

White Paper on PYURE Efficacy

Bringing the Cleansing Power of the Sun Indoors

It is well established that hydroxyl radicals are the means by which nature keeps the air we breathe free of unsafe levels of chemicals and microorganisms. Hydroxyls are present throughout the troposphere due to the sun's ultraviolet energy reacting with ambient gases.^{1,2} During a sunny day, typical concentrations are 3-10 million hydroxyl radicals in each cubic centimeter of ambient outdoor air.^{1,2,3} Hydroxyls are the main driving force behind the daytime decomposition of volatile organic compounds (VOC) and inorganic gases.^{3,4}

Hydroxyl radicals formed outdoors do not exist naturally indoors as they react so fast with ambient VOC that they are rapidly consumed. PYURE technology was developed to generate natural levels of hydroxyls indoors to minimize unsafe levels of chemicals and microorganisms that otherwise accumulate. PYURE has demonstrated in a number of controlled studies that its systems rapidly reduce the levels of microorganisms in air and on surfaces. PYURE technology also improves indoor air quality by reducing total volatile organic compound levels (TVOC) and eliminating odors. These experiments are supported by extensive real-world use, in which PYURE technology was used to make air "fresher", reduce odors and control the growth of microorganisms (see [case studies here](#)).

PYURE's proven efficacy is derived from its unique mechanism of action, which produces hydroxyl radicals. These hydroxyl radicals then react with VOC, producing organic peroxy (C-O-O·) and oxy (C-O·) radicals, which are also powerful cleansers. PYURE products are designed to produce hydroxyls and organic oxidants indoors in the same quantities found outdoors in our atmosphere, which ensure efficacy and safety. These cleansing agents are well known to kill bacteria, viruses and mold, and to rapidly decompose a broad range of aliphatic and aromatic chemicals such as formaldehyde, limonene, benzene, toluene, xylene and styrene.⁴ They are nature's way of safely keeping the air we breathe free of harmful levels of chemicals and pathogens.

Reduction of Airborne Pathogens

Innovative BioAnalysis (Costa Mesa, California), a certified laboratory with biosafety level 3 facilities, conducted trials using three separate portable PYURE products: the MDU/Rx™, Slimline™ and Myspace™ devices. Innovative Bioanalysis assessed the ability of each device to reduce live SARS-CoV-2 virus in air. All three devices were shown to significantly and rapidly reduce live **SARS-CoV-2** levels, relative to controls:

- > 99% reduction after 20 minutes by the MDU/Rx™ and > 99.99% after 80 minutes
- > 97% reduction after 20 minutes by the Slimline™ and > 99.97% after 80 minutes
- > 95% reduction after 20 minutes by the Myspace™ and > 99.95% after 80 minutes

The Innovative Bioanalysis reports on SARS-CoV-2 testing for each PYURE device can be found here: [MDU/Rx™](#), [Slimline™](#) and [Myspace™](#).

Aerosol Research & Engineering Laboratories (ARE Labs, Olathe, Kansas), a certified laboratory specializing in the study of aerosolized microorganisms, assessed the impact on selected viruses, bacteria and mold of the PYURE MDU/Rx™ device. Results demonstrated over 99% reduction vs. controls within 30 minutes, and reductions below the limit of detection in 60 to 120 minutes.

- > 99.999% reduction of **MS2** in 90 minutes (simulant for RNA viruses such as SARS)
- > 99.99% reduction of **Phi-X174** in 90 minutes (simulant for DNA viruses such as smallpox)
- > 99.999% of **Staphylococcus epidermidis** in 60 minutes (Gram-positive bacterium)
- > 99.999% of **Erwinia herbicola** in 120 minutes (Gram-negative bacterium)
- > 99.998% of **Aspergillus niger** in 90 minutes (black mold)

The full ARE Lab report on aerosolized bacteria, viruses and fungal spores can be found [here](#).

Reduction of Pathogens on Surfaces

PYURE products have been tested by a number of licensed, independent labs against a variety of surface bound pathogens including bacteria, viruses and fungi. Below is a summary of how certain PYURE devices reduced various pathogens on hard, non-porous surfaces relative to controls.

Innovative BioAnalysis tested the MDU/Rx™, Slimline™ and Myspace™ devices, assessing the ability of each to reduce live **SARS-CoV-2** virus on a glass surface. Results were:

- > 99.999% reduction of the SARS-CoV-2 virus after 2 hours with the MDU/Rx™
- > 99.999% reduction of the SARS-CoV-2 virus after 2 hours with the Slimline™
- > 99.993% reduction of the SARS-CoV-2 virus after 2 hours with the Myspace™

The Innovative Bioanalysis reports on SARS-CoV-2 testing for each PYURE device can be found here: for the [MDU/Rx™](#), [Slimline™](#) and [Myspace™](#).

Researchers at the University Vita-Salute San Raffaele, Milan, Italy tested the portable MDU/Rx™ and IDU™ induct device against additional strains of viruses, bacteria and fungi. Both devices were found to significantly reduce the viability of pathogens on glass surfaces, relative to controls. The MDU/Rx™ and IDU™ achieved the following:

- > 99.999% reduction of the **H1N1 Influenza** virus after 6 hours
- > 99.99% reduction of **Adenovirus** (type 5) after 6 hours
- > 99.99% reduction of **Poliovirus 1** after 6 hours
- > 99.99% reduction of **Murine norovirus** after 6 hours

The translated University Vita-Salute San Raffaele report on surface testing can be found [here](#).

Innovative BioAnalysis conducted independent tests to assess the MDU/Rx™ device's ability to reduce various pathogens inoculated on glass plates. A number of viruses and bacteria were tested, including the resistant bacterial strains Methicillin-resistant *Staphylococcus aureus* (MRSA) and Vancomycin-resistant *Enterococcus faecium* (VREF). The MDU/Rx™ device was found to significantly and rapidly reduce the viable levels of these pathogens, relative to controls:

- > 99.99% reduction of ***Escherichia coli*** after 3 hours
- > 99.97% reduction of ***Salmonella enterica*** after 3 hours
- > 99.98% reduction of ***Staphylococcus aureus*** after 6 hours
- > 99.99% reduction of **MRSA** after 7 hours
- > 99% reduction of **VREF** after 6 hours
- > 98% reduction of ***Clostridium Difficile*** after 8 hours

The Innovative BioAnalysis report for *Escherichia coli* can be found [here](#). The reports for the other surface pathogen tests are available from PYURE upon request.

Improvement of Indoor Air Quality

A study conducted by Columbia Analytical Services (Sun Valley, California), an independent, laboratory certified to undertake atmospheric studies, assessed the impact of a PYURE MDU™ device on indoor air quality. The study measured a significant reduction in TVOC while the device was operated. During the three-hour study, ozone accumulation averaged 11 parts per billion (ppb). There was no accumulation of carbon monoxide and formaldehyde levels were only marginally higher than background concentrations and stayed well within the range typically seen indoors. The key findings from the Columbia study were as follows:

- TVOC reduced by over 40%
- Ozone levels increased from 1.9 ppb to 13 ppb after 1 hour, dropping to 7 ppb after 3 hours
- No carbon monoxide was detected
- Formaldehyde increased from 9 ug/m³ to 14 ug/m³ after 1 hour and 12 ug/m³ after 3 hours
- Acetaldehyde levels were unchanged
- No other aldehydes were detected

The report published by Columbia Analytical Services can be found [here](#).

An additional study was conducted by Columbia Analytical Services over 15 hours with similar results:

- TVOC were reduced relative to ambient levels
- Ozone concentrations remained near ambient levels and were below 20 ppb
- Formaldehyde levels remained at a mean value of 16.5 ppb, near ambient levels
- Acetaldehyde levels remained at a mean value of 4.2 ppb, near ambient levels

The additional report published by Columbia Labs is available from PYURE upon request.

Practical Experience

PYURE products have been used successfully by customers for odor abatement, including odor from cigarette smoke, fires, mold and mildew. PYURE devices have also demonstrated their ability to eliminate H₂S resulting from wastewater treatment, reduce TVOC in industrial applications, and reduce microbial levels in hospitals, medical facilities and food and beverage processing plants. Information on successful outcomes for PYURE technology is available in several case studies that can be found [here](#).

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References

1. D. R. Crosley (1995) "The measurement of OH in the atmosphere, *J. Atm. Sci.* 52, 3299-3314.
2. D. Stone, L.K. Whalley, and D. E. Heard (2012) "Tropospheric OH and HO₂ radicals: field measurements and model comparisons", *Chem. Soc. Rev.* 41, 6348-6404.
3. D. E. Heard, "Analytical Techniques for Atmospheric Measurement", Blackwell Publishing, 2006 – professor at the University of Leeds, UK) and references cited therein.
4. R. Atkinson, "Kinetics and Mechanisms of the Gas-Phase Reactions of the Hydroxyl radicals with Organic Compounds", Journal of Physical and Chemical Reference Data, Monograph No.1, 1989.