Photocatalysis Technology
New Functionalities to Improve Air Quality

abolin

The Problem: Air Pollution

Significant improvements have been made on emissions control, but more work is needed to have cleaner air.

Several environmental agencies and NGOs are raising the awareness of the health risks related to pollution.

In previous years, the major focus has been on CO2 and Particulate Matter (PM10 and PM2.5), however NOx levels have become well known for their contribution to the pollution problem.

Photocatalysis provides a way of converting otherwise harmful pollutants into harmless materials.

Various studies have shown that the other several actions implemented to control pollution such as Low Emission Zones (LEZ), the use of eco-friendly engines and cleaner fuels have not provided the expected results and other technologies are required.

Exposure to NOx causes multiple respiratory complications for the global population including airway inflammation in healthy people and increased respiratory symptoms in people with asthma.

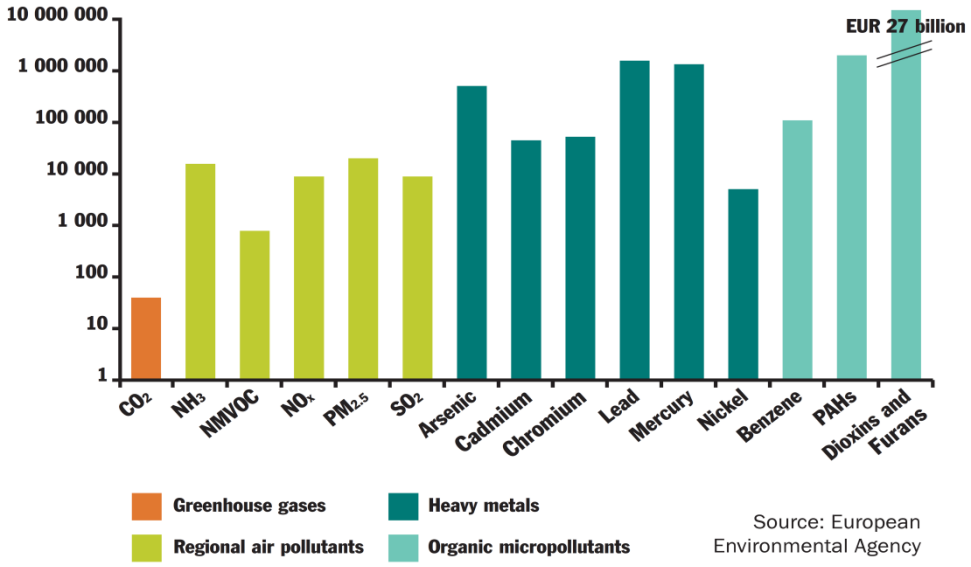
A recent study revealed that more than 1,100 schools in London are within 150m distance from roads carrying more than 10,000 vehicles a day. The same study showed that people living near roads carrying more than 10,000 vehicles a day are vulnerable to heart diseases and that air pollution could be responsible for 15 to 30% of all new cases of asthma in children.

The Health Costs

Air pollution has a relevant negative impact on our economy

The cost of damage caused by emissions in 2009, just from the industrial facilities reporting into the E-PRTR (European Pollutant Release and Transfer Register), is estimated as being at least EUR 102–169 billion. Fifty per cent of the total damage cost occurs as a result of emissions from just 191 (or 2%) of the approximately 10,000 facilities that reported at least some data for releases to air in 2009. Three quarters of the total damage costs are caused by the emissions of 622 facilities, which comprise 6% of the total number.

Damage costs (EUR/ tonne)



Source: European Environmental Agency

Focus on NOx

Sources

Nitrogen dioxide (NO_2) is a reactive gas that is mainly formed by oxidation of nitrogen (NO) . High temperature combustion processes (e.g. those occurring in car engines and power plants) are the major sources of nitrogen oxides, NOx, the term used to describe the sum of NO and NO_2. NO makes up the majority of NOx emissions.

A small part is directly emitted as NO_2, typically 5–10% for most combustion sources, with the exception of diesel vehicles. There are clear indications that for traffic emissions, the direct NO_2 component is increasing significantly due to increased penetration of diesel vehicles, especially newer diesel vehicles (Euro 4 and 5). Such vehicles can emit up to 50% of their NOx as NO_2 (e.g. Grice et al., 2009) because their exhaust after treatment systems increase the direct NO_2 emissions.

Effects on Human Health

Negative health effects can be seen as a result of short-term exposure to NO_2 (e.g. changes in lung function in sensitive population groups) and long-term exposure (e.g. increased susceptibility to respiratory infection). Epidemiological studies have shown that diseases such as bronchitis in asthmatic children increase in association with long-term exposure to NO_2. Reduced lung function is also linked to NO_2 at concentrations currently found in cities in Europe and North America (WHO 2008). It should be noted that as NO_2 is highly correlated with other pollutants (in particular PM) it is difficult to differentiate the effects of nitrogen dioxide from those of other pollutants in epidemiological studies.

Nitrogen compounds have acidifying effects but are also important nutrients. Excess deposition of atmospheric nitrogen can lead to a surplus of nutrient N in ecosystems, causing eutrophication (nutrient oversupply) in terrestrial and aquatic ecosystems. Excess nitrogen supply can lead to changes in unique terrestrial, aquatic or marine animal and plant communities, including biodiversity loss (EEA, 2010).

Nitrogen oxides play a major role in the formation of ozone. They also contribute to the formation of secondary inorganic aerosols (SIAs), through nitrate formation, contributing to PM10 and PM2.5 concentrations.

Trends in NO_2 and NOx Concentrations

The trends in concentrations are linked to changes in emission sources. EU emissions of NOx fell 44% in the period 1990–2009 and 8% from 2008 to 2009. Nevertheless, total NOx emissions in 2009 were about 12% higher than the aggregated emissions ceiling set in the NEC (National Emissions Ceilings) Directive for 2010.

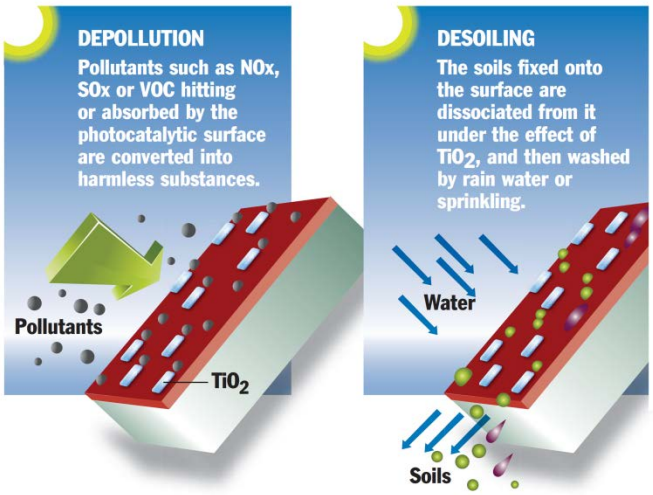
Transport is the dominant sector for NOx emissions, accounting for 49% of the total in 2009, followed by the energy sector, which contributed 20% of the total. These two sectors have substantially reduced emissions since 1990. Actual emissions from vehicles (often termed ‘real world emissions’) may exceed the allowed emissions specified in the Euro emission standards for each vehicle type. This is particularly the case for NOx emissions from light-duty diesel vehicles. EU Member States regularly update the emission factors used in their emission inventories and their previously reported emissions.

Abolin Co. Photocatalysis Technology

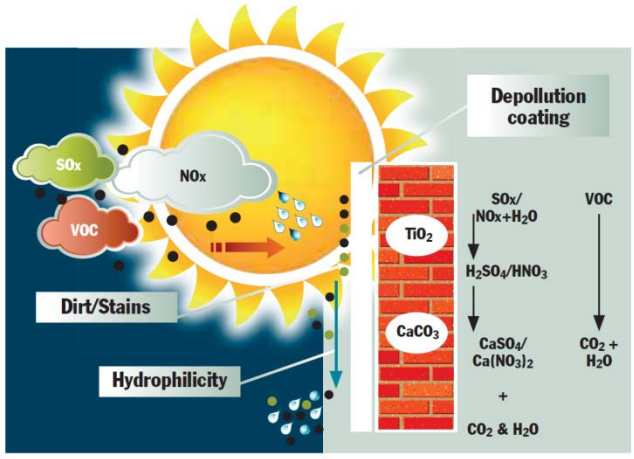
Photocatalysis

Adding new functionalities to a surface Photocatalysis is a natural reaction occurring in presence of light, water and oxygen. The reaction is accelerated by a catalyst (Titanium dioxide – TiO_2) and it is activated by the energy of the UV light ("photo").

When TiO_2 is exposed to UV light, electron-hole pairs are generated, facilitating reduction and oxidation reactions through the formation of adsorbed free radicals on TiO_2 surface. These radicals are extremely highly reactive species, capable to degrade the pollutants hitting or absorbed onto the photocatalytic surface; the reaction of degradation converts harmful materials, such as nitrogen oxides, sulphur oxides, VOC (volatile organic compounds) into harmless substances. The catalyst is not consumed by this reaction, ensuring a continuous process during the service life of a photocatalytic surface.



Titanium dioxide is a raw material widely used in various applications. It is the white pigment coloring most of the items we see and use in our daily life. Coatings, wall paints, plastics, and paper are just a few examples where TiO_2 is used, to achieve white color as well as to reach the required level of opacity. Titanium dioxide is present not only in white colored materials, but it's a key component whenever opacity is needed.



Specialty qualities of TiO_2 are used in ceramics, in electronics, in cosmetics and even in drugs and foodstuffs, as well as in catalytic applications for industrial processes.

Photocatalytic TiO_2 has specific properties and it is different from the pigmentary version. The morphology and the characteristics of its ultrafine particles are developed to achieve the best catalytic activity and to allow an optimal incorporation into a variety of matrix. Specific photocatalysts are developed for use in paints, coatings, cement-based materials or for direct application on surfaces (for examples on filtering media for air treatment).