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**Source:** Vejerano, E., Rao, G., Khachatryan, L., Cormier, S., Lomnicki, S. (2018). Environmentally Persistent Free Radicals: Insights on a New Class of Pollutants. *Environmental Science and Technology*. 52(5): 2468-2481.

**Contact:**
vejerano@mailbox.sc.edu

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European Commission

# Science for Environment Policy

## Environmentally persistent free radicals: what do we know about this newly recognised class of pollutants?

**The most important findings from over a decade of research into environmentally persistent free radicals (EPFRs), a new class of environmental pollutants, are presented in a recent review.** These toxic particles could be partly responsible for some of the health problems, such as asthma, associated with particulate matter (PM) exposure. The researchers issue a warning that some engineered nanomaterials (ENMs) could increase levels of EPFRs in the environment.

**Scientists have known about the existence of EPFRs for over 50 years.** However, it is only in the past decade that they have really started to understand their properties and potential health risks. While research into EPFRs is still in its infancy, the study provides a wide-ranging overview of what is known about these pollutants so far, as well as highlighting key knowledge gaps.

EPFRs are contaminants contained in $PM_{2.5}$ (particulate matter less than 2.5 micrometres in size) and ultrafine particulate matter (under 100 nanometres). They are mostly produced during combustion of organic material and were first discovered in the 1950s in coals, chars (carbon left over following coal combustion in air) and soot. In the 1970s they were linked with the health effects of cigarette smoke, but their environmental presence in air, soil and fly ash only became apparent in the 2000s.

During combustion, EPFRs form when by-products emitted from organic materials react with and form on the surface of particles of 'transition metal' oxides, such as copper or iron oxide. Other atmospheric free radicals typically have lifetimes of only a fraction of a second, but EPFRs survive for up to several months. This persistence allows them to be transported long distances which increases the risk of human exposure — and thus, potentially, health risk.

Research has suggested that EPFRs may play a role in a number of health issues, particularly cardiovascular and respiratory conditions. For instance, one study[1] has shown that baby mice exposed to EPFRs were much less likely to survive flu than those who were not exposed. EPFR-exposed rodents have been found to be at increased risk of asthma attack, heart disease and reduced blood flow.

Lab studies[2] have shown that EPFRs damage human cells. Furthermore, studies on unborn mice exposed to PM that contained EPFRs exhibit an increased risk of developing asthma post-birth[3]. The study suggests that EPFRs could be responsible for some of the health effects, such as asthma and severe respiratory infections, currently associated with PM pollution more broadly. However, the researchers also advise treating the results of such health studies with caution. As yet, no research has made concrete, direct links between EPFRs and human health impacts.

*Continued on next page.*

1. Lee, G. I., Saravia, J., You, D., *et al.* Exposure to combustion generated environmentally persistent free radicals enhances severity of influenza virus infection. Part. *Fibre Toxicol*. 2014, 11 (1), 57.

2. Balakrishna, S., Lomnicki, S., McAvey, K. M., *et al.* Environmentally persistent free radicals amplify ultrafine particle mediated cellular oxidative stress and cytotoxicity. Part. *Fibre Toxicol*. 2009, 6 (1), 11.

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# Environmentally persistent free radicals: what do we know about this newly recognised class of pollutants? *(continued)*

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Research to date has found that EPFRs are present in the environment at levels which are high enough to cause health issues, as implied by animal and human cell studies. Studies conducted in Germany[4], Saudi Arabia and the US have provided figures of around $10^{16}$ to $10^{17}$ free radicals per gram of atmospheric PM. The EPFR content of PM will vary by location, depending on local combustion emissions; the review's researchers predict that concentrations will be higher in Beijing and New Delhi than in London and Paris, for instance.

Research suggests that EPFRs may also potentially form during incineration on some engineered nanomaterials (ENMs) with similar properties to metals — such as fullerenes (balls, 'cages' or tubes of carbon atoms), carbon nanotubes and nano-silica. This possibility remains hypothetical and is based upon known concepts and principles of chemistry and physics, rather than direct evidence. Nonetheless, this concern deserves more research, given that products containing ENMs, on the consumer market, continue to rise and that many of these will be incinerated and emitted into the atmosphere.

3. Wang, P.; You, D.; Saravia, J.; *et al.* Maternal exposure to combustion generated PM inhibits pulmonary Th1 maturation and concomitantly enhances postnatal asthma development in offspring. Part. *Fibre Toxicol*. 2013, 10 (1), 29.

4. Arangio, A. M., Tong, H., Socorro, J., *et al*. Quantification of environmentally persistent free radicals and reactive oxygen species in atmospheric aerosol particles. *Atmos. Chem. Phys*. 2016, 16 (20), 13105–13119