The Rapid Assessment of Pigment Photoactivity

Justin Searle[*] & Dave Worsley[#]
[*] The Engineering Doctorate Centre in Steel Technology, University of Wales Swansea, Singleton Park, Swansea, SA2 8PP.
[#] Department of Materials Engineering, University of Wales Swansea, Singleton Park, Swansea, SA2 8PP.

Coil coated steel is an increasingly popular option for architects looking to add bright colours and dynamic styling to their structures. The painted finish provides both an aesthetic coating and a protective barrier against corrosion. These coatings invariably contain TiO_2, an inorganic pigment that provides excellent opacity, however TiO_2 is a semi-conducting material. This means it can absorb a photon of energy in sunlight creating excited species capable of degrading the surrounding organic matrix (i.e. the paint). While commercially available pigments are coated to hinder this degradation process, the photoactivity of the pigment can still affect the long-term performance of the coating. Assessment of the TiO_2 pigments is usually performed via external weathering studies or in accelerated UV cabinets, the results of which are often open to interpretation and 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 both the kinetics and chemical mechanism of the PVC photodegradation. The purpose designed irradiation cell comprises a single machined block of aluminium sealed with a glass window. The 230mm x 95mm test panel is introduced via an easily sealed slot at the end of the cell. The total volume of the circulatory system is $777cm^3$. Air is flowed through the cell by means of pre-drilled ports in the aluminium block located on either side of the test sample. The 20 entry ports are drilled to be 50% smaller than the exit ports to ensure rapid mixing and even gas flow over the sample under test. This unique system also incorporates an airflow switch, which enables headspace gas sampling via adsorption tubes to be carried out. Subsequent GC-MS analysis can provide an aid in mechanistic evaluation of the paint photodegradation by enabling the identification of the volatile intermediate degradation products.

We have found that this testing apparatus can be used to provide an exceptionally rapid assessment of TiO_2 pigment photoactivity in paint systems. Emulsion paints pigmented with 20% (by solid weight) TiO_2 of various grades were prepared. These coatings were then applied to 230mm x 95mm glass plates and had a dry film thickness of 120µm. On irradiation using UV black lamps (λ_{max} 365nm and intensity of 4 x 10^{17} photons s^{-1} as measured by potassium ferrioxalate actinometry). The rates of CO_2 evolution were measured and found to be different for each pigment (ranging from 0.002µmol $hour^{-1}$ m^{-2} to 0.14 µmol $hour^{-1}$ m^{-2}). There was an excellent correlation obtained with the results of xenon arc weathering performed over 2000 hours in standard conditions and our new testing procedure. We have extended the work to rank pigments of very similar photoactivity (all A grades) and in all cases the testing procedure is able to accurately rank pigment photoactivity with 2-6 hours compared to standard test which take 6 months under the most rapid of conditions.

Keywords : TiO_2 photodegradation, photoactivity test, PVC Paint