.7 ± 0.0	4.4 ± 0.0
		saline	4.0 ± 0.0	3.7 ± 0.0
sippy cup 1: rubber ring	24.3 ± 2.9	milk formula	ND	
		orange juice	0.41 ± 0.01	1.7 ± 0.0
sippy cup 1: transparent cap	9.4 ± 1.0	milk formula	ND	
		orange juice	0.07 ± 0.01	0.7 ± 0.1
sippy cup 2: spout cover	2.1 ± 1.5	milk formula	0.93 ± 0.02	43.8 ± 0.9

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PACKAGING TECHNOLOGY AND SCIENCE
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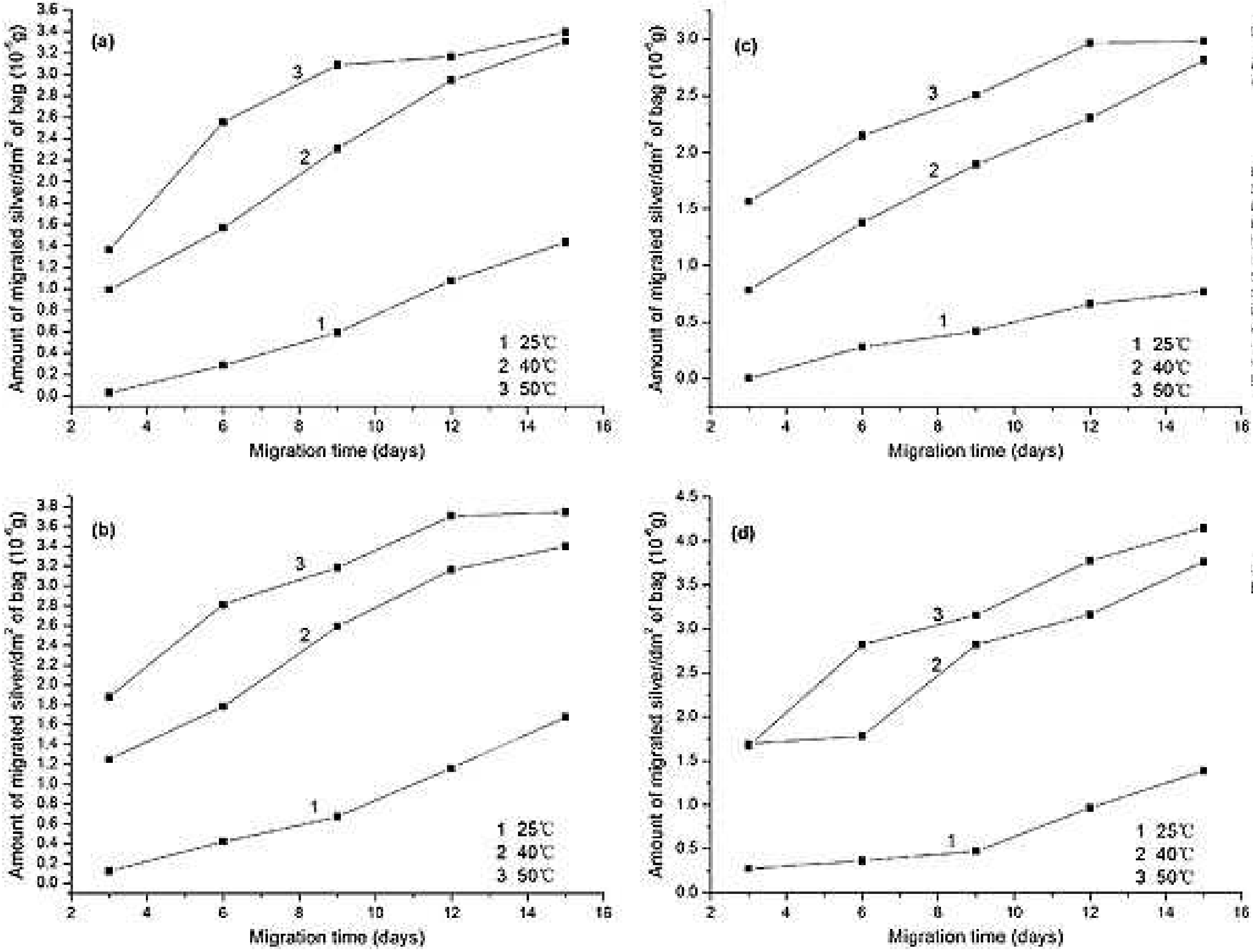
Published online 14 April 2011 in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/pts.958

Nanosilver Migrated into Food-Simulating Solutions from Commercially Available Food Fresh Containers

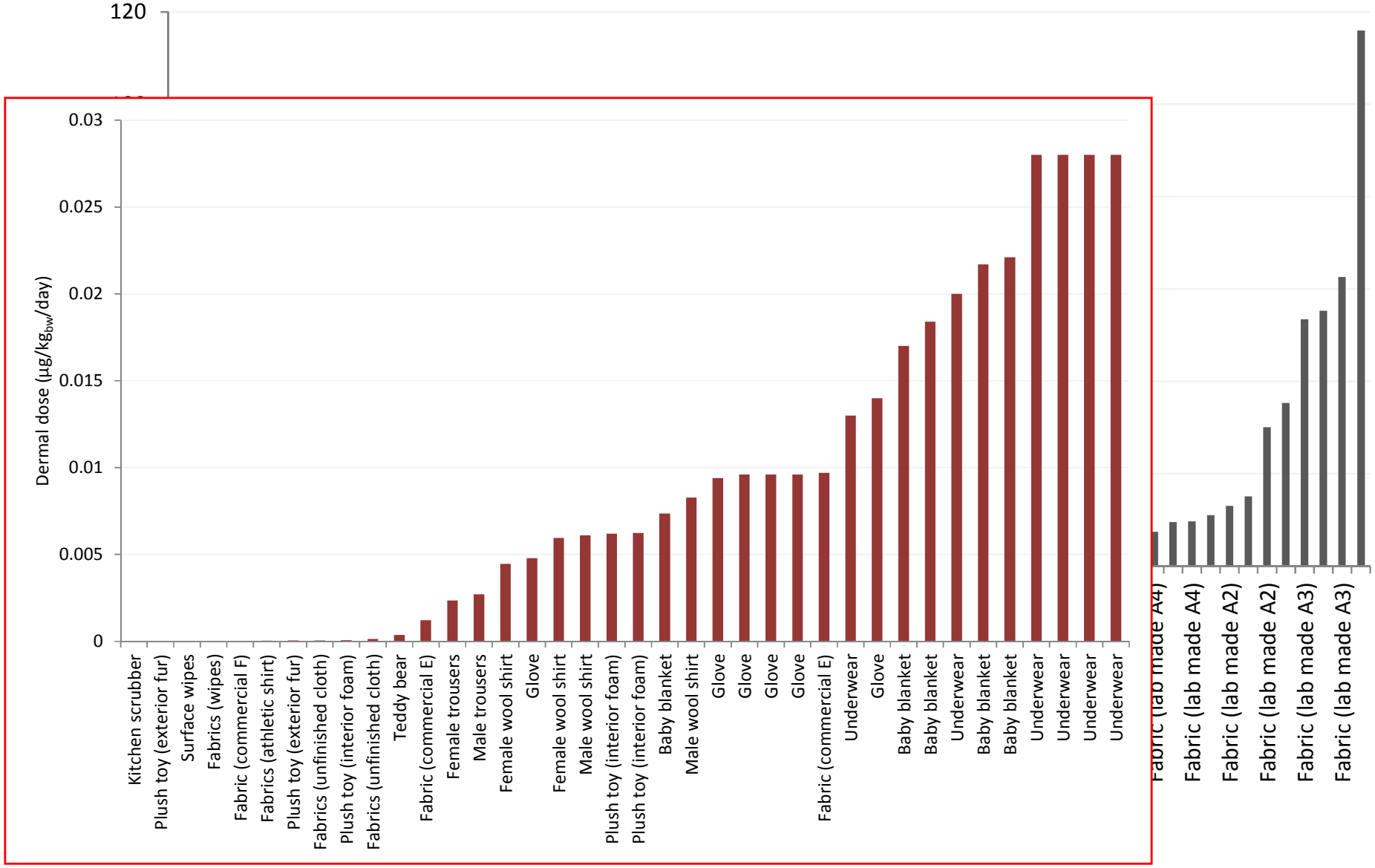
By Yanmin Huang,[1,2] Shuxiang Chen,[1,3]* Xin Bing,[1] Cuiling Gao,[1,3] Tian Wang[1] and Bo Yuan[1]



…l agent, but the safe impacts of …s that migrate from the consumer …echnology. This paper describes …(polyethylene plastic bags). In …out 25°C) to 50°C, the range of …nds of food-simulating solutions …digestion method was used for …sive X-ray (SEM/EDX) analysis …ives, and the atomic absorption …contained 100 µg (Ag)/g (plastic …und, indicating the migration of …amount of nanosilver migration …© 2011 John Wiley & Sons, Ltd.

…se of their potential application …Emerging Nanotechnologies at

Dermal exposure, Ag



Challenges

- Studies may contain relevant data but still may not be suitable for exposure estimation
- Scenarios and experimental setups of ENM release vary from study to study
- No standardized way how to present the data and/or do the ENM characterization
- Realistic conditions vs. worst case scenario?
- ENM-specific exposure estimation?

Conclusions

- Release data needed on ”most used consumer products”
- Release data need for the most relevant use scenario
- Limited number of studies report data in format suitable for R.15, but some do (around 50%)
- R. 15 can be used, but should it?
  - Not developed for particles
  - Based on mass and not, for instance, particle number

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Thank you for your attention!

Questions?

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