Concrete that Cleans Itself and the Air

Photocatalytic cement helps oxidize pollutants

BY MARCO BARBESTA AND DAN SCHAFFER

Can a construction material remove pollutants from the air as it keeps its surface clean?

It sounds incredible, but after 10 years of development and testing in Italy and France, such a product is now available in North America. The product, TX Active, is a patented portland cement developed by Italcementi Group and produced in North America by its U.S. subsidiary, Essroc.

The key to TX Active's properties are photocatalytic components that use the energy from ultraviolet rays to oxidize most organic and some inorganic compounds. Air pollutants that would normally result in discoloration of exposed surfaces are removed from the atmosphere by the components, and their residues are washed off by rain (Fig. 1). So, this new cement can be used to produce concrete and plaster products that save on maintenance costs while they ensure a cleaner environment.

Fig. 1: A demonstration of the cleaning action of photocatalytic cement concrete. The panel on the right contained TX Active

SMITING SMOG

According to the American Lung Association, one out of every three members of the U.S. population lives in an area with unhealthful levels of ozone (O_3).[1] The primary ingredient of smog, ozone is an extremely reactive gas molecule that reacts chemically with lung tissue, causing decreased lung function, respiratory infection, lung inflammation, and aggravation of respiratory illnesses.

The raw ingredients for ozone are nitrogen oxides (NO_X)—produced primarily by internal combustion engines—and volatile organic compounds (VOCs)—hydrocarbons that have evaporated from chemical plants, refineries, factories, gas stations, and paints. Ozone is created when the two raw ingredients are combined in the presence of heat and sunlight.

Italcementi tests have demonstrated that a road paved with concrete made with the photocatalytic cement can reduce NO_X levels by 20 to 80%, depending on atmospheric conditions. A building with photocatalytic precast concrete cladding can do the same.

Because the proprietary compound oxidizes both NO_X and VOCs, it combats ozone at the source. Other chemicals known to be oxidized using photocatalytic cement include:

- Inorganic compounds such as SO_X, CO, NH_3, and H_2S;

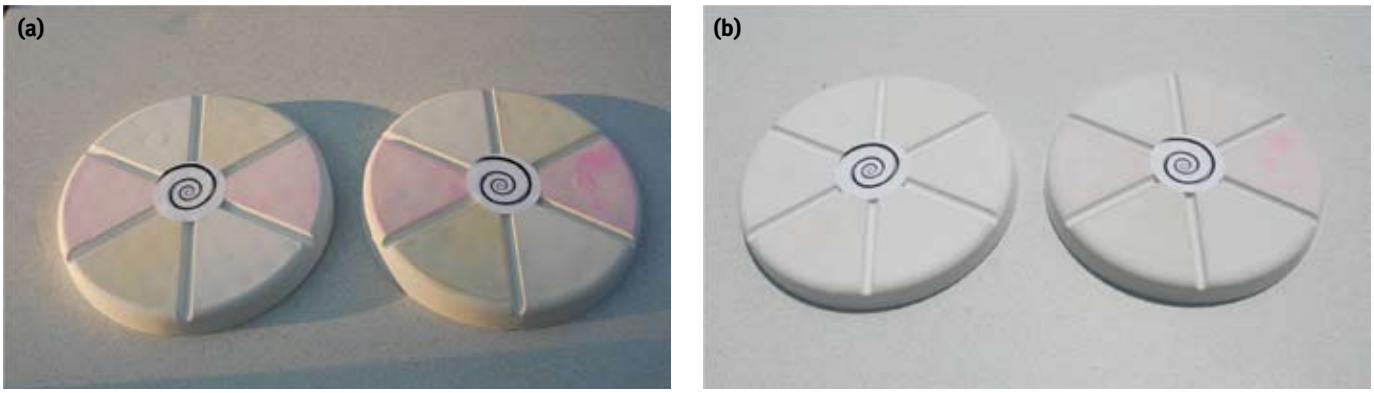

Fig. 2: These discs made of concrete containing white TX Active cement demonstrate the product's self-cleaning properties: (a) samples after initial staining with various contaminants; and (b) samples after 6 hours of exposure to sunlight

- Organic compounds such as alcohol, acids, and aromatics;
- Chlorinated organic compounds such as dioxins and chloro benzene; and
- Pesticides such as diazinon and atrazine.

The final products of the reactions include harmless quantities of nitrates and sulfates. Studies have shown that these by-products are negligible and do not contribute significantly to soil and ground water nitrification.

Interestingly, it's expected that the best results from photocatalytic cements will be obtained in the worst pollution conditions. It's estimated that in Milan, Italy, where air quality standards sometimes force local administrators to shut down automobile traffic for a full day at a time, could become 50% cleaner if just 15% of the buildings and roads were resurfaced with photocatalytic cement products.

The product promises to provide significant improvements in urban air quality, as it also can reduce microorganisms such as bacteria and fungi and is capable of eliminating odors associated with pollutants. Residents of urban areas in Italy have reported that some unpleasant odors have disappeared after the product was installed nearby.

COMPOSITION

Proprietary technology

In addition to portland cement binders, the product in its current proprietary formulation contains photocatalytic titanium dioxide particles. Italcementi laboratories are continuing their research and development for more effective raw materials and application techniques. TiO_2 in its basic form is used in products we use daily, such as toothpaste, sunscreen, and cosmetics to mention a few. In fact, titanium dioxide is used as a white pigment by paint manufacturers to enhance colors.

The first commercial products featuring photocatalytic properties included:

- Self-cleaning items (lamps, car coatings, and construction materials);
- Anti-fog products (mirrors and glass); and
- Anti-bacterial products (tiles, fibers, and air and water purifiers).

Over the last few years, scientific and engineering interest in the application of photocatalysts has grown tremendously. In 2003, for example, over 800 international patent applications were published.

Applications

Photocatalytic cement is already being used for sound barriers, concrete paver blocks, and façade elements. Other applications include:

- Precast and architectural concrete panels;
- Pavements, road surfacing, and sidewalks;
- Portland cement-based plaster for finish coat applications;
- Concrete masonry units, roof tiles, and cement-based tiles; and
- Cement-based restoration products.

For cost effectiveness, the best applications include any product used in thin layers or produced in a two-stage manufacturing process (with structural and face mixtures).

In one of the more innovative applications, Italcementi has successfully partnered with lighting system makers to develop artificial lighting systems that generate enough ultraviolet light to activate the photocatalytic process. The lighting system and photocatalytic cement concrete have been used in the renovation of a heavily trafficked tunnel in Rome.

Cement types

In the U.S., TX Active is available as gray or white portland cement Type I, II, or III complying with ASTM

Fig. 3: The architectural precast elements for the bell tower at Dalton State College were produced by Metromont Corporation

C150.[2] In Canada, TX Active is available in gray or white portland Cement Type GU, MS, and HE complying with CSA A3001.[3] The product is offered in two formulations. The first, TX Arca, offers the self-cleaning properties demonstrated in Fig. 2 against atmospheric compounds that stain concrete over time. The second, TX Aria, adds depolluting qualities to the self-cleaning properties of TX Arca.

AVAILABILITY

Photocatalytic cement has already been used in North America. A white precast concrete carillon tower was recently constructed at Dalton State College in Georgia (Fig. 3). The 23 m (75 ft) tall tower is the centerpiece of a new quadrangle project and is visible from a nearby freeway, so it's important that it remains pristine.

Hyacinth Place, an affordable "green" housing complex in Highland Park, IL, has courtyard areas with concrete pavers incorporating photocatalytic cement. The pavers help clean the air as well as store and filter storm water that would have normally been nuisance runoff.

Finally, photocatalytic cement was recently used to produce two 9 m (30 ft) tall gateway elements at the entrances to the new I-35 W bridge in Minneapolis, MN. These gleaming white concrete sculptures represent the international symbol for water and serve as markers to remind travelers they're crossing the Mississippi River. With the help of advanced technology and energy from the sun, they'll remain proud symbols for decades to come.

THE COMPANIES BEHIND THE TECHNOLOGY

The Italcementi Group, based in Bergamo, Italy, is the fifth largest cement producer in the world and combines expertise with the cultures of 22 countries on four continents. Its North American subsidiary is Essroc, a portland cement producer with a heavy presence in the northeast quadrant of the U.S. TX Active is readily available from Essroc for use in the U.S. (including Puerto Rico) and Canada.

References

1. American Lung Association, "State of the Air 2008," New York, 2008, 200 pp.

2. ASTM C150-07, "Standard Specification for Portland Cement," ASTM International, West Conshohocken, PA, 2007, 8 pp.

3. CSA A3001-08, "Cementitious Materials for Use in Concrete," Canadian Standards Association, Mississauga, ON, Canada, 2008, 240 pp.

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