Evaluation of the capability of Airlite technology in reducing VOC and NOx pollution

Introduction

The reduction of pollutants in confined environments using Airlite technology was evaluated upon the request of customers of Advanced Materials Srl.

Samples treated with Airlite technology have been tested to evaluate their ability in reducing the amount of VOC (Volatile Organic Compounds) and NOx (nitrogen oxides) in a confined environment. Measurements were carried out in simulated conditions, after burning a cigarette in a test chamber and comparing the residual amount of harmful compounds in the presence or in the absence of Airlite treated surfaces. An appropriate ratio between the air volume in the chamber and the surfaces of treated samples was chosen in order to be representative of a fully furnished work environment.

Indoor environment

The term "indoor" refers to non-industrial everyday life and work environments and, particularly to those dedicated to housing, leisure, work and transport. This definition also refers to public offices, private and public structures (i.e. hospitals, schools, offices, barracks, hotels, banks, etc.), buildings intended for recreational and social activities (cinemas, restaurants, bars, shops, sports facilities, etc.), public and private transport (car, train, plane, ship, etc.).
Indoor pollutants, which can act individually or combined with other factors, cause the decrease in environmental comfort and represent a risk for health both in the short and long term. Among indoor pollutants, chemical compounds (organic and inorganic compounds), physical specie (ionizing and non-ionizing radiations) and biological agents (microorganisms, molds, mites) are grouped.

As shown by some investigations conducted at European level, considering urban centers, people spend 95-97% of the time in confined spaces; 2.4% in means of transport and 1% in open air spaces (outdoor). Exposure to indoor pollution is dominant compared to outdoor.
It is worth noticing that indoor air quality is affected both by the presence of internal pollution sources and by the quality of the external air. The main internal sources of pollution are determined by human activities, construction materials, furnishings and air treatment systems; among these, one of the most important sources is tobacco smoke, in addition to the combustion processes of fuels. Other possible internal sources of pollution are represented by working tools (such as printers, plotters and photocopiers), cleaning products for the house, antiparasitic products, glues, adhesives, solvents, etc.

Exposure to pollutants in indoor air may be responsible for the occurrence of specific pathologies or aggravation of pre-existing conditions in more vulnerable sections of the population such as children, who spend most of their time at home and at school. Some studies conducted in Northern Europe have shown how asthma in children and adolescents has also been positively associated with presence in the school environment of volatile organic compounds (VOC).

Targeted studies have shown that in the presence of internal pollution sources and with low levels of air recirculation, the presence of pollutants (in particular the levels of volatile organic compounds) in indoor environments can exceed 10-20 times those detected on the outside, as in the case of formaldehyde.
Some VOCs such as benzene and formaldehyde are classified by IARC (International Agency for Research on Cancer) as carcinogens - Group 1: confirmed human carcinogen.

Volatile Organic Compounds

VOCs family includes a wide class of substances with various chemical / physical characteristics and main definitions are resumed as follows:

- In the document “Indoor Air Quality: Organic Pollutants” WHO classifies the VOCs into 4 groups (very volatile, volatile, semi-volatile, particulate matter) based on boiling points, with a lower limit between 50-100 °C and a upper limit between 240-260 °C.
- The European Concerted Action (ECA) in the Evaluation of VOC document shows a classification of VOCs based on chromatographic retention time: "all volatile organic compounds, eluted in a capillary column coated with 100% of dimethylpolysiloxane, in the retention interval comprised between n-hexane (C6) and hexadecane (n-C16) "; this range corresponds to boiling points between 50-290 °C.
- According to UNI EN ISO 16000-5 Part 5: Sampling strategy for volatile organic compounds (VOCs) takes over the classification of VOCs according to WHO.
- The European Union (EU) in Directive 1999/13 / EC on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and in some plants, implemented in Italy by Ministerial Decree 44/04, defines VOC "any organic compound having a vapor pressure of 0.01 kPa or greater at 293.15 K, or having a corresponding volatility in particular conditions of use".
- Subsequently, the EU in the Directive 2004/42 on the limitation of emissions of volatile organic compounds resulting from the use of solvents in specific paints and varnishes, as well as in car body products, implemented in Italy with Legislative Decree 161/06, defines VOC "any organic compound having an initial boiling point equal to or less than 250 °C measured at a standard pressure of 101.3 kPa".

In this document the definition proposed by the WHO has been used, considering that this definition is widely followed at international level by Institutions responsible for health protection.

Nitrogen oxides

Nitrogen oxide air pollution almost exclusively refers to the term NOx which indicates the weighted sum of nitrogen monoxide (NO) and nitrogen dioxide (NO_2) that are present in atmosphere.

Nitrogen oxide (NO) is a colorless, tasteless and odorless gas; it is also called nitric oxide. It is mainly produced during high temperature combustion processes together with nitrogen dioxide, being its precursor. Nitrogen dioxide (NO_2) is a yellow-red toxic gas, with a strong and pungent odor and with great irritating power; it is a powerful oxidant, very reactive and therefore highly corrosive.

Test chamber

Glove Box mod. SGS20: PMMA glove box chamber (absorption of light radiation in the ultraviolet area compared to glass (PMMA up to about 285 nm, glass up to about 320 nm)).

Dimensions (l x w x h): 900x650x750mm, weight about 45Kg, width = 1200mm including pre-chamber with inclined front wall. Front-front wall with n ° 2 flanges for gloves and n ° 2 latex gloves thickness mm 0.5 long-sleeved size 9, with safety o-ring.

Right side wall with installed n ° 1 anticorodal pre-chamber, internal dimensions Ø 186 mm and length 280 mm with circular section with double sealed door, external and internal.
Left side wall with opening door of size 300x400mm.
Upper wall with n ° 1 pressure gauge for measuring internal pressure.
Outlet hole, feedthrough, closed filter holder with absolute filter H14 (047), flow shut-off ball valve, centrifugal aspirator.
Intrinsically safe overpressure valve.
Filtering of an absolute type similar to the previous inlet air.
Equipped with:

- n ° 1 sealed internal power socket, positioned on the back wall.
- n ° 1 fluids hole with valve and hose connector for Ø mm 8 pipe, positioned on the side wall.
- PLC control panel with 3.5" color touch screen for managing process parameters, alarms and services.

Polluting source

Test with cigarette smoke consists in the exposure to toxic agents generated by the combustion of tobacco. It is a combination of over 4000 substances, including toxic, irritant or carcinogenic compounds. The most immediate effects of exposure to secondhand smoke are eyes and nose irritation, headaches, dry throat, dizziness, nausea, cough and other respiratory problems. Furthermore, it causes an increased risk of ischemic diseases, cardiovascular diseases and pneumonic cancer. It is responsible for respiratory diseases of childhood (otitis, asthma, bronchial pneumonia). Smoking of pregnant women, or exposure to secondhand

smoke causes a significant reduction in birth weight, is associated with sudden infant death (SIDS, Sudden Infant Death Syndrome), and has serious consequences for the development of respiratory function of children.

Experimental set-up

For the detection of the VOC values the following instrumental set-up was employed:

GrayWolf DirectSense IAQ Standard Tablet 7 "Indoor Air Quality Survey & Monitoring complete with:

- IQ-610 Probe for measurement of CO2, CO, ppb VOCs,% RH, Temperature, dew point & derived values of humidity

IQ-610 probe:

SENSOR	INSTR.RES (ppm)	RANGE (ppm)	SENSOR LOD (ppm)	SENSOR DRIFT	T_{90} RESPONSE	RECO'D CALIBRATION FREQUENCY	EXPECTED LIFE
Carbon Dioxide (CO_2)	1	0 to 10,000	1	<80ppm/year	<= 20s	<= 12 months	> 10years
Nitric Oxide (NO)	0.1	0.0 to 250.0	0.2	< 5%/year	< 45s	<= 12 months	36-60 months
Carbon Monoxide (CO)	0.1	0.0 to 750.0	<0.3	< 5%/year	< 25s	<= 12 months	36-60 months
VOC Low Range	0.001	0.000 to 20.000	0.005	< 10ppb/day (zero drift)	< 5s	< 12 months factory	> 5years

Data analysis

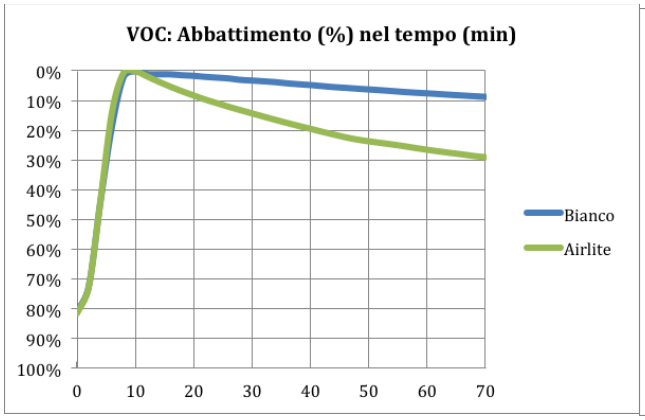
1_Analysis of the background level (blank test)
In order to evaluate the effectiveness in reducing selected pollutants by the Airlite technology, a blank test was performed in the absence of an active surface inside the test chamber. In this way it was possible to evaluate the natural decrease of pollutants within the test chamber.

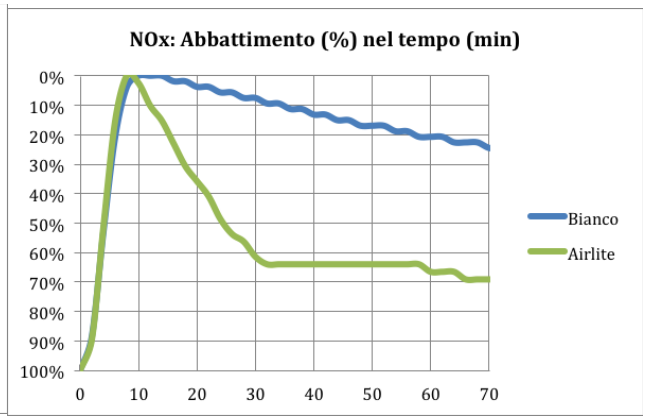
2_ Determining the level of pollutant reduction
For the assessment of pollutants reduction in the presence of Airlite treated surfaces, the test chamber was positioned near a stained-glass wall in order to simulate a common room. Inside the test chamber was placed a plasterboard panel treated with Airlite measuring 450x360mm. Measurements were carried out during 70 minutes: within this time range, a first fast increase in concentrations of pollutants was observed due to the combustion of the cigarette, while during the following 60 minutes an active reduction of pollutants was registered due to the active degradation of Airlite surfaces.

Results

In the following graphs, the measured values normalized with respect to the maximum concentration of the single pollutant are shown.

Pollutant reduction is shown on the axis of the ordinates and on the abscissa it is instead reported the duration of the test expressed in minutes. In the same graph is overlapped the curve of the blank test, without an active surface inside the test chamber.





Closing remarks

The obtained results show that, even in the presence of high pollutants concentration (generated by cigarette smoke), Airlite shows a NOx reduction about 45% higher than the normal control condition (absence of active surface), and a reduction of VOC about 20 % higher compared to control.
Considering the Airlite paint, the contribution of VOC to the environment is to be considered null.

24 May 2017

Prof. Alberto Cigada