

# Characterization of an Aerosol Generated During Application of a Nano TiO<sub>2</sub>-Enabled Antimicrobial Spray Product onto a Surface: Pulmonary and Cardiovascular Responses to Inhalation Exposure in Rats

V. Castranova<sup>1</sup>, B. Chen<sup>2</sup>, D. Frazer<sup>2</sup>, D. Schwegler-Berry<sup>2</sup>,  
A. Afshari<sup>2</sup>, W. McKinney<sup>2</sup>, T. Sager<sup>2</sup>, J. Reynolds<sup>2</sup>,  
K. Krajnak<sup>2</sup>, S. Waugh, R. Mercer<sup>2</sup>, T. Thomas<sup>3</sup>

<sup>1</sup> West Virginia University School of Pharmacy, Morgantown, WV

<sup>2</sup> NIOSH, Morgantown, WV

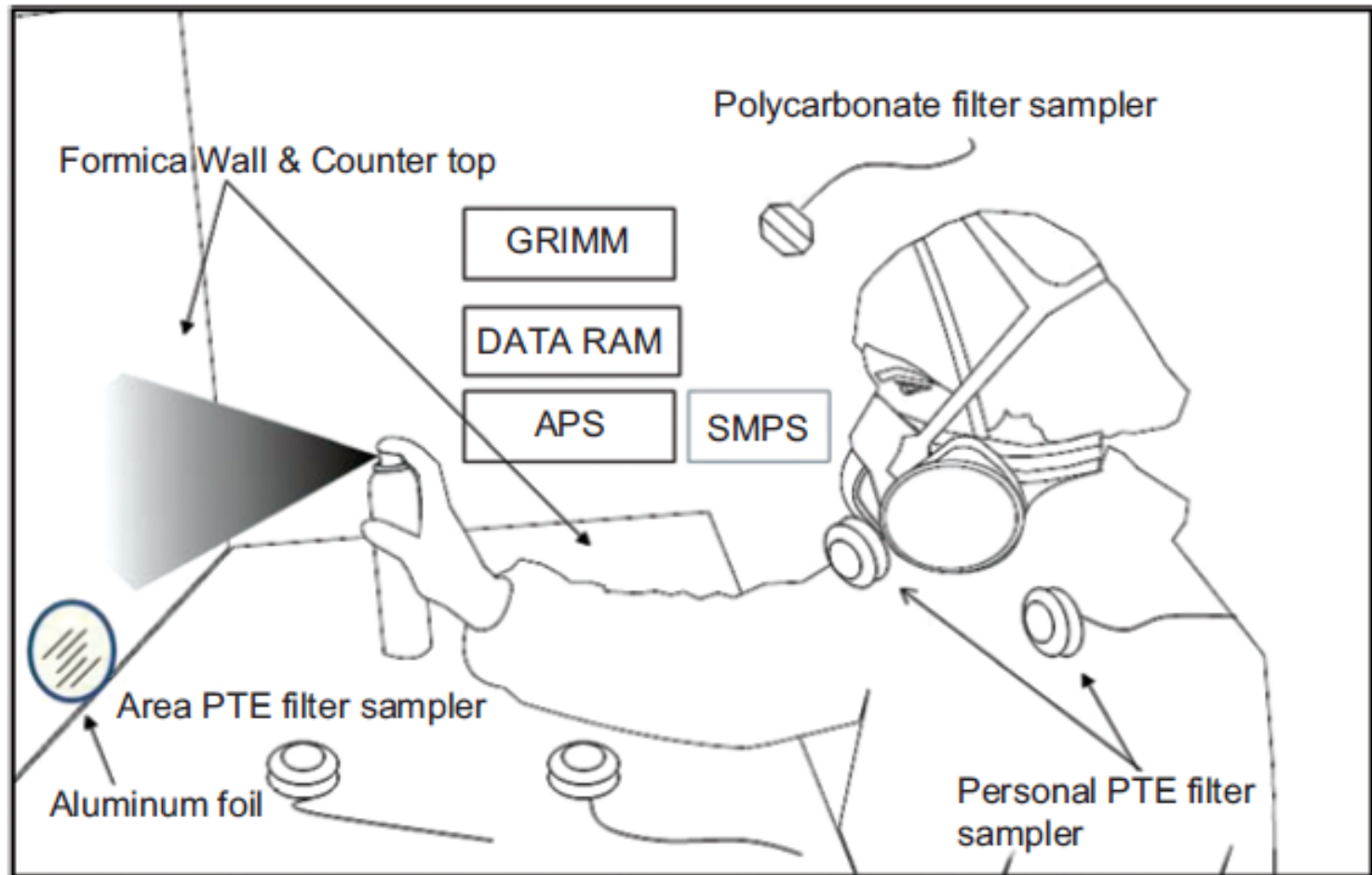
<sup>3</sup> CPSC, Bethesda, MD

# Characterization of an Aerosol Generated during Application of a Nano TiO<sub>2</sub>-enabled Antimicrobial Spray Product to a Surface

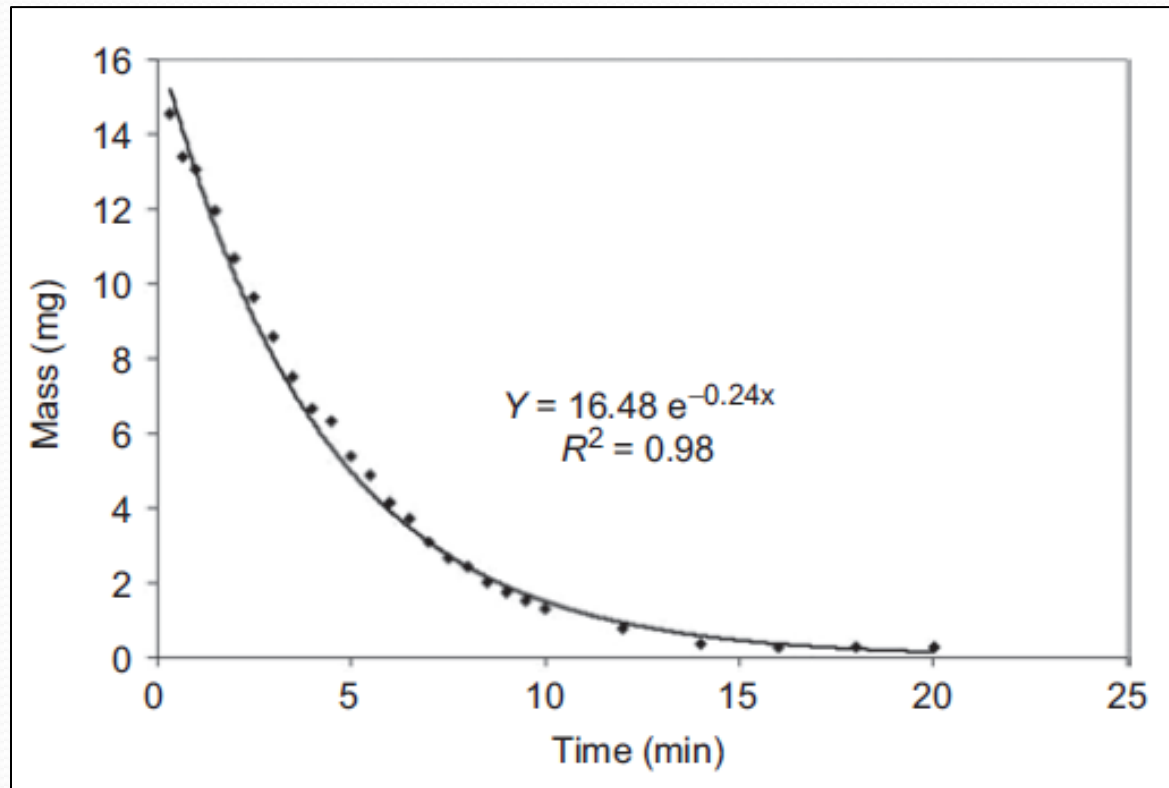
- Operator 24 inches from wall
- Spray can held 8 inches from wall
- Spray back and forth for 2.5 minutes
- Sample in the breathing zone

Chen et al. Inhal. Toxicol. 22: 1072-1082, 2010

**Figure 1**  
**Realistic Exposure Scenario**



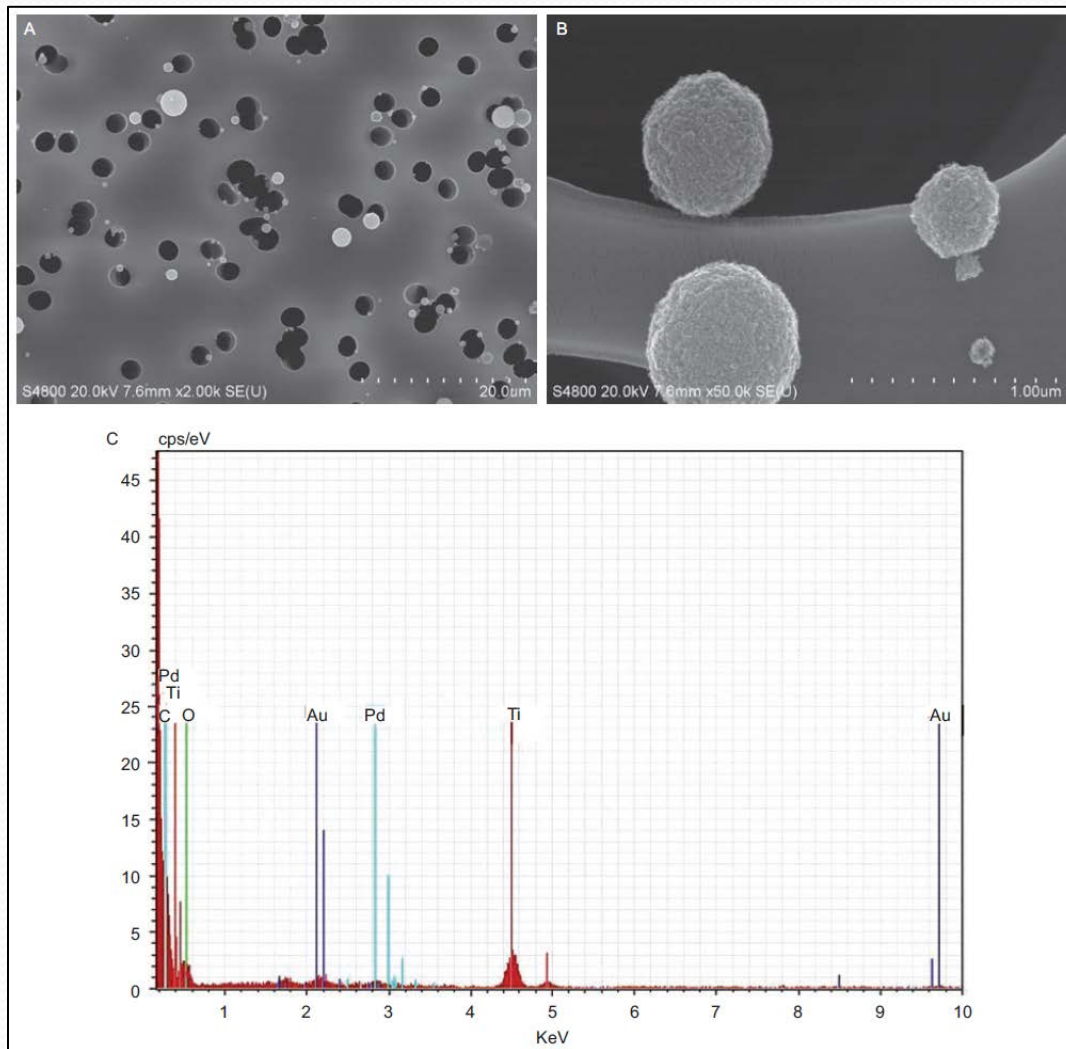
**Figure 2**  
**Generated Aerosol Concentration**



- Filter samples
  - Wet = propellant + particles =  $204 \text{ mg/m}^3$
  - Dry = particles =  $3.4 \text{ mg/m}^3$

# Figure 3

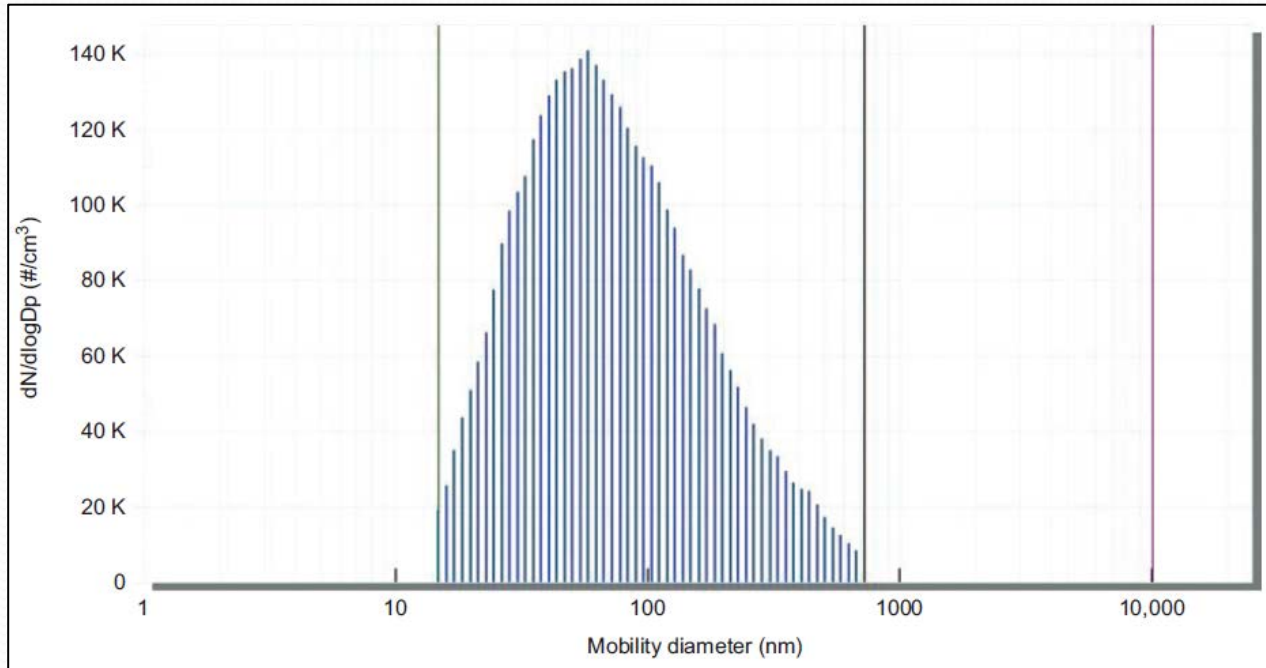
## Particle Morphology, Size, and Composition (SEM & EDX)



## Particle Morphology, Size, and Composition (cont.)

- SEM and EDX
  - Diameter = 40 nm – 3.5  $\mu$ m
  - Composition = Ti & O (coating of Au & Pd on C filters)

**Figure 4**  
**Particle Number and Size**



- APS/SMPS
  - Total particles:  $1.6 \times 10^5$  p/cm<sup>3</sup>
  - Count median diameter = 75 nm
  - Nanoparticles =  $1.2 \times 10^5$  p/cm<sup>3</sup>

# Spray Can Aerosol Characteristics

	Total Particle	Nanoparticle
Number Concentration	<b>1.6x10<sup>5</sup>p/cm<sup>3</sup></b>	<b>1.2x10<sup>5</sup>p/cm<sup>3</sup></b>
Size Distribution	--	--
CMD	<b>75 nm</b>	--
MMD	<b>395 nm</b>	--
MMAD	<b>836 nm</b>	--
Mass Concentration	<b>3.4 mg/m<sup>3</sup></b>	<b>0.17 mg/m<sup>3</sup></b>
Cal. Alveolar Burden /min.	--	--
Human	<b>0.075 µg/m<sup>2</sup></b>	--
Rat	<b>0.03 µg/lung</b>	--

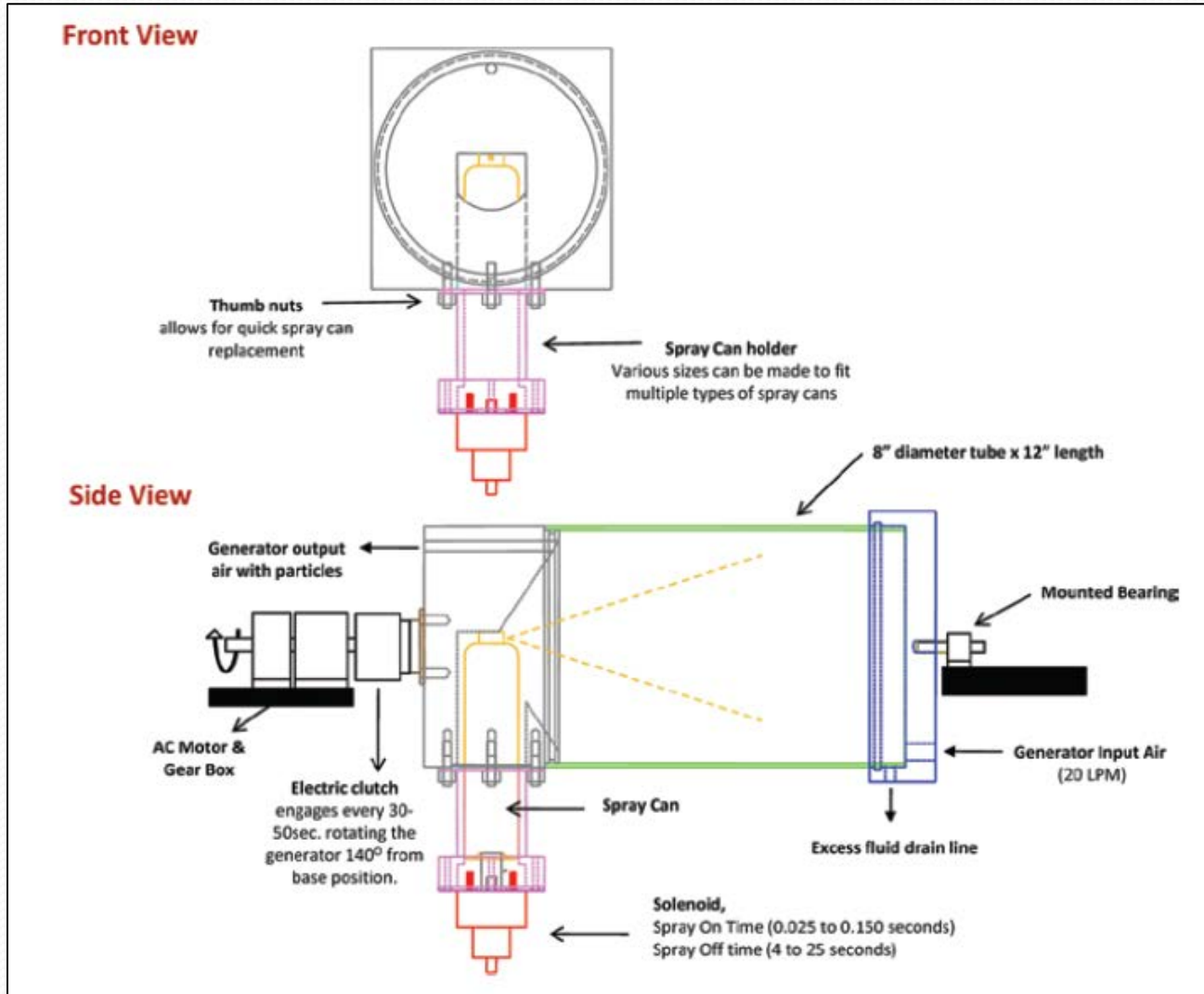


# Inhalation Exposure of Rats to Nano TiO<sub>2</sub>-Enabled Antimicrobial Spray Aerosol

- Pulmonary exposures result in low, medium, and high lung burden
- Monitor responses 24 hr. post-exposure
  - Pulmonary (breathing rate, inflammation, and cell injury)
  - Cardiovascular (vascular responsiveness)
- Relate to consumer risk

McKinney et al. Inhal. Toxicol. 24:447-457, 2012

# Figure 5 Aerosol Generator



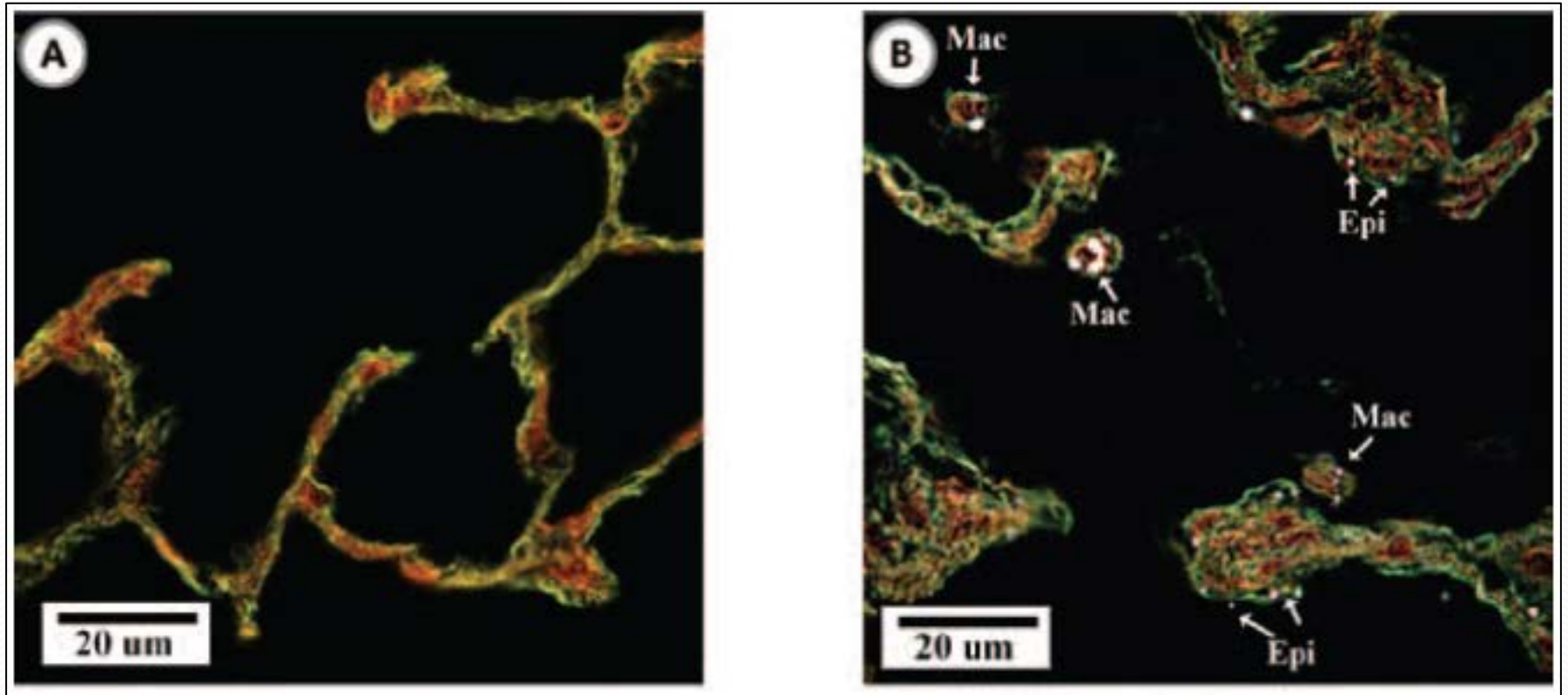
## Table 2 Rat Inhalation Exposure

Table 1. Animal exposure conditions.

Exposure conditions	Total Exposure Dose		
	(mg/m <sup>3</sup> min)	Spray cans used	No. of rats exposed
2.62 mg/m <sup>3</sup> , 2 h, 1 day	314 (low dose)	½	12
1.72 mg/m <sup>3</sup> , 4 h/day, for 2 days	826 (medium dose)	2	9
3.79 mg/m <sup>3</sup> , 4 h/day, for 4 days	3638 (high dose)	8	9

- CMD = 110 nm

**Figure 6**  
**Pulmonary Deposition of Nano TiO<sub>2</sub>**



**Figure 7**  
**Effect of TiO<sub>2</sub> Spray Inhalation on Breathing Rate**

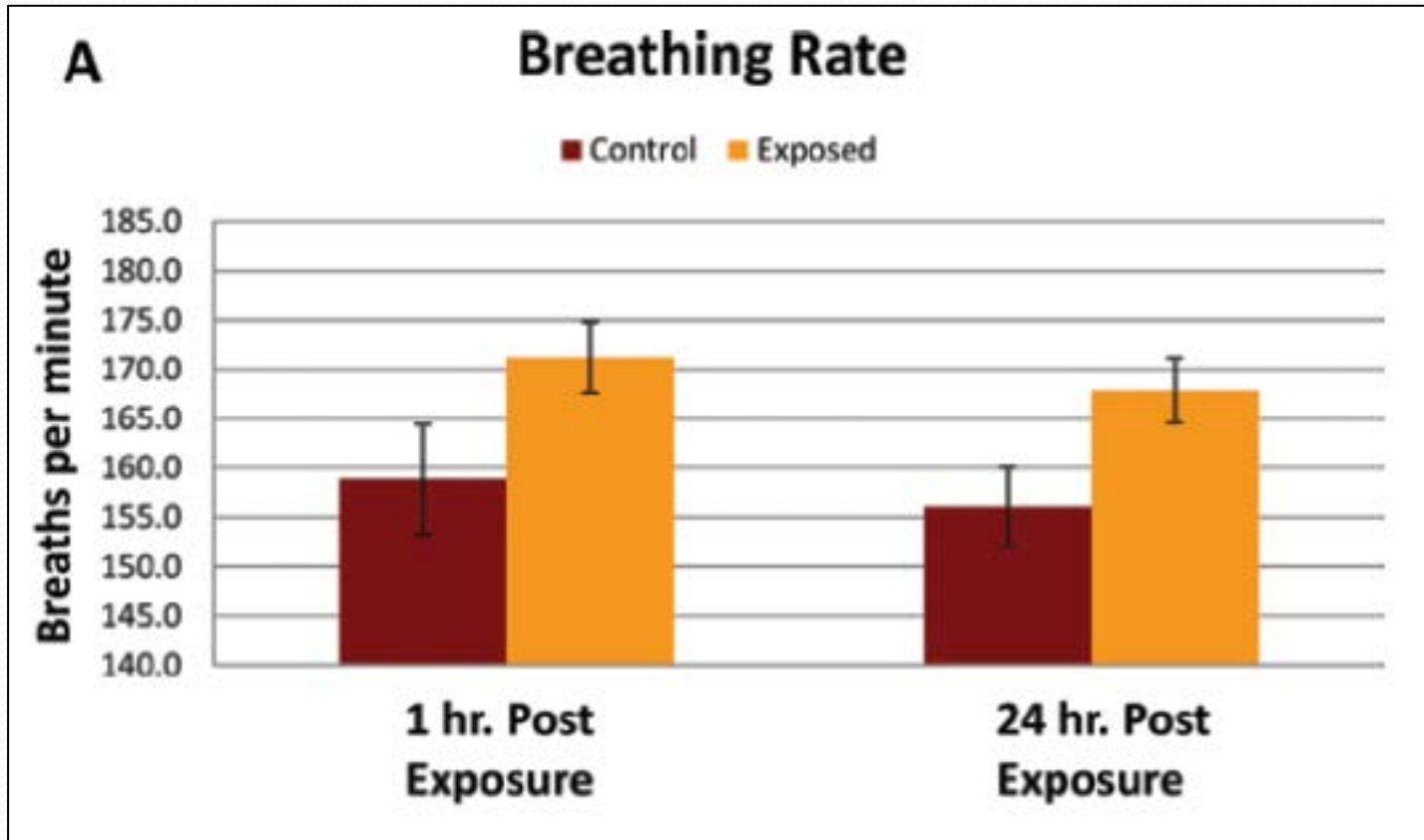
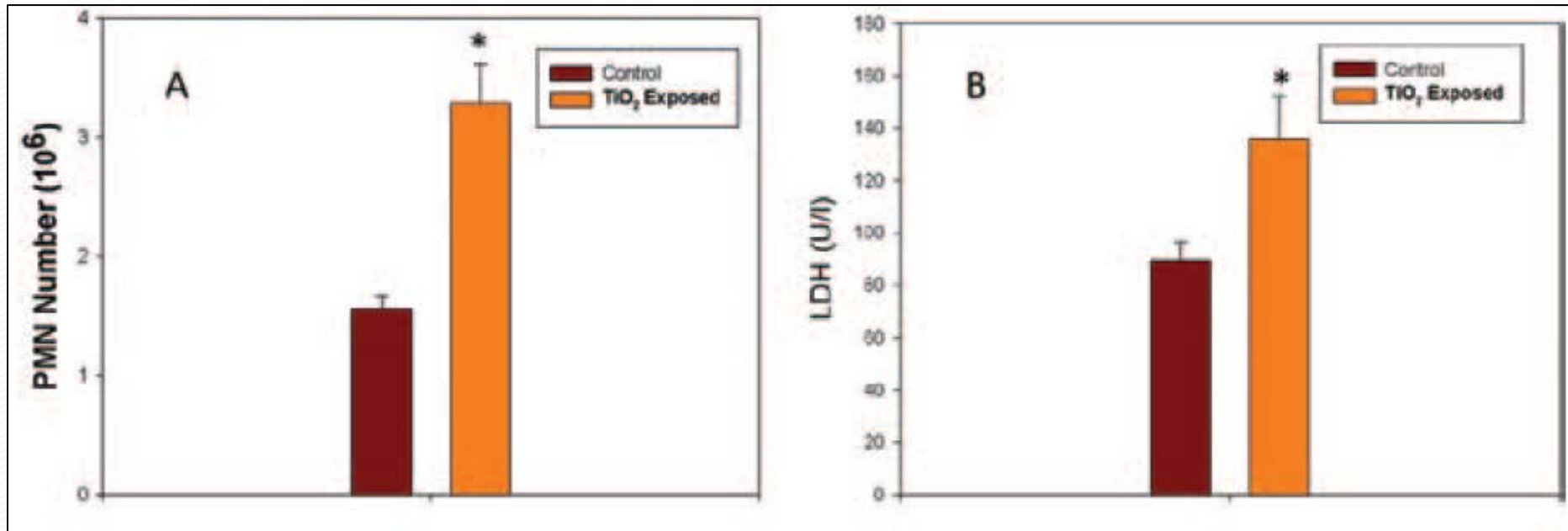


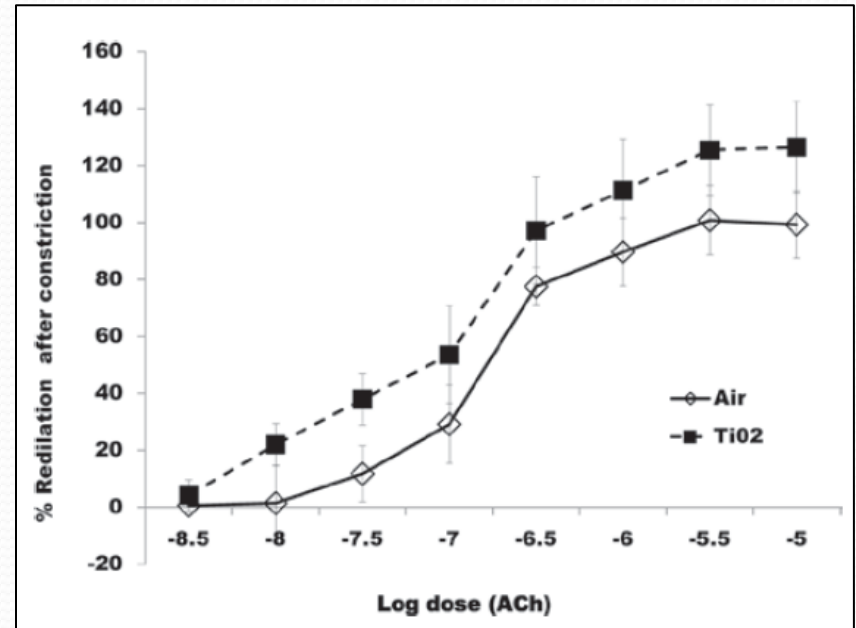
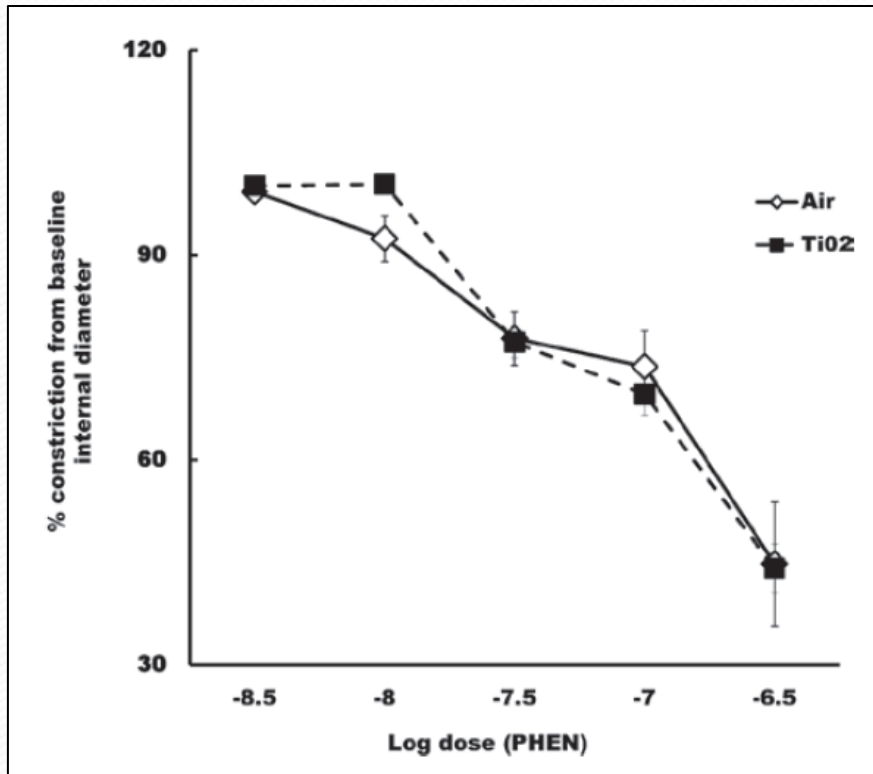
Figure 8

Effect of TiO<sub>2</sub> Spray Inhalation on Inflammation and Damage



## Figure 9 and 10

### Effect of TiO<sub>2</sub> Spray Inhalation on Tail Artery Responsiveness



# Risk Analysis

- From exposure measurements during application, human alveolar burden would be  $0.075 \mu\text{g TiO}_2/\text{m}^2$  of alveolar epithelium/minute =  $0.03 \mu\text{g}/\text{rat lung}/\text{minute}$ .
- Rat alveolar depositions were  $3.74 \mu\text{g}$ ,  $9.83 \mu\text{g}$ , and  $43.31 \mu\text{g}$ .
- These lung burdens would be achieved in 2, 5 ½ , and 24 hours of application, respectively.
- Therefore, expected consumer use would result in an alveolar lung burden below the NOEL in this rat study.