CORROSION SCIENCE AND TECHNOLOGY, Vol.8, No.3(2009), pp.116~118

Understanding the Degradative Effects of Different Climatological Conditions on Architectural Coatings: Progress Report on Korea Institute of Construction Materials Site Comparison Study of Seosan (Korea) Outdoor Exposure Testing Facility

Yoon Choi†, Soonjin Pyo, Junsik Seo, Inmo Yang, Seungjin Kim, and Sangmyoung Kim

Reliability Assessment Centre Korea Institute of Construction Materials 405-010, Gunpo-si, Korea
(Received March 19, 2007; Revised June 9, 2009; Accepted June 9, 2009)

Korea Institute of Construction Materials founded Seosan Outdoor Exposure Test Site 2005 at Korea, which is a part of Worldwide Exposure Network (WEN). To evaluate the test site along with other exposure test sites, three different types of paints have been under real time weathering conditions at three major weathering test facilities around the world. Using these test specimens several spectroscopic experiments along with physical tests have been performed. Also acceleration tests have been performed using the same paints. The correlation of weathered paints among three different test facilities and accelerated test results has been compared. From the results the reliability of Seosan Weathering Test Facility and reasonable life time prediction tests are discussed.

Keywords *: weathering, paint, glass transition temperature, gloss change, color difference*

1. Introduction

Deteriorating physical properties of modern chemical products, as a function of time, are an avoidable consequence and it is important to know the reasons and mechanisms behind. Based on the understanding of these, reasonable predictions of the 'ageing process' would be anticipated and the prediction of the useful lifetime can be calculated. This is not a simple matter so one of the best ways to simulate the actual service conditions is achieving data from outdoor exposure tests along with indoor acceleration tests. Then, better understanding of the ageing process and more plausible life time predictions can be achieved.

For this purpose Seosan Outdoor Test Site was founded at Seosan, South Korea at 2004, which is a part of Worldwide Exposure Network (WEN). To investigate degradation process of products as well as to know the correlation of Seosan test results with other test site results, three different types of polymer based paints have been under real time exposure condition at three major weathering test facilities around the world. Among the samples alkyd type paint showed the most obvious aged phenomena. Hence, using these specimens several spectroscopic experiments along with physical tests have been performed. Also acceleration tests have been carried out using the same paint. The results presented here are part of on going project that are planned to last for 10 years.

† Corresponding author: j.yoon.Choi@kicm.re.kr

2. Experimental

2.1 Outdoor test sites

Outdoor weathering test for the samples initiated at July 2004 at Seosan (Korea), Florida (USA) and Okinawa (Japan). The details of physical and geological information of these test sites are shown at Table 1.[1)]

2.2 Sample preparation and experimental setup.

The paint used for this test, which is soy-bean modified TiO_2 added alkyd paint with curing agents of lead naphthenate and cobalt naphthenate, was supplied by Nippon Paint Co. Ltd. The paint was spray-coated on aluminum substrate of 120 um film thickness. As was already reported,[2)] it was known that the most severe ageing process was shown at a sample exposure angle of 30^o for Seosan and Okinawa and 26^o for Florida. So the experimental results presented here had been exposed at these angels.

Gloss measurements were performed using BYK Gardner Haze Gloss after KS M 5000-3312 at detecting angle of 60^o. Glass transition temperature (T_g) of specimen

Table 1. Outdoor Test Sites Information

	Seosan Korea	Florida USA	Okinawa Japan
Classification	Seaside, Industrial	Semi-tropical	Semi-tropical
Longitude	126°21'(E)	80°27'(W)	125°19'(E)
Latitude	36°59'(N)	26°52'(N)	24°44'(N)
Above See Level (m)	6.5	3.0	50.0
Total UV exposure (MJ/m^2)	278	280	367
Total daylight exposure (MJ/m^2)	6029	6558	5108
Average Temperature (℃)	12.1	24	23.5
Average Humidity (%)	72	78	78

* The values above mentioned for Seosan is based on data collected between July 2004 and June 2005

was measured using a rigid body pendulum tester supplied by A&D RPT-3000 W. Surface chemical changes were investigated using a chemiluminescence spectroscopy from Tohoku Electronic CLA FS1A. Using this instrument total amount of photon was counted for each specimen at 150 ℃ for 25 minutes. Accelerated weathered samples were prepared with an ATLAS Xenon Weather O Meter CI 5000 after ASTM G-155 at 0.35 W/m^2 at 340 nm. Chromatic coordinates (L, a and b) were measured using a Color I5 spectrophotometer (GretagMacbeth) according to KS M ISO 7724-3.

3. Results and discussion

Aged and accelerated weathering tested samples were investigated with several different experimental techniques. Test results from different techniques are presented at the following Figures 1~3.

Gloss change and color difference can be an optical index of material changes due to weathering. This would be arisen from the chemical changes of specimen surface that is triggered by weathering. As can be seen in Fig. 1, continual gloss decrease can be seen until 12 months then it stabilizes. Color difference shows an abrupt increase at the initial three months then small but gradual increase can be seen for the next 15 months.

The increase of glass transition temperature (T_g) of outdoor exposed samples as a function of time is seen in Fig. 2. This increasing trend may imply that until 18 months chemical crosslinking reaction is predominant for this system. Therefore, increasing crosslinking density of the samples induced the resultant increasing T_g.[3] Chemiluminescence (CL) spectroscopic results can indicate the lev-

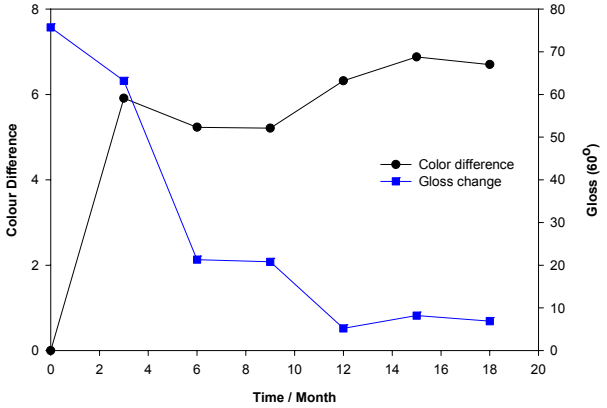

Fig. 1. Color and gloss changes as a function of time for outdoor exposed samples

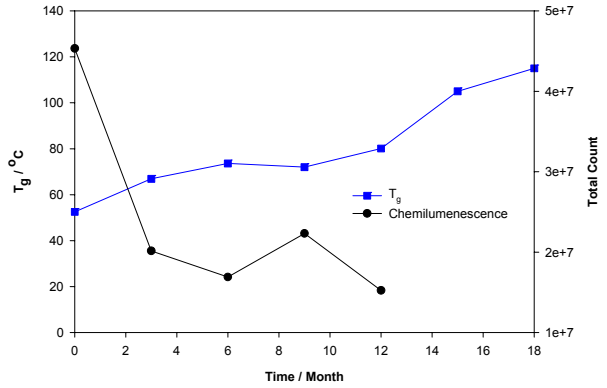

Fig. 2. Glass transition temperature and chemiluminescence spectroscopic changes as a function of time for outdoor exposed samples

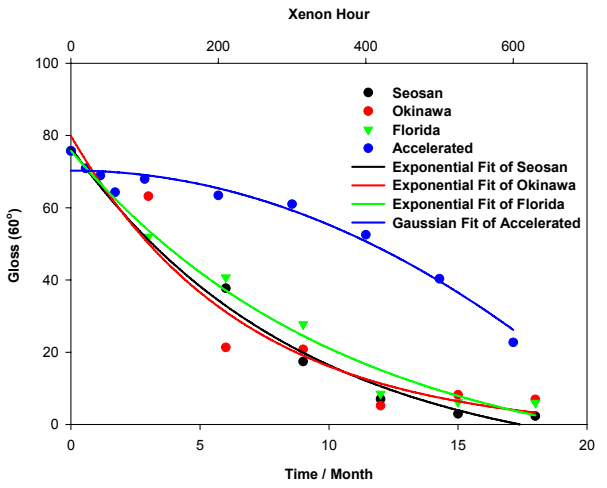

Fig. 3. Gloss changes at different outdoor exposure sites and accelerated samples.

Table 2. Empirical fitting results of data presented in Fig. 3

	Mathematical Fitting Model	R^2 value
Data from Seosan	An exponential decay model	0.99
Data from Okinawa	An exponential decay model	0.93
Data from Florida	An exponential decay model	0.99
Data from Xenon	A Gaussian decay model with	0.96

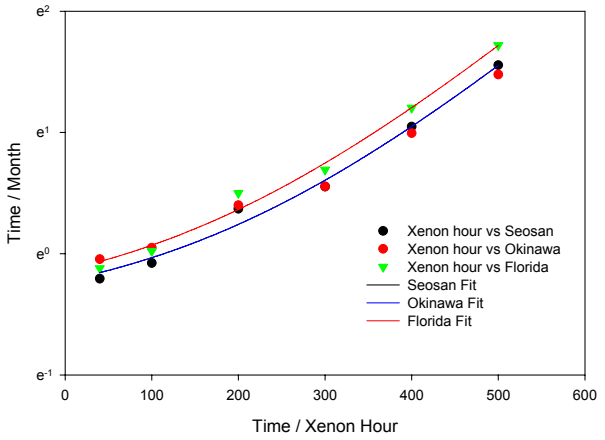

Fig. 4. The correlation between outdoor exposure and accelerated samples' gloss changes

el of oxidation on the surface, which can be an index of the degree of weathering.[4] As was seen in Fig. 1, initial 3-month shows the biggest changes.

Fig. 3 shows gloss changes of samples at different outdoor test sites and their empirically fitted results. The mathematical model and its R^2 values are presented at Table 2. The mathematical models are empirical but showed good agreement with experimental results. The models are only used to see the averaged pattern of changes based on limited number of experimental results.

Fig. 4 presents the correlation of gloss changes between outdoor exposed samples and accelerated ones. The correlation, which is an exponential rise pattern, was deduced from the generalized mathematical results shown at Fig. 3. As could be seen the correlation of Seosan and Okinawa shows a good agreement and the correlation of Florida shows similar trend.

4. Conclusions

Although the presented data and their analysis are limited, empirical data analysis shows an exponential decaying model represents the gloss changes of alkyd paint as a function of weathering time. The gloss changes of accelerated samples do not agree with an exponential decay model but with a Gaussian decay model. Further study will be required to understand this. As was shown in Fig. 4, the outdoor weathered samples of Seosan and Okinawa agree well and shows same trend with the one of Florida. From these, it can be proven that the Seosan Weathering Test Facility provides a trustable weathering conditions comparing with other international weathering test sites.

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