



HEALTH EFFECTS OF EXPOSURE TO DIESEL EMISSIONS

Bruce K. Hope, Ph.D.

Air Quality Division

Oregon Department of Environmental Quality

Portland, Oregon

hope.bruce@deq.state.or.us



Diesel emissions (DE)

- ◆ **Not a unique “chemical”**
 - Complex mixture of various solid particles & gasses
 - Created by incomplete combustion of hydrocarbons
 - Composition influenced by various operating factors
- ◆ **Constituents have known cancer and non-cancer adverse health effects**
 - Carcinogenic potential of DE itself is highly controversial
 - Can be a very good toxicant delivery mechanism
- ◆ **Measurement as a unique entity is challenging**



Vapor phase

◆ Unreactive gases

- Water vapor, nitrogen, carbon dioxide

◆ Gaseous air pollutants

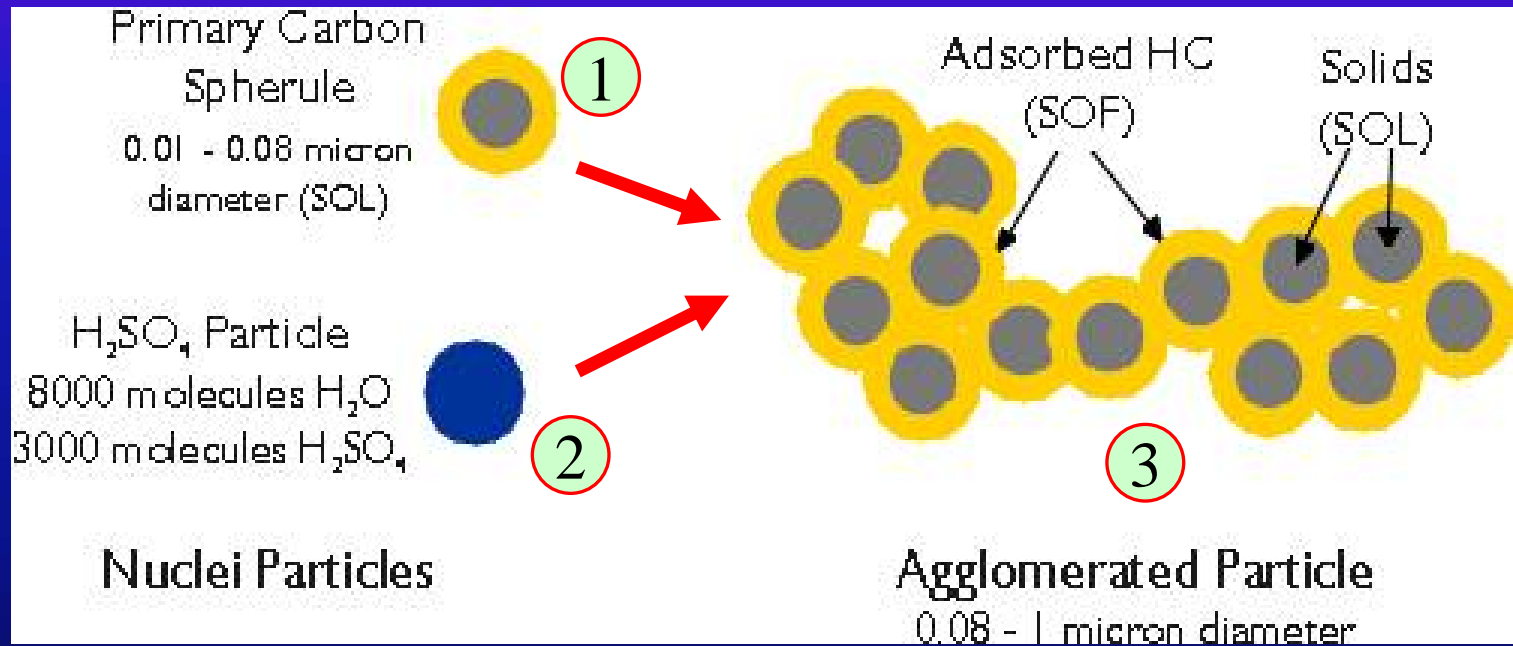
- Nitrogen oxides (NO_x), sulfur oxides (SO₂, SO₃), carbon monoxide, volatile organic compounds (VOC)

◆ Carcinogenic air toxics

- Benzene (leukemia, lung cancer)
- Formaldehyde (nasal passage cancer)
- 1,3-butadiene (bladder cancer)



Forming a particle



- (1) Ultrafine solid carbon particles (soot, *nuclei particles*) coated with adsorbed hydrocarbon (HC) materials
- (2) Ultrafine sulfuric acid liquid (H₂SO₄) particles also formed as nuclei particles
- (3) Nuclei particles rapidly stick to each other to form larger *agglomerated particles* that are respirable (fine) particulates (i.e. PM_{2.5} components)

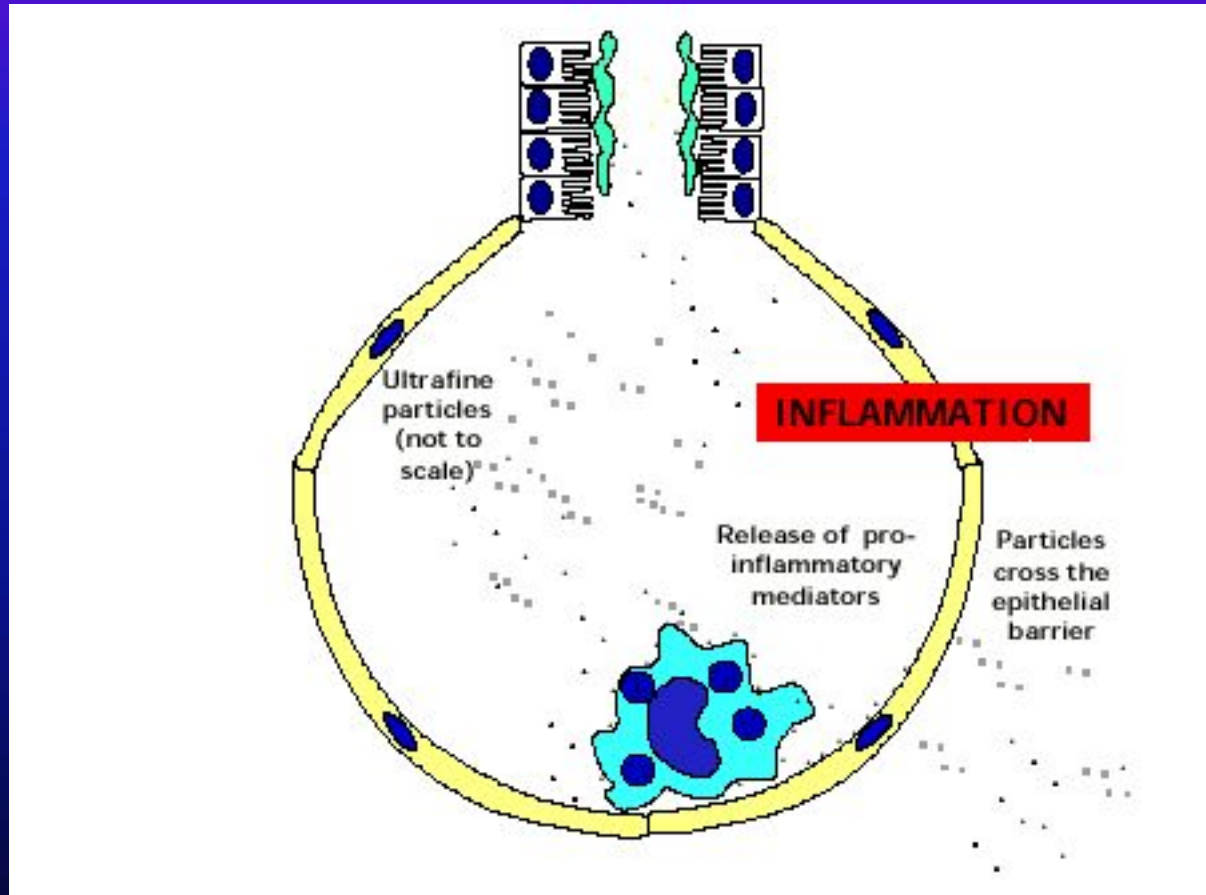


Particulate phase

- ◆ Majority (> 80%) of DE are respirable particles
 - Ultrafine particulates (<0.1 μM)
 - Fine particulates (0.1 - 2.5 μM)
- ◆ Elemental carbon (soot)
 - Tiny, highly adsorbant particles
 - Chemically unreactive
 - Not directly toxic but can lead to particle overload
 - May act as tumor promoter by inducing release of inflammatory mediators



Particles in the lungs



Release of inflammatory mediators in lung tissue stimulated by ultrafine particles



Particulate phase

◆ Inorganic compounds

- Sulfate, nitrate, metals, other trace elements
- May act directly or indirectly to induce oxidative stress in lung tissues

◆ Traces (<1% by mass) of adsorbed organic compounds

- Polycyclic aromatic hydrocarbons (PAHs)
- Nitroarenes (nitro-PAHs)
- Oxidized PAH derivatives



Adsorbed PAHs

- ◆ **PAHs adsorbed to diesel exhaust particles**
 - Carries PAHs/other organics deep into lung airways
 - Ultrafines can carry adsorbed load across cell membranes
- ◆ **Polycyclic aromatic hydrocarbons (PAHs)**
 - 7 probable human carcinogens (includes BaP)
 - 25+ possible human carcinogens
- ◆ **Nitroarenes**
 - Hydrocarbons with attached nitro (-NO₂) chemical groups
 - Several compounds are highly mutagenic



Contributing to particles

◆ Engine types

- 50-80x and 100-200x more particulates than automobiles (older engines)

◆ Operating conditions

- Idling, acceleration (really bad), deceleration

◆ Fuel

- Low-sulfur diesel - less SO_x gases and H_2SO_4 particles
- Better quality diesel fuels have lower aromatics (PAHs)

◆ Maintenance



Cancer potential of diesel

