How are EPFRs Formed?

Environmentally Persistent Free Radicals (EPFRs) are formed in combustion and thermal processes including hazardous waste incineration and diesel combustion. These processes create tiny particles called Particulate Matter (PM). PM is classified as coarse (10-2.5 μm), fine (2.5-0.1 μm), and ultrafine (0.1 μm and smaller). (To put this size into perspective, a human hair is approximately 70 μm in diameter, so the largest fine particle is still 30 times smaller than that.) 90% of ultrafine particles are formed from combustion sources, and these particles have the potential to penetrate in to the deepest portion of the lungs (the alveolar region). These particles provide the perfect breeding ground for EPFR formation. The free radical first forms a "loose" bond with the surface of the particle. Next, the EPFR is formed when the loosely bonded free radical forms a chemical bond with metals present in the particle in order to stabilize its own unpaired electron. This process reduces the metal allowing the attached EPFR to have a half life of up to several days rather than the fractions of a second of a normal free radical. EPFRs are also present in some contaminated soils as well as in ambient air. A recent Baton Rouge air sample revealed that airborne fine PM contained EPFRs with concentrations of 10^{17}- 10^{18} radicals/g of air.

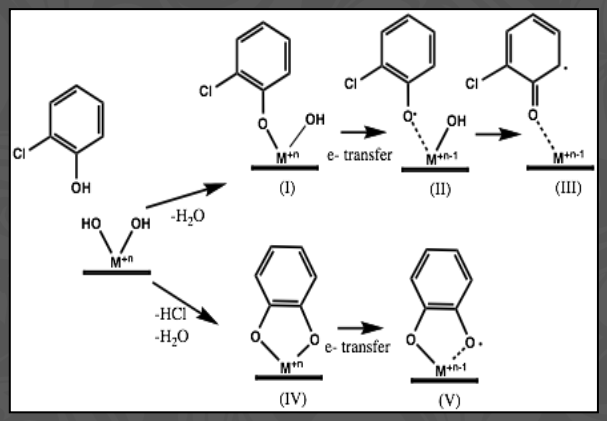

Figure 1

Cormier, et. al.

EPFRs:

Environmentally Persistent Free Radicals

Superfund Research Program

NIEHS

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What is a Free Radical?

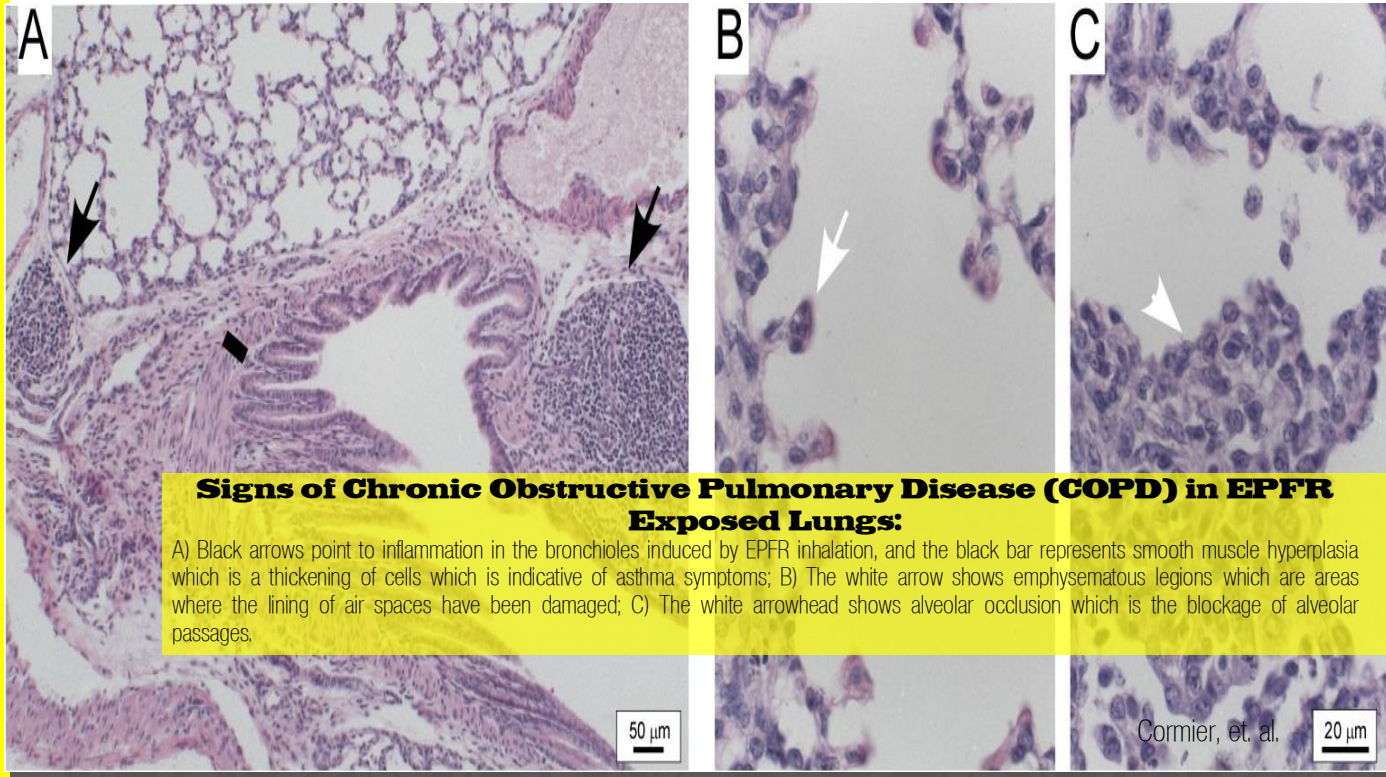
A free radical is an atom or group of atoms that has an unpaired electron and it therefore very unstable. In order to become stable, these free radicals will "steal" electrons from other atoms with which they come in contact with causing the donor atom to become unstable leading to a chain reaction. This process occurs very quickly with millions of molecules being affected in a matter of nanoseconds. Free radicals are both naturally occurring and anthropogenically created. Some natural free radicals are utilized in the body's immune responses to kill viruses and bacteria, but foreign free radicals stemming from tobacco smoke, toxins, or pollutants, can cause cell damage and induce an inflammatory response which can cause a wide range of biological damage. These types of free radicals have a very short life span.

What are EPFRs?

Environmentally Persistent Free Radicals (EPFRs) are free radicals that have a much longer life span than most free radicals and are therefore more persistent in the ambient environment. These radicals are much more stable and can induce more oxidative stress in biological systems.

Figure 1- The Formation of EPFRs:

1) A pollutant forms a weak bond with a metal on the surface of a particle (physisorption); 2) Water or hydrogen chloride is released to form a strong bond with the metal (chemisorption); 3) Chemisorption reduces the metal when the pollutant takes an electron from it resulting in the formation of the radical; 4) OH- is released forming the stable EPFR



Signs of Chronic Obstructive Pulmonary Disease (COPD) in EPFR Exposed Lungs:

A) Black arrows point to inflammation in the bronchioles induced by EPFR inhalation, and the black bar represents smooth muscle hyperplasia which is a thickening of cells which is indicative of asthma symptoms; B) The white arrow shows emphysematous legions which are areas where the lining of air spaces have been damaged; C) The white arrowhead shows alveolar occlusion which is the blockage of alveolar passages.

How do Environmentally Persistent Free Radicals Affect Human Health?

EPFRs can be environmentally persistent but also biologically active by generating cell damaging reactive oxygen species (ROS). These ROS induce oxidative stress, a defense mechanism in the body where the immune system "over-responds" to invaders. When this process is started by free radicals it becomes a contributor to heart and lung dysfunction as well as DNA damage. This works by the EPFR's ability to "piggy-back" on particulate matter (PM) which is then inhaled and transferred to the alveolar region of the lungs. This site will easily transport particles to other tissues in the body because of its close relation to the blood stream and the high amount of blood flow.

How can I Protect Myself from Environmentally Persistent Free Radicals?

The LSU Superfund Research Program is currently investigating the impacts of EPFRs to better understand their formation and how they affect the body in order to make recommendations for preventing the formation and reducing human exposure. To lessen your exposure to air pollution, avoid strenuous activity outdoors when there are air quality advisories and exercise away from roadways and other sources of emissions.

To check your local air quality conditions visit http://airnow.gov/.

For further information on PM visit: http://www.epa.gov/air/particlepollution/basic.html.

To learn more about EPFRs and LSU's Superfund Research Program visit http://www.srp.lsu.edu/.