Transfer of nano particles from surfaces-to-hand and from the hand to the perioral area

Araceli Sánchez Jiménez[1], Anne Sleeuwenhoek[1], Derk Brouwer[2], John Cherrie[1,3]

[1] Centre for Human Exposure Science, Institute of Occupational Medicine, UK
[2] School of Public Health, University of Witwatersrand, South Africa,
[3] School of Life Sciences, Heriot Watt University, UK

araceli.sanchez@iom-world.org

OEESC, conference
19-21 September, Manchester,UK

Motivation

- Importance of dermal and ingestion exposure:
  - Transfer of contaminants from surfaces to hands is one of the main routes of dermal exposure.
  - Contact of the mouth with contaminated hands or objects is a potentially significant factor in ingestion exposure (Cherrie et al. 2006).
- Evidence of different transfer efficiencies (TE) by surface contact with particle size:
  - Rodes *et al.* (2001) an increase TE for metals and organic contaminants with decreasing particle size, with levels at 25 microns typically two or more times higher than those at 100 microns
  - Gorman Ng. (2013) found particle size influence TE for micron particles of calcium carbonate and magnesium carbonate

NOT PREVIOUS WORK ON TRANSFER OF NANOPARTICLES!

Two EU projects on dermal exposure to nanoparticles

European Committee for Standardization

CEN project

EC mandate to CEN, CENELEC and ETSI: M/461 Nanotechnologies (Deliverable 9: WI137054) “Workplace Exposure-Guidance document of assessment of dermal exposure to manufactured nanoparticles”

Task : Estimate TE from surface to hand for micron and nano ZnO

SUN

Sustainable Nanotechnologies Project

SEVENTH FRAMEWORK PROGRAMME

SUN project

(EU 7th framework programme no. 604305)

Develop a Decision Support System for practical use by industries and regulators for safe design and production of nano-enable products.

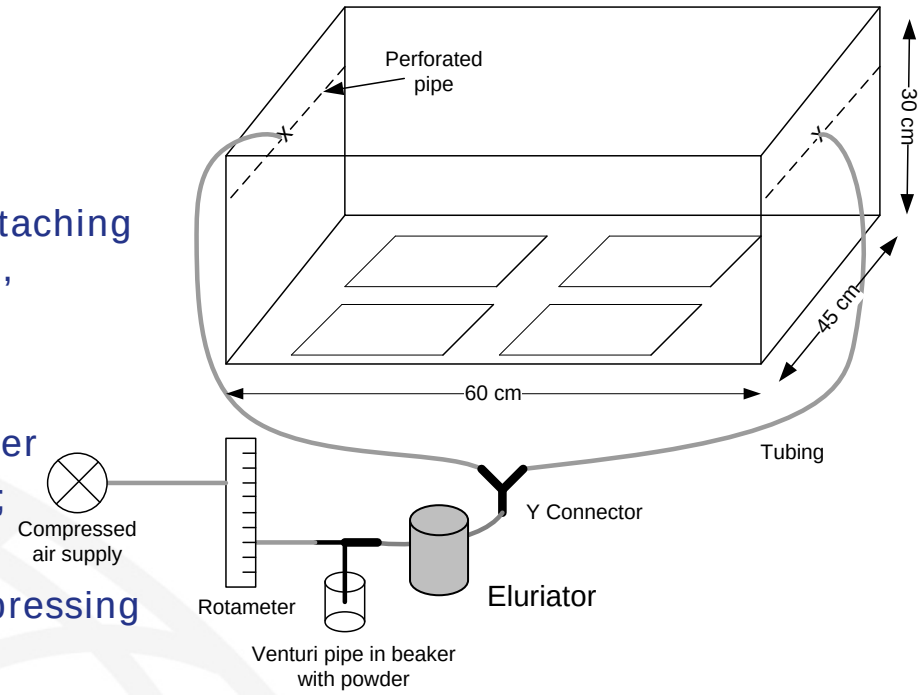
Task: Estimate TE from hand to perioral for SiO_2

IOM

CEN project: surface-to-hand TE

1) Powder aerosolization

- 2 grams ZnO micron or nano size powder
- Eluriator to remove large particles
- 30 mins settling period
- Particle size on surfaces investigated by attaching Nucleopore filters to the surface of the box, examined using SEM



2) Hand-to surface-contact

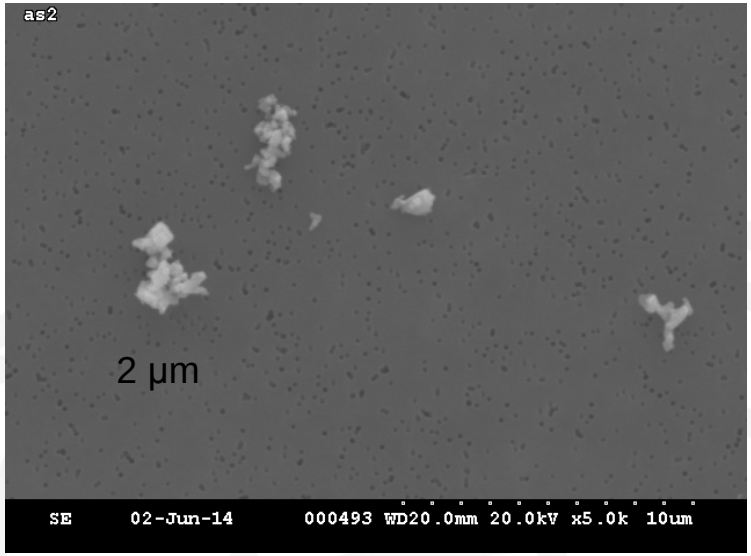
- Two surfaces: galvanised steel & Pine timber
- Methodology followed: Christopher (2008); Gorman Ng *et al* (2013)
- Volunteer applied ~ 50 N force for 5 secs pressing palm and fingers onto surface
- Wipe method
- Tape striping

3) GLMM fitted to the TE data:

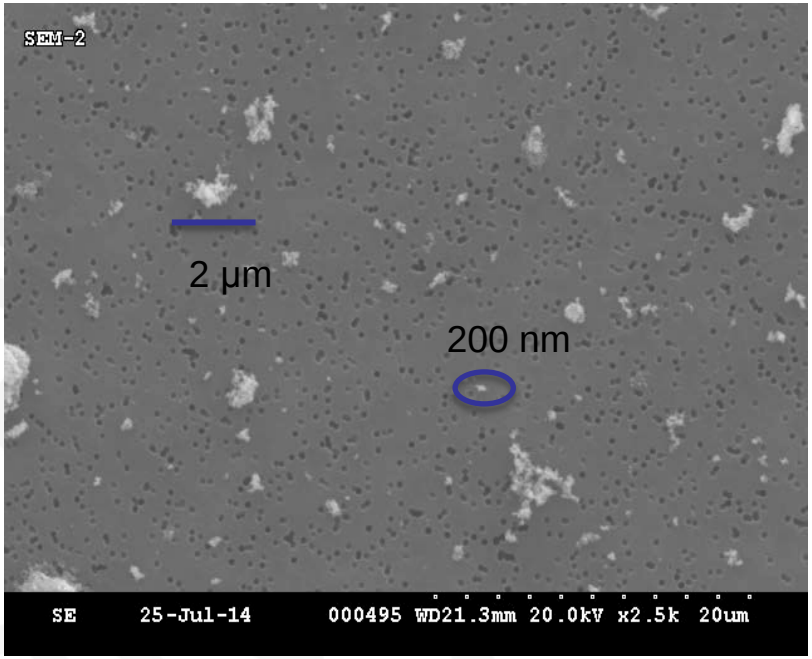
- Moisture
- Loading
- Micron vs nano
- Surface type

IOM

CEN results: SEM analysis

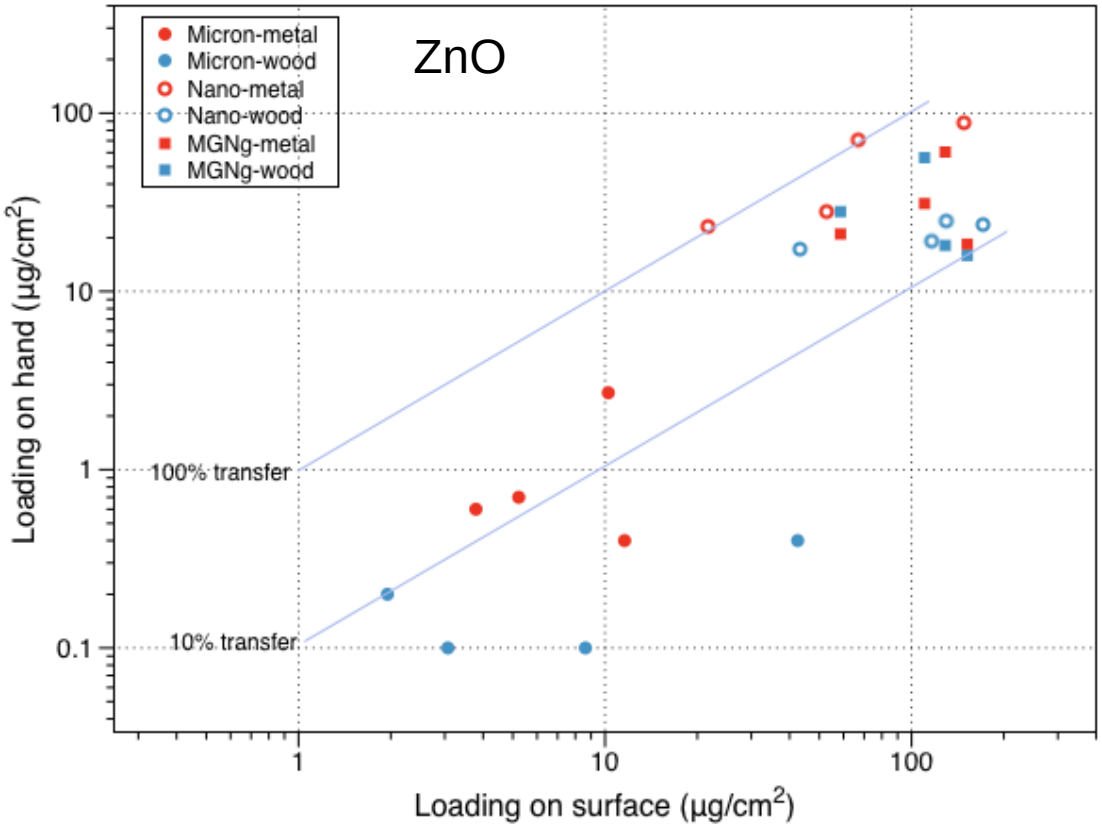


Deposited micron size ZnO



Deposited nano size ZnO

CEN results: surface-to-hand



Surface	Particle size	N	Transfer efficiency (%)			Surface loading (mg/cm²)		Moisture (mMho)		Predicted transfer efficiency (%)
			Range	GM	GSD	GM	GSD	GM	GSD	
Metal	Micron	4	3.5 – 27	12	2.4	7	1.7	166	2.3	10
	Nano	4	53 – 106	77	1.4	58	2.2	38	3.4	90
Wood	Micron	4	0.9 – 10	2	3.2	7	3.9	406	1.4	2.8
	Nano	4	14 - 40	20	1.6	103	1.8	311	1.3	17

IOM

GM=geometric mean GSD = geometric standard deviation

CEN results:

- Calculated TE ranged from 14-106% for nano and 0.9-27% for micron ZnO

- Statistically significant variables:
  - PS = particle size (0=micron-size, 1= nano-size) $p < 0.001$
  - S = surface (0=metal, 1=wood), $p < 0.001$
  - L = loading, $p < 0.005$
  - Moisture : NOT SIGNIFICANT

- The final statistical model was:

$$\ln(TE) = 3.5 + 3.4 \times PS - 1.3 \times S - 0.6 \times \ln(L)$$

SUN project (hand to perioral TE of SiO_2)

- What factors influence transfer and can be easily measured?

Substance specific	Subject specific	Experimental settings
Dustiness/ **particle size**	Skin & saliva ph	Removal method
Adhesion properties: - shape - surface area - isoelectric point -surface charge -**moistness**	Skin condition: **- moisture** **- TEWL** -roughness -skin disruptions	**Loading**
Viscosity		

SUN experiment design

N samples	MOISTNESS	LOADING IN FINGER	MOISTURE FINGER (µSi)	MOISTURE PERIORAL (µSi)	TEWL FINGER (g/m²h)	TWEL PERIORAL (g/m²h)
6	HIGH	HIGH				
6	HIGH	LOW				
6	MEDIUM	HIGH				
6	MEDIUM	LOW				
6	LOW	HIGH				
6	LOW	LOW				
Total =36						

Measured with a corneometer, DermaLab, Cortex Technology

Loading finger
High loading: > 1.51 mg
Low loading: < 1.50 mg

Moistness
High: > 5 %
Medium: 0.5- 5 %
Low: 0-0.5 %

SUN methodology

Filter loading

CEN methodology

- Problems getting loading sufficiently high to detect Si > LOD in perioral region
- Problems getting homogenous loading across filters
- Problems getting samples for SEM analysis : SiO_2 agglomerates very quickly!

Transferred to finger

CEN methodology

- ~ 50 N force for 5 secs pressing

Transferred to perioral

Gorman Ng *et al* (2013)

- ~ 50 N force for 10 secs pressing

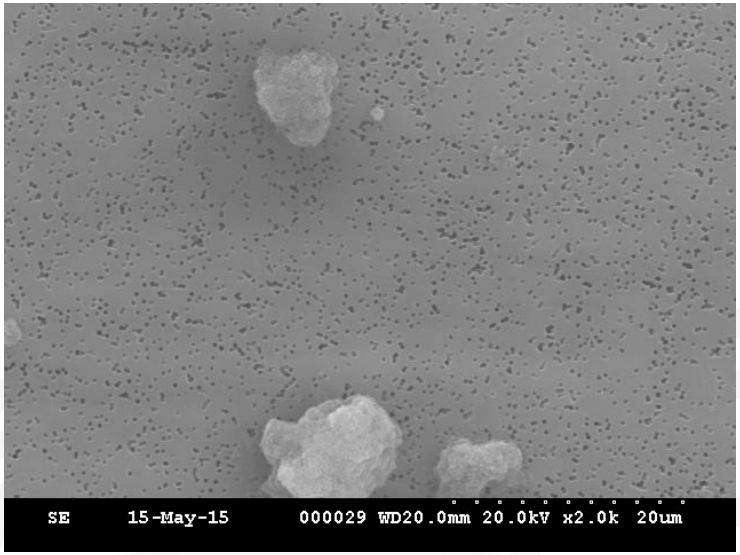
Wipe removal method

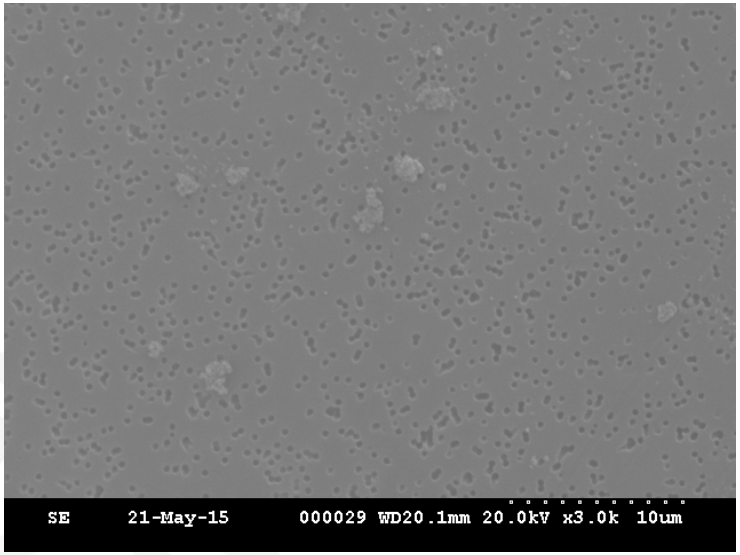
Gorman Ng *et al* (2013)

- Hypaclean Clinical wipes (70% w/w of isopropyl alcohol), using a standardised wiping
- 1 wipe
- Background after 6 tests

IOM

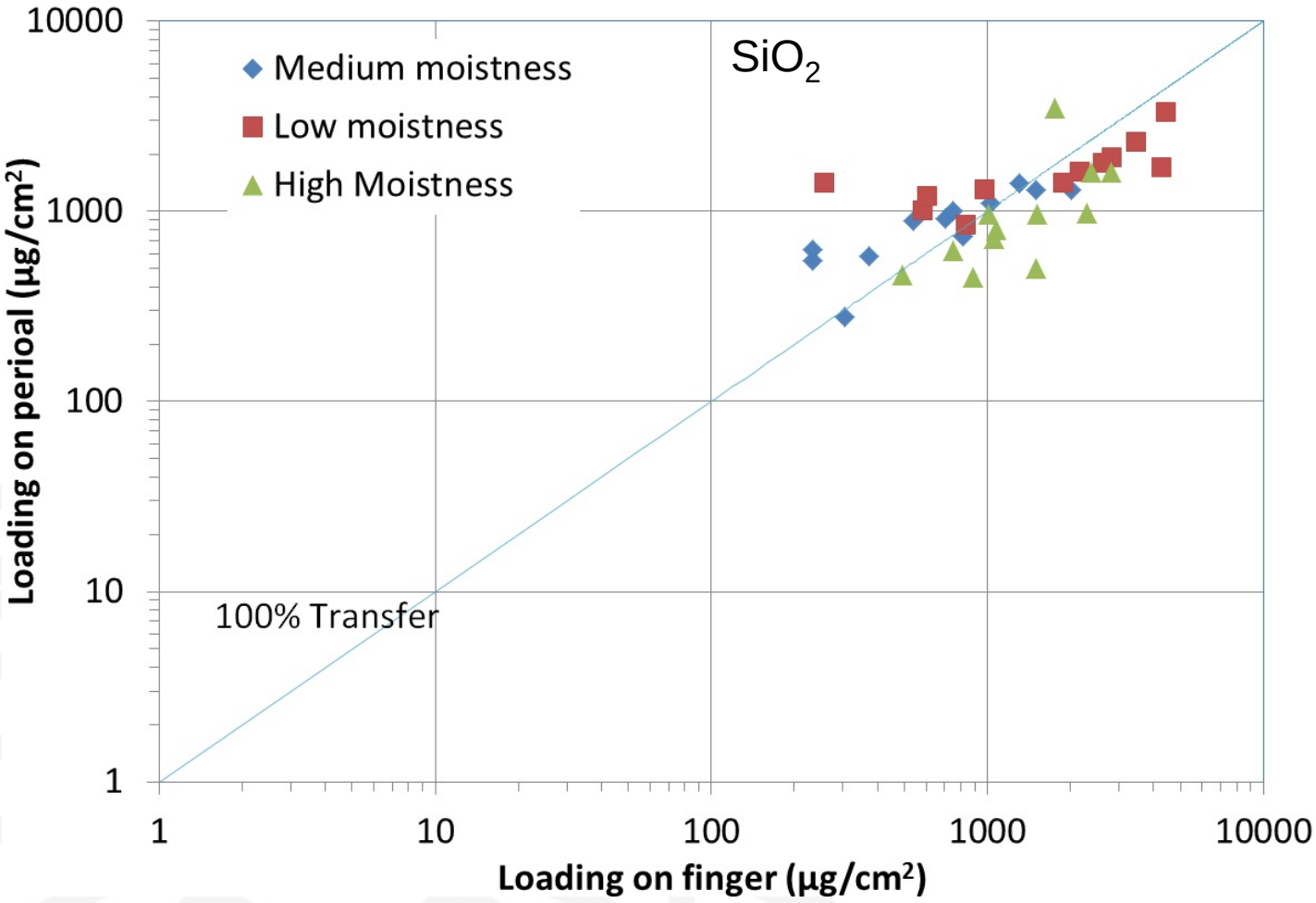
SUN: results SEM analysis SiO_2





Fast agglomeration leads to a wide range of agglomerate sizes

SUN results



Moistness (Particle size)	N	TE (%)		Loading (ug/cm²)		TEWL perioral	
		GM	GSD	GM	GSD	GM	GSD
LOW	12	101	4.9	1,521	2.5	54	2.1
MEDIUM	12	126	2.6	651	2.0	32	1.3
HIGH	12	70	2.8	1,297	1.7	145	4.2

SUN results:

- Calculated TE ranged from 33% to 545%
  - Contamination (SiO_2 is everywhere)
  - 1 wipe not enough to remove all SiO_2 in perioral area

- Statistically significant variables:
  - L = loading, $p < 0.001$
  - $TEWL_{perioral}$, $p < 0.005$

- The final statistical model was:

- $Ln(TE) = 5.15 - 0.55 \times Ln(L) - 0.001 \times TEWL_{Perioral}$
- $R^2 = 0.61$

IOM

SUMMARY

- Nano ZnO more effectively transferred to skin than micron-size particles.
- Surface to finger transfer influenced by particle size, surface and loading.
- Finger to perioral transfer influenced by loading, $TEWL_{perioral}$

CONCLUSIONS

- Difficult to pick-up the nanospecificity.
- No nano-specific variables provide good estimate of TE.
- Agglomeration of nanoparticles likely to influence TE but difficult to include variable in model.

Acknowledgements

European Committee for Standardization

Sustainable Nanotechnologies Project

Grant agreement: no. 604305