TX Active Photocatalytic Concrete Technology

TX ACTIVE®

Essroc
Italcementi Group

AGENDA

- Introduction
- Photocatalysis
  - History
  - Premier Projects
- Concrete in Practice
- Self-Cleaning
- De-Polluting


Pollution and
it’s Effects

CAUSES OF POLLUTION

There are more than 120 primary organic and inorganic pollutants. (*Environmental Protection Agency)*

The main polluting agents are mostly produced by human activities:

- **Cars emissions**
- **Power plants, industries, incinerators**
- **Heating from fossil fuel**
- **Pesticides**
- **Mining and agricultural operations**

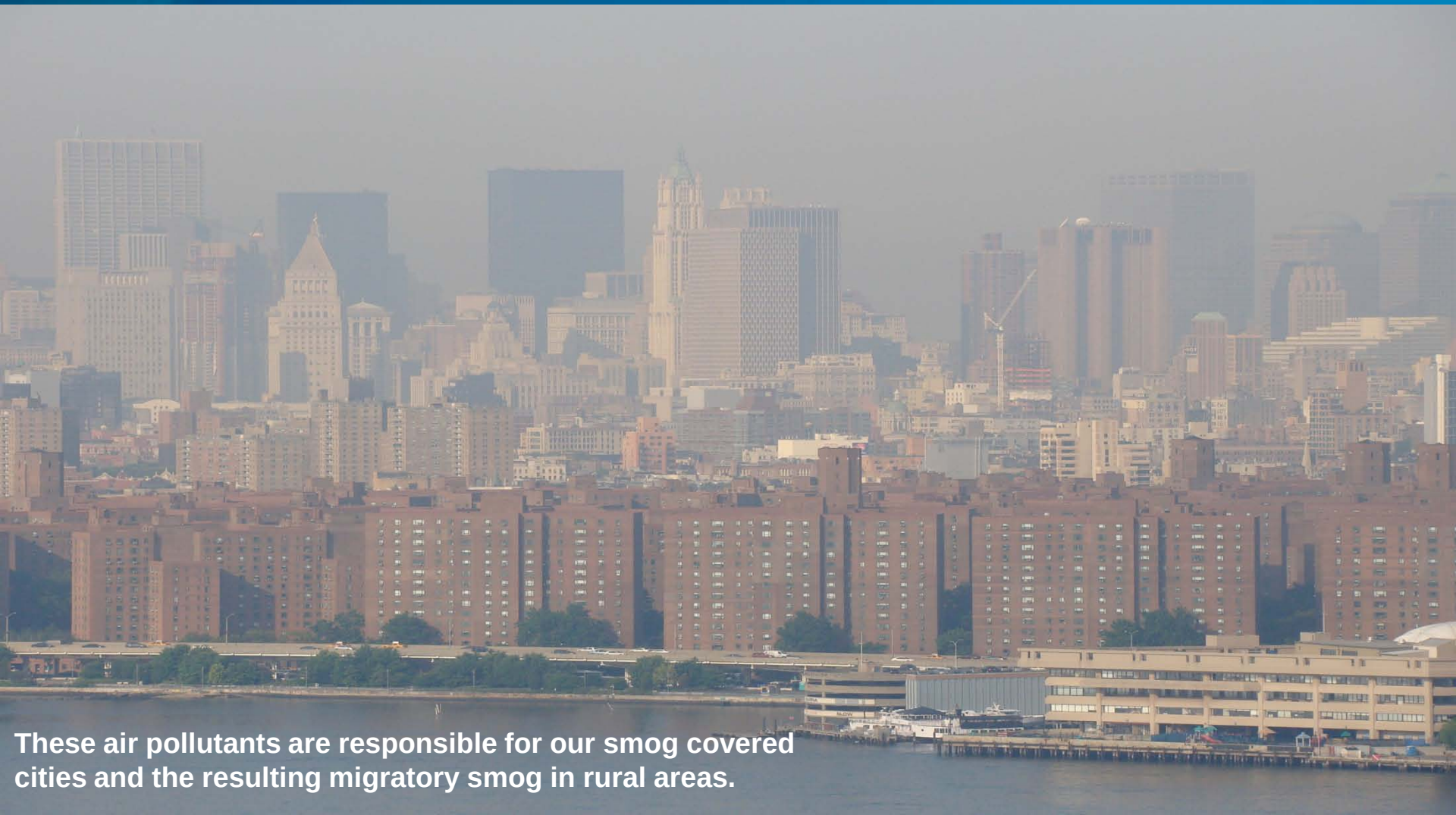
POLLUTANTS MONITORED BY EPA

The EPA tracks emissions of six principal air pollutants considered to be significant factors in negatively impacting the quality of human health.

Six Pollutants:

- **Carbon monoxide**
- **Sulfur oxides**
- **Particular matter**
- **Volatile organic compounds**
- **Nitrogen oxides**
- **Lead**

POLLUTANTS MONITORED BY EPA



These air pollutants are responsible for our smog covered cities and the resulting migratory smog in rural areas.

EFFECTS OF OZONE

Ozone is a gas that occurs both in the Earth's upper atmosphere and at ground level. Ozone can be "good" or "bad" for people's health and for the environment, depending on it's location in the atmosphere.

VOC's + NO_X + Sunlight = Ozone

VISIBLE EFFECTS

The effects of pollution are visible on building exteriors throughout our cities and towns…

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…and cost thousands of dollars to remove.

HEALTH ISSUES

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- Aggravation of Respiratory and Cardiovascular Disease
- Decreased Lung Function
- Increased Severity of Respiratory Symptoms
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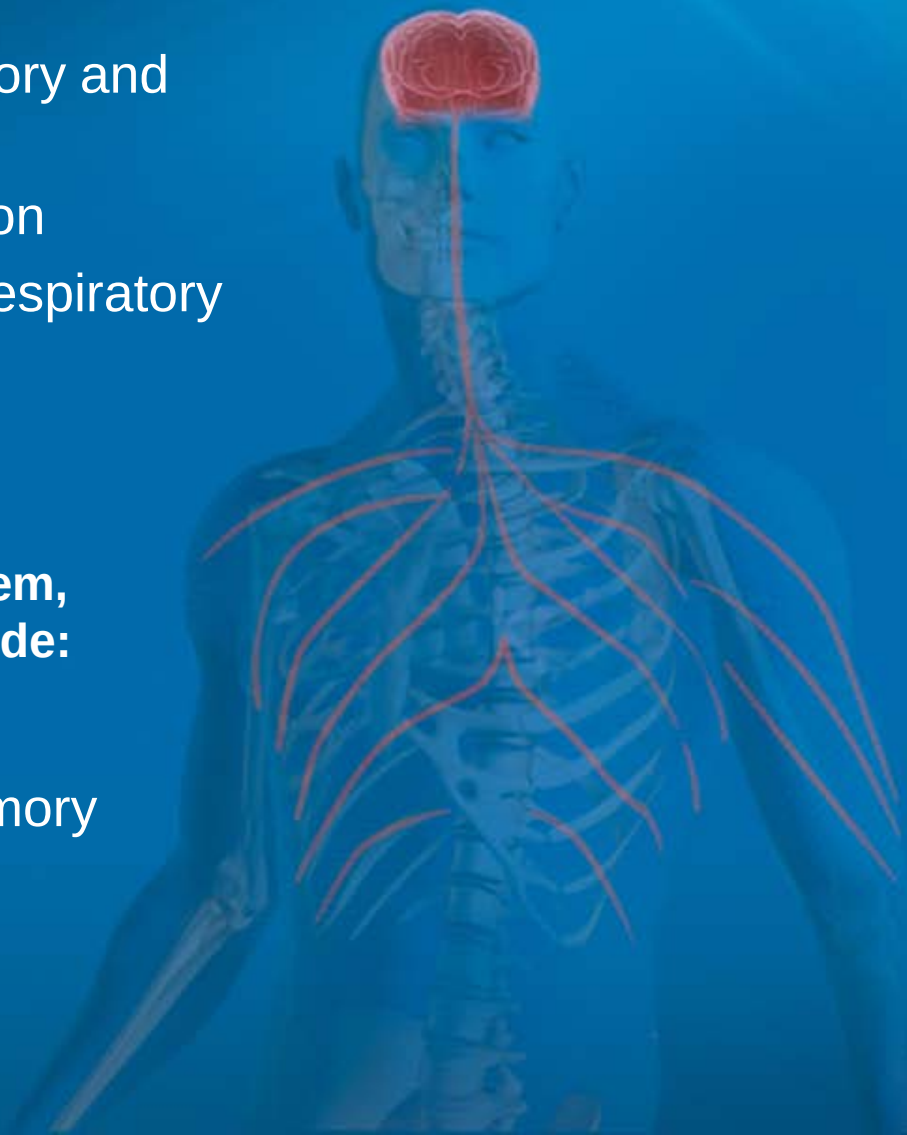
Effects on the Nervous System, specific to the brain, to include:

- IQ Loss
- Impact on learning, memory and behavior



HEALTH ISSUES

- Aggravation of Respiratory and Cardiovascular Disease
- Decreased Lung Function
- Increased Severity of Respiratory Symptoms
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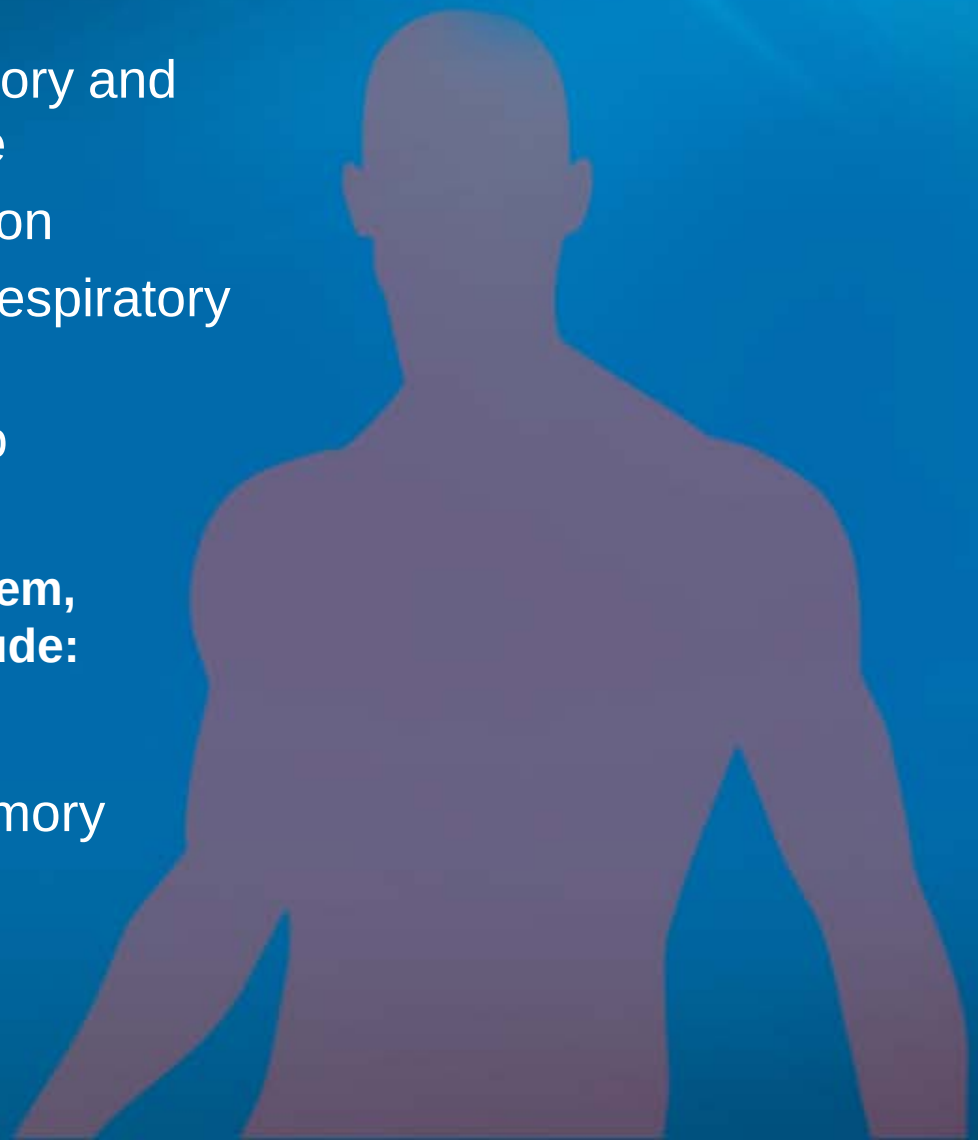
Effects on the Nervous System, specific to the brain, to include:

- IQ Loss
- Impact on learning, memory and behavior
- Cancer
- Premature Death



ENVIRONMENTAL CONCERNS

- **Damage to vegetation** including reduced tree growth and crop yields
- **Acid rain** as a form of SO_2 and NO_X deposition
- Concentrations of heat-forming **greenhouse gases** that may contribute to warmer global temperatures

USE OF SUNLIGHT

The solar energy reaching the earth surface is about 10,000 times the yearly worldwide energy consumption.

In the past, the sun was considered something to protect people from.

But now, through the development of photocatalytic cementitious materials, the sun's rays may represent one of the solutions to the pollution issue.

Photocatalysis

WHAT IT MEANS

Photocatalysis

Photo – defined simply as light

Catalyst – a substance that accelerates a process, increasing the rate of a reaction, without being consumed in that process.

CURRENT CATALYST

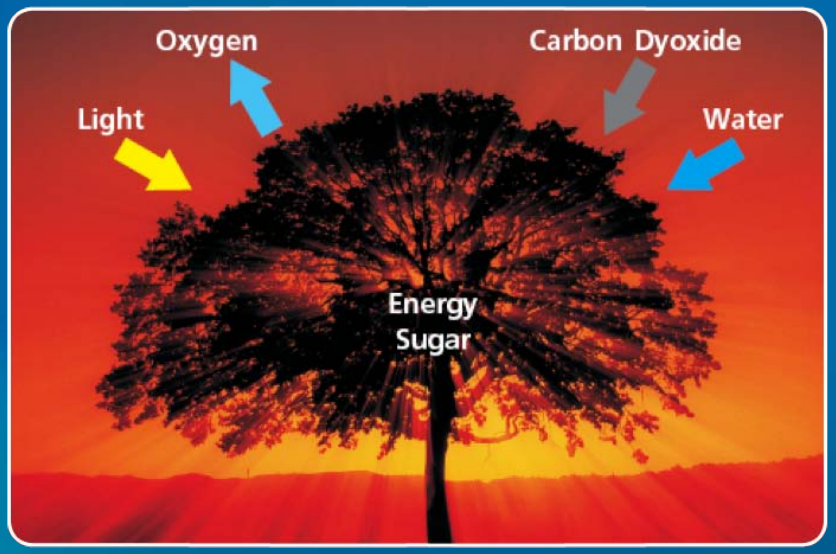
Titanium Dioxide

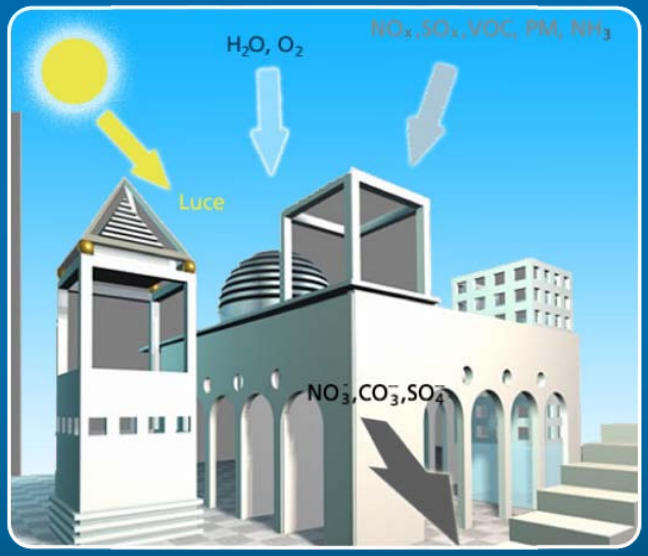
occurs in nature as the minerals rutile, anatase, and brookite. These oxides are the source of commercial titanium.

- Due to it's brightness and high refractive index, TiO_2 is the most widely used white pigment
- Approximately four million tons of pigmentary TiO_2 are consumed annually worldwide
- Applications include paints, inks, coatings, plastics, papers, foods, medicine, and toothpaste

PHOTOSYNTHESIS & PHOTOCATALYSIS

- **Photosynthesis: A chemical reaction by which carbon dioxide and water combine producing oxygen and the sugars that plants need for growth.**
- **This is accomplished by light acting on light-sensitive pigments called chlorophylls.**

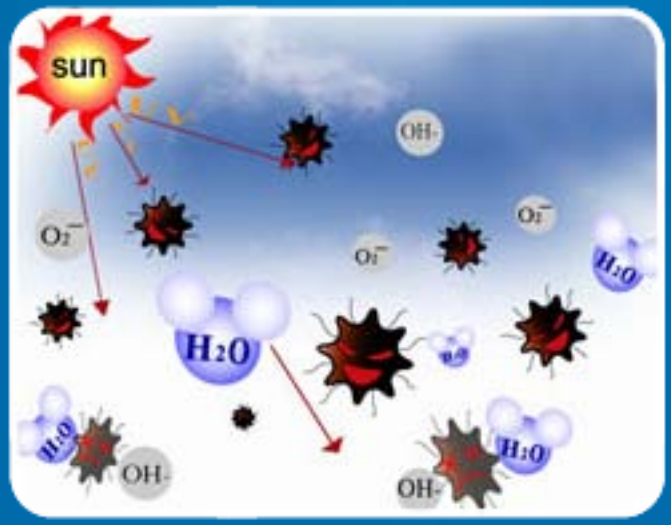




PHOTOCATALYTIC ACTIVITY

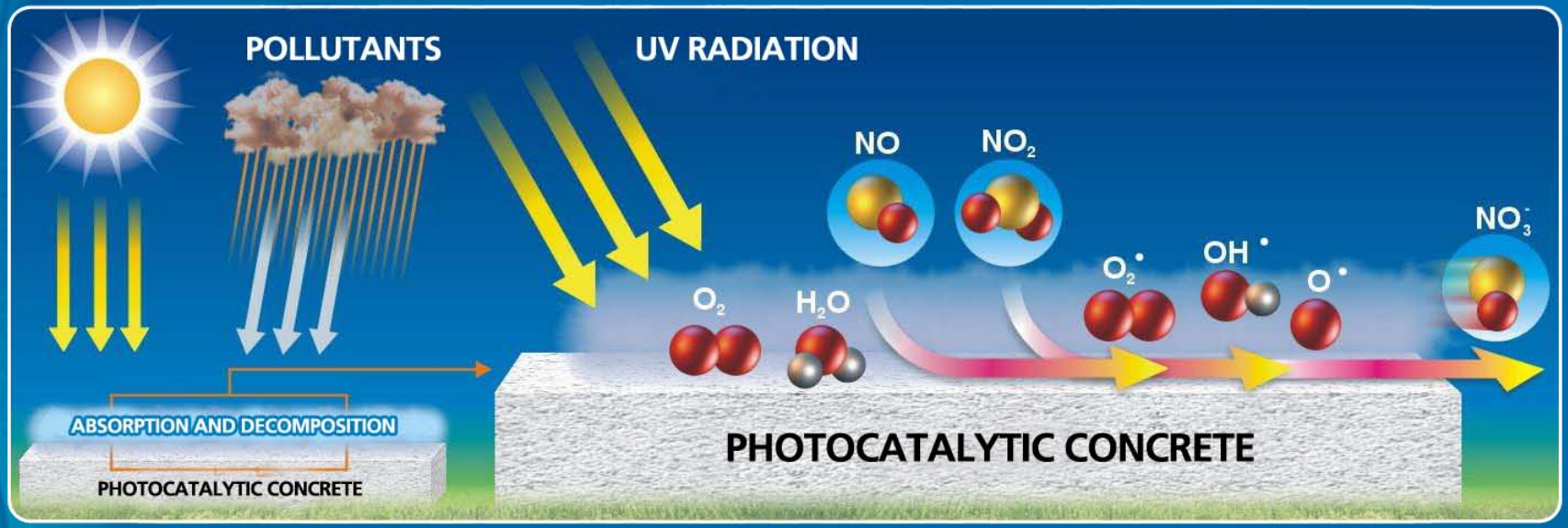
Thanks to the energy coming from light, photocatalysts induce the production of strong oxidating agents that are able to decompose, by oxidation, organic and inorganic toxic compounds existing in the atmosphere.

Accordingly, by decomposing pollutants more quickly, photocatalysis speeds up those oxidation processes that would naturally occur but at very low speed.



PHOTOCATALYTIC ACTIVITY

The photocatalytic mechanism applied to cementitious materials



TIMELINE

Development of photocatalytic concrete technology

1961 1962 1963 1964 1965 1966 **1967** 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981

1967

The discovery of Titanium dioxide's photocatalytic properties when scientists observed the splitting of water on a TiO_2 electrode under ultraviolet (UV) Light

PRODUCTS THAT UTILIZE THIS TECHNOLOGY

- Glass
- Ceramic Tile
- Clear Coat
- ...And Many More

TIMELINE

Development of photocatalytic concrete technology

1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010

Early 1990's

Japanese companies initiate research into photocatalytic concrete technology.

TIMELINE

Development of photocatalytic concrete technology

1990 1991 1992 1993 1994 1995 **1996** 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010

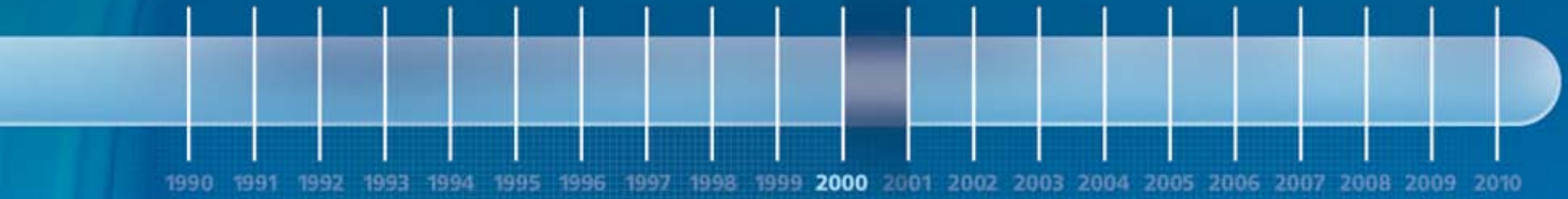
1996

European research into the self-cleaning benefits of photocatalytic concrete technology begins in response to a market need to construct the precast panels for the Dives in Misericordia Church Project.

DIVES IN MISERACORDIA CHURCH • ROME, ITALY

TIMELINE

Development of photocatalytic concrete technology



2000

European research into the de-polluting benefits of photocatalytic concrete technology begins with the launching of the PICADA project.

PICADA

Photocatalytic
Innovative
Covering
Applications for
De-pollution
Assessment

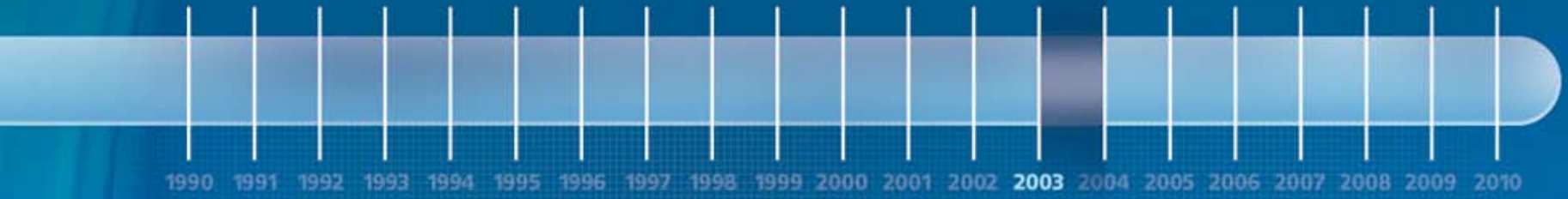
Objective: Develop and assess coverings for de-pollution based on photo-catalysis

Duration: 2001-2005

www.picada-project.com

TIMELINE

Development of photocatalytic concrete technology



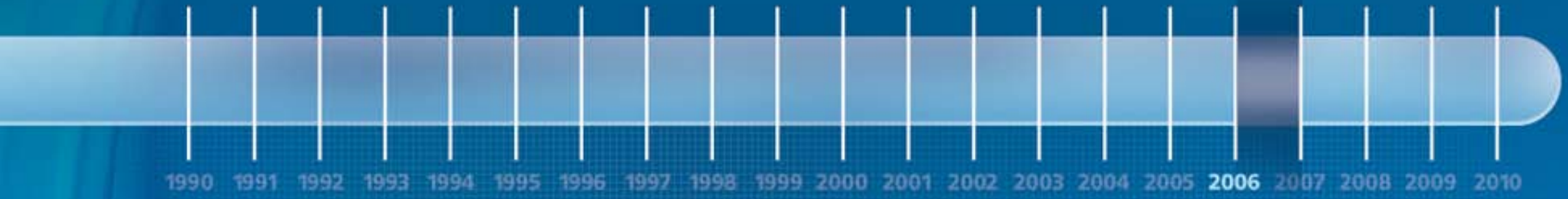
2003

First large scale field tests

CHAMBERY MUSIC MUSEUM • CHAMBERY, FRANCE

TIMELINE

Development of photocatalytic concrete technology



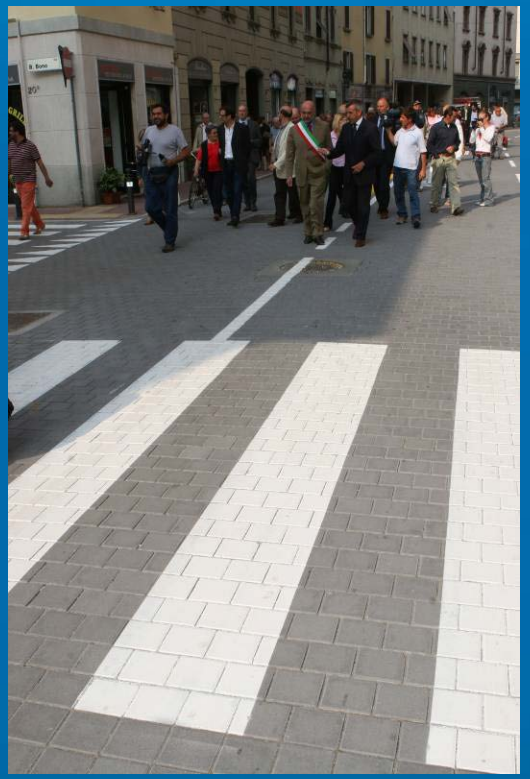
2006

Launch of a photocatalytic range of products

AIR FRANCE HEADQUARTERS • FRANCE

BORDEAUX POLICE DEPARTMENT • BORDEAUX, FRANCE

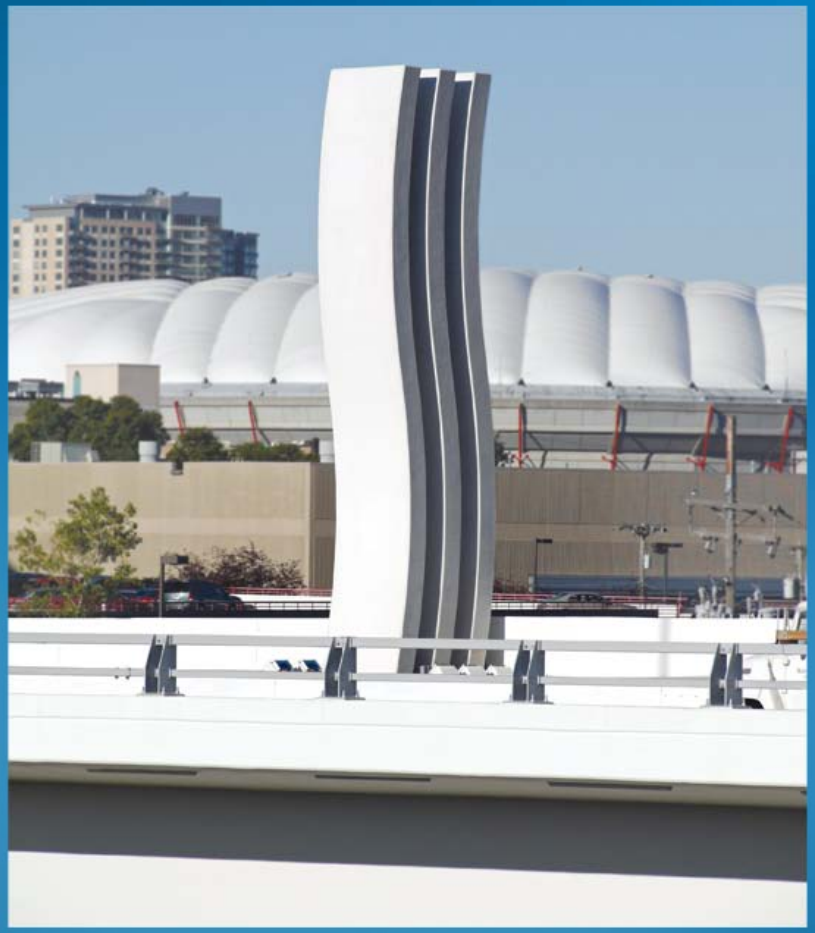
BORGO PALLAZZO • BERGAMO, ITALY



LSU BASKETBALL PRACTICE FACILITY • BATON ROUGE, LA

THE BELL TOWER • DALTON, GEORGIA

I-35 GATEWAY ELEMENTS • MINNEAPOLIS, MINNESOTA



GOVERNOR MIFFLIN SCHOOL • SHILLINGTON, PENNSYLVANIA

Concrete in Practice

CEMENT PRODUCTION

Photocatalytic cement is an ASTM C150 cement incorporating the “active” ingredient (catalyst) in a uniform homogenous manner.

CONCRETE PROPERTIES

Fresh Concrete Properties

- Workability
- Rheology
- Heat generation
- Finishability

Hardened Concrete Properties

- Compressive Strength
- Flexural Strength
- Durability
- Air Void System
- Permeability

CONCRETE IN PRACTICE

Mix Designs:

- Normal mix designs procedures are applicable to photocatalytic concrete…ACI 211, etc.
- Same attention as concrete produced with OPC.
  - Air content
  - Water cement ratio
  - Quality aggregates

Concrete Production:

- Manufacturing procedures same as normal concrete, however extra care should be taken to avoid contamination.

Concrete Curing:

- All concrete must be properly cured to attain maximum strength, reduce permeability, obtain durable concrete and attain desired properties – photocatalytic concrete is no different.

SURFACES, TREATMENTS, & COATINGS

Smooth, sand-blasted, and acid-etched surfaces are acceptable; however, an exposed aggregate surface will result in lower effectiveness.

Surface sealers and coatings are not suitable and must be avoided because they prevent UV light from contacting the concrete surface.

CONCRETE APPLICATIONS

Photocatalytic cement can be used in all concrete and cement based applications, but cost effective applications need to be considered.

Considering that the reaction only takes place on the surface, photocatalytic cement is not required throughout the entire homogeneous section of a concrete wall or slab.

Thinner layers will suffice and manufacturing processes that utilize a dual-stage approach are most cost effective.

ARCHITECTURAL PRECAST

1 1/2" FACE MIX

1 1/2" FACE MIX

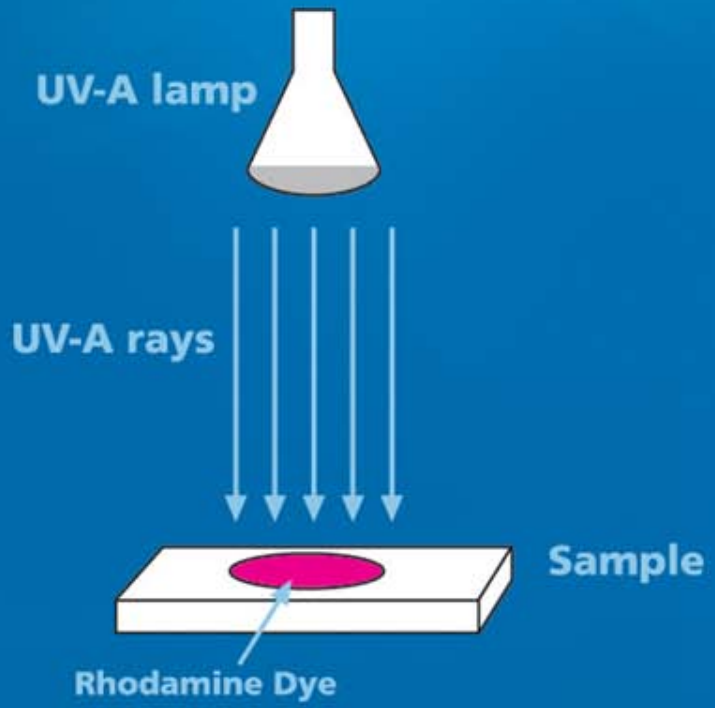
INTERLOCKING CONCRETE PAVERS

5/8” FACE MIX ↓

5/8” FACE MIX →

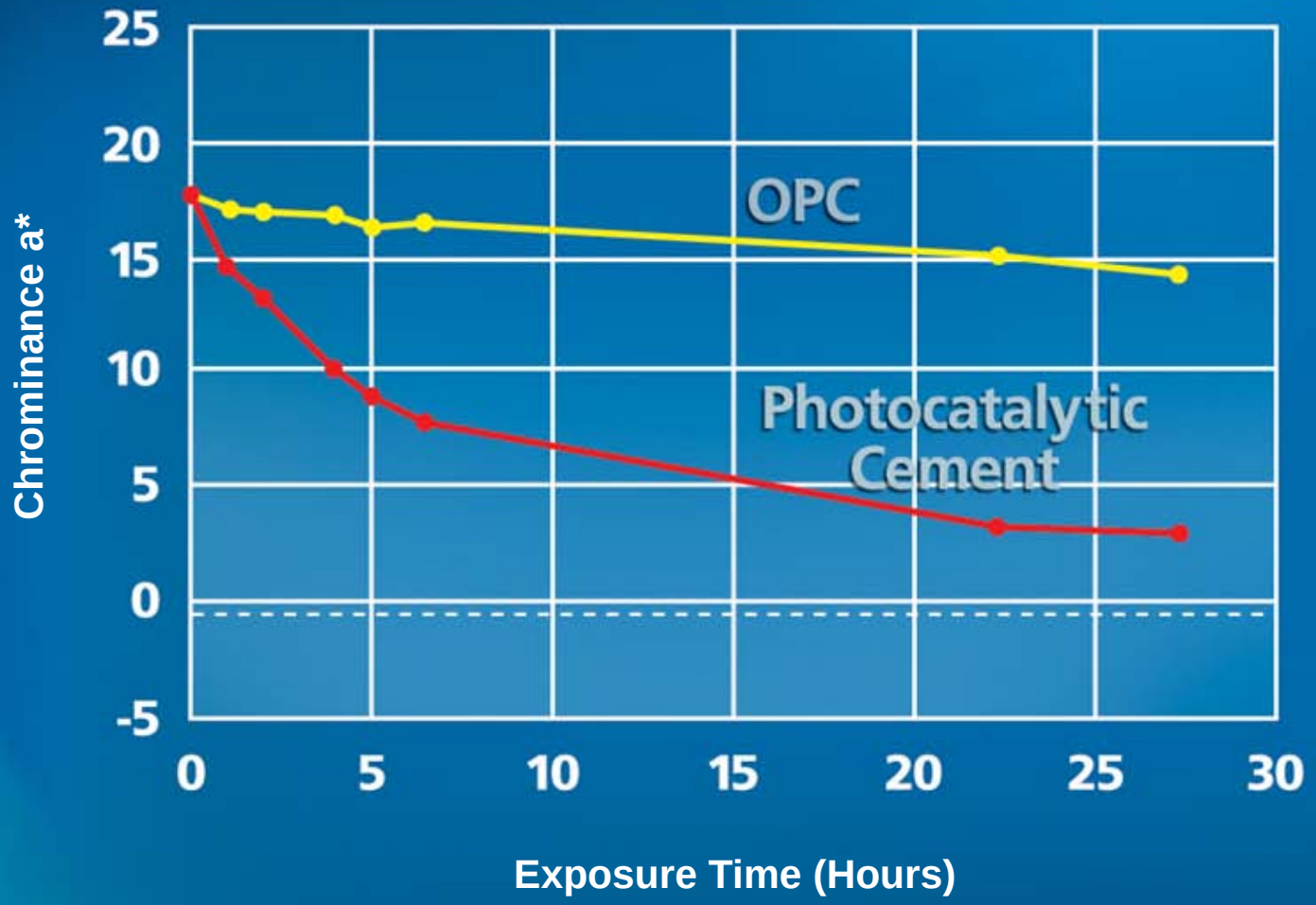
Self-Cleaning Effect

HOW SELF-CLEANING IS MEASURED?



Colorimetric method to determine the photocatalytic activity of hydraulic binders.

VISUAL RESULTS



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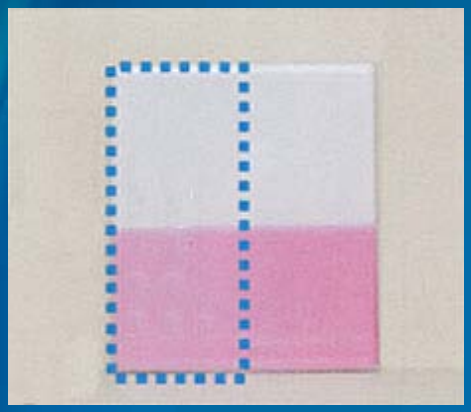


CASE STUDY

SELF-CLEANING IN PRACTICE

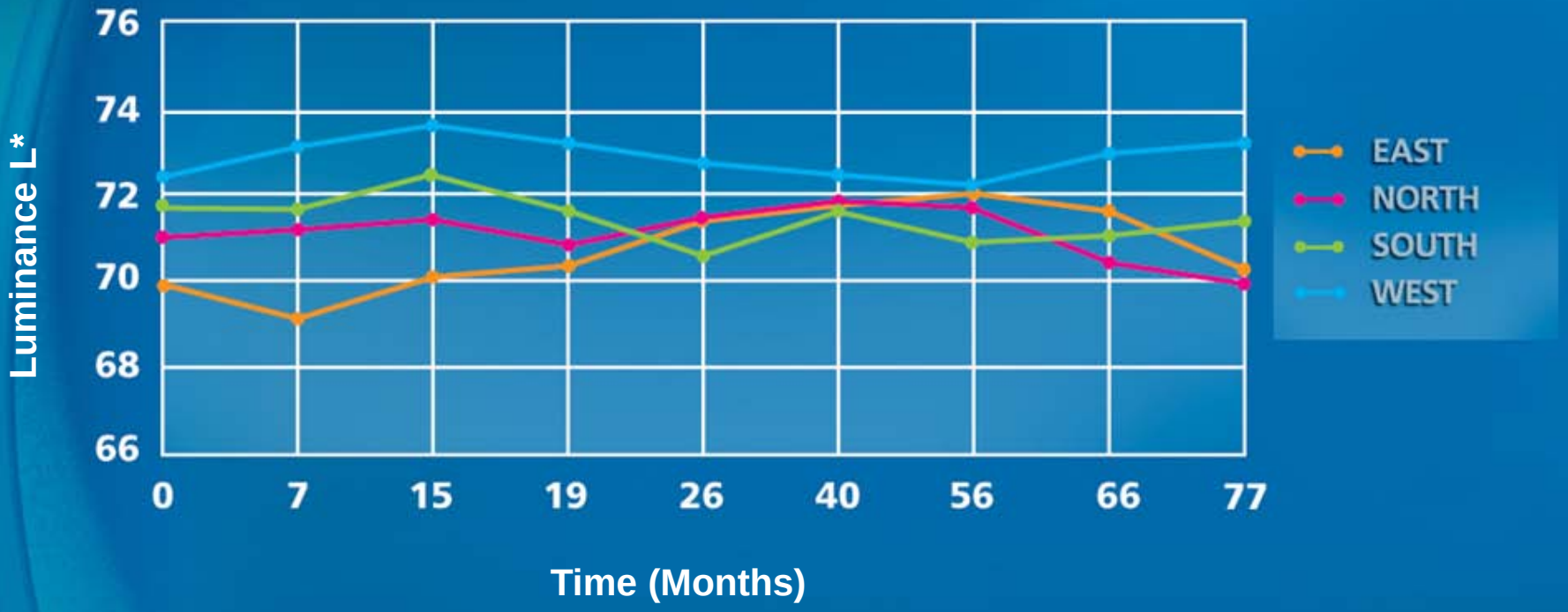
Cite de la Musique, Chambery, France

CASE STUDY

FIELD TESTING THE EFFECT OF UV DIFFUSION

CASE STUDY

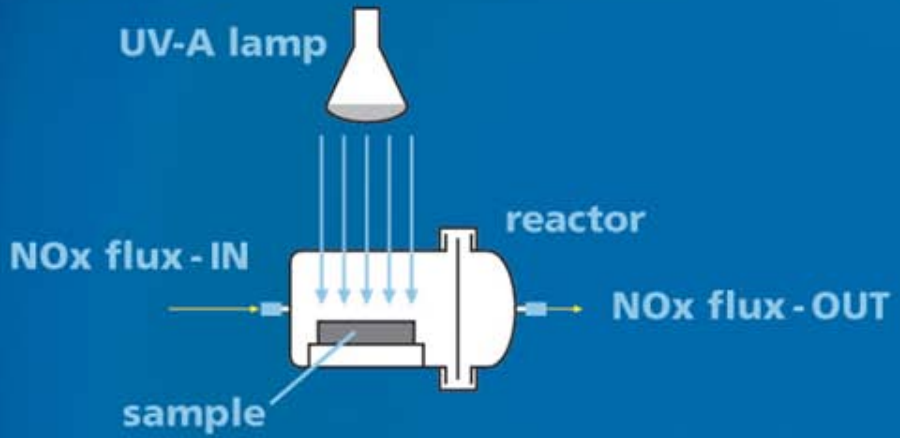
COLOR MONITORING

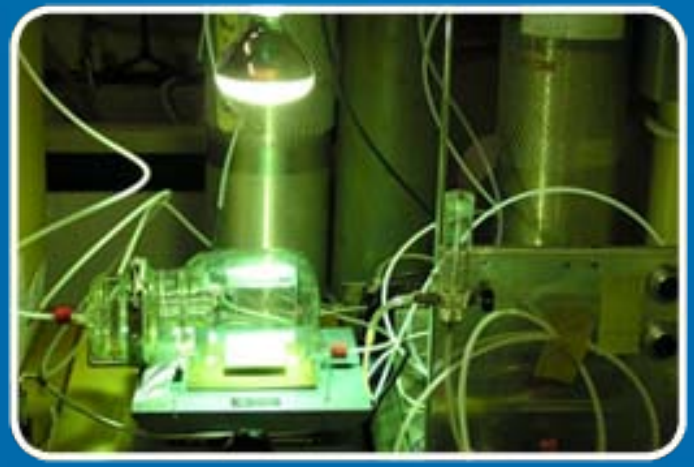



De-Polluting Effect

HOW IT'S MEASURED

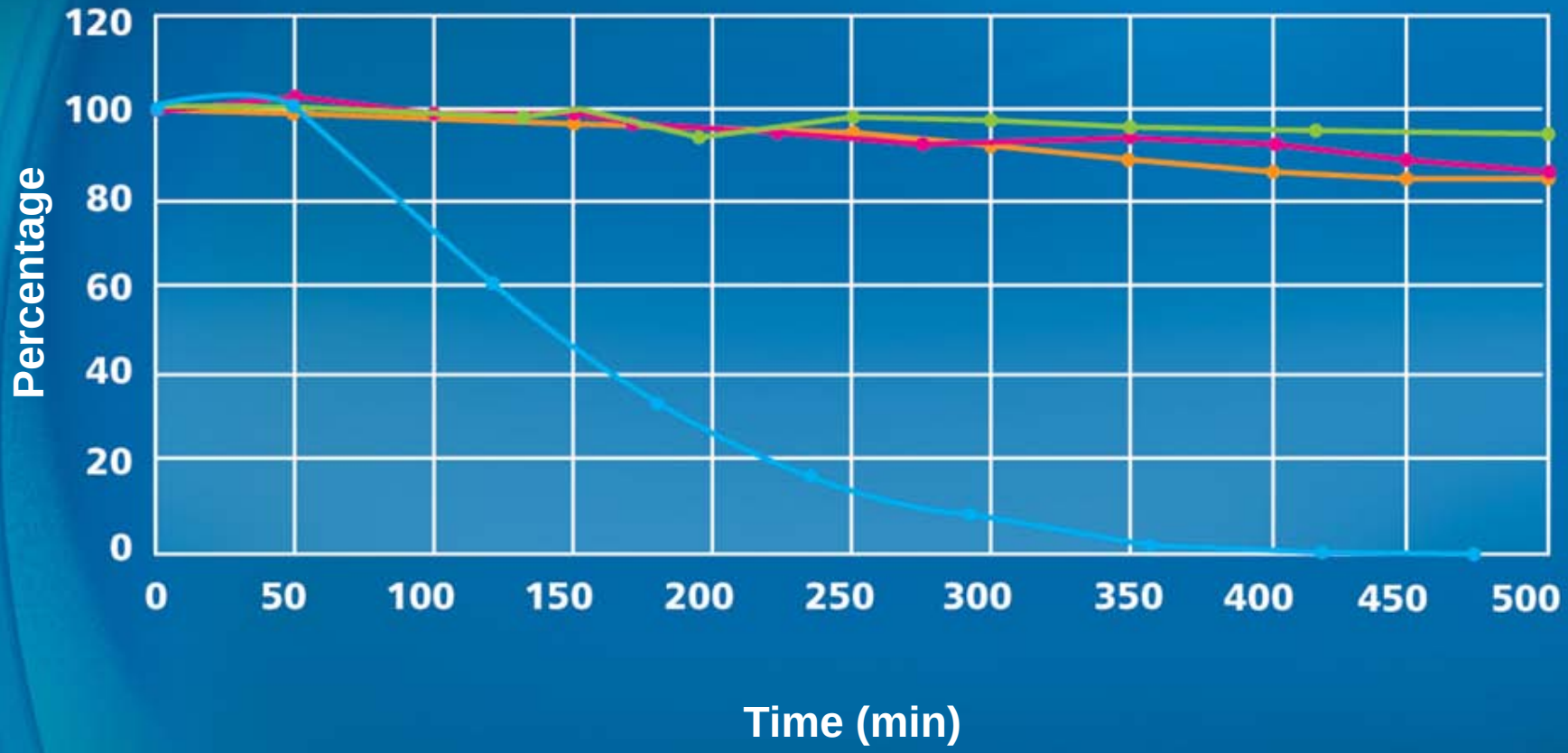
Measuring Pollution Abatement





Test for the measurement of the photocatalytic activity of cement-based or ceramic samples, by chemiluminescence analysis.

ISPRA NOx DESTRUCTION TEST RESULTS



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