3M Science. Applied to Life.™

Improving Our Climate

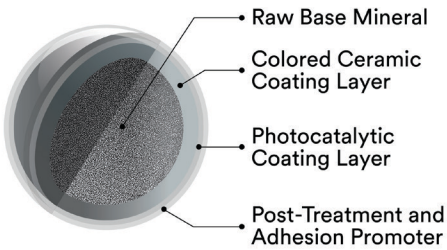
# 3M™ Smog-Reducing Granules

3M applies photocatalytic science to roofing granules enabling smog-fighting performance.

## Overview

At 3M, we use science every day to improve lives and help solve society's toughest challenges. We like to imagine a world where all communities are safe, healthy and thriving—where increased energy efficiency, reduced greenhouse gas emissions and access to clean air and water enhance human health at home and at work. Still, nearly 4 in 10 Americans live in places with unhealthy levels of air pollution[1]. Since reducing air pollution remains critical to public health[2], 3M is addressing this environmental challenge by creatively applying science to help reduce smog[3] and help improve the air we breathe.

3M developed Smog-Reducing Granules to help reduce smog pollution (nitrogen oxides or $NO_x$) using roofing materials. Integrated throughout a roof's surface, 3M's roofing granules are designed with a specialized photocatalytic coating applied to the base mineral. The specialized coating on the granule is activated by the sun's ultraviolet (UV) rays. As sunlight hits the roof containing the smog-reducing granules, radicals are generated and transform nitrogen oxide gases into water-soluble ions improving air quality. This smart solution for pollution mitigation can help communities contribute toward their nitrogen oxides ($NO_x$) reduction efforts.




## The recipe for smog pollution

The world is facing many global challenges, including air quality impacts on human health. Ground level (or "bad") ozone triggers a variety of health problems and it's caused by smog pollution.

The raw ingredients for smog include $NO_x$ (nitrogen oxides) and VOCs (volatile organic compounds). In the presence of sunlight, it creates ground level ozone which is harmful to human health.

Nitrogen oxides ($NO_x$) are made up of a group of gases including nitric oxide (NO) and nitrogen dioxide ($NO_2$). While these gases are harmful to human health and the environment, $NO_2$ is of greater concern. Breathing ozone can trigger a variety of health problems, particularly for children, the elderly, and people of all ages who have lung diseases such as asthma[4].

While it is thought many people think smog pollution is only a big city problem, it is understood that smog is a general problem and as you zoom in and look at $NO_x$ concentrations at the street level[5], smog can be an anywhere problem if you're located near a heavily traveled road or other industrial area.[6]

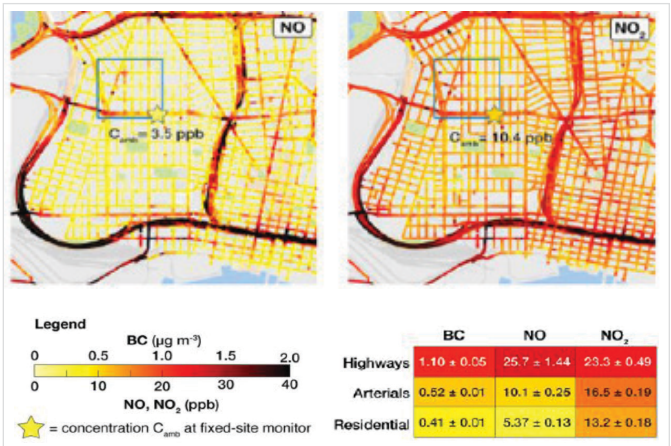



*Figure 1: Apte et. Al, 2017. Environ. Sci. Technol.*

## 3M solution to improving air quality

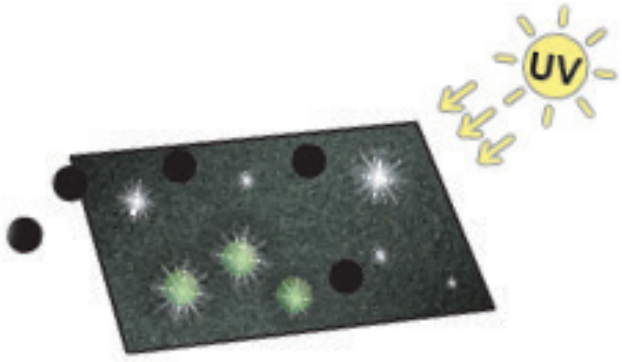
3M™ Smog-Reducing Granules are used throughout the surface and contain a specialized coating layer that is activated by UV light and generates free radicals (oxygen and hydroxyl). The radicals come in contact with the smog (NO and $NO_2$) gases transforming them or converting them to water soluble nitrate ions ($NO_{3-}$). The ion deposits simply wash away over time fully regenerating the surface to produce more radicals with the capability to fight smog continuously.

## Photocatalytic science explained

Photocatalytic (catalyst activated by UV to accelerate the rate of a chemical reaction) materials have been used in construction for years, but not widely adopted in roofing materials

and never integrated into asphalt shingles. Asphalt shingles make up 75% of residential roofing materials installed each year so smog-fighting shingles have the capacity to make a strong impact on the environment by improving air quality.

- Inspired by the power of trees, roofs with 3M Smog-Reducing Granules can become a smog fighting surface.
- The photocatalytic coating layer of 3M™ Smog-Reducing granules generates surface-bound hydroxyl (·OH) radicals when activated by the sun.
- The radicals, around the smog reducing granules, cause the smog gases (the nitrogen oxides in smog) to be transformed into nitrate ions. Nitrate ions are a more plant usable form of nitrogen. These compounds are deposited on the roof and wash away with the rainwater over time.




## 3M collaborates with LBNL to test efficacy

Not only has 3M been working on this technology over the last 10+ years, but 3M has a working contract with Lawrence Berkeley National Laboratory (LBNL) to demonstrate the applicability of the technology[6]. 3M continues to work with LBNL through continued evaluation of granule and shingle samples for the efficiency of photocatalytic materials towards air purification.

Granule and shingle samples were tested by LBNL in an exposure chamber constructed with a flow reactor and UV irradiation source. The air exiting the chamber is monitored and recorded in real time.

- Fresh production shingles and lab created samples along with shingles samples were validated by exposure in the field during different seasonal periods.
- Performance testing occurred using NO- and $NO_2$-enriched gases flown through the reactor. Downstream of the system, NO and $NO_2$ concentrations were recorded in real-time prior, during and after UV illumination, validating efficacy of the tested material in reducing smog ($NO_x$) concentrations.

## Summary

Homeowners and building owners can support local smog reduction efforts by choosing shingles or other roofing materials with 3M Smog-Reducing Granules. The surface of the roof not only provides protection, but also helps remove smog pollutants from the air we breathe. No compromises, just performance.

## Key Terms

| | |
|---|---|
| **Smog** | Smog is made up of nitrogen oxides ($NO_x$) and hydrocarbons also called volatile organic compounds (VOCs) in the presence of sunlight |
| **$NO_x$** | The group of gases called nitrogen oxides made up of NO and $NO_2$ |
| **NO** | Nitric oxide |
| **$NO_2$** | Nitrogen dioxide |
| **UV (Ultraviolet)** | Energy produced by the sun (the invisible portion and highest energy of the solar spectrum |
| **Radicals** | hydroxyl (·OH) radicals, generated by UV, are chemically reactive toward other substances |
| **O** | Oxygen gas |
| **·OH** | Hydroxyl radical |
| **Catalyst** | A substance that increases the rate of a chemical reaction |
| **Photocatalytic** | Activated by UV to accelerate the rate of chemical reaction |
| **Transform** | The conversion of radicals attacking the $NO_x$ (smog gases) and turning them into a more plant usable form of nitrogen |
| **Water-Soluble Ions** | Another term for $NO_3$, which is a nitrate ion |
| **Nitrate Ion** | Plant usable byproduct of smog conversion |

## References


[1] State of the Air®. American Lung Association. Retrieved from lung.org/research/sota/key-findings.

[2] Health Effects of Ozone and Particle Pollution (2017). American Lung Association. Retrieved from lung.org/our-initiatives/healthy-air/sota/health-risks/.

[3] Smog, Soot, and Other Air Pollution from Transportation (2017). Environmental Protection Agency. Retrieved from epa.gov/air-pollution-transportation/smog-soot-and-local-air-pollution.

[4] Ground-Level Ozone Pollution epa.gov/ground-level-ozone-pollution.

[5] EPA's Environmental Justice Screening and Mapping Tool ejscreen.epa.gov/mapper.

[6] De-pollution efficacy of photocatalytic roofing granules (2019). Buildings and Environment. Retrieved from sciencedirect.com/science/article/pii/S0360132319302264.



**Industrial Mineral Products Division**
3M Center, Building 223-4NE-13
St. Paul, MN 55144-1000 USA

Phone 1-800-447-2914
Web 3M.com/smog-fighter