

The measured study of natural weathering performance of reflective thermal insulation coating in hot-summer and warm-winter region

Zhao Xia¹, Weng Dafu², Gu Jie³, Li Binbin³

¹. Xiamen Academy of Building Research Group Co., Ltd. 361004 Xiamen, PR China

². Xiamen Engineering Centre Inspection Co.,Ltd. 361004 Xiamen, PR China

³. Xiamen academy of Building Research and Industrialization Co.,Ltd. 361004 Xiamen,PR China

zhaoxia65@163.com

Abstract. In order to study the attenuation performance of solar direct reflectance of reflective thermal insulation coating under natural weathering, we conducted a measured study on five coatings with the built natural weathering platform. After the 18-month natural weathering experiments, the color of coating templets turn undertint or black with coating layer pulverized and fallen off, some of the templets starting to crack, fall off and go mouldy. Meanwhile, the reflectance ratio of reflective thermal insulation coating decreased significantly after 3 to 6 months, the degree of attenuation of the five templets is 2% to 28%. After 18 months' exposure to the blazing sun, the most significant degree of attenuation reached 46%. The solar direct reflectance of coating templet of the same brand remained high as before after natural weathering with an initial high solar direct reflectance

1. Introduction

The reflective thermal insulation coating is made of synthetic resin, which is a based coating, functional organic pigments (eg. infrared paint, cenosphere, metal particles, etc.) and auxiliaries. The reflective thermal insulation coating possesses a high solar direct reflectance and a high hemispherical emittance.

^[1] According to the characteristics of distribution of the solar energy, the reflective thermal insulation coating reflects more solar radiation with a good heat insulation property in near-infrared wavelengths compared with the regular coating.

The application of the reflective thermal insulation coating in the building field starts in the Lawrence Berkeley national laboratory (LBNL) in the United States. The study from LBNL shows that the urban surface temperature can decrease about 20% after the reflective thermal insulation coating is widely used on the roof surface. ^[2-5] In addition, the reflective thermal insulation coating can save energy, relieve the effect of heat island, and slow down the global warming. However, as a result of the impacts of the natural environment, which are wind, rain, frost and biological growth, etc., the solar direct reflectance of the coating attenuates to a relatively steady state. ^[6] What is more, the application effects of the reflective thermal insulation coating vary in different climatic region, and there are few measured studies of natural weathering performance. We conducted a measured study on the natural weathering performance of the reflective thermal insulation coatings with five common coatings being the objects

2. Experiment

In order to research the coating of natural weathering, Five kinds of reflective thermal in-solation



coating were tested on this experiment. The coatings were provided number for A-0.6、A-0.8、H-0.6、H-0.8、S-0.8。

Table 1 Essential information of five kinds of reflective thermal in-solation coating

Brand	Number	Colors
A	A-0.6	White
	A-0.8	Yellow
H	H-0.6	White
	H-0.8	Yellow
S	S-0.8	White

2.1. Make templets

The base material of templet were mortar plate. Because of size requirement of Lambda950 UV/Vis/NIR Spectrophotometer, mortar plates coating the reflective thermal in-solation coating would be made. And the dimensions of length, width, and depth were 100mm, 100mm,×10mm.

The exposure test fence used to insolate templets, and the dimensions of length, width, and depth were 1410mm, 1810mm,×1000mm. Exposure to the direction perpendicular to sunray.

Construction Procedure:

Step One: Sanding the exposure test fence.

Step Two: Spray under-lacquer.

Step Three: Coating the reflective thermal insulation paint twice. It should be noted that the second coating had to begin after the first coating completely dry.

Step Four: Coating the finishing paint.

2.2. Insolating and Sampling

Templets were marked exposure test fence and insulated on the roof (as shown in Figure 2). And same kind of coating were marked in same exposure test fence designed to prevent mix-ups. Exposure test fences distance parapet above 1.5 m.



Figure.1 Exposure Test

In the process of experiment, the sampling frequency was specified in templets every three month, and each time for each templet take three blocks. To prevent contamination of sampling and inspecting, each templet were packaging by grease-proof paper.

2.3. Detecting Instrument

Detecting instrument was Lambda950 UV/Vis/NIR Spectrophotometer, and the measurement was 250nm ~2500nm (as shown in Table 2)

Table 2 Essential information of Lambda950 UV/Vis/NIR Spectrophotometer

Model	Manufacturer	Wavelength Coverage	Precision	
			UV~VIS	NIR
Lambda950	PerkinElmer	175~3300nm	±0.8nm	±0.3nm

3. Test results

3.1. Appearance changes

According to the Figure.3, the colors of the coatings vary from each other after 18-month's exposure to the blazing sun, compared with the templets without exposure to the blazing sun. As a result of solar radiation, wind, rain and atmospheric gas pollutants, the color of coating templets turn undertint or black, with the coating layer pulverized and fallen off, being transparent in the end.



Figure.2 Contrast between aged templets and new templets

The Figure.4 shows the appearance of templets after natural weathering. Due to the high temperature in summer in Xiamen, templets, which are affected by the climate stress, blistered, cracked and dropped off. Furthermore, the humidity is high in hot-summer and warm-winter region throughout the year, which makes it easier for templets to grow mold or breed microorganisms. Therefore, when applying the reflective thermal insulation coating in this region, not only should the coatings possess a fair property of anti-physical change, but also the properties of damp-proof and stain resistant.



a) blister

b) crack

c) grow mold

Figure.3 The common characteristics of coating templets after natural weathering

3.2. The Determination of Solar Direct Reflectance

3.2.1 The Determination of the Initial Value of Solar Direct Reflectance. We measured the initial value of solar direct reflectance within the wavelength coverage of 250 to 2500nm of the coating templates using spectrophotometer before exposure to the blazing sun, the initial value curve of solar direct reflectance of the five coatings shows Figure.5.

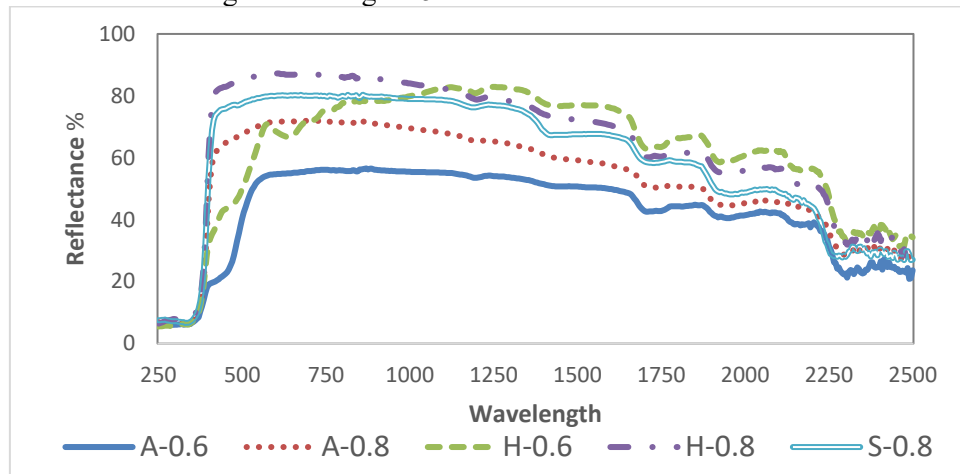


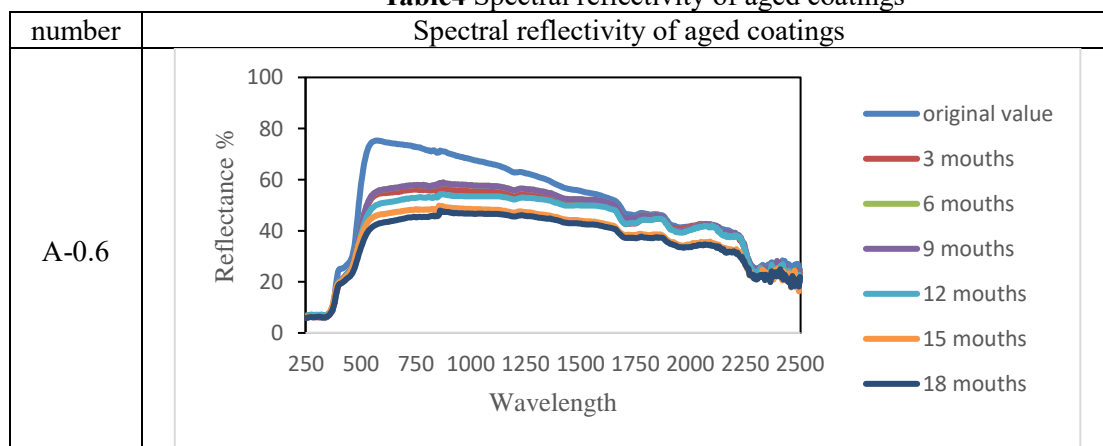
Figure.4 The comparison of the initial value curve of solar direct reflectance of each coating Based on the computational formula of reflectance, we calculated the solar direct reflectance for the whole wave band, the results of five coatings are summarized in Table 3.

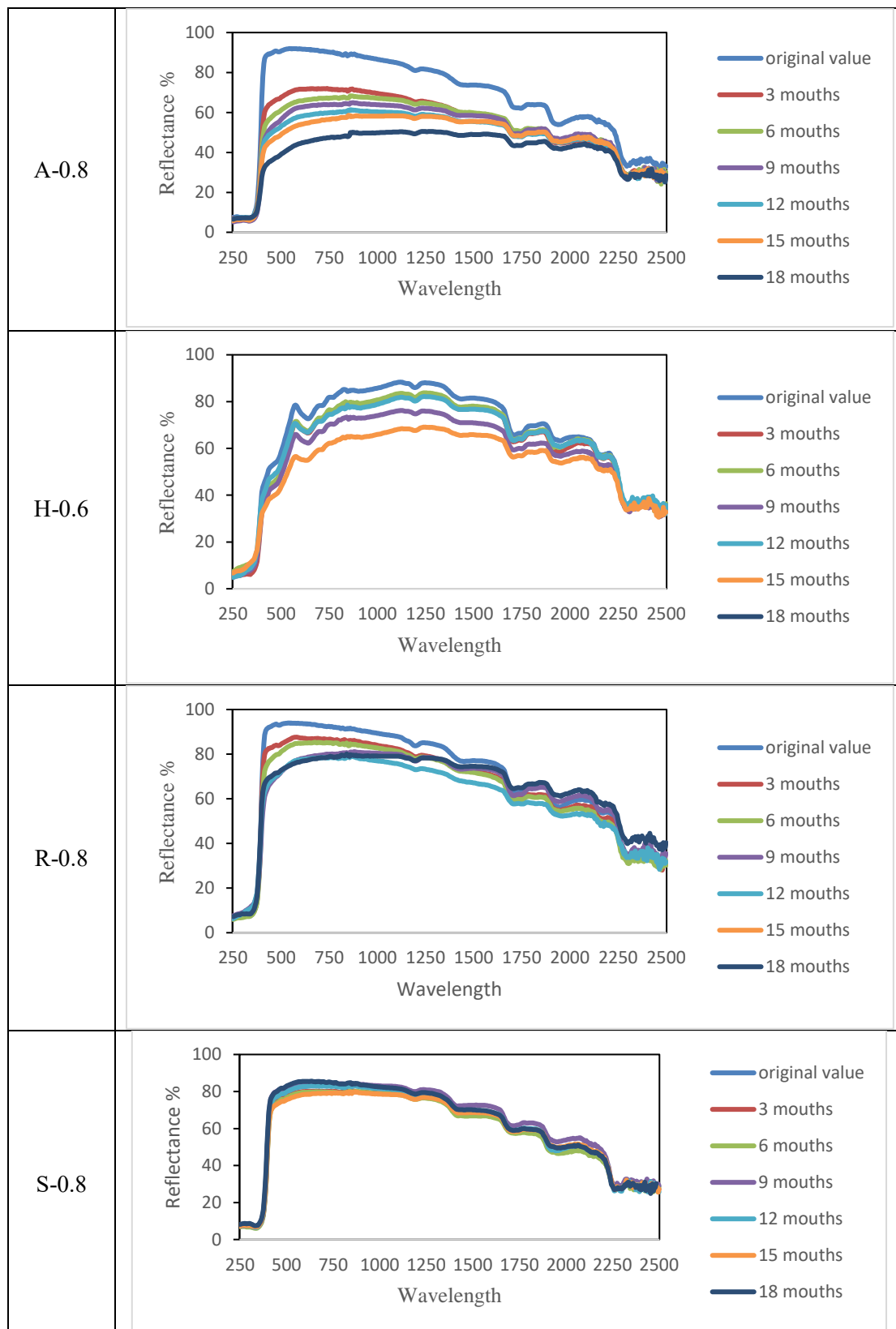
Table 3 the Initial Value of Solar Direct Reflectance of Each coating

The number of coating	A-0.6	A-0.8	H-0.6	H-0.8	S-0.8
solar direct reflectance	62%	0.83%	68%	81%	73%

3.2.2 The Attenuation Law of Natural Weathering. We measured the solar direct reflectance of coating templates with different exposure time using spectrophotometer, the natural weathering spectrum reflectance ratio of coatings within 250nm to 2500nm wave band are showed in Table 4.

Table4 Spectral reflectivity of aged coatings





By analyzing the Figure 6, we found that the solar direct reflectance of the majority of the coating templets decreased significantly after 3-6 month's exposure. The decline of the solar direct reflectance

of A-0.6, A-0.8, H-0.6, H-0.8 and S-0.8 is 19%、28%、8%、7%、2% respectively.

After 18-month's exposure to the blazing sun, the solar direct reflectance of the five coating templets became constant. Compared with the initial value of the solar direct reflectance, the attenuation trend of A-0.6 and A-0.8 is the high, which is 34% and 46% respectively; the attenuation trend of H-0.6 and H-0.8 is in the middle, which is 25% and 15% respectively; S-0.8 attenuate little. In which, after 12 to 18 months' of exposure to the blazing sun, the attenuation trend of templet A-0.6, A-0.8 and H-0.6 slowed downed overall, the solar direct reflectance of templet S-0.8 and H-0.8 tended to rise slightly. The reason for the rise can be that the rain wash in the summer makes the impurity in the surface of templet decrease. In this way, the accuracy of measured solar direct reflectance increased with less disturbance.

In addition, the solar direct reflectance of templet A-0.8 with a high initial value remained higher than that of A-0.6 as before. Same for the comparison of H-0.6 and H-0.8. Therefore, the solar direct reflectance of coating templet of the same brand remained high as before after natural weathering with an initial high solar direct reflectance.

According to the study, the solar direct reflectance of common roofing materials (eg. cement brick, tile) is 0.2 to 0.3.^[7] However, the solar direct reflectance of five coating templets after exposure to glazing sun is 0.4 to 0.8. Consequently, the solar direct reflectance of the reflective thermal insulation coating after natural weathering is still higher than that of common roofing materials, which can conserve energy and lower the temperature in summer. In this way, the reflective thermal insulation coating is applicable in hot summer and warm winter region to some extent.

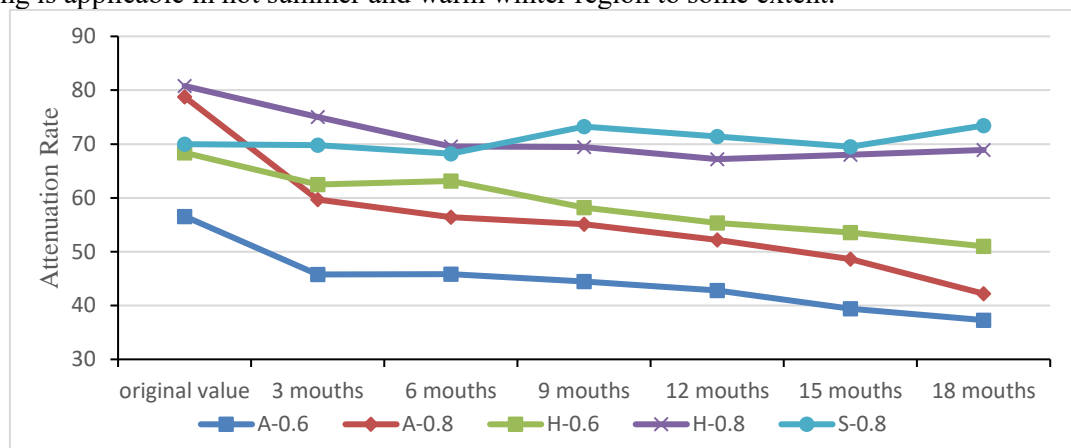


Figure 5 Attenuation diagram of five kinds of reflective thermal insulation coating

4. Summary

We studied the attenuation performance of reflective thermal insulation coatings in hot summer and warm winter region by building the natural weathering measured platform for the coatings and conducting measured experiments of natural weathering for 18 months. The results of the appearance of reflective thermal insulation coatings during natural weathering measured period show that some of the coating templets produced different levels of cracking, blisters and mold. After 3-6 months' exposure to the blazing sun, the solar direct reflectance of the coatings dropped most significantly. Of the five templets, the most significant attenuation reached 28%, while the lowest was 2%. After 18-month exposure, the highest attenuation of solar direct reflectance reached 46%, while the templet with the lowest amount of attenuation attenuated little. What is more, the solar direct reflectance of coating templet of the same brand remained high as before after natural weathering with an initial high solar direct reflectance. In addition, the solar direct reflectance of some templets tended to rise slightly after exposure to the blazing sun. However, according to the research on the solar direct reflectance of common roofing materials in hot summer and warm winter regions, the solar direct reflectance of the coating with the most significant attenuation is still higher than that of common roofing materials, which can conserve energy and lower the temperature in summer. In this way, the reflective thermal insulation coating is applicable in hot summer and warm winter region to some extent.

References

- [1] Ministr of Housing and Urban-Rural Development of the People Republic of China. JGJ/T 359-2015 Technical Specification for Application on Architectural Reflective Thermal Insulation Coating [S]. China Architecture & Building Press, 2015.
- [2] R. Levinson, H. Akbari, Potential benefits of cool roofs on commercial buildings: conserving energy, saving money, and reducing emission of greenhouse gases and air pollutants, *Energy Efficiency* 3(1) (2012) 53-109
- [3] A.H. Rosenfeld, J.J. Romm, H. Akbari, M. Pomerantz, Cool communities: strategies for heat island mitigation and smog reduction, *Energy and Buildings* 28(1) (1998) 51-62
- [4] H. Akbari, L.S. Rose, H. Taha, Analyzing the land cover of an urban environment using high-resolution orthophotos, *Landscape and Urban Planning* 63(2003) 1-14.
- [5] H. Akbari, S. Menon, A. Rosenfeld, Global cooling: increasing world-wide urban albedos to offset CO₂, *Climate Change* 94(2009) 275-286.
- [6] Zhuang Chaoqun. Natural Aging Processes of Reflective Roofs and Its Effects on Energy Consumption [D]. Chongqing University, 2015.
- [7] Zhao Xia, Zhuang Chaoqun, Li Binbin. Survey research the Solar Reflectance of roof covering in Xiamen [J]. *Wall Materials Innovation & Energy Saving in Buildings*, 2016, 62-64.