TITANIUM DIOXIDE SELF-CLEANING COATING FOR CRITICAL INFRASTRUCTURE PROTECTION

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ABSTRACT

Self-cleaning building materials is a form of passive safety technology that can be used to provide increased resistance against in CBRN incidents. This paper is aimed at evaluating the effectiveness of a self-cleaning coating based on a dispersion in ethanol of titanium dioxide powder at 0.5 gr/L distributed directly on stone materials. The parameters matter of the study were stealthiness, performance against a toxic industrial chemical (TIC) and durability.

Keywords: Titanium Dioxide; Self Cleaning Coating; Toxic Industrial Chemicals; Building Materials

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Introduction:

Our work highlights self-cleaning building materials as passive safety technologies, which can inherently provide increased resistance against a CBRN incident or speed up the return to full efficiency after the incident. A number of experimental evidences have confirmed the ability Titanium dioxide to oxidise organic molecules (Cassar *et al.*, 2004). It has also been demonstrated that these coatings have anti microbial activity which leads to oxidization of microorganisms, such algae (Linkous *et al.*, 2002) and bacteria (Zhang & Chen, 2009; Gupta *et al.*, 2013; Sikong *et al.*, 2010; Haghi *et al.*, 2012; Jain *et al.*, 2012). Also the use of photocatalyst in degradation of CWA is well documented (Vorontosov *et al.*, 2004, 2005; Ming-Show *et al.*, 2006).

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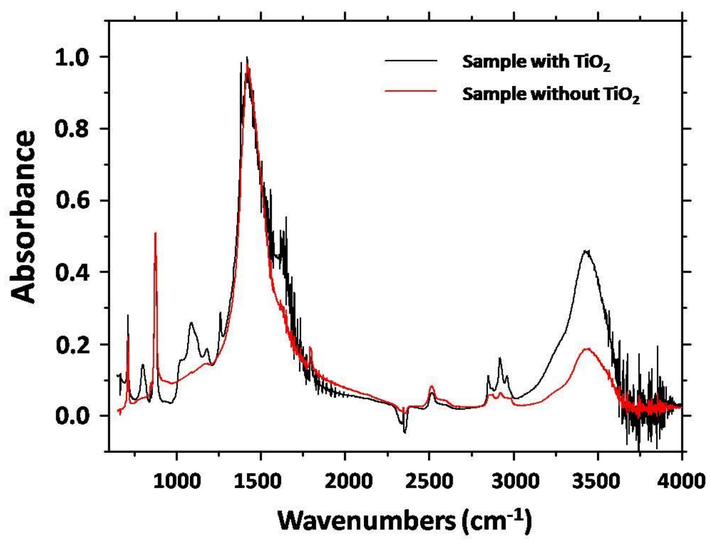
This paper is aimed at evaluating the effectiveness of a self-cleaning coating based on a dispersion in ethanol of micrometer size Degussa P25 TiO_2 powder at 0.5 gr/L spread directly on carbonatic stone materials. The parameters analyzed were: performance against hydrogen sulphide, a toxic industrial chemical (TIC), durability and stealthiness. The protected stone is exposed to hydrogen sulphide and irradiated with UV, the following photocatalyzed reactions occurs.

$$H_2S + O_2 \rightarrow H_2SO_4$$

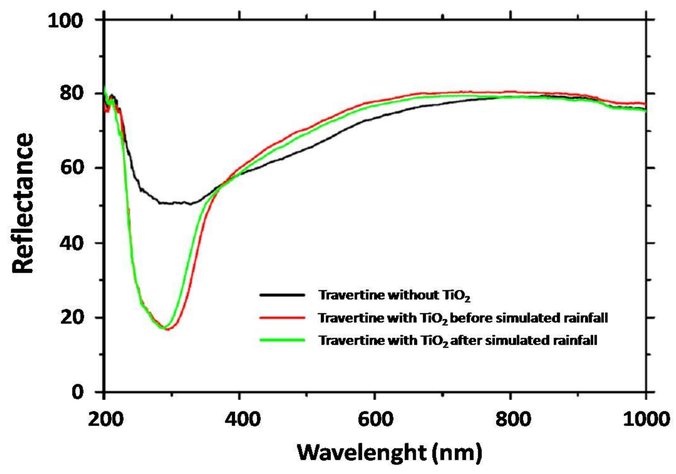
$$H_2SO_4 + CaCO_3 \rightarrow CaSO_4 + H_2O + CO_2$$

This highly toxic hydrogen sulphide is converted to not toxic calcium sulphate. This fact is demonstrated by the following FTIR spectra that show the formation of sulphate ion on the surface of carbonatic stone material during irradiation, fact that not occur if the titanium dioxide is not present.

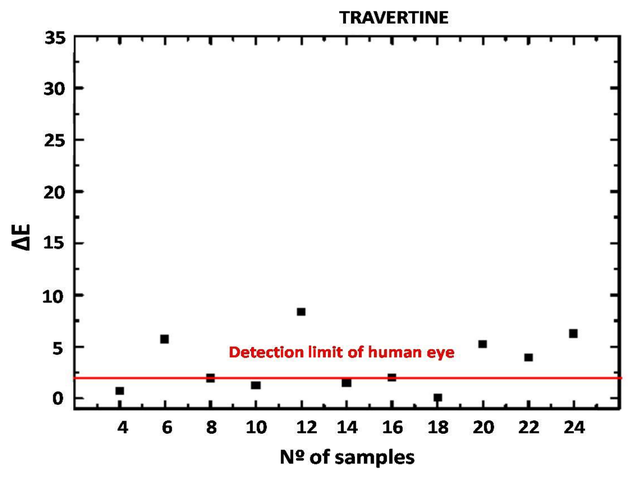


Bands	Attribution
1090 cm^{-1} medium	SO_4^-
1117 cm^{-1} shoulder	SO_3H^-
1184 cm^{-1} weak	SO_3H^-
1470 cm^{-1} strong	C=O
3500 cm^{-1} wide	OH

Due to its strong 320 nm absorbance band, TiO_2 can be detected (as shown by the difference between the black and red lines in following figure 6). It is observed that there is no difference between the UV spectra obtained in Figure 5 before (red line) and after (green line) simulated rainfall.



From the reflectance UV-Vis spectra, a quantitative measure of colour can be obtained. It is expressed as a point in a limited three-dimensional space, which are called chromatic coordinates. A value of DeltaE= 2 is considered as the limit of sensitivity of the human eye. This value is reported in Figure 4, which also shows the measures of variation of colour on 25 TiO2 treated travertine plates, where these variations are averaging on the same order of magnitude.



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Conclusion:

In this work self cleaning materials have been qualitatively evaluated. Also a easy to do and low cost treatment demonstrate interesting performance of durability and have the capability of oxidize, and then partly remove from air, a Toxic Industrial Chemical. We also evaluated that a single treatment on common stone material can be considered of low visibility. It is necessary to underline that additional studies are required to properly evaluate the performance of self-cleaning mortar and concrete to obtain a more precise assessment of these materials in CBRN Defence.

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