

The Effects of Coloured Pigments on Titanium Dioxide Photocatalysed Polymer Degradation

Andrew J Robinson*, Jenet Wray and David A Worsley

The Engineering Doctorate Centre in Steel Technology,
University of Wales Swansea, Singleton Park, Swansea,
SA2 8PP.

Email: ajrobinson77@hotmail.com

Coil coated steel is an increasingly popular option for architects providing both an aesthetic coating and a protective barrier against corrosion. The organic coatings invariably contain TiO₂, an inorganic pigment that provides excellent opacity. However TiO₂ is a semi-conducting material. This means it can absorb photons of energy in sunlight creating excited species capable of degrading the surrounding organic matrix (i.e. the paint). While commercially available pigments are coated, the photoactivity of the pigment can still affect the long-term performance of the organic coating. Assessment of TiO₂ pigments is usually performed via external weathering studies or in accelerated UV cabinets, the results of which can take a minimum of 6 months.

Using a specially developed irradiation cell and a circulatory system connected to an FTIR spectrometer, it is possible to evaluate the kinetics of the polymer photodegradation by monitoring CO₂ evolution^{1,2}. Model Polyvinylchloride (PVC) systems pigmented with 30% (weight for weight) TiO₂ of various grades were prepared. These coatings were then applied to 230mm x 95mm glass plates and had a dry film thickness of 20µm. On irradiation using UV black lamps the rates of CO₂ evolution were measured and found to be different for each pigment (ranging from 0.1µmol min⁻¹ m⁻² to 1.2 µmol min⁻¹ m⁻²). The rates of CO₂ evolution summarized in Figure 1 are directly related to the grade assigned by the manufacturer and so the test is both rapid and reliable.

Due to the excellent optical properties of TiO₂ it is used in many other colour formulations to improve the opacity and therefore covering power of the coating. When incorporated into a coloured system the interaction with other pigments will affect the photoactivity of the TiO₂. Figure 2 illustrates the effect of adding 1% of a coloured pigment (Black Carbon, Yellow Titanium Oxide Chromate, Red Diketo Pyrrolo Pyrrole, Blue Phthalocyanine, Green Phthalocyanine) to a 30%w/w TiO₂ pigmented PVC paint. The rate of reaction changes throughout the exposure. For TiO₂ only and inorganic(yellow and black) additives, an initial rate becomes accelerated after a set amount of degradation which is a result of acid catalysis. Organic pigments also show an initial burst of activity reflecting facile oxidation of pre-adsorbed molecules on the TiO₂.

Figure 3 illustrates the effect of pigment loading on rates of degradation. Higher pigment additive loadings (giving lower reflectance values) tend to lower rates of degradation for all additions except black. The carbon used is a conductor and at low concentrations where it does not screen all light, acts as an electrical contact between excited TiO₂ particles. The yellow (TiO₂ based) pigment provides little shielding of the TiO₂ and is in itself photoactive, the red pigment appeared to produce higher rates of degradation than blue and green (due to catalytic breakdown fragments) of the red dye.

The test system developed appears to be reproducible, simple to use and rapid for both assessing TiO₂ and TiO₂ pigment interaction.

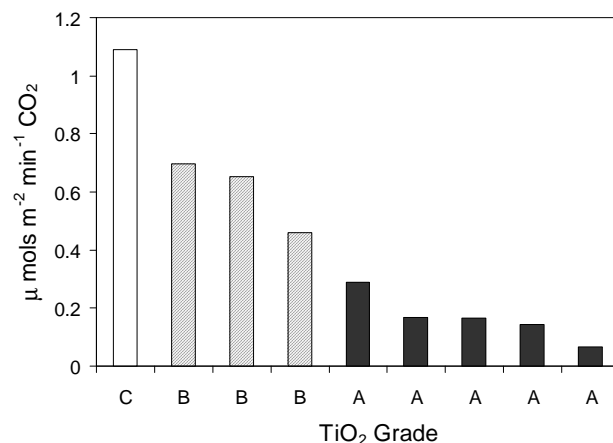


Figure 1. Rate of CO₂ evolution for different grades of TiO₂

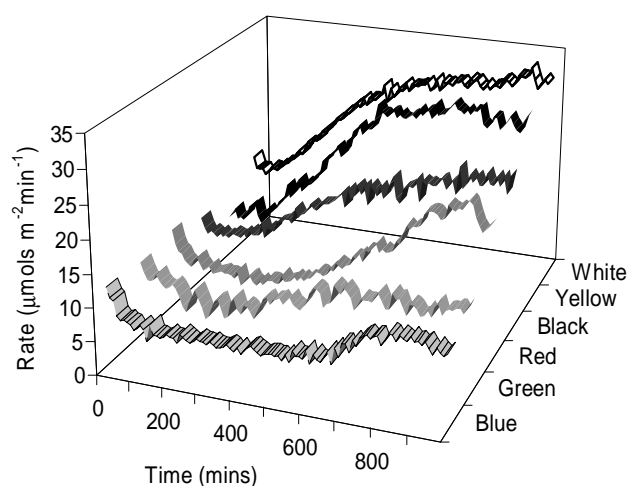


Figure 2. Instantaneous CO₂ evolution rate for 1% pigment loadings

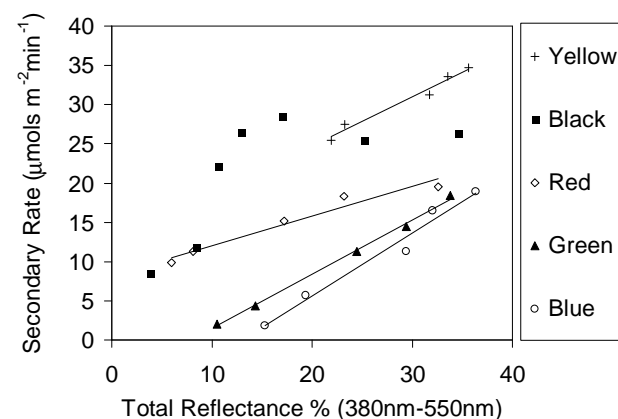


Figure 3. Rate of CO₂ evolution vs. reflectance

References:

1. Worsley, D.A., Searle, J.R., *Material Science and Technology*, (2002), **18**, P681
2. Robinson, A.J., Searle, J.R., Worsley, D.A. *Material Science and Technology, Accepted for publication* (2003)