Degradation of Primary Mirrors under Accelerating Aging Tests

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1. Introduction

The degradation of materials in CSP plants is one of the most important aspects to be taken into account for the feasibility of the technology [1]. It has been identified that one of the degradation mechanisms of weathered solar reflectors is degradation by UV radiation [2]. However, this degradation mechanism is not well characterized because it is temperature dependent [3]. This paper focuses on the study of this dependence.

2. Method

Interaction of UV radiation and temperature on samples from a marketed silvered-glass 4-mm reflector was studied by applying the accelerated ageing tests summarized in Table 1 for a total of 3000 h of testing.

Test code	Tested material	Radiation	Temperature (°C)	Weathering chamber
UV-60	4-mm glass mirror	Fluorescent UVA-340 lamp, 0.9 W/m^2, 290-400 nm	60	ATLAS UVTest
UV-37	4-mm glass mirror		37	
UV-37 Glass	Bare solar glass		37	
60	4-mm glass mirror	N/A	60	ATLAS SC 340 MH, VÖTSCH

Table 1. Summary of accelerated ageing tests carried out in this study.

Spectral hemispherical reflectance, $\rho_{\lambda,h}\ (\lambda, \theta_i, h)$, at λ = [320, 2500] nm and θ_i = 8º, was measured each 500 h with a spectrophotometer model Lambda 1050 manufactured by Perkin Elmer, with an integrating sphere of 150 mm diameter. To properly appreciate the reflectance degradation in the same scale, the hemispherical reflectance drop $\Delta\rho_{\lambda,h}$ was calculated by subtracting the initial value $\rho_{\lambda,h}(i)$ from the value after subjecting the sample to a certain test time $\rho_{\lambda,h}(f)$ for each wavelength.

3. Results and conclusions

It has been observed that samples subjected to accelerated ageing tests with UV radiation at a temperature of 60°C experience a drop in hemispherical reflectance in the wavelength range from 320 to 820 nm, with the most significant drop being around 345 nm, see Fig. 1. This drop in the hemispherical reflectance becomes more and more accentuated as the hours of testing to which the samples are subjected increase. Once the drop in reflectance has been verified in this UV and temperature test, we have proceeded to discern which of the two factors (UV radiation or temperature) are the cause of this drop in reflectance, or whether it is the combination of both factors that produces such drop. Samples of the same material have been subjected to accelerated ageing tests at a temperature of 60°C and with UV radiation at a temperature of 37°C, see Fig. 2. In addition, the results of this material have been compared with those of a bare glass to determine whether this drop is also related to transmittance changes in the glass or to reflective changes in the reflective layer. Fig. 2 shows that both temperature alone and radiation alone affect the hemispherical reflectance of this

material, although to a much lesser extent than the combination of both. On the other hand, in this same figure it can be seen that the bare glass subjected to the UV radiation test does not undergoes any significant drop in the transmittance, except for a small drop in the wavelength range from 320 to 400 nm that need further study.

After 3000 h of accelerated aging test, it can be said that the degradation observed in the tested mirrors is mainly due to the combination of two factors, UV radiation and temperature. However small it may be, it cannot be neglected that just the presence of radiation or temperature alone can already lead to a slight degradation of the mirrors. Therefore, it would be necessary to perform an elemental analysis to see what changes are taking place in the composition of the mirror that are leading to the observed degradation. In addition, it would be useful in future studies to evaluate a third factor to see how it influences this degradation process, i.e. humidity.

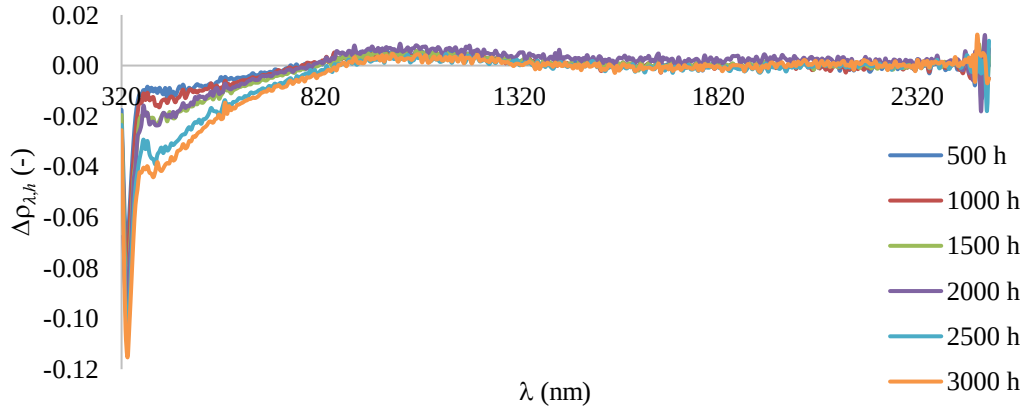

Fig. 1: Hemispherical reflectance drop [320-2500 nm] after reflector samples were subjected to an accelerated ageing test with UV radiation at a temperature of 60°C.

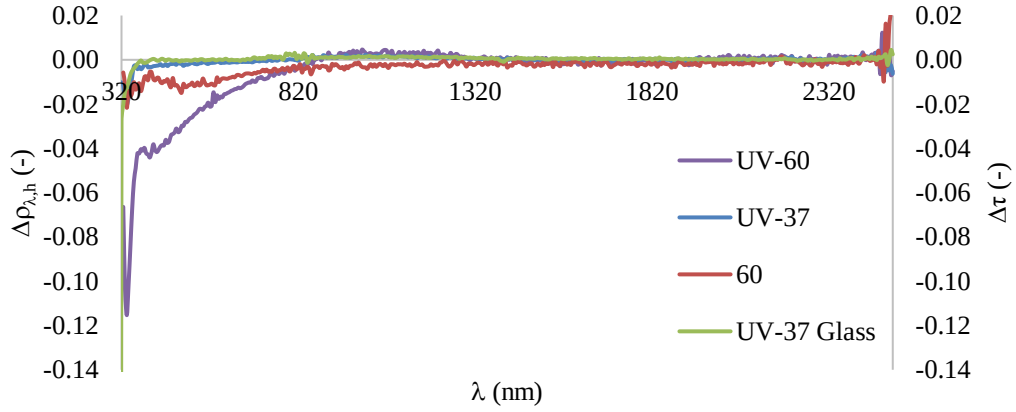

Fig. 2: Hemispherical reflectance drop and transmittance drop [320-2500 nm] after reflector and bare glass samples, respectively, were subjected to 3000 h of different accelerated ageing test (see Table 1).

References

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