

Photo-activity measurements of pigmented thin PVC layers using the dye sensitized solar cell principle.

M. Wijdekop, J.C. Arnold.

The Engineering Doctorate Centre in Steel Technology, University of Wales Swansea, Singleton Park, Swansea, SA2 8PP. email: mwijdekop@hotmail.com

Paints based on PVC (Poly Vinyl Chloride) are widely used to protect strip steel against corrosion and to provide a colored coating for aesthetic purposes. The coatings usually contain TiO₂, an inorganic white pigment that provides excellent opacity. TiO₂ however is a semiconductor; its electrons can be transferred into an excited state by absorbing light. When these excited electrons fall back to the ground state, the energy they release can trigger the degradation of organic species in the coating, mostly the PVC base and the added plasticizers. Different grades of TiO₂ have different levels of photo-activity; this property strongly affects the long-term weathering performance of the coatings.

The coloring of the coatings is generally provided by organic pigments, which are often Phtalocyanines (phtcn). Studies aimed at testing the stability of pigmented PVC-based coatings have been conducted using accelerated weathering UV-cabinets. Here it was found that coatings pigmented with both hexadecachloro-copper phtalocyanine green (C.I. Pigment Green 7) and a mixed Cr/Sb/Ti Oxide (C.I. Pigment Brown 24, a TiO₂ doped with Chromium and Antimony) showed rapid plasticizer degradation. The high photo-activity of this pigment combination is thought to be due to sensitization.

In order to test the photo-activity of pigmented PVC coatings, an experimental set-up based on the Grätzel cell¹ was used. The TiO₂ particles were applied by bar-coating a 30% solution in PVC onto a glass plate with a transparent conducting oxide (TCO) on the surface, to form the negative photo-electrode. A 5 cm² layer with a thickness of 10 microns was applied in all experiments. The positive counter-electrode is another glass plate with a TCO layer on the surface, onto which a graphite layer is applied to improve its conducting properties.

Between the two electrodes an electrolyte solution is injected, which makes it a conducting device that can absorb light and transform it into an electric current. This cell was connected to a voltmeter in order to measure the open circuit voltage, the short circuit current and the internal resistance, during irradiation with a lightbulb and with UV-A light tubes. Three different grades of TiO₂, and the mixed Cr/Sb/Ti Oxide (both on its own and in combination with the phtcn green pigment), were tested in this way. Kronos 2220 is a high performance commercial TiO₂ grade, TR60 is a medium performance grade, and Degussa P25 is a very photo-active (anatase) grade.

In Fig. 1 it can be seen that the measured open circuit voltages of the TiO₂ grades increase according to their expected photo-activity. The mixed Cr/Sb/Ti Oxide has a high response in UV-A light, but a low one in normal light. When 3% phtcn green is added, there is a medium response in normal light; this points at sensitization.

Fig. 2 shows that the short circuit currents during UV-A irradiation increase in the same way.

Addition of phtcn green also decreases the internal resistance in the cell during irradiation (Fig. 3).

This system seems to be a quick and easy way to test the photo-activity of paint systems. Another application could be in photovoltaics, as the cells are easy to fabricate.

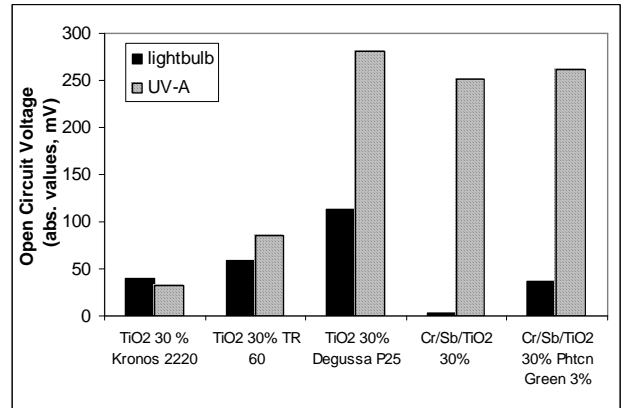


Figure 1: Open circuit voltage responses to irradiation of PVC coatings with different grades of TiO₂, and with mixed Cr/Sb/Ti Oxide with phtcn green added.

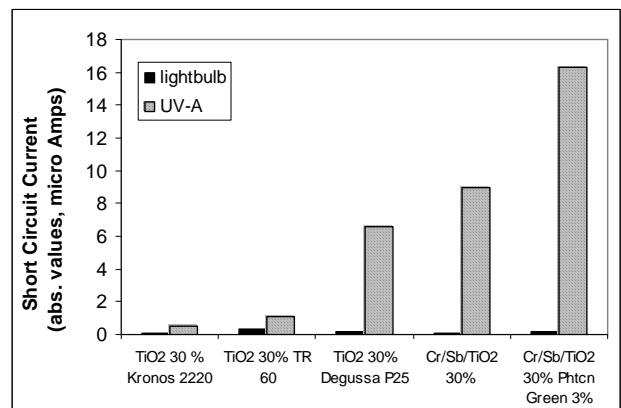


Figure 2: Short circuit current responses to irradiation of PVC coatings with different grades of TiO₂, and with mixed Cr/Sb/Ti Oxide with phtcn green added.

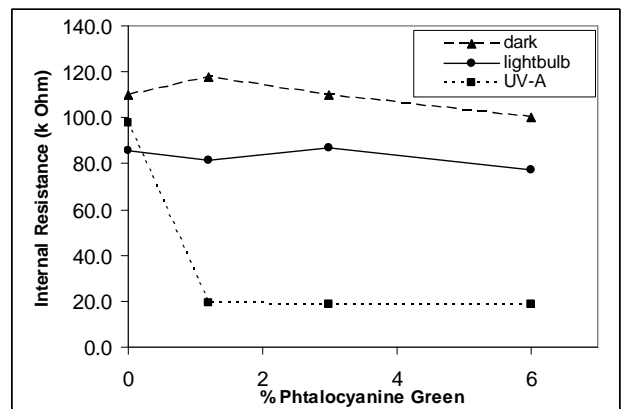


Figure 3: Internal Resistance measured for 30% Cr/Sb/Ti Oxide in PVC as a function of the phtcn green concentration in PVC, in the dark and under irradiation of a lightbulb and UV-A light tubes.

1) B. O'Regan, M. Grätzel, Nature 353, 737-739 (1991).