BRINGING THE OPEN AIR FACTOR (OAF) INDOORS

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1. Introduction

In the late 20th century, Alan Mole, a mostly self-taught polymath operating in his spare time outside of mainstream academia, solved the centuries old mystery of the origin of the natural and powerful outdoor 'Open Air Factor' that makes us mostly safe from infection outdoors (Mole 2004).

That knowledge has directly led to a revolutionary 'hydroxyl diffuser' technology which destroys or neutralises all types of germs, allergens and odours and most other irritants and harmful pollutants, throughout entire indoor spaces, while people remain safely present (Airora 2023).

2. The mysterious 'open air factor'

The recognition that outdoor air has germicidal properties was widely exploited during the late 19th and early 20th centuries in the treatment of tuberculosis, where patients underwent 'open-air therapy' to help them heal (Henderson 2009). It was further exploited by military surgeons during the First World War who used the same open-air technique to disinfect and heal severe wounds and by doctors to treat influenza patients during the 1918-19 pandemic (Hobday *et al* 2022).

There appears to have been little further interest in the germicidal properties of outdoor air following this period and during the 1950s chemical therapies superseded 'open air therapy', and interest diminished.

During the 1960s and 1970s these germicidal properties were briefly revisited by UK biodefence scientists at Porton Down (Hobday *et al* 2022) who conducted experiments proving that open air has a potent germicidal effect. However, not knowing the origin of the effect, they simply called it the 'Open Air Factor' or OAF. The Porton Down scientists demonstrated that OAF effect occurred outside but didn't occur inside unless ventilation rates were very high indeed. From this they deduced that whatever the active agent was, it was clearly very short lived. However, they ultimately failed to identify the active agent, as at that time no test technique was sensitive enough to identify and measure the OAF present in the air.

When this research ended in the 1970s, interest in the OAF again fell away except amongst a small group of scientists, including Alan Mole, who were determined to unravel the mystery.

3. Uncovering the active germicidal agent

In the years that followed, atmospheric hydroxyl radicals[1] (commonly 'hydroxyls' and known as 'The Detergent of the Atmosphere' because of their war of attrition against atmospheric pollutants) were recognised as one possible source of the germicidal effect. Others contended that, given typical concentrations, their very short life and their creation at random locations, they were statistically unlikely to react with harmful viruses, bacteria and moulds in sufficient numbers to be the OAF germicide. Instead, other Reactive Oxygen Species (ROS)[2] might play a dominant role (Hobday *et al* 2022).

But by the turn of the 20th century, by persistently focussing on advances at the intersection of atmospheric chemistry, microbiology and aerobiology Alan Mole concluded, and experimentally demonstrated, that OAF wasn't just hydroxyls in general and / or other ROS, but principally a particular subset of hydroxyl radicals that are created in a particular way, such that they became a powerful targeted germicide.

There are multiple sources of hydroxyls in outdoor air. The most common daytime source being a photochemical reaction which creates randomly dispersed hydroxyls. However, another significant source is the natural 24-hour outdoor reaction of ozone with aromatic essential oils emitted from plants (Geyer *et al* 2003). The defining feature of this second source is that the underlying cascade reaction condenses, and has a strong propensity to occur on surfaces, including the surfaces of particles such as harmful viruses, bacteria and moulds (Dark *et al* 1970). It is those hydroxyls, created from this condensing reaction at the very surface of viruses, bacteria and moulds, which make them such a powerful germicide.

Fortunately, humans, animals, and plants have evolved over millennia to co-exist with hydroxyls and their reaction by-products (Martenez *et al* 2020). Atmospheric hydroxyls cannot enter the blood stream or tissues within the body, because skin and mucosal membranes have evolved to provide a protective barrier.

Clearly, as hydroxyls were not just a powerful outdoor germicide, but were also not harmful to humans, they held considerable promise in infection prevention.

4. Bringing the Outdoors, Indoors

Over the last decade 'air cleaners' based on creating hydroxyl radicals by photocatalytic oxidation (PCO) as pioneered by NASA have become available (Perry *et al* 2011). However, because the life of a hydroxyl radical is so short, their impact outside of the air cleaner is, whatever the claims made, strictly limited. In fact, these hydroxyls radical 'air cleaners' basically act as filters and share all the same physical limitations as other filters, principally that typically only 50% of the ever-changing air in a room passes through the filter and is 'cleaned' (Novoselac *et al* 2009).

Given the limited performance of PCO air cleaners, Hydroxyl Diffuser technology has been developed to replicate the outdoor essential oil cascade reaction continuously throughout entire indoor spaces and calibrated to create a hydroxyl concentration at the lower end of those typically found outdoors.

The concentration of hydroxyls in the lower atmosphere has been determined to generally lie between $0.5x10^6$ per cm^3 and $5x10^6$ per cm^3 (Hewitt *et al* 1985) depending on many factors, including time of day, humidity, temperature, season etc. (NASA 2018). In general, the concentration is lowest at the poles and highest at the equator.

The hydroxyl concentration created by the diffuser has been measured and calibrated to typically fall within the range of 1 to $3x10^6$ per cm^3 with a focus on $2x10^6$ per cm^3.

Measuring hydroxyl concentration is however not easy, and so alternative technologies developed by both Leeds University Atmospheric Chemistry Group and the UK's National Health and Safety Laboratory were used to cross check measurements during the calibration process.

Detailed experimentation determined that the quantity of essential oil and ozone necessary to create the required hydroxyl concentration was fortunately very low, well below any cautionary, advisory or regulatory limits.

In fact, by employing the latest sensor technology, a Hydroxyl Diffuser is able to measure the air quality in real time and dynamically adjusts its outputs to ensure that, where pre-existing background ozone levels are found to be too high, the resultant level falls to well within all advisory and regulatory limits.

The resultant technology has been tested by independent laboratories in the UK, Canada and the USA and typical results include (PHE 2006 and 2007, BRE):

- Inactivating high concentration benchmark MS-2[3] airborne virus in less than 5 minutes according to Public Health England (Porton Down no less!).
- Inactivating high concentration MRSA[4] on glass in 1 hour according to Public Health England.
- A simulated sneeze test with high concentration of bacteria saw a greater than 99% reduction in transmitted live bacteria after only 600mm according to BRE & IOM Stafford – the hydroxyl cascade is demonstrably so powerful that it creates a real time person to person infection shield.

And the benefits have been demonstrated to go well beyond virus, bacteria and mould inactivation. Hydroxyls also remove all odours, break down all VOCs and most other polluting gasses and damage the protein and tertiary structure of allergens so that they are no longer recognised by the body's immune system (Finlayson-Pitts 1999; Kawamoto *et al* 2006; Kazuo *et al* 2016; Martinez *et al* 2020, Garrison 2020).

5. By-products of the hydroxyl cascade reaction

Indoor air is typically far more polluted than outdoor air, and so it is necessary not just to replicate the necessary hydroxyl cascade indoors, but also to ensure that the resultant reactions with typical indoor pollutants don't result in any harmful by-products.

In terms of by-products, the world leading UK Building Research Establishment (BRE), Indoor Air Quality Group, was asked to develop a test and evaluation regime to establish the product's safety. That regime was focussed on two principal issues; are all by-products safe at the concentration created and do any by-products accumulate over time.

BRE concluded that:

- None of the by-products, at the concentration created, either from the underlying process, nor from their reaction with any of the typical VOCs found indoors, are known to be harmful. This is the first time that such a comprehensive analysis has been carried out and involved not just the BRE but also two specialist Universities, Leeds and York, to identify each and every by-product.
- None of the by-products accumulated over time, be they particulates or VOCs, indeed most reduced over time.

6. Conclusions

Extensive testing has shown Hydroxyl Diffuser technology to be both highly effective and safe. Applied indoors, it promises to significantly reduce the likelihood of harm from infections, allergens and irritants.

References

Airora (2023). https://www.airoa.com

BRE (2021). Test report P119878-1000

Dark, F. A., Nash, T. (1970). Comparative toxicity of various ozonized olefins to bacteria suspended in air. *Journal of Hygiene* PMID: 4914088

Finlayson-Pitts, B.J., Pitts, J.N. Jr. (1999). The Chemistry of the Upper and Lower Atmosphere". *Academic Press, San Diego*

Garrison, W. M. (2020). Reaction mechanisms in the radiolysis of peptides, polypeptides, and proteins. *Chemical Reviews* **87(2)**: 381–398

Geyer A., Bächmann K. et al. (2003). Nighttime formation of peroxy and hydroxyl radicals during the BERLIOZ campaign: Observations and modelling studies. *Journal of Geophysical Research: Atmospheres.* **108(D4)**

Henderson, D. A. (2009). Smallpox: The Death of a Disease – The Inside Story of Eradicating a Worldwide Killer*. Published by Prometheus Books*.

Hewitt, C. N., Harrison, R. M. (1967). Tropospheric concentrations of the hydroxyl radical—a review. *Atmospheric Environment* (1967). **19(4)**: 1985, Pages 545-554

Hobday, R. A., Collignon, P. (2022). An Old Defence Against New Infections: The Open-Air Factor and COVID-19. *Cureus* PMID: 35875284

Kawamoto, S., et al. (2006). Decrease in the Allergenicity of Japanese Cedar Pollen Allergen by Treatment with Positive and Negative Cluster Ions. *International Archive of Allergy and Immunology* **141(4)**

Kazuo, N., et al. (2016). Exposure to positively and negatively charged plasma cluster ions impairs IgE binding capacity of indoor cat and fungal allergens. *World Allergy Organization Journal* PMID: 27660668

Martínez, V. R., Arañó, L. M. et al. (2020). Evidence of OH· radicals disinfecting indoor air and surfaces in a harmless for humans method. *International Journal of Engineering Research & Science* **6(4)**

Mole, A. (2004) Patents 101549244, 1799330, 2415774, 8398923 and 7763206

NASA (2018). Detergent-like Molecule Recycles Itself in Atmosphere.

Novoselac, A., Siegel, J. A. (2009). Impact of placement of portable air cleaning devices in multi zone residential environments. Building and Environment **44** 2348–2356

Perry, J. L., Frederick, K. R. at al. (2012). A Comparison of Photocatalytic Oxidation Reactor Performance for Spacecraft Cabin Trace Contaminant Control Applications. American Institute of Aeronautics and Astronautics

PHE (2006 and 2007). Health Protection Agency Test reports 40/06 and 63/07

Footnotes

1. Hydroxyl Radicals OH (commonly Hydroxyls) are the second most powerful oxidising agent after fluorine. Hydroxyls are abundant in outdoor air, with a typical concentration of $2x10^6$ per cm^3 during daylight hours. They are highly reactive with a life span in the atmosphere is typically less than one second.
2. Reactive oxygen species (ROS) are highly reactive chemicals formed from diatomic oxygen (O2), including not just hydroxyl radicals but also peroxides, superoxide, singlet oxygen, and alpha-oxygen.
3. the US CDC has confirmed that the hydroxyl diffuser's ability to inactivate MS-2 Coliphage means that it will destroy ALL types of pathogenic bacteria and viruses, including all those in the coronavirus family (which includes the SARS-CoV-2 coronavirus that causes COVID-19). Like all coronaviruses, MS-2 is a positive sense single-stranded RNA virus but studies have shown that it is many times harder to inactivate than a coronavirus.
4. Methicillin-resistant Staphylococcus aureus (MRSA) infection is caused by a type of Staphylococcus bacteria that's become resistant to many antibiotics.

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