

## Abstract

The main objective of the research being the subject of the dissertation was to assess the use of the photocatalytic paints for decomposition of organic air pollutants by determining the activity of commercial photocatalytic paints against model pollutant – benzo[a]pyrene.

White water-thinnable commercial photocatalytic paints manufactured by Pigment company in Piryce, Poland were utilized in presented research. These were respectively:

- FA – silicate facade paint designed for painting interior and exterior construction elements,
- DR - silicate facade paint designed for painting interior and exterior construction elements in civil engineering,
- IN – acrylic paint designed for painting interior walls and ceilings,
- LX – latex paint designed for paint rooms vulnerable to dirt.

Photocatalytic paints FA and DR expressed low activity in decomposition of benzo[a]pyrene, regardless of the source of radiation, temperature, relative humidity and exposure time used. Observed levels of decomposition were most likely the results of photolysis of contaminant on the surface of the paint.

Organic photocatalytic paints IN and LX revealed photocatalytic activity in decomposition of benzo[a]pyrene. This decomposition proceeded preferably during the tests carried out in the weathering chamber with UV intensity of 17.5 W/m<sup>2</sup>, high temperature and low relative humidity inside the chamber. These paints have also shown high activity during the decomposition tests carried out inside the constructed photocatalytic reactor utilizing UV or fluorescent lamps as a radiation source. Increased activity of photocatalytic paints under conditions of low relative humidity was probably a result of anatase structured TiO<sub>2</sub> present inside the paints changing its surface character from hydrophobic to hydrophilic under UV irradiation. Desorption of water from paint surface also lead to increased number of available active sites. Presence of large amounts of water vapour resulted in rapid adsorption of water molecules on the surface, which deactivated the photocatalyst due to increased charge carrier recombination.

Analysis of the composition of paints showed presence of anatase and rutile phase of TiO<sub>2</sub> in mass ratio of 1:2. However, it has been shown, that the photocatalytic activity of materials was affected by other paint constituents. In case of mineral paints the presence of potassium, due to the use of potassium water glass as one of the ingredients, has prevented an access to the active anatase form of TiO<sub>2</sub>. Porous structure of the paint, due to the use of **Abstract**

various fillers (i.e.  $\text{CaCO}_3$ ), also had negative impact on the activity. Pollutants adsorbed in-side the porous structure had limited access to UV radiation.

The effect of coating thickness on the efficiency of the decomposition of benzo[a]pyrene was also analyzed, as well as the ability for UV radiation to penetrate through the porous paint structure. It has been found that the depth of penetration of UV radiation for LX paint was 9  $\mu\text{m}$  and 20  $\mu\text{m}$  for more porous DR paint.

Latex LX and acrylic IN photocatalytic paints revealed ability to undergo hydrophilic conversion under UV irradiation. This phenomenon was suppressed under conditions of high humidity inside the photocatalytic reactor, which was related to the increased charge carrier recombination under conditions of high surface hydroxylation of active  $\text{TiO}_2$  form. Hydroxyl radicals generated on the surface of photocatalyst are easily desorbed in aqueous media, causing oxidation of organic compounds in water. However, in the gaseous environment they become easily accessible electron trapping centres, what results in the reduced activity of the photocatalyst.

Attempts to identify the degradation products of benzo[a]pyrene using GC-MS were unsuccessful due to the leaching of large amounts of paint constituents from the surface.

Stability tests of FA and LX photocatalytic paints showed no significant changes in their structure due to UV irradiation. In the case of LX paint only a minimal mineralization of the organic binder was noticed after 70 hours of exposure, but it was deemed to be insufficient to suggest instability of the structure of the paint. According to the small photocatalytic activity of the mineral paints it can be assumed that their stability will be similar to the paints without any addition of the photocatalytically active  $\text{TiO}_2$ .

Additional measurements of the photocatalytic activity paints with use of smart ink tests confirmed the findings obtained from the previous studies. The organic photocatalytic paints demonstrated the ability to generate charge carriers under UV irradiation. Mineral paints have shown little activity in these tests, within the range of measurement error.

Photocatalytic paints have great potential for application, providing self-cleaning ability to facades, interior walls and ceilings as well as improved quality of air. However, one needs to be aware of the risks associated with the potential formation of harmful intermediate products during decomposition of pollutants and paint constituents, as well as any negative influence of the photocatalytic process on the stability of obtained coatings.