By Dr. Jyothi Rangineni and Eric Astrachan

Photocatalytic Tiles: Uses and Limits

In practice, surface cleaning of building façade, involves considerable trouble, time, and chemical detergents leading to inevitable high costs. Is there a way to overcome this? An answer to this question can be photocatalytic tiles, which are antimicrobial, self-cleaning and decompose pollutants with a little help from sunlight, oxygen, and moisture available in the air. The end result is a tiled façade, a cleaner, healthier environment, and fewer cleaning costs.

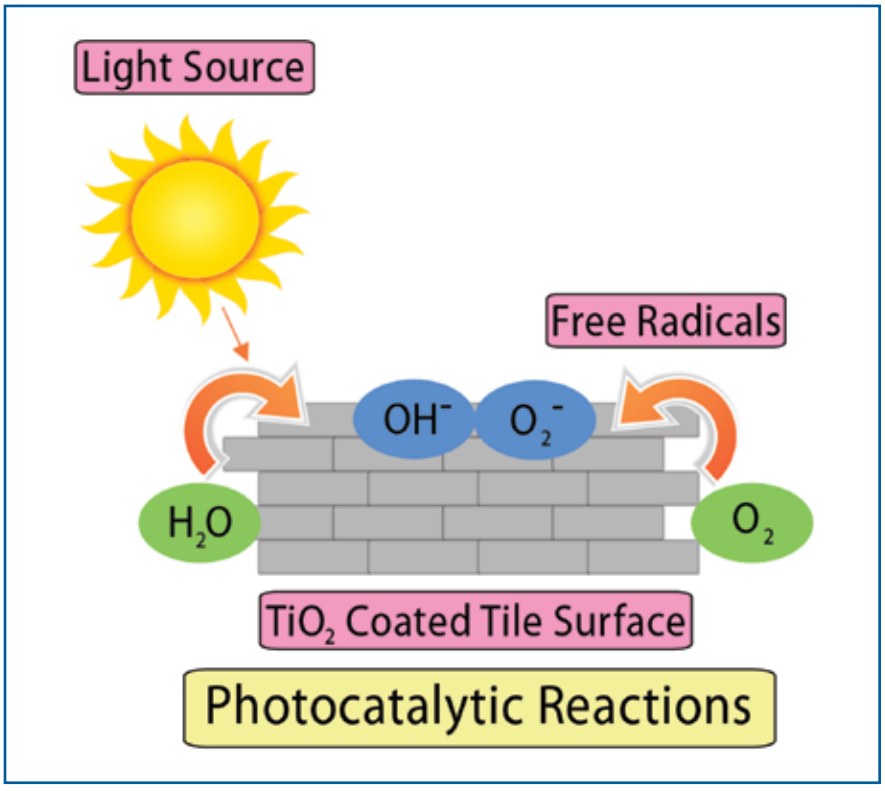
Q: What are photocatalytic tiles?

First, we need to define some of the science behind this technology. A *photocatalyst* is generally defined as a semi-conducting metal that produces charged free radicals from freely available water and oxygen in the presence of light (usually UV) without self-deterioration. Due to the charge on these free radicals, they are extreme biological and chemical reactants. There are many photocatalysts. Of these, titanium dioxide (TiO_2) has been thoroughly researched for its photocatalytic activity. TiO_2 exists in three forms, and of these, the *anatase* form is an effective photocatalyst under UV irradiation. Since the discovery and development of photocatalytic properties in the 1970s, TiO_2 has been well-researched leading to a better understanding of photocatalytic reactions. Ceramic tiles with thin layers of TiO_2 on their surface have now emerged on the market bearing with them these unique properties.

The following is specific to TiO_2, but other photocatalysts exist and exhibit similar properties.

Q: What are the properties of photocatalytic tiles?

TiO_2 as a photocatalyst has many benefits. It is an inert substance with no known human toxicity. TiO_2 photocatalysts generate strong oxidizing power when illuminated with UV light with wavelengths of less than 385 nm.



Right: A photocatalyst is generally defined as a semi-conducting metal that produces charged free radicals from freely available water and oxygen in the presence of light (usually UV) without self-deterioration.

With hydroxyl radicals and superoxide ions, irradiated TiO_2 photocatalysts can decompose organic compounds by participating in a series of oxidation reactions leading to carbon dioxide. TiO_2 also increases the *hydrophilicity* or wettability of a surface by increasing the water angle contact between water and the TiO_2 coated surface. These properties of TiO_2 and other photocatalysts provide three important benefits.

Antimicrobial action: Photocatalytic TiO_2 effectively kills a variety of microorganisms including bacteria, viruses, fungi, mold and algae. The free radicals generated during photocatalysis kill the microorganisms by disintegrating and decomposing the cell wall, and the hydrophilicity helps in clearing the biological debris from the surface.

Deodorizing: The free radicals also induce the breakdown of Volatile Organic Compounds (VOCs) by destroying molecular bonds in them. Some of the odor-causing compounds in the environment include formaldehyde, gasoline and many other hydrocarbons. Photocatalysts also degrade organic staining agents.

Air Purification: Through its photocatalytic activity, TiO_2 also helps purify the environment by breaking down harmful pollutants such as nitrogen oxides (NOx). NOx cause a wide variety of health and environmental impacts, and NOx together with SOx (sulfur dioxide and sulfur trioxide) are major contributors to "acid rain."

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Q: What are the uses of photocatalytic tiles?

The self-cleaning property of photocatalytic tiles promotes their application in varied areas such as hospitals, kitchens, urban buildings, etc. Apart from the three aforementioned benefits, use of photocatalytic tile may

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lead to fewer chemical and sanitizing agents' being used, while improving air quality and reducing harmful organic and inorganic pollutants. The pollutants are not merely transferred from one medium to another but can be removed from the environment given sufficient time and exposure. Such properties make the photocatalytic tile an appropriate choice for outdoor applications in areas prone to higher levels of pollution.

Q: What are the limits of TiO_2?

The efficiency of a TiO_2 coating depends on the uniformity of the TiO_2 layer; tiles without gaps in the TiO_2 coating exhibit better activity. As a coating, the TiO_2 photocatalyst operates in a wide range of temperatures but with less activity at temperatures lower than 50°F. Low humidity is another factor which affects photocatalysts. Such environmental constraints limit the activity of photocatalytic tiles in regions with cold or dry days.

While TiO_2 is not self-deteriorating, meaning that the photocatalytic activity is not diminished with use, oil, salt, and dirt on the tile's surface will decrease its photocatalytic efficiency in the absence of rain. Activity can be restored in most cases by re-exposing the catalyst by rinsing off the blocking agents.

Q: Are there recognized test procedures to evaluate photocatalytic tiles?

Yes, there are test methods available to evaluate the properties of photocatalytic tiles. Tile Council of North America (TCNA) runs *ISO 27447* (*test method for antibacterial activity of semi-conducting photocatalytic materials*) to evaluate the antibacterial activity of photocatalytic tiles against both gram positive and gram negative bacteria.

TCNA also conducts tests to determine the potential to degrade organic compounds using methods *UNI 11259* (*Rhodamine B test method*) and *ISO/DIS 10678* (*determination of photocatalytic activity of surfaces by degradation of methylene blue*). Additionally, TCNA can perform *ISO 22197* (*test method for air purification performance of semi-conducting photocatalytic materials*) to test for the removal of NOx pollutants.

In conclusion, through innovation and advanced technology, the tile industry is leading the way to a greener and healthier future. **TILE**

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About the Author

Dr. Jyothi Rangineni is a Research Scientist at Tile Council of North America. She is responsible for research and development of new testing standards for TCNA members and TCNA's Product Performance Testing Laboratory. Dr. Rangineni has over 10 years experience in research and experimental design in Microbiology.