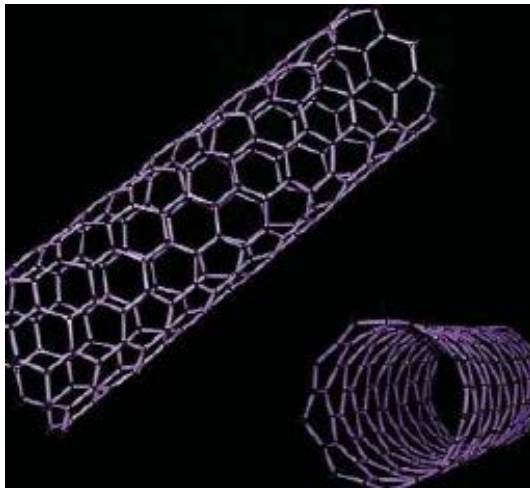


USING A MODIFIED ELECTRICAL AEROSOL DETECTOR (MEAD) FOR NANOPARTICLE EXPOSURE ASSESSMENTS IN A CARBON BLACK MANUFACTURING INDUSTRY



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Inhalatory exposure assessment for **nanoparticles**

□ Exposure metrics

- Mass concentration
- Surface area concentration
- Number concentration

Oberdörster, 2000

□ Deposition

- Head
- Tracheobronchial
- Alveolar

Greim et al. 2001
IARC, 2002
Yamakoshi et al. 2003
HSE, 2004

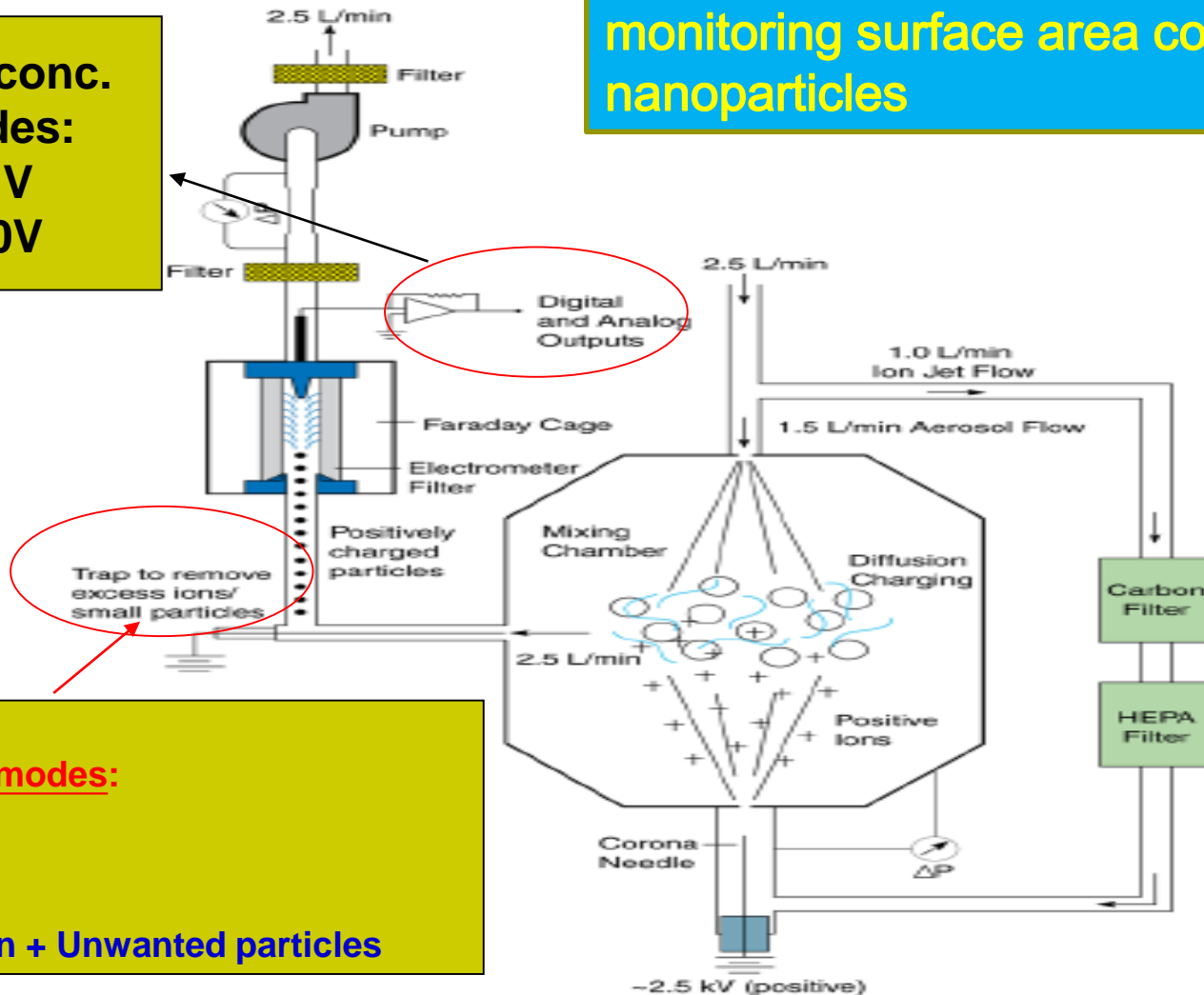
Scanning mobility particle sizer (SMPS)

- Widely used to measure the number of concentrations of nanoparticles of different sizes
- Converting the measured number concentration into the surface area concentration
- Using ICRP lung deposition models to estimate exposures on H, TB, AL regions
- **Bulky and Expensive** (Brouwer et al., 2004)

TSI Nanoparticle Surface Area Monitor (NSAM) (Fissan et al., 2007)

Surface conc.
Two modes:
TB: 100 V
ALV: 250V

TSI has modified the EAD to NSAM for monitoring surface area conc. of nanoparticles



ION Trap

Two voltage modes:

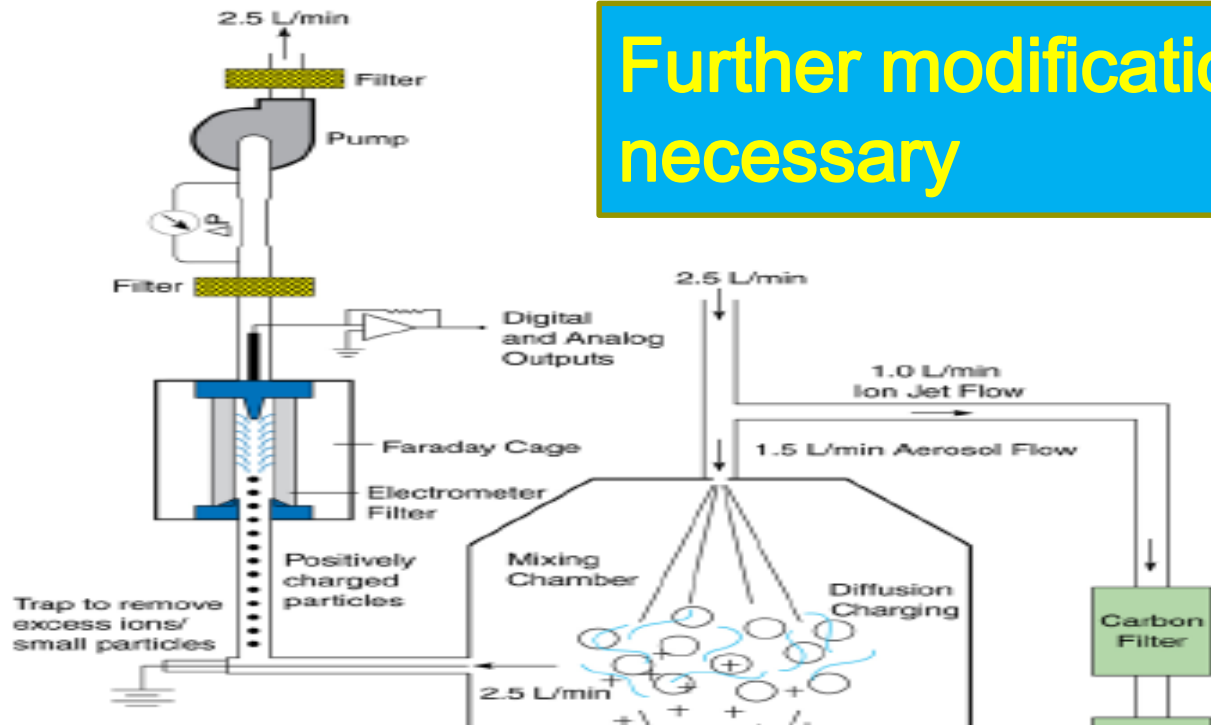
100 V

250 V

To remove:

Excessive ion + Unwanted particles

TSI Nanoparticle Surface Area Monitor (NSAM) (Fissan et al., 2007)



Further modification is necessary

Problems remained:

1. Surface area conc. of the H region?
2. Number conc. of the H, TB, and ALV regions?

MODIFIED ELECTRICAL AEROSOL DETECTOR (MEAD)

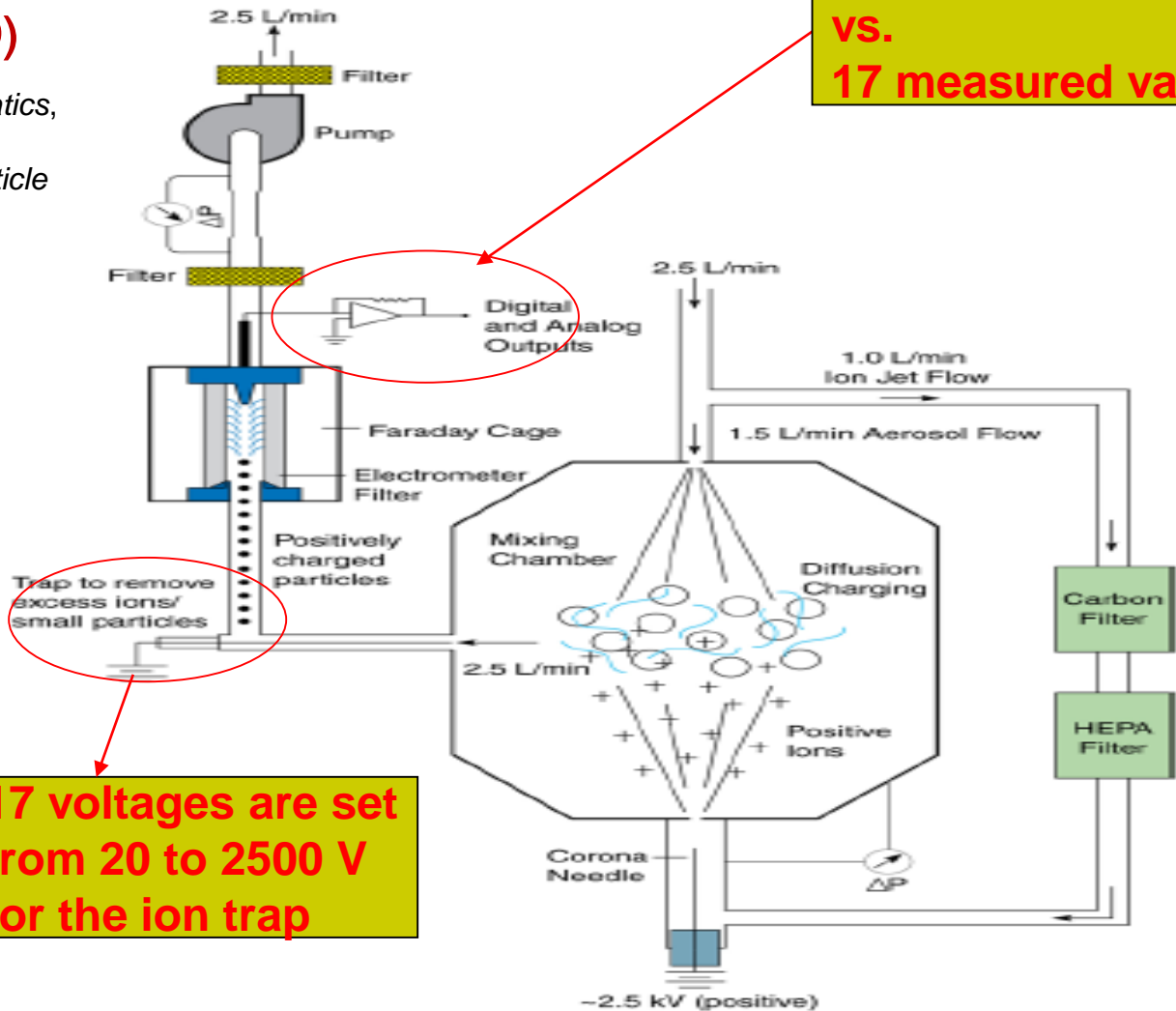
Journal of Electrostatics, 2009, 67: 765–773.
Journal of Nanoparticle Research, 2009; 11: 111–120.

$$\chi(\text{CMD}, \sigma_g, N_t) = \frac{\sum_{i=1}^m |C_i - M_i|}{m}$$

$$N(\ln d_p) = \frac{N_t}{\sqrt{2\pi \ln \sigma_g}} \exp\left(\frac{-(\ln d_p - \ln \text{CMD})^2}{2 \ln^2 \sigma_g}\right)$$

17 calculated readouts (C_i) vs. 17 measured values (M_i)

17 voltages are set from 20 to 2500 V for the ion trap





Research Question:

- Can MEAD be used to characterize the number and surface area concentrations of the head, tracheobronchial, and alveolar region depositions?

Material and Methods

- Field sampling
 - An oil furnace carbon black manufacturing plant
- Sampling sites
 - **Three workplaces** were chosen:-
 - Pelletizing
 - Packaging
 - Warehouse
 - **Background** nanoparticle concentrations:
 - The **upwind side** of the selected carbon black manufacturing plant

Material and Methods

- **Sampling instrument:**

- **MEAD**

- **Reference instruments**

- **For particle surface area concentrations: NSAM** (TSI model 3550)

- **For number concentrations: SMPS** (TSI Inc., Model 3936, St. Paul, MN, USA)



Results and Discussion

Number-based size distributions of nanoparticles (1–1000 nm) obtained from MEAD for the outdoor background, workplace background, and workplace exposure of the three selected process areas (n= 4)

Sampling site	Outdoor background		Workplace background		Workplace exposure			
	CMD (nm)	σ_g	CMD (nm)	σ_g	1 st mode		2 nd mode	
	CMD (nm)	σ_g	CMD (nm)	σ_g	CMD (nm)	σ_g	CMD (nm)	σ_g
Packaging			42.7	1.84	25.5	3.1	165	2.1
Warehouse	48.3	1.78	41.1	2.04	24.2	1.8	166	2.2
Pelletizing			NM ^a	NM ^a	39.2	3.2	124	2.0

^aNM = Not measured

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Sampling site	Outdoor background		Workplace background		Workplace exposure 1 st mode		Workplace exposure 2 nd mode	
	CMD (nm)	σ_g	CMD (nm)	σ_g	CMD (nm)	σ_g	CMD (nm)	σ_g
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Number concentrations and surface area concentrations of nanoparticles (1–1000 nm) for the three selected process areas

Sampling site	<u>Number concentration</u> (#/cm ³ × 10 ³)			<u>Surface area concentration</u> (μm ² /cm ³)		
	Outdoor background	Workplace background	Workplace exposure	Outdoor background	Workplace background	Workplace exposure
Packaging		3.46	25.7		192	782
Warehouse	3.41	18.6	42.1	203	240	1195
Pelletizing		NM ^a	13.7		NM ^a	441

^aNM = Not measurement

Number concentrations and fractions (values in parentheses) of nanoparticles (1–1000 nm) deposited on the H, TB, and A regions of the respiratory tract for the three selected process areas (n= 4)

Sampling site	Total (#/cm ³ ×10 ³)	Number concentrations (#/cm ³ ×10 ³)			Total (#/cm ³ ×10 ³)
		H	TB	A	
Packaging	25.7 (100%)	4.98±3.03 (19%)	4.45±2.71 (17%)	16.4±13.0 (64%)	499
Warehouse	42.1 (100%)	6.79±6.64 (16%)	7.18±7.66 (17%)	28.3±44.4 (67%)	500
Pelletizing	13.7 (100%)	2.08±0.29 (15%)	2.35±0.28 (17%)	9.47±1.09 (68%)	503

20%

20%

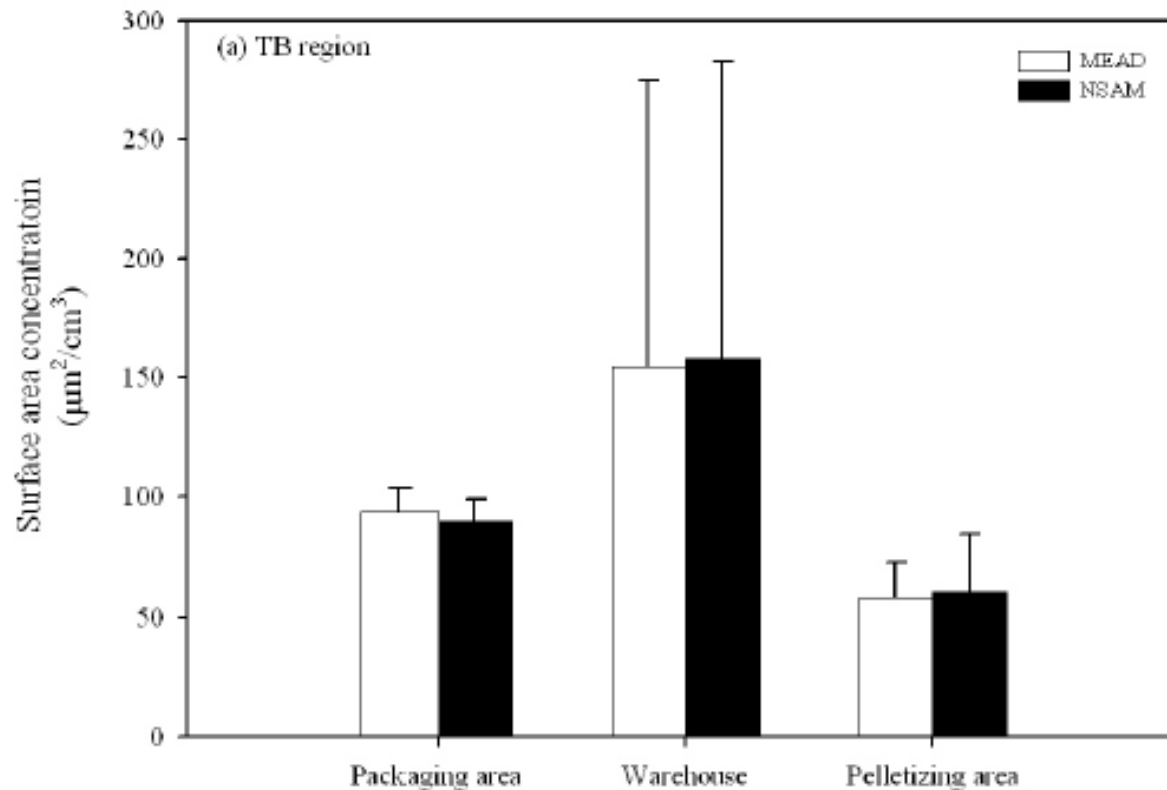
60%

Surface area concentrations and their corresponding fractions (values in parentheses) of nanoparticles (1–1000 nm) **deposited on the H, TB, and A** regions of the respiratory tract for the three selected process areas (n= 4)

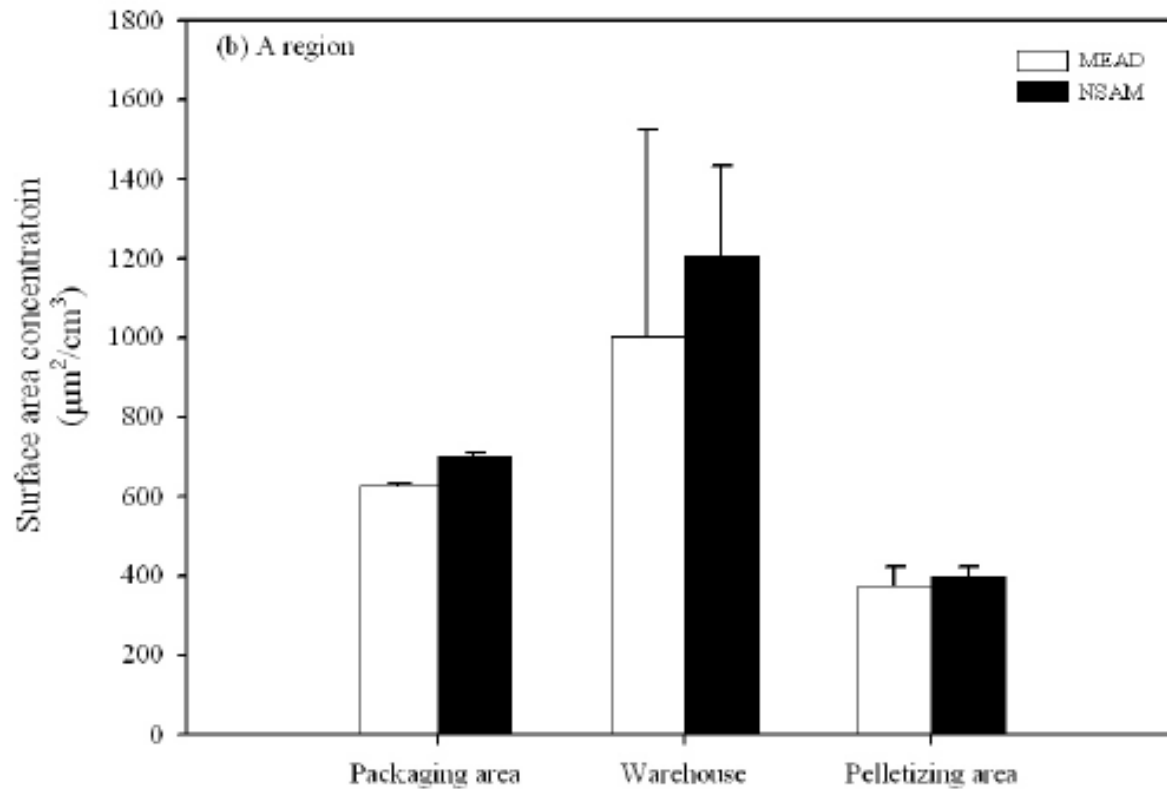
Sampling site	Total ($\mu\text{m}^2/\text{cm}^3$)	<u>Surface Area Conc</u> ($\mu\text{m}^2/\text{cm}^3$)		
		H	TB	A
Packaging	782 (100%)	62.6±14.2 (8%)	93.8±1.97 (12%)	625±9.55 (80%)
Warehouse	1195 (100%)	35.9±515 (3%)	155±124 (13%)	1003±523 (84%)
Pelletizing	441 (100%)	8.82±9.12 (2%)	57.3±13.7 (13%)	374±49.4 (85%)

Using different exposure metrics will results in different exposures to different regions of the respiratory tract

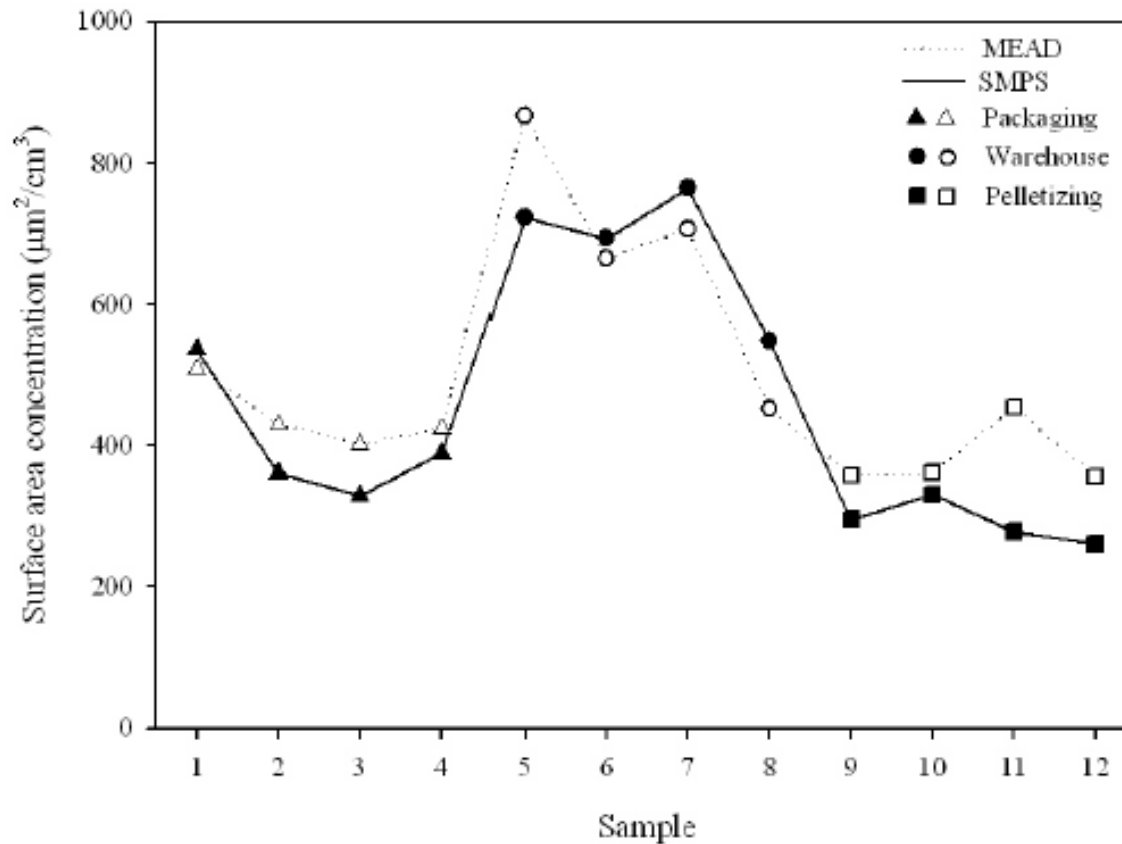
Comparing surface area concentrations of nanoparticles in the TB measured using MEAD with that measured using NSAM



Comparing **surface area concentrations** of nanoparticles in the **AL** measured by the **MEAD** with that measured by the **NSAM**



Comparing **total surface area concentrations** obtained from **SMPS** with that from **MEAD**



Conclusions

- Both NSAM and MEAD obtained quite comparable results.
- No significant difference can be found between the results obtained from SMPS and MEAD.
- Suitability of using MEAD in the field for nanoparticle exposure assessments

4th EU-Asia Dialogue on Nanosafety



Thank you!