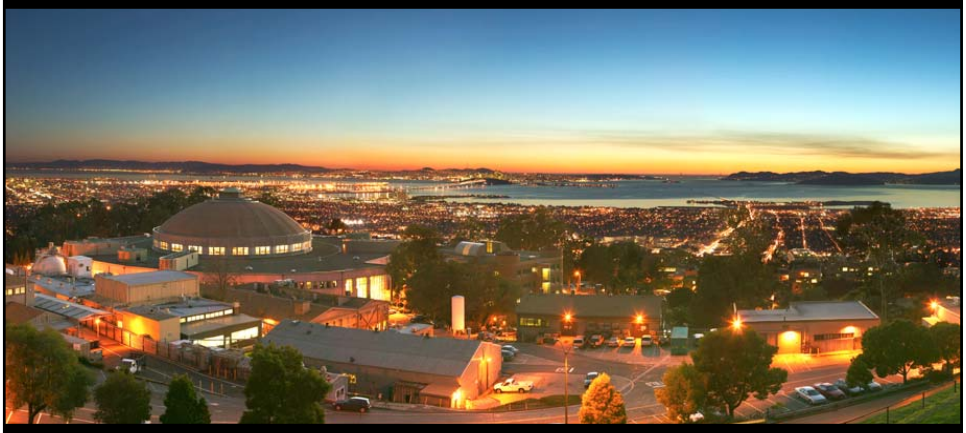
Renewable Energy Sources
New Fuels, New Issues



Donald Lucas
Lawrence Berkeley National Laboratory
Yuma Pacific Section 2008 Annual Meeting Jan. 24, 2008

Issues and problems

- Learning from the past – the MTBE story
- Particles and other emissions (including nanotechnology issues)
- Transformations in the exhaust and in the atmosphere
- Different health effects
  - lung cancer, water pollution, global warming
- Testing new fuels

Some recent investigations/studies

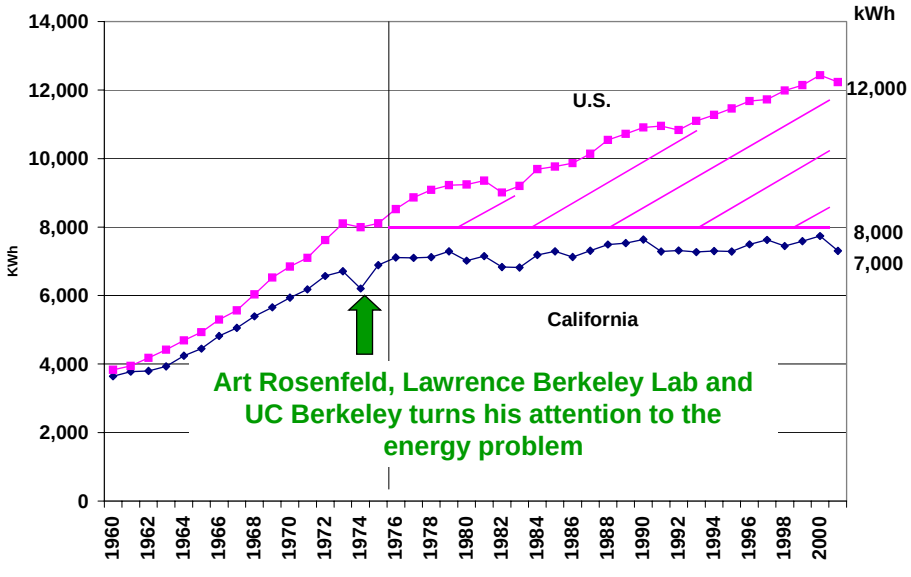
California EPA – Multi-media Working Group (ongoing)

Institute of Medicine Roundtable: Environmental Health, Energy, and Transportation: Bringing Health to the Fuel Mixture (Nov., 2007)

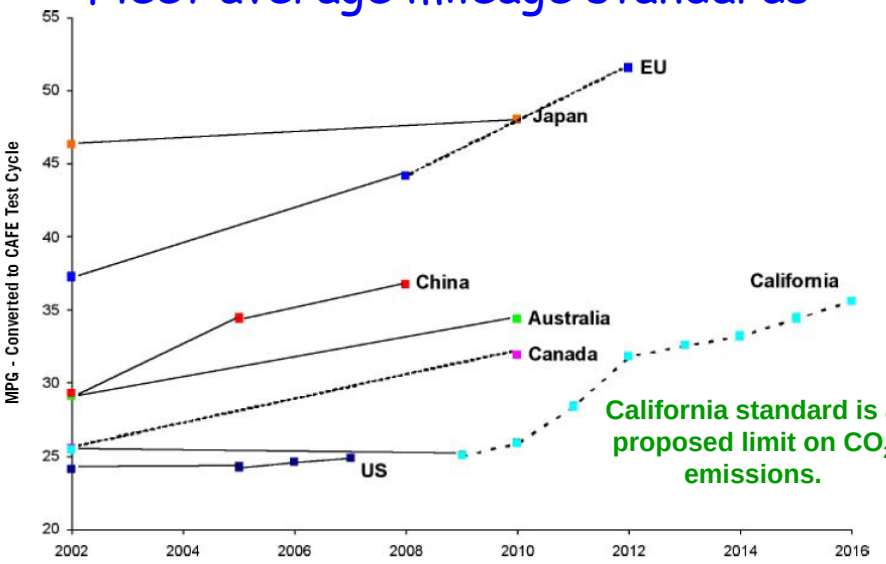
10th International Congress on Combustion By-Products and their Health Effects (Proceedings to be published in Env. Health Perspectives, 2008)

Nanoscale Safety at DOE (DOE P 456.1) (2008)

Electricity Consumption/person in the US and California

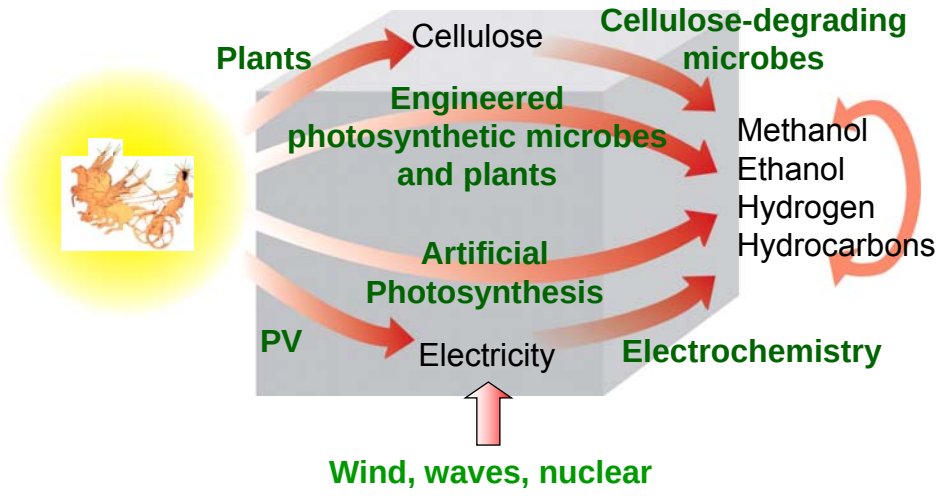


Fleet average mileage standards



Notes: (1) dotted lines denote proposed standards
(2) MPG = miles per gallon

Helios: Lawrence Berkeley Laboratory and UC Berkeley's attack on the energy problem



Firepit in Xuan Wei County, China

Firepit in Hesse Hall, UC Berkeley

Why are particles different?

- Particles may be linked to more than 10 million premature deaths (tobacco, solid fuel burning, air pollution)
- 70% of airborne fine particles are from combustion
- Their physical and chemical properties can change with their dimensions (unlike molecular species)
- They are often mixtures, with surfaces that differ from the bulk properties (adsorbed species).
- They can change in the environment – oxidation, agglomeration, fragmentation, solubility, etc.

Why are particles different?

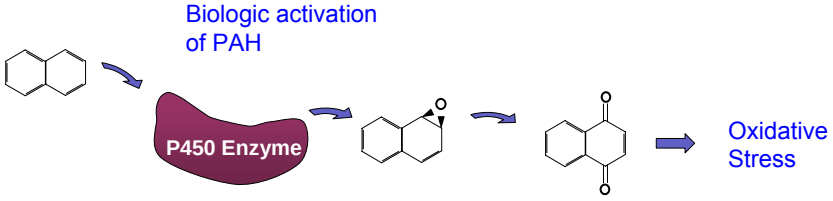
- Primary soot particles are nanosized (20 – 30 nm); particles as small as 1 nm are measured
- Combustion particles (e.g., diesel soot) produce cancer
- It is still not clear what properties lead to their toxicity
- The smaller the particle the longer they last in the atmosphere
- Exposure routes/experimental design are important factors

Soot may result in adverse health effects by causing oxidative stress in a cellular environment

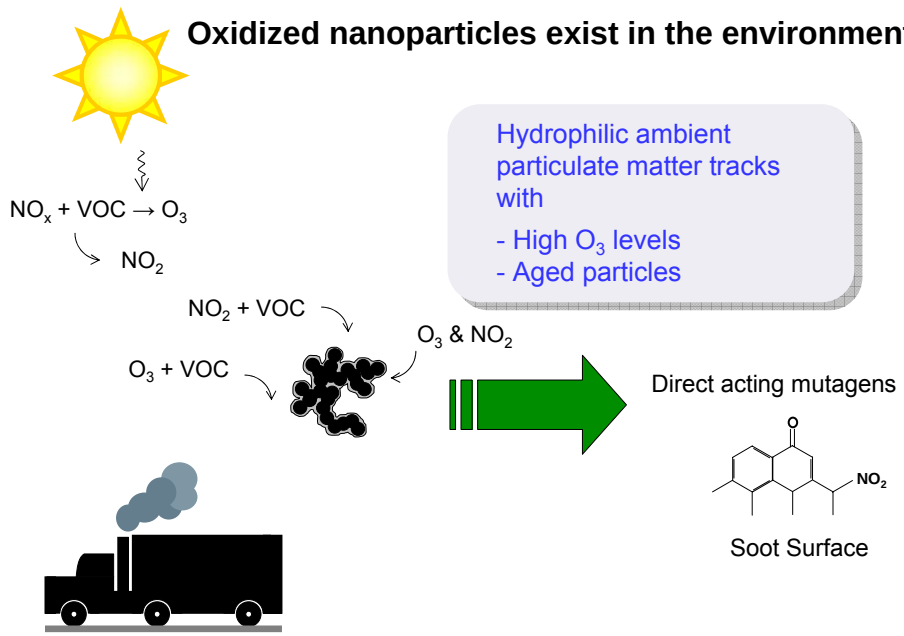
Oxidative stress = generation of reactive oxygen species ($\cdot O_2$, H_2O_2 or $\cdot OH$) that damage the cell

Potential sources of oxidative stress:

- Particles
- Transition metals
- Polycyclic aromatic hydrocarbons (PAH)
- Mixtures or other chemicals



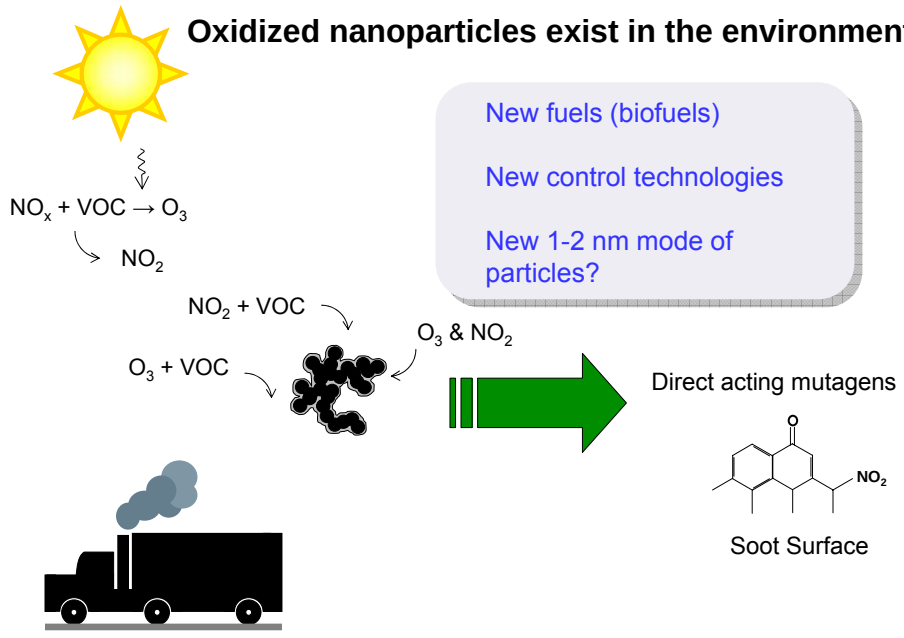
Oxidized nanoparticles exist in the environment



Hydrophilic ambient particulate matter tracks with

- High O_3 levels
- Aged particles

Oxidized nanoparticles exist in the environment



New fuels (biofuels)

New control technologies

New 1-2 nm mode of particles?

Emissions change with fuel, but that's not the only factor

Fuel type

Engine conditions (technology, speed, load, temperature, lubricating oils)

Post-combustion technology (converters, traps, exhaust gas recirculation)

Fuel components (hoses, seals)

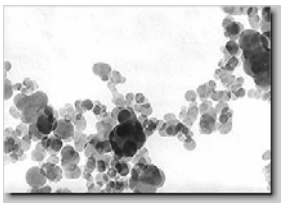
Ambient/atmospheric conditions

Endpoints of health effects, dose, exposure

Predictive modeling conditions

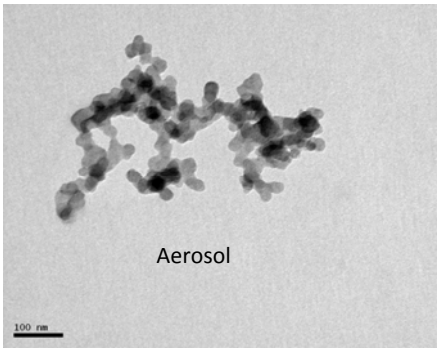
Local vs. global effects

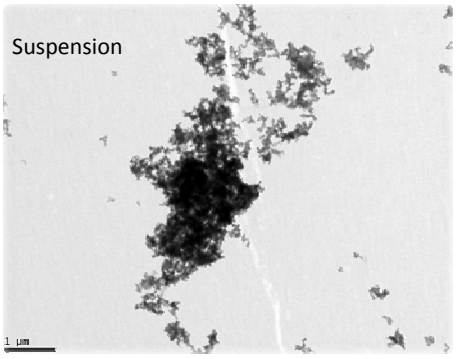
Carbon black respiratory exposure: Does size matter?



- Nanosize carbon instilled in mice causes more inflammation than larger size carbon black particles (Heyder et al. *EHP* 114:328-333)
- Inflammation enhanced by reactive chemicals (e.g., transition metals) on their surfaces (Brown, et al. *Occup Environ Med.* 57:685-691; Wilson, et al. *Toxicol Appl Pharmacol*. 184:172-179)
- IARC (Int'l Agency for Research on Cancer) deems carbon black a group 2B carcinogen

Aerosol compared to suspended particles (unoxidized soot)





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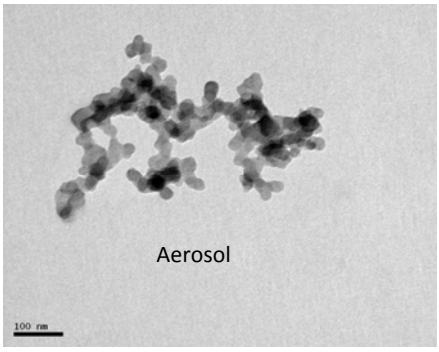
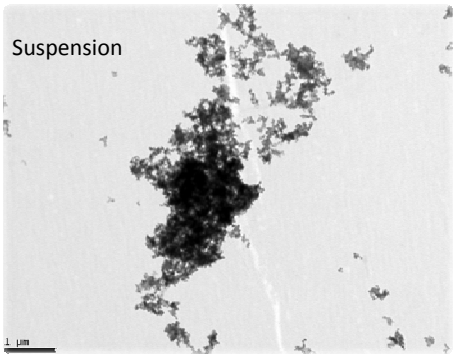
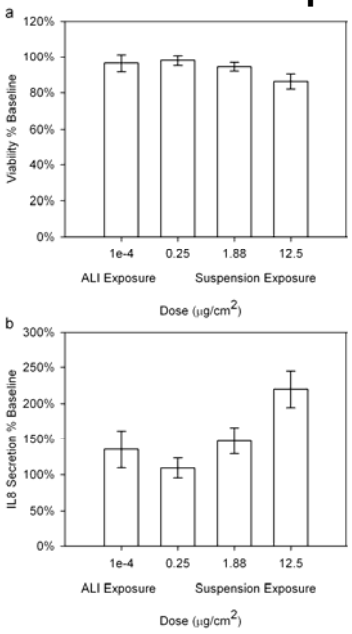


Nanoparticles in biological fluids can also rapidly agglomerate

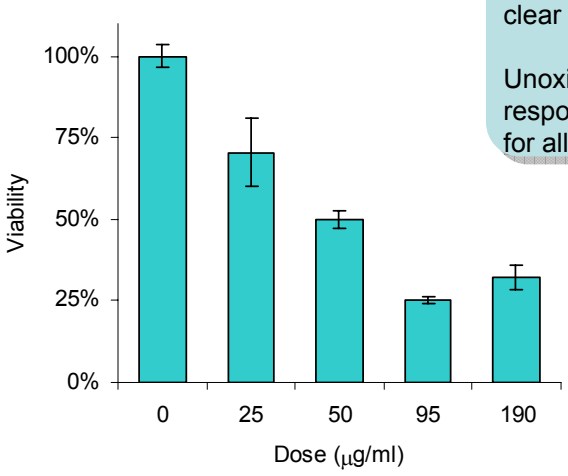


Air-liquid interface compared to suspension



Exposure using the air-liquid interface produces a similar response at a dose 20,000 times lower!

Dose response to oxidized soot



Oxidized soot resulted in a clear dose response

Unoxidized soot had no dose response with viability ~ 90% for all doses

Issues and problems 1/3

- Learning from the past
  - Methanol? Butanol?
  - Ethanol in Brazil
  - Diesel blends – ethanol in diesel. What kind of fuel is it?
- Transformations in the exhaust and in the atmosphere
- Direct vs. indirect health effects (lung cancer vs. global warming)
- Don't forget it's not only the fuel (lube oil)

Issues and problems 2/3

- Testing new fuel blends
  - Epi too long term
  - Animal studies expensive
  - In vitro studies not the best
  - Can we screen for some things? Use baseline fuels/engines?
  - New fuels, new issues – comingling, vapor pressure, water contamination
  - Air liquid interface exposure vs installation

Issues and problems 3/3

- Are we controlling the correct parameter (particle mass)?
- Should we control surface area, surface chemistry, size distribution? What about synergistic effects?
- How to measure effects in workers? Blood tests? What should we look for?

Thanks!

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- Dietert Grunert
- Chris Stipe
- Brian Higgins
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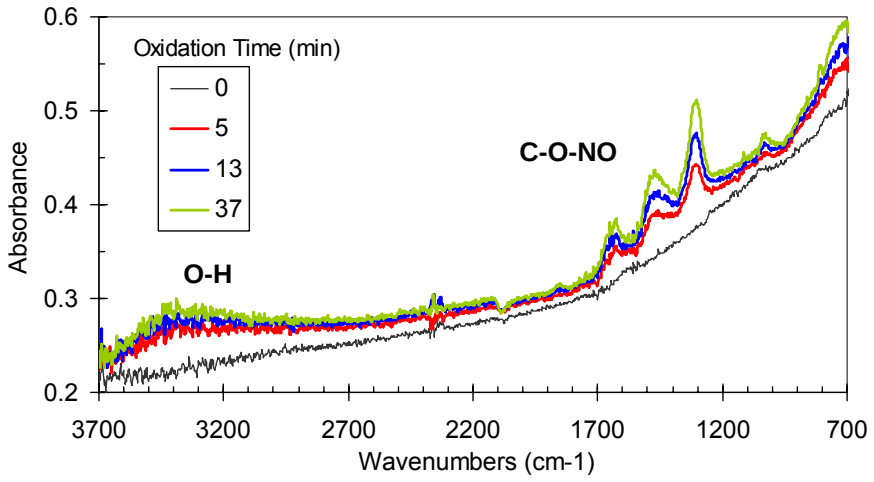
“Clean” soot oxidized with ozone/NOx



Tom Kirchstetter and Odelle Hadley
Lawrence Berkeley National Laboratory, 2007