



## Pavement Technology, Inc.

# STOP. LOOK. LEARN.

## **Real Science. Real Results.**

# Achieve Up to 60% NOx Capture with Pollution-Reducing Photocatalytic Pavements

The PlusTi<sup>™1</sup> family of pollutionremoving and heat-reducing asphalt and concrete penetrants fortified with photocatalytic titanium dioxide (TiO<sub>2</sub>), from Pavement Technology, Inc., reduce vehicular exhaust pollution and mitigate the effects of Urban Heat Islands (UHI). TiO<sub>2</sub>-enhanced pavements create an air-purifying and solar-reflective top boundary that perpetually regenerates itself throughout the life (LCA) of the pavement, resisting oxidative weathering and traffic-related wear, while materially contributing to compliance with the Clean Air Act (CAA) and U.S. EPA's stringent National Ambient Air Quality Standard (NAAQS). Technical assistance is available from the manufacturer and its trained field representatives.



Variously tested and patented as A.R.A.-1 Ti™ asphalt rejuvenator/sealer, Ti-Intro CME™ all-purpose penetrant, JOINTBOND Ti™ longitudinal joint stabilizer and Litho1000 Ti™ concrete sealer/hardener.

## The Vehicular Pollution Challenge

According to the EPA's "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018" report, CO<sub>2</sub> emissions from mobile sources are the most significant contributor to harmful CO<sub>2</sub> Eq. greenhouse gas (GHG) emissions, such as nitrogen oxides (NOx) and sulfur oxides (SOx) formed during internal combustion processes. Vehicles introduce one of these dangerous toxins—nitrogen dioxide (NO<sub>2</sub>)— into the environment, increasing ozone concentrations that form the nucleus of unhealthy photochemical smog.

The near-road microenvironment (ME) is a significant area of policy and practice concern for modern urban planners, regulators and sustainability managers. Emissions from cars and trucks are the major source of anthropogenic airborne toxins, which cause atopic disorders such as asthma and even deadly pulmonary and cardiovascular diseases.

As the ozone concentrates, the percentage of airborne nitrogen undergoing oxidization also increases, resulting in an increasingly higher percentage of NO<sub>2</sub> in the atmosphere. Research has identified a clear association between serious environmental, ecological and human health issues and the presence of photochemical smog, acid rain and NOx.

The ratio of  $NO_2$  to NOx has been significantly increasing in our urban centers over the years due to a substantial increase in population and associated traffic.

## Solar-Based NOx Capture

EPA technical data shows more than two-thirds of atmospheric NOx is emitted from mobile sources. Several approaches, including photocatalysis, have been studied as methods for counter-acting NOx emissions.

Photocatalysis is the acceleration of a photoreaction (light absorbing) in the presence of a catalyst. A natural semiconductor material, such as TiO<sub>2</sub>, activated by ultraviolet spectrum (UV) light creates hydroxyl radicals and superoxide through spontaneous oxidation-reduction reactions. These powerful oxidants aggressively decompose organic pollutants, such as NOx and volatile organic compounds (VOCs).

As a photocatalyst, TiO<sub>2</sub> is a multifaceted photo-responsive material<sup>2</sup> rapidly gaining increased scientific and commercial interest for near-roadway MEs due to its ability to advance a host of positive environmental and ecological benefits.



**Up to 60% Pollution Capture** – TiO<sub>2</sub>-reactive surfaces capture and oxidize a variety of pollutants and contaminants, including those emitted by vehicles,

such as NOx and VOCs, reducing ozone pollution and mitigating acid rain formation.



**Reduced UHI** – TiO<sub>2</sub>-treated surfaces provide a solarreflective top boundary that lessens pavement-related radiative forcing (RF) by reducing heat absorption and

the convective re-release (pavement emissivity) from solar radiation. The result is a genuinely "cool pavement" that mitigates Urban Heat Island (UHI) effects and extends the life-cycle (LCA) of pavements by slowing down oxidation.<sup>3</sup>



**Rapid Water Displacement** 

 TiO<sub>2</sub>-enhanced pavements are super-hydrophilic, enabling rapid surface water release. The result is a pavement that is self-

cleaning, removing contaminants and preventing staining. The significantly enhanced hydrophilic properties are indicated for improved weatherrelated road safety by rapidly displacing rain and inhibiting ice formation.<sup>4</sup>

## **Product Stock**

- A.R.A.-1 Ti<sup>®</sup> Asphalt
- Litho1000<sup>Ti®</sup> Concrete
- Ti-intro CME<sup>®</sup> All Substrates

## Markets

- Urban/Suburban Municipalities and Counties
- DOTs
- Airports

## **Compatible Substrates**

Asphalt and Concrete surfaces of any age, including:

- Pavements
- Bridge Decks
- Tunnels
- Parapet Walls
- Parking Structures



PTI, with a half century of experience introducing nano-chemical technologies to pavements, has developed photocatalytic solutions that deeply penetrate pavement surfaces to deliver photocatalytic grade TiO<sub>2</sub> into depth at optimal load for sustained photo-oxidation of pollutants and UHI mitigation.

The product stock can be applied to almost any asphalt or concrete substrate using PTI's advanced application apparatus, and at a fraction of the cost of more archival means to clean air, reduce heat build and extend infrastructure life cycle.

For more information contact Michael Durante, MDurante@pavetechinc.com

## **Manufacturer and National Distributor**

D&D Emulsions, Inc., Mansfield, OH Pavement Technology, Inc., Westlake, OH

<sup>2</sup> Polymers, Light and the Science of TiO₂, DuPont<sup>™</sup> Ti-Pure<sup>®</sup> Titanium Dioxide, Dow DuPont, www.dow-dupont.com.

<sup>3</sup> Gopalakrishnan K, et al., Climate Change, Energy, Sustainability, and Pavements, Springer, 2014.

<sup>4</sup> Arainpour F and Farzaneh M, On Hydrophobic and Icephobic Properties of TiO<sub>2</sub>-Doped Silicon Rubber Coatings, Department of Applied Sciences, Universite du Quebec, International Journal of Theoretical and Applied Nanotechnology, 2012.

## **Specifications/Testing**<sup>16</sup>

## **Depth of Penetration**

Pavements treated with A.R.A.-1 Ti maltene-based asphalt rejuvenator showed delivery of high concentrations of photocatalytic grade TiO<sub>2</sub> both at the surface and well below wearing-course depth.

#### TiO<sub>2</sub> Penetration Orlando International Airport



Source: Texas A&M Transportation Institute (TTI)

## **NOx Reduction Efficiency**

Results showed that the pavements impregnated with A.R.A.-1 Ti maltene-based asphalt rejuvenator and Litho1000<sup>TI</sup> concrete sealer/hardener had NOx reductions ranging from 42 to near 60 percent.

## NOx Reduction – Orlando International Airport and Charlotte County (FL)

Site	NO Reduction Efficiency (%)						
0.06–0.08 gsy > TiO <sub>2</sub>	Control Sample	A.R.A1 Ti Sample A	A.R.A1 Ti Sample B	Litho1000 <sup>™</sup> Sample A	Litho1000 <sup>™</sup> Sample B		
Orlando International	NEGL	45%	<b>43</b> %	53%	57%		
Charlotte Co. (FL)	NEGL			<b>42%</b>	<b>46</b> %		
		Ti-intro CME Concrete Sample A	Ti-intro CME Concrete Sample B	Ti-intro CME Asphalt Sample A	Ti-intro CME Asphalt Sample B		
Charlotte Co. (FL)	NEGL	<b>48</b> %	47%	<b>49</b> %	50%		

Source: Texas A&M Transportation Institute (TTI)

Patents: US 9,493,378 B2 and US 8,899,871 B2



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#### **Solar Reflective Index**

Results showed that the pavements impregnated with A.R.A.-1 Ti maltenebased asphalt rejuvenator, Litho1000<sup>Ti</sup> concrete sealer/hardener and Ti-intro CME pollution-reducing penetrant had SR value improvements ranging from 55 to 85 percent, placing all treated surface courses well above USGBC LEED for UHI mitigation.<sup>7</sup>

#### **Solar Reflectance**

(a) Orlando International Airport (b) Charlotte County (FL)

Compound/ Substrate	Solar Reflectance Index Value (SRI)					
Application Rate (a)	Control Sample	Control Sample	0.10 gsy	0.10 gsy	0.08 gsy	0.08 gsy
A.R.A1 Ti/ Asphalt	9	8	40	39		
Litho1000 <sup>TI</sup> / Concrete	24	24			38	38
Application Rate (b)	Control Sample	0.03 gsy	0.06 gsy			
Ti-intro CME/ Asphalt	11	30	34			
Ti-intro CME/ Concrete	20	37	42			
Litho1000™/ Concrete	25	41	46			

Source: Texas A&M Transportation Institute (TTI)

## Super Hydrophilic Surfaces

Results showed that the pavements impregnated with A.R.A.-1 Ti maltene-based asphalt rejuvenator improved water displacement by as much as 40 percent, creating an antimicrobial surface and a much safer roadway.

#### Water Contact Angle (WCA) – FDOT Test Bartow (FL)

Site	Water Contact Angle°							
A.R.A1 Ti	Control Sample	TiO₂ 1 Visible Light	TiO₂ 1 UV Light	TiO₂ 2 Visible Light	TiO₂ 2 UV Light			
FDOT Test	<b>81</b> °	<b>82</b> °	51°	81°	<b>50°</b>			

Source: Texas A&M Transportation Institute (TTI)

5 Zollinger DG and Joshaghani A, Laboratory Investigation of the Effect of TiO<sub>2</sub> Topical Treatments on Concrete and Asphalt Samples, Texas A&M Transportation Institute, May 2019.

- 6 Zollinger DG and Joshaghani A, Solar Reflectance Analysis of TiO<sub>2</sub> Penetrant Treatments on Concrete and Asphalt Samples, Texas A&M Transportation Institute, August 2019.
- 7 U.S. Green Building Council USGBC), LEED V4 Heat Island Reduction (HIR) via Solar Reflectance Index (SRI) > 50% 29, www.usgbc.org.

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