

Relationship Between Composition and Toxicity of Engine Emissions

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How do we determine physical/chemical drivers of respiratory health effects?

1. **Statistical exploration of data**

Requires many different cases (>4) tested and characterized identically.

e.g., PCA/PLS analysis of 7 engine emission samples showed strong associations between inflammation and particle organic carbon, hopanes, and steranes (McDonald et al. *Environ Health Perspectives*, 2004).

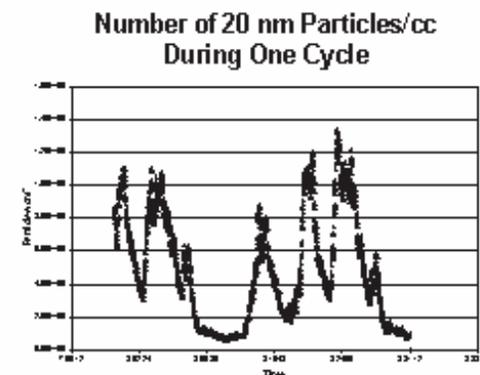
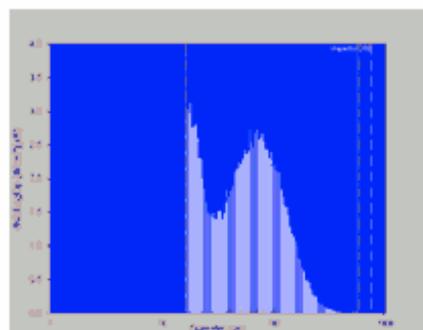
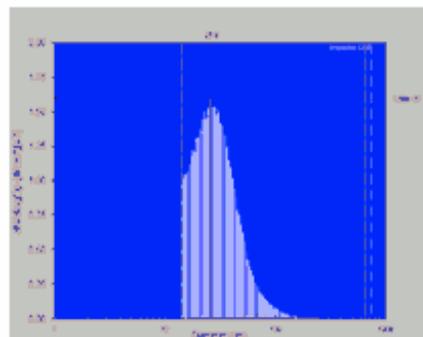
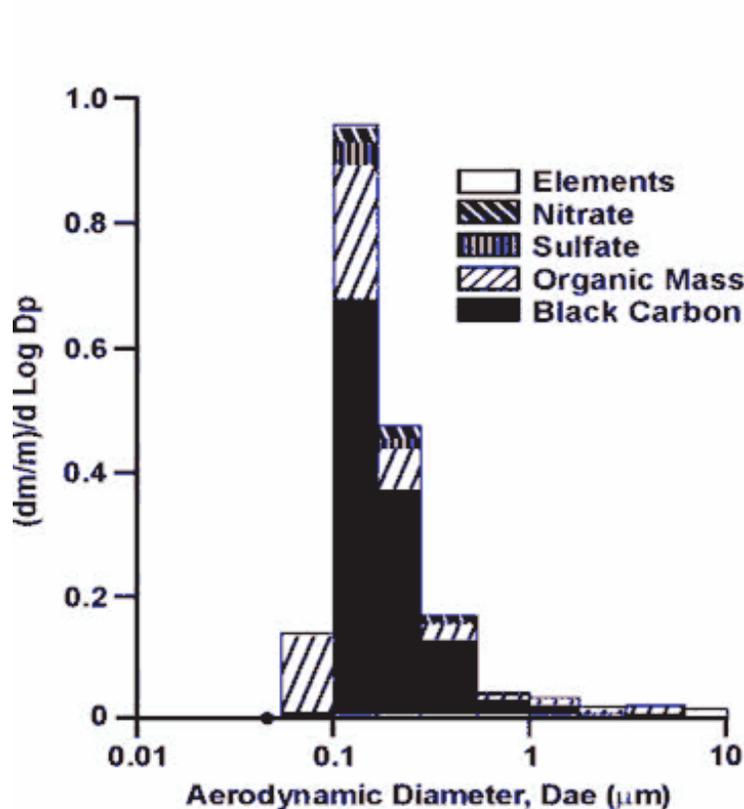
2. **Manipulation, Synthesis of Exposure Atmosphere or Sample**

e.g., filtering, stripping, or size classifying specific components; adding components; altering composition by “tweaking” operation of system.

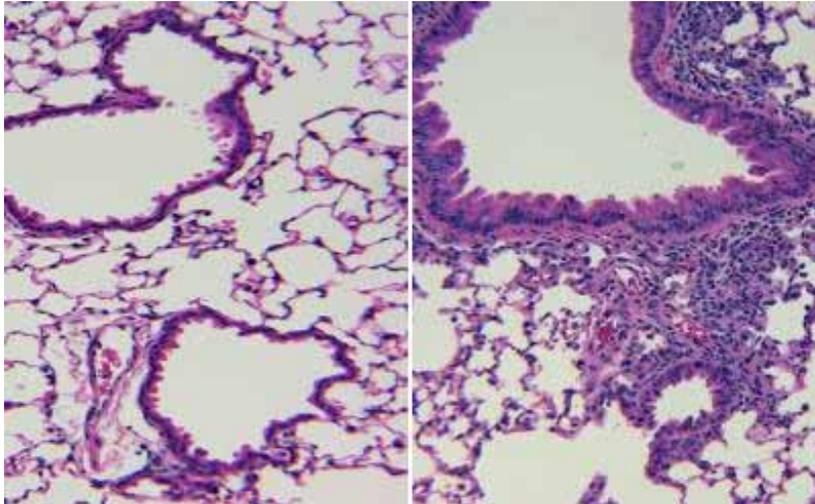
Physical characteristics and gases can only be examined by direct exposure (not collected material)

Experience shows in vitro tests useful for mechanistic studies and “proof of concept”, but do not compare with animal models for extracted samples (Seagrave et al. 2003)

Particle Composition and Size- NERC Diesel Study



NERC Diesel Exhaust Study showed increased RSV pathology and slowed clearance of RSV from lung.

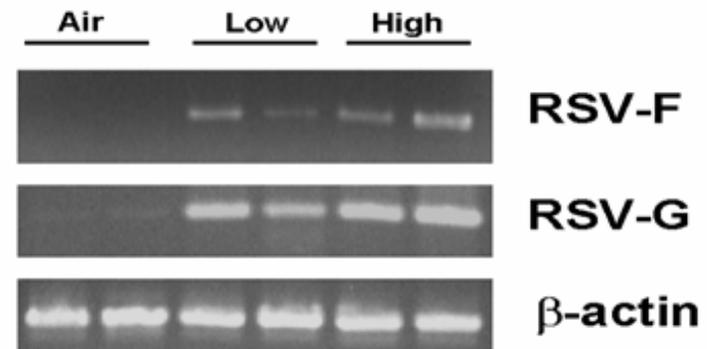


Control

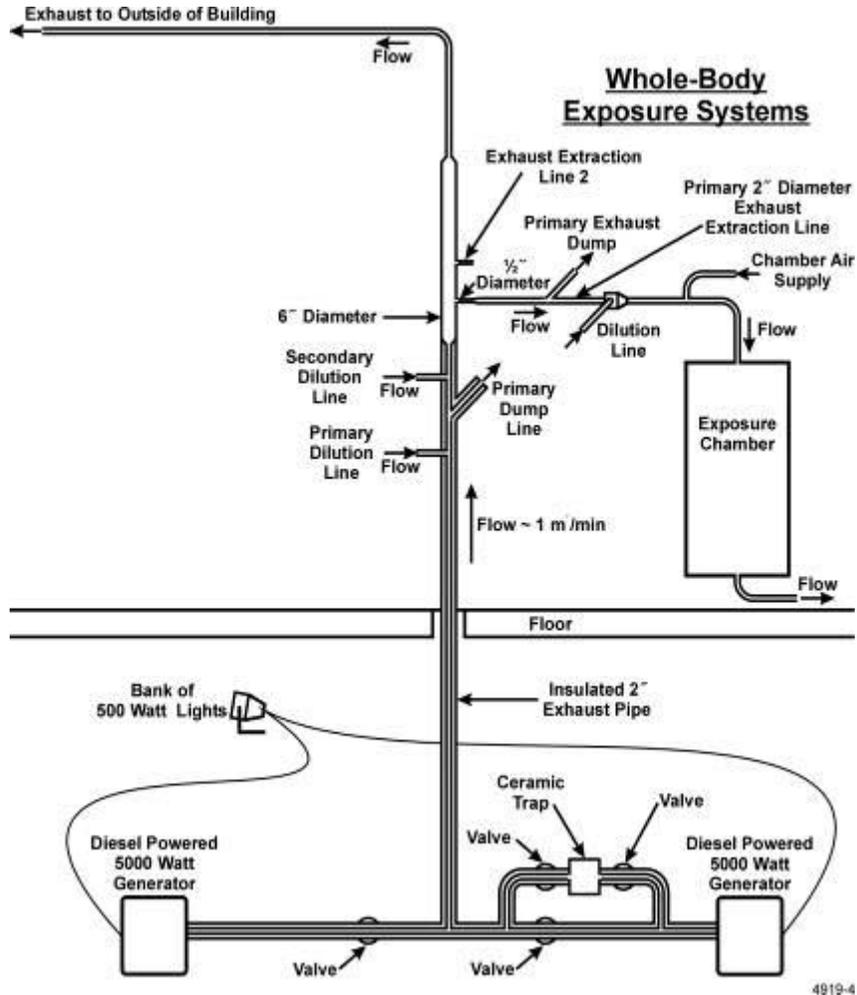
High

Pathology of Small Airways
e.g., DE

- More respiratory syncytial virus RNA was present at 4 days after infection in DE-exposed mice



Follow-On Exposures



*Exposure system described in McDonald et al.
2004. Aerosol Sci. Technol. 38: 62-78, 2004.*

Study Design

- 1. Partial Load
- 2. High Load
- 3. Emiss. Red.

200 mg/m³ PM (1&2)
or equiv. dilution (3)

7 d exposure
C57Bl6 Mice

Group 1

Group 2



Sacrifice immediately after
Last exposure day

Instillation of
RSV



Sacrifice at 4 days

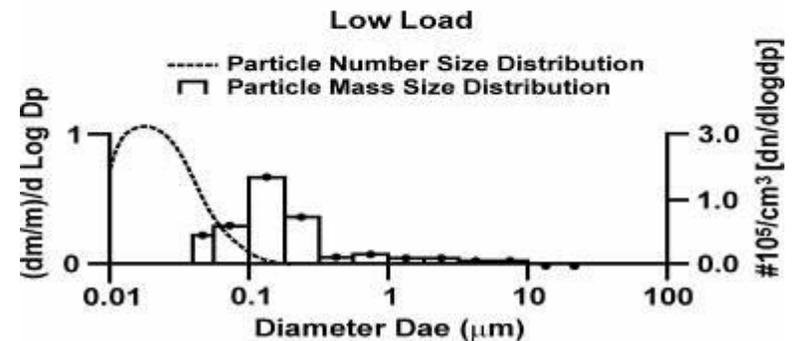
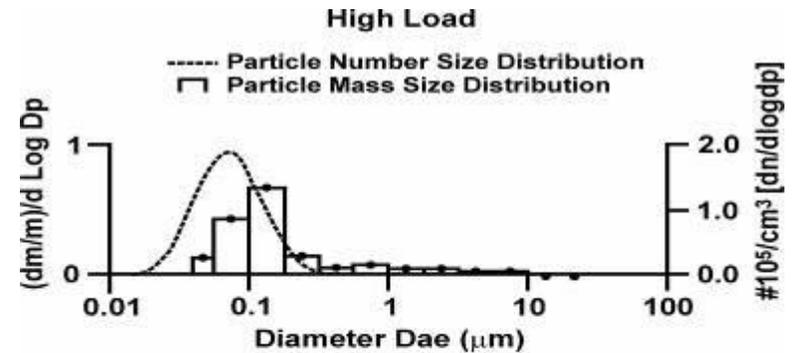
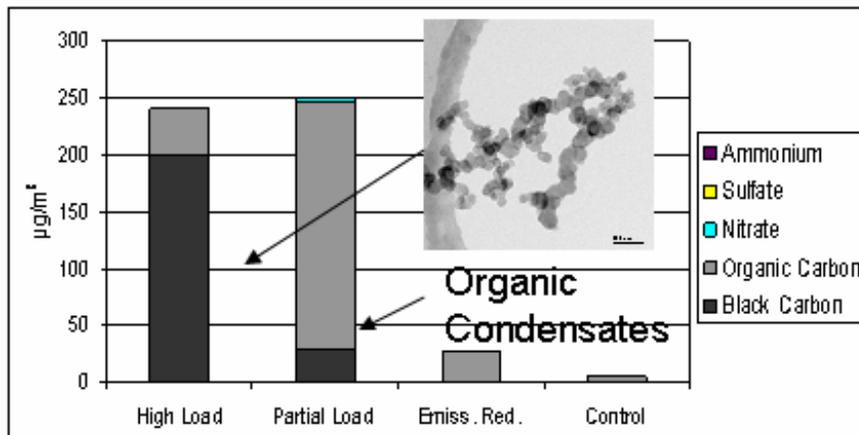
Viral Clearance

Lung pathogenesis

Lung inflammation

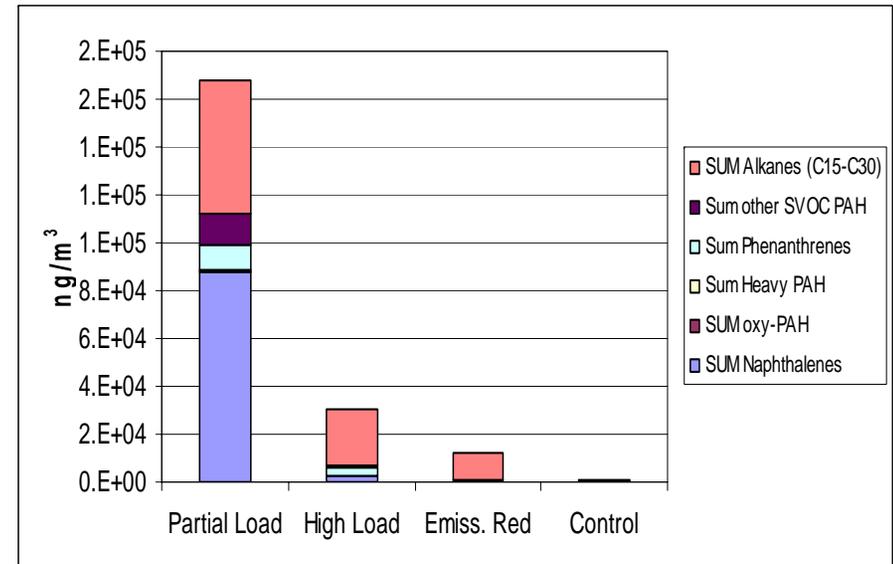
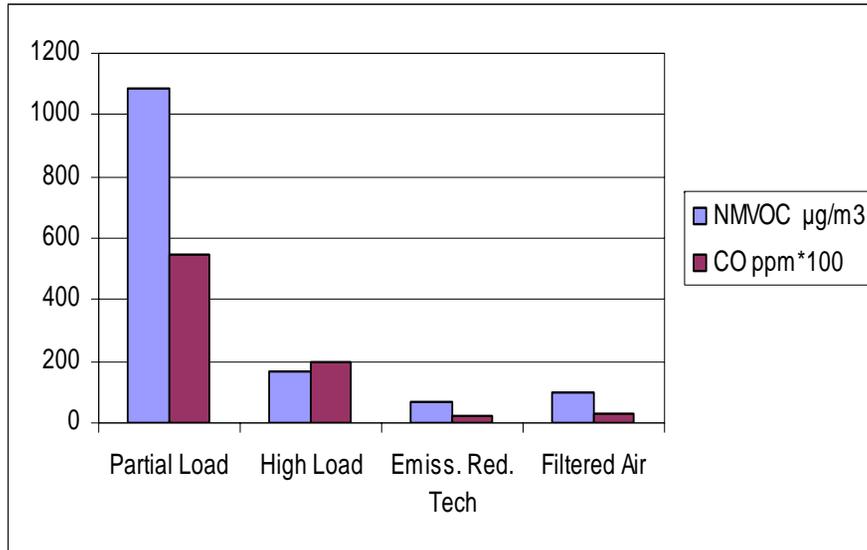
Lung inflammatory/oxidative stress indicators

Particle Composition and Size

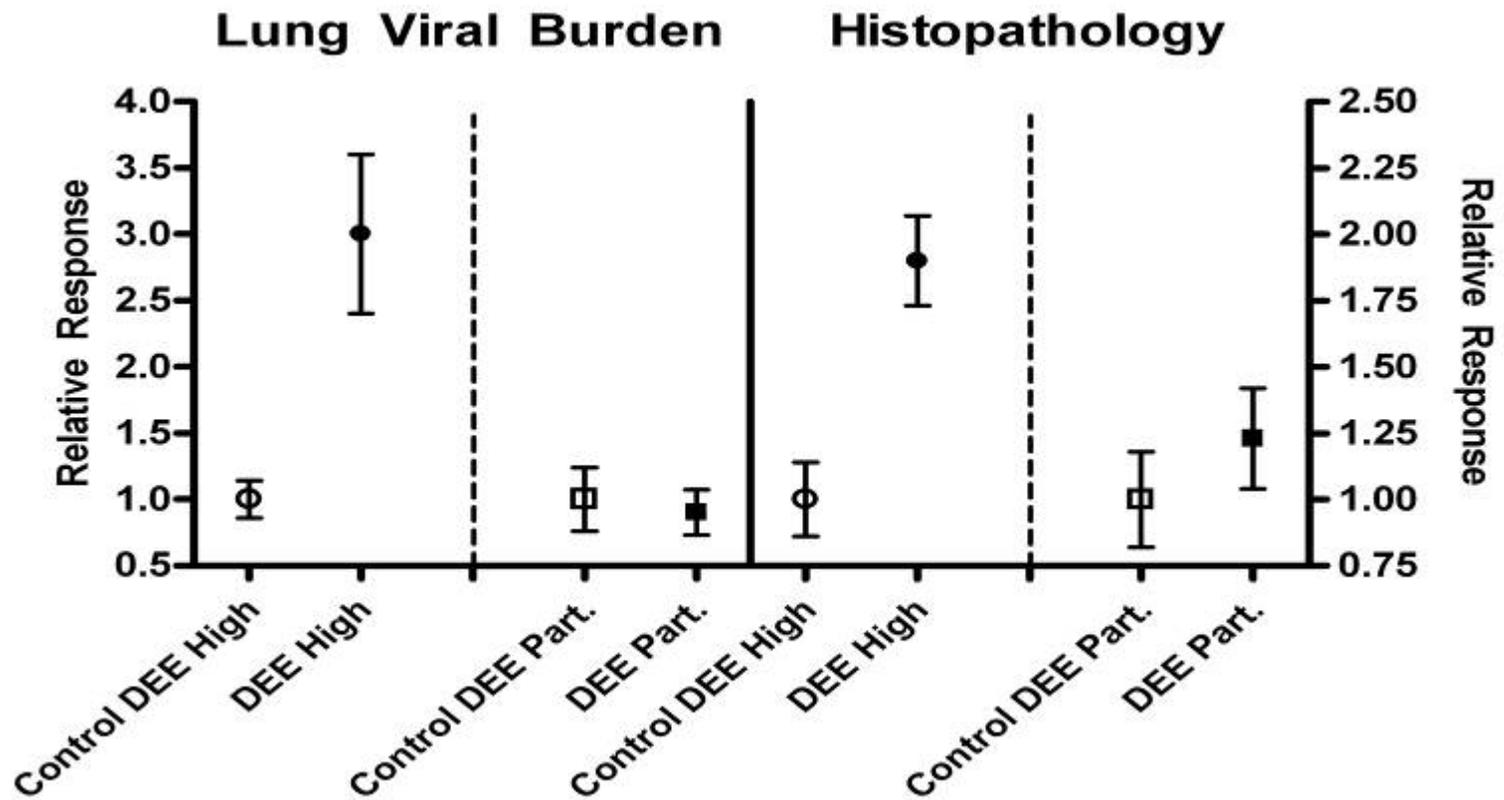


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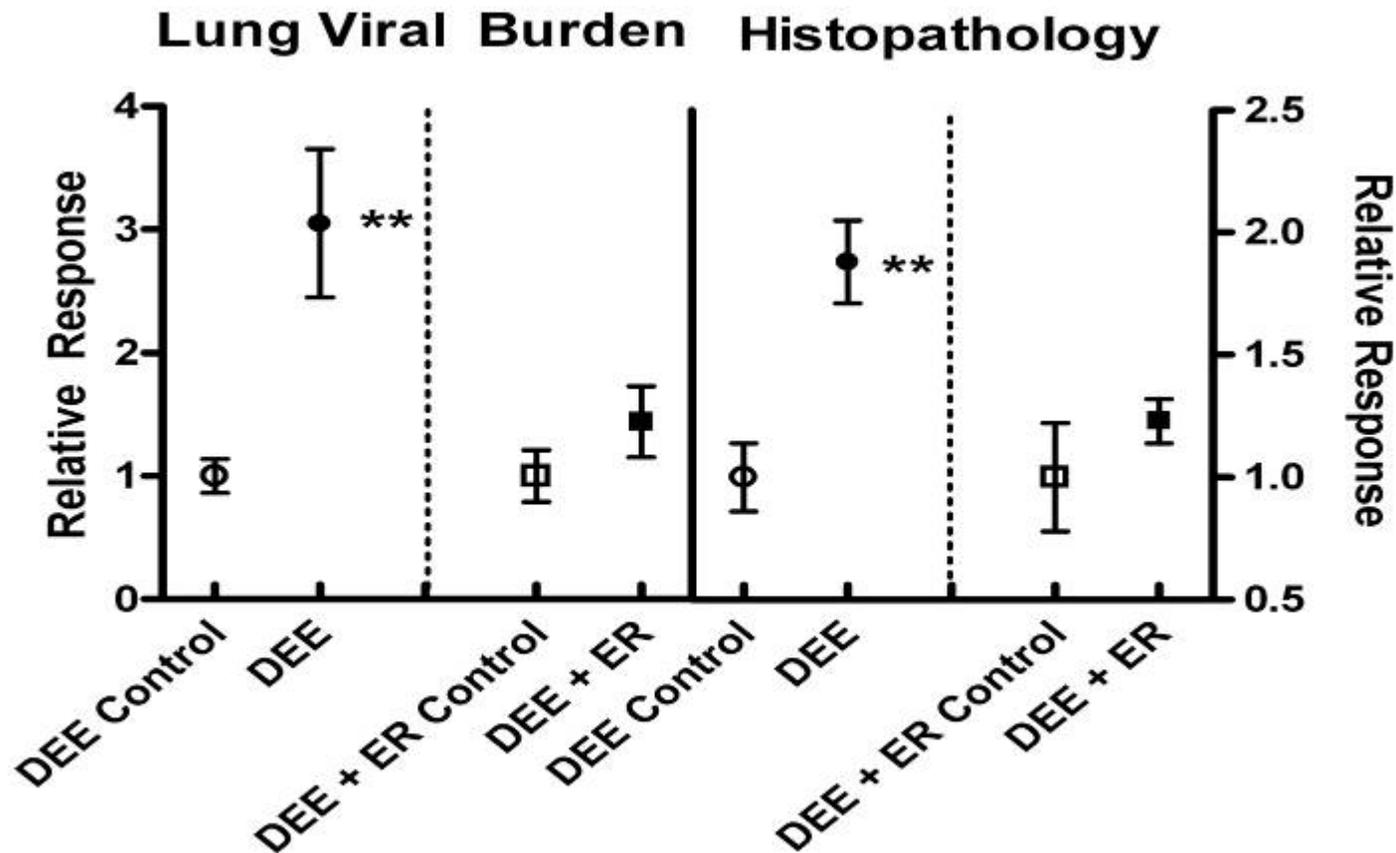
Gas and Semi-volatile Composition



Exposure to DEE High, but not DEE Part. exhaust, resulted in diminished viral clearance and increased lung inflammation (by histopathology) in RSV infected mice.



Exposure to DEE, but not DEE + ER, resulted in diminished viral clearance and increased lung inflammation (by histopathology) in RSV infected mice.

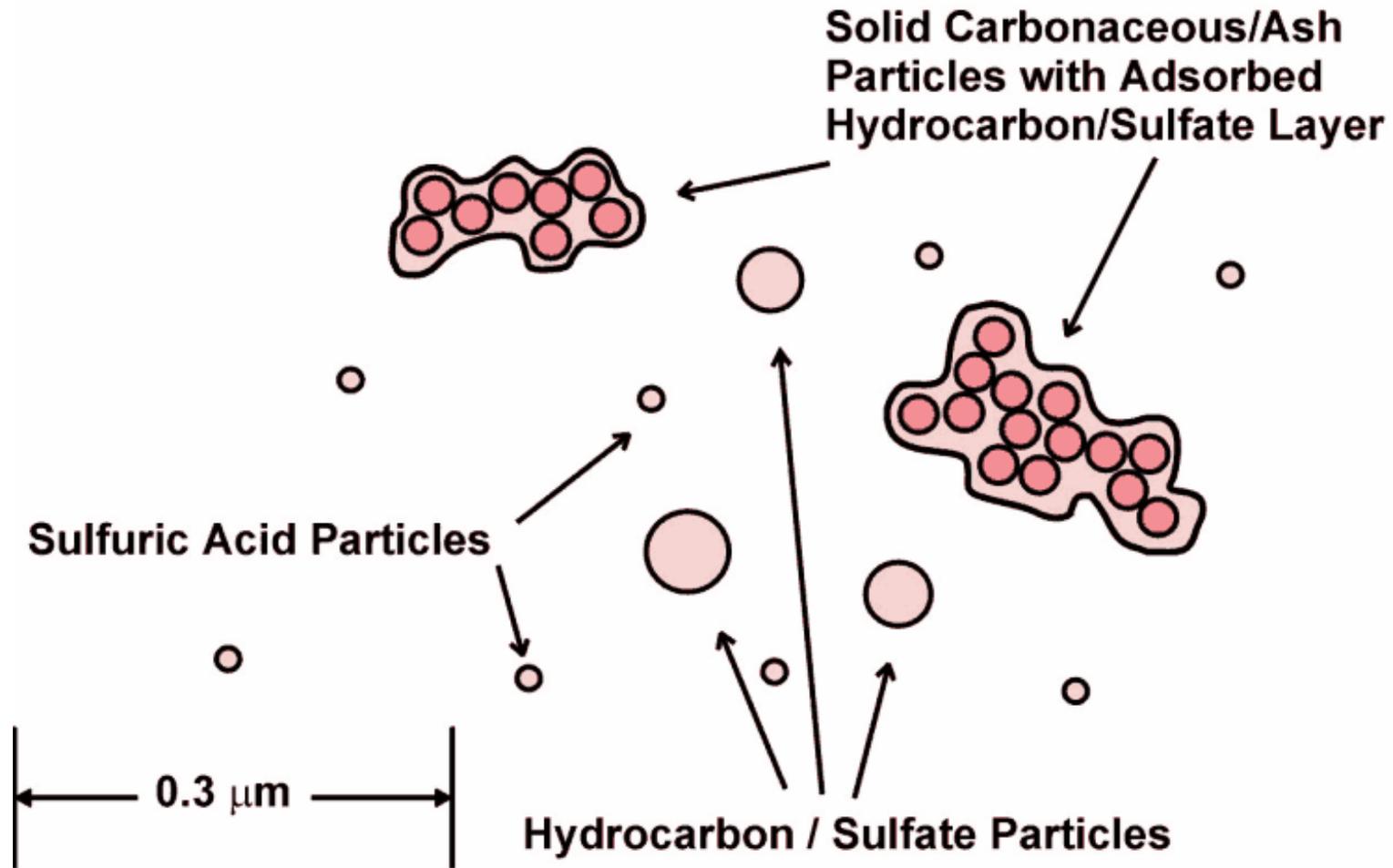


McDonald et al., *Environ Health Perspectives*, 2004

Summary

- **High engine load conditions resulted in:**
 - Decreased organic (both VOC and PM) & CO content
 - Increased black carbon
 - Increased particle size
 - Increased health hazard
- **Use of catalyzed particle trap:**
 - Decreased VOC, CO, PM,
 - NO_x only slightly reduced
 - Decreased health hazard

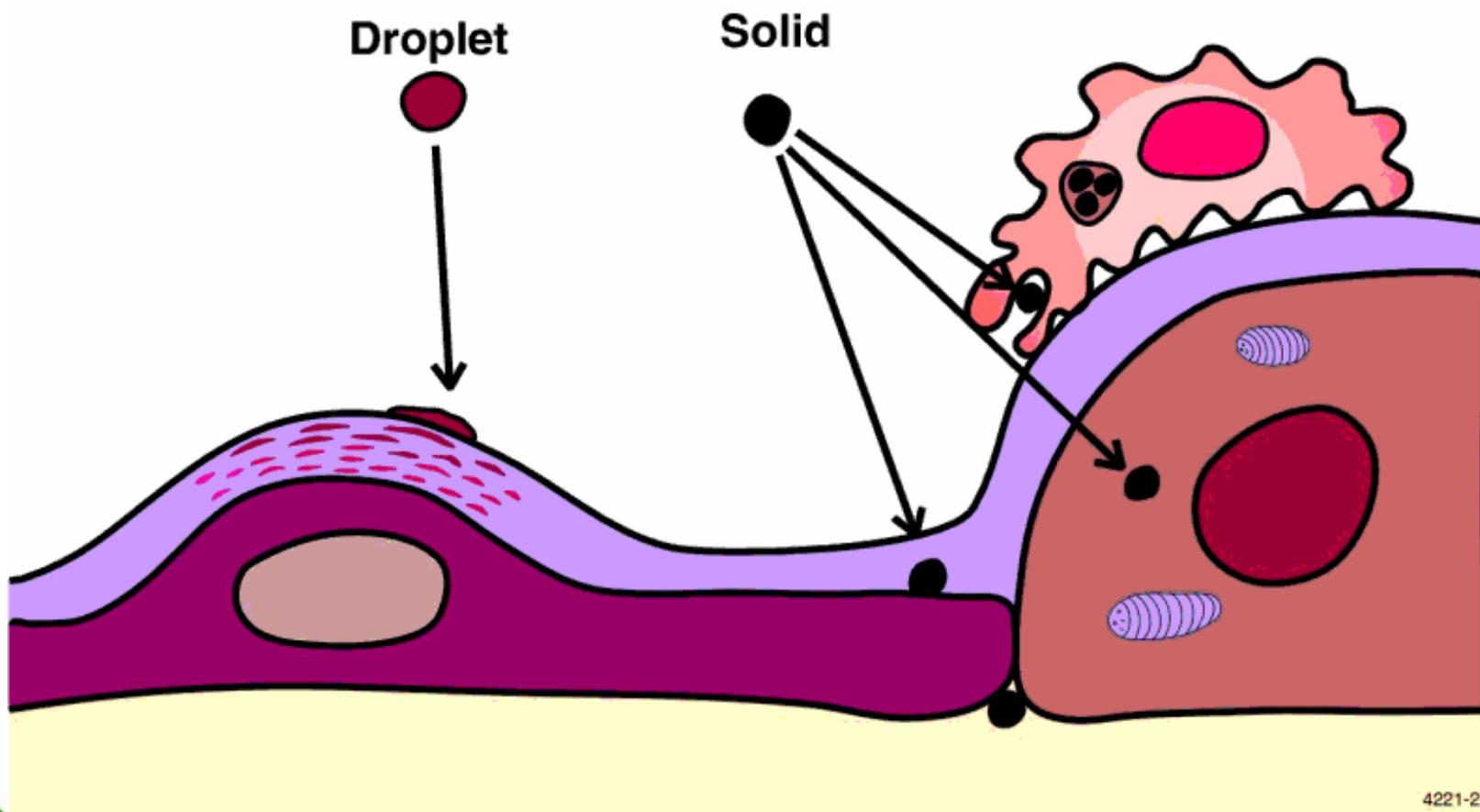
Particle Composition and Structure



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Solid and liquid particles may “behave” differently at lung surface

ULTRAFINES/NANOPARTICLES

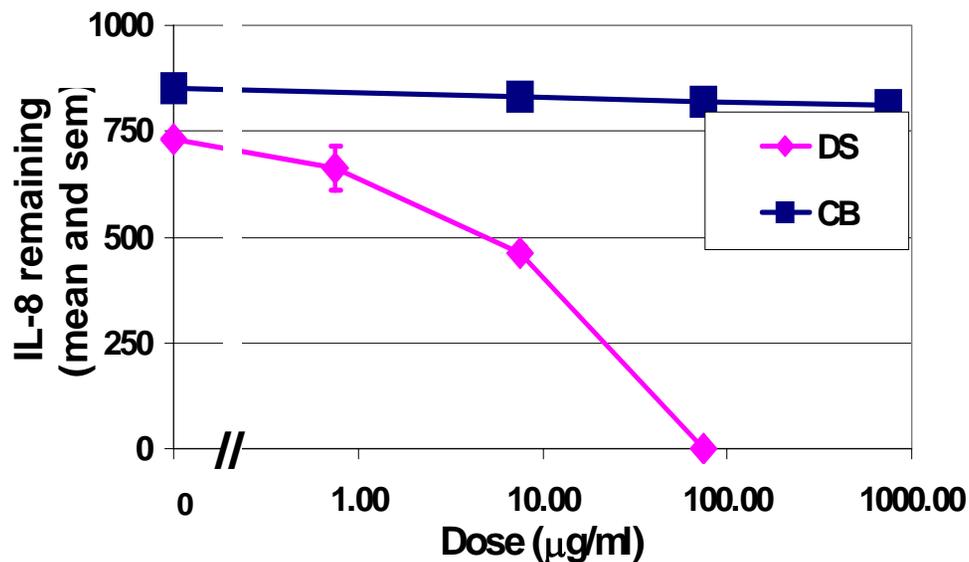


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One Possible Mechanism?

Diesel PM (SRM2975) Binds IL-8

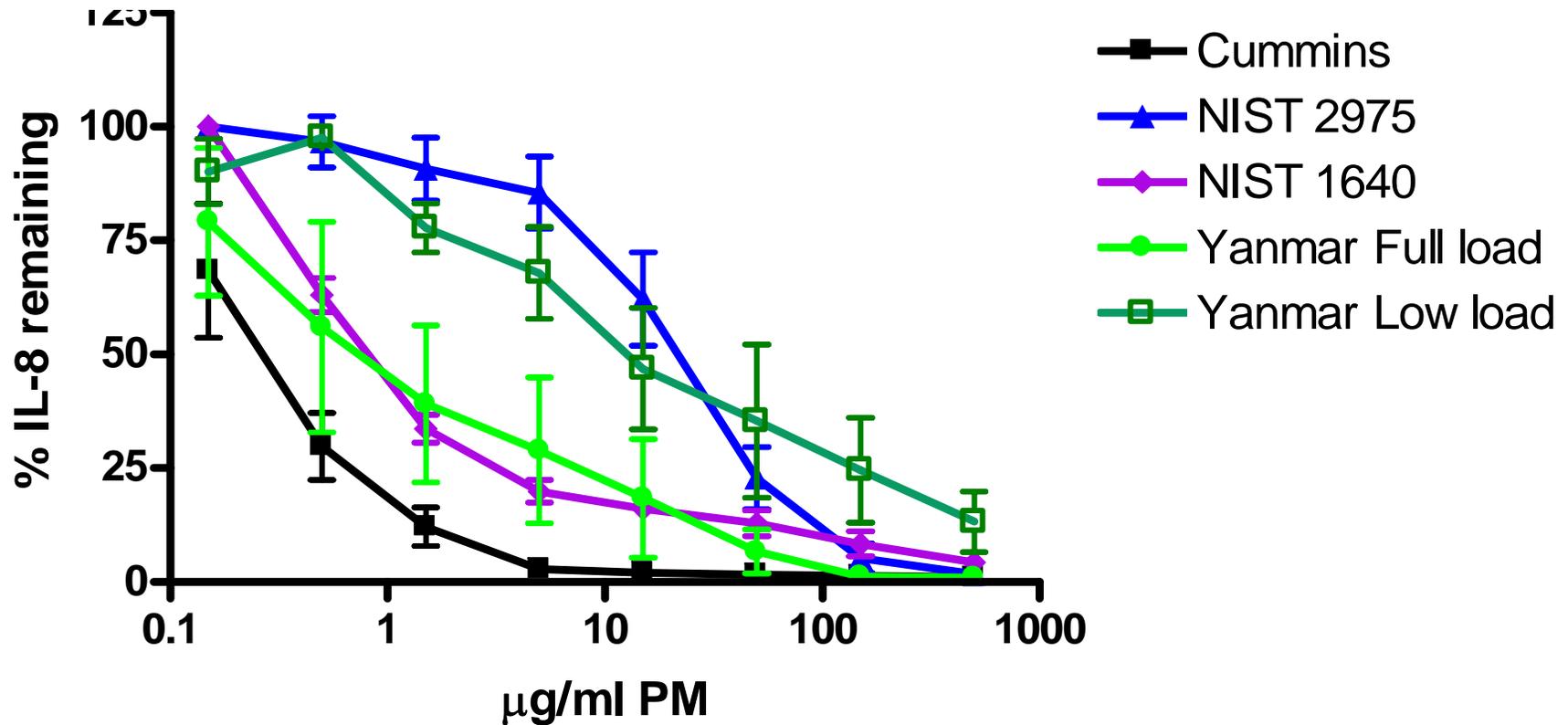


IL-8 “tells” inflammatory cells to move to a site of injury.

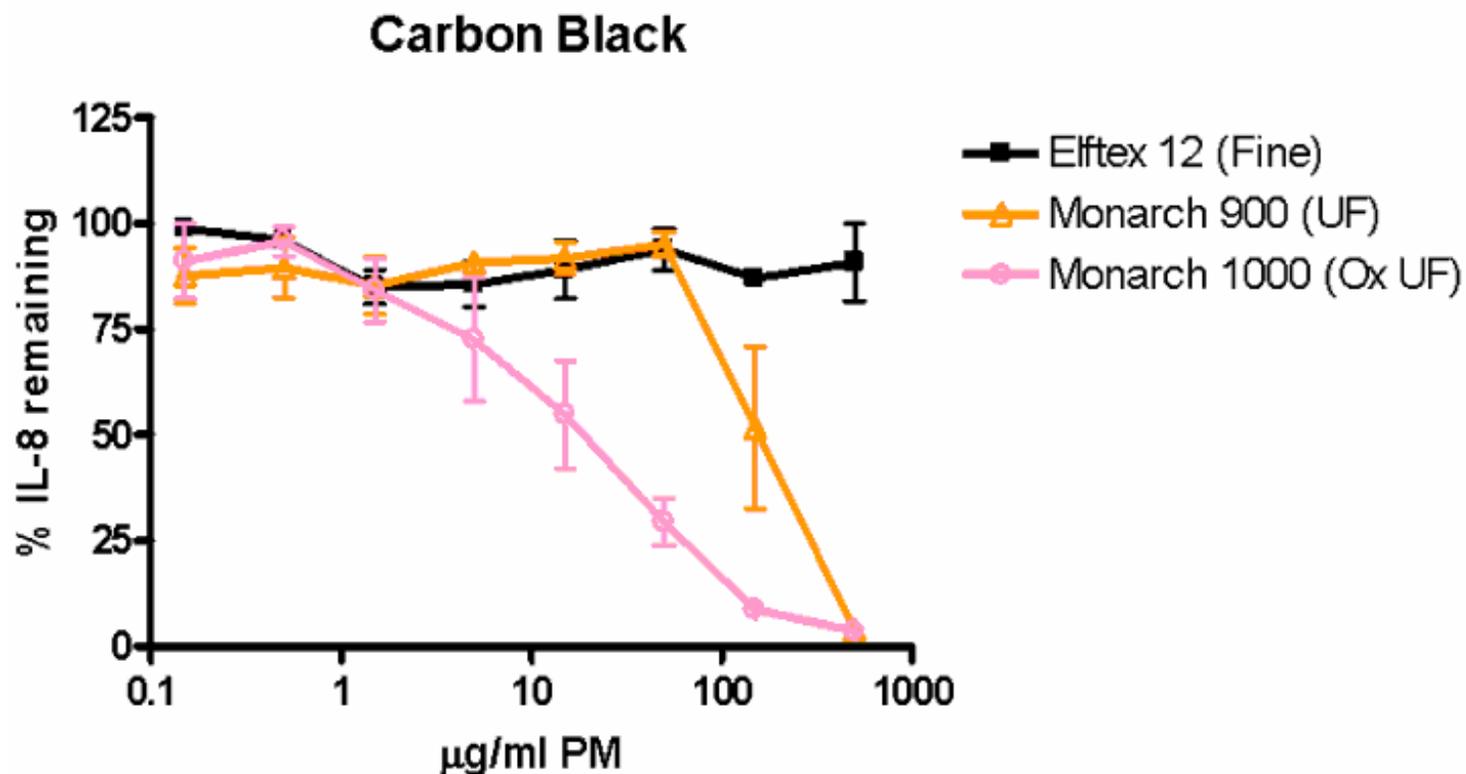
Diesel carbon may “concentrate” these proteins by binding to them.

Seagrave et al., DEER Proceedings, 2002

All carbon are not created equal!



Surface Morphology and Chemistry May Be Important



Take Home Messages

Inhalation exposure results suggest black carbon may be an important driver of inflammation and susceptibility to infection.

- **NOx species, volatile organics, and particle size less**

important than composition of solid particles.

- ***In vitro* studies suggest a possible mechanism for causing**

inflammation.

- **Likely interaction with other components needs testing**

- **Emissions reduction technology diminished effects**



Acknowledgments

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NERC

NIEHS

HEI

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Carbon/Ions

BP: Global Fuels Technology Group

Donation of BP-15 fuel

