SNO-STR-93-002

Report on Aging of DCA Samples from OCLI's August Production Run

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This is a more complete report replacing the version dated January 13, 1993.

1 Introduction

We have aged in de-ionized water for 10 years-equivalent 10 samples; 6 samples designated by R1S1 from the initial aging procedure and 4 samples designated by R1S2 which began aging 1 month later. The relatively small reflectivity changes in 8 of the 10 samples indicates a successful coating run. The failures that are observed can be mostly explained and avoided if precautions are taken during concentrator production.

The aging was conducted at a temperature of 65C with water flow of 1 cm/hr. The samples were slightly bent and placed in an ABS holder that provided slight compression and contact between two samples to simulate conditions in the production concentrators. The device used is summarized in STR-92-077. For R1S1 the maximum conductivity was approximately 4.0μS/cm with an estimated average of 2.3μS/cm and for R1S2 the maximum conductivity was approximately 2.3μS/cm with an estimated average of 1.6μS/cm.

The reflectivity measurements were made with our Perkin-Elmer Lambda III spectrophotometer in water at an incident angle of 60° over the wavelength range of 200nm to 900nm. The aged and unaged samples that were used for reflectivity measurements were received from OCLI as separate samples with matching identification numbers, cut from the production sheet by OCLI as specified in the coating contract.

2 Results and Conclusions

The results are

- 8 samples show average relative reflectivity loss of 1.2% with standard deviation of 2.3%.
- 2 samples visibly failed on the front side.
- No visual failures of the coating on the back side.

Two sets of reflectivity measurements, Data Set 1 and 2, were conducted on R1S1 to verify consistency of results. The RMS of the difference of the data sets is 1.8% which is taken as the level of reproducibility of the spectrophotometer.

The ratio of reflectivities of aged to unaged was calculated at 500nm in H_2O at 60°.

Sample $R1S1$ ($side1 - side2$)	*RelativeReflectivity* *DataSet1* (%)	*RelativeReflectivity* *DataSet2* (%)
596 – 5	100.4	100.7
269 – 67	100.4	99.2
62 – 14	102.1	102.2
494 – 107	97.6	96.7
838 – 201	98.4	97.4
234 – 806	92.3, 55.0	86.7, 47.3

Sample R1S2 (*side*1 − *side*2)	*RelativeReflectivity DataSet*1 (%)
722 − 65	98.2
596 − 5	94.3
151 − 177	96.8
838 − 201	100.4

A histogram of the combined data set of R1S1 and R1S2 is shown in figure 1.

Excluding the visibly failed samples, 234-806 from R1S1 and 151-177 from R1S2, the average loss in reflectivity is 1.2% with a standard deviation of 2.3%. The mean and standard deviation were calculated from a data set consisting of the average reflectivity of R1S1 samples from data sets 1 and 2 along with the reflectivity values of the R1S2 samples. The coating specifications state that aging should not change the reflectivity by more than 2%.

Do to an error in labeling it is suspected that the sample labeled 62-14 has only been aged for 4.3 years-equivalent, 838-201 for 6.1 years-equivalent and 151−177 for 14.3 years-equivalent.

The R1S1 failed sample is labeled 234-806. On the aged sample there is a dark 8mm wide strip along the entire length of one edge. The relative reflectivities on and off-of the strip are 47% and 87%, respectively. The ratio of aged to unaged reflectivities for the entire wavelength range along with that of a sample that did not fail is plotted in figure 2 .

First, one should note the oscillation in the 234-806 lines. The effect has previously been observed in data from failed samples where the data was acquired using our Beckman UV5270 spectrophotometer with an attached integrating sphere. This is typical of coating failure where the reflective aluminum layer has oxidized as noted in STR-??-???. The oscillation appears both on and off of the strip, indicating that the entire surface of the sample has failed. The fact that the graph of the good sample shows no waviness indicates that our measurement technique is sensitive to such coating failures.

Secondly, this strip is similar in dimension to those visibly apparent on some unaged samples. These strips are caused by the overlap of the sheet and frame during the coating process, leaving an uncoated strip along the sheet edge. Due to the configuration of the frame, such strips should only occur on the sides of the sheet and should not occur on the leading or trailing ends. The failed sample shows this strip on the leading edge. It is possible that the corresponding sheet was incorrectly positioned in the frame during the coating procedure. Since the strip is not visible on the unaged sample, such a defect may not be visible on other sheets. To avoid similar failures that may occur to petals in the concentrators I propose that a 10mm to 15mm strip along the entire edge of all sheets be discarded.

The R1S2 failed sample is 151-177. The aged sample developed 0.5mm wide dark, regular, horizontal strips emanating inward from both side edges on the upper-half of the sample. I see no obvious cause of the failure but suspect either improper preparation before coating or possible malfunction of the coating apparatus.

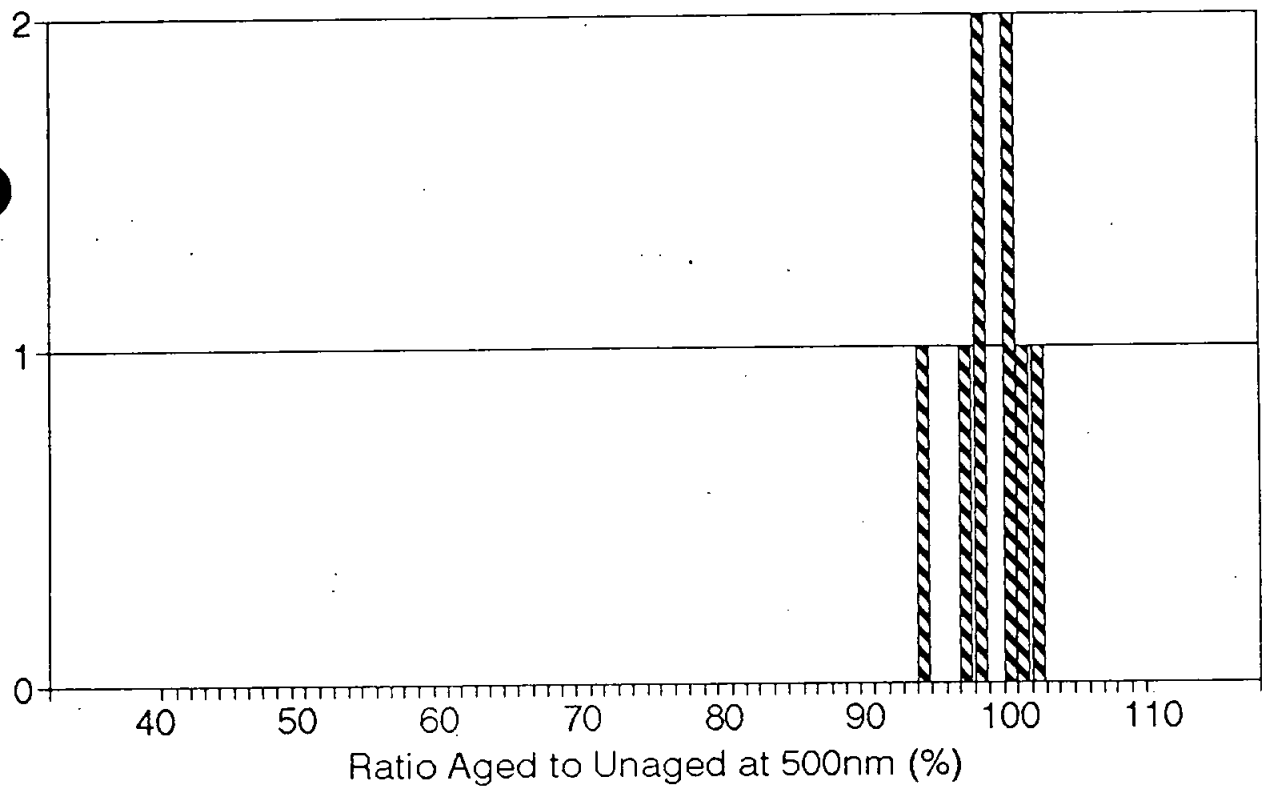
The reflectivity value at 500 nm listed above is for a section of the sample that does not show the failure. This value has not been included in the determination of the mean reflectivity and standard deviation. Reflectivity data from the striped region contains oscillations and reduced reflectivity , confirming the failure of the coating. The results are shown in figure 3.

The standard grazing-angle yellow sheen is observed on the back side of all samples, aged

Figure 1

Histogram of Relative Reflectivities

Data Sets: <R1S1>, R1S2



and unaged, indicating that the coating has not failed on the back side.

To protect the front surface of all samples during storage, I cover them with a protective plastic film that is identical to that used by OCLI. Upon repeated removal of this film from four of the samples, 269-67, 62-14, 234-806 and 494-107, sections of the dielectric coating stuck to the film. These sections are approximately 2mm wide and vary in length from 2mm to 25mm in length.

Since samples 269-67 and 494-107 were unaged while 62-14 and 234-806 were aged, the destruction of the coatings adhesion is not a result of the aging procedure. I suspect the cause is related to a score line approximately 2mm from the sample edge. There are many such lines on various samples and were probably made during the shearing process at OCLI. The close proximity of the score line to the bare edge may allow the water to easily penetrate the coating from two opposite directions, facilitating the destruction of the coating's adhesion.

To avoid this problem, special care should be taken during the petal shearing process so that similar score lines do not occur.

A large, white spot approximately 1.4cm in diameter appeared on the back of samples 62-14, 722-65, 596-5 and 151-177 where each was in contact with the ABS holder. The cause of the mark may be leaching from the ABS holder. Since it is localized on the back of the DCA, I suspect that this poses no threat to long-term light collection.

Figure 2

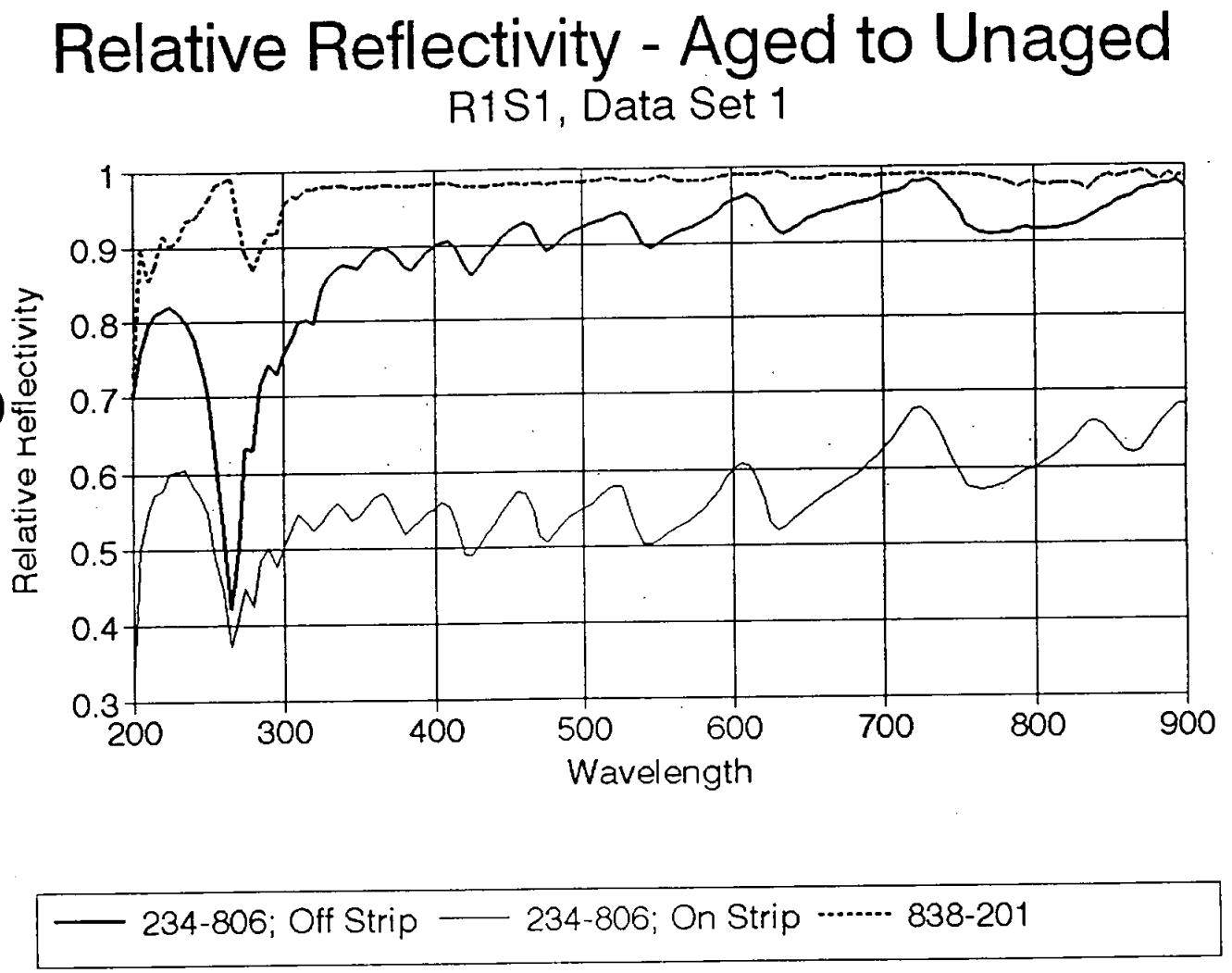
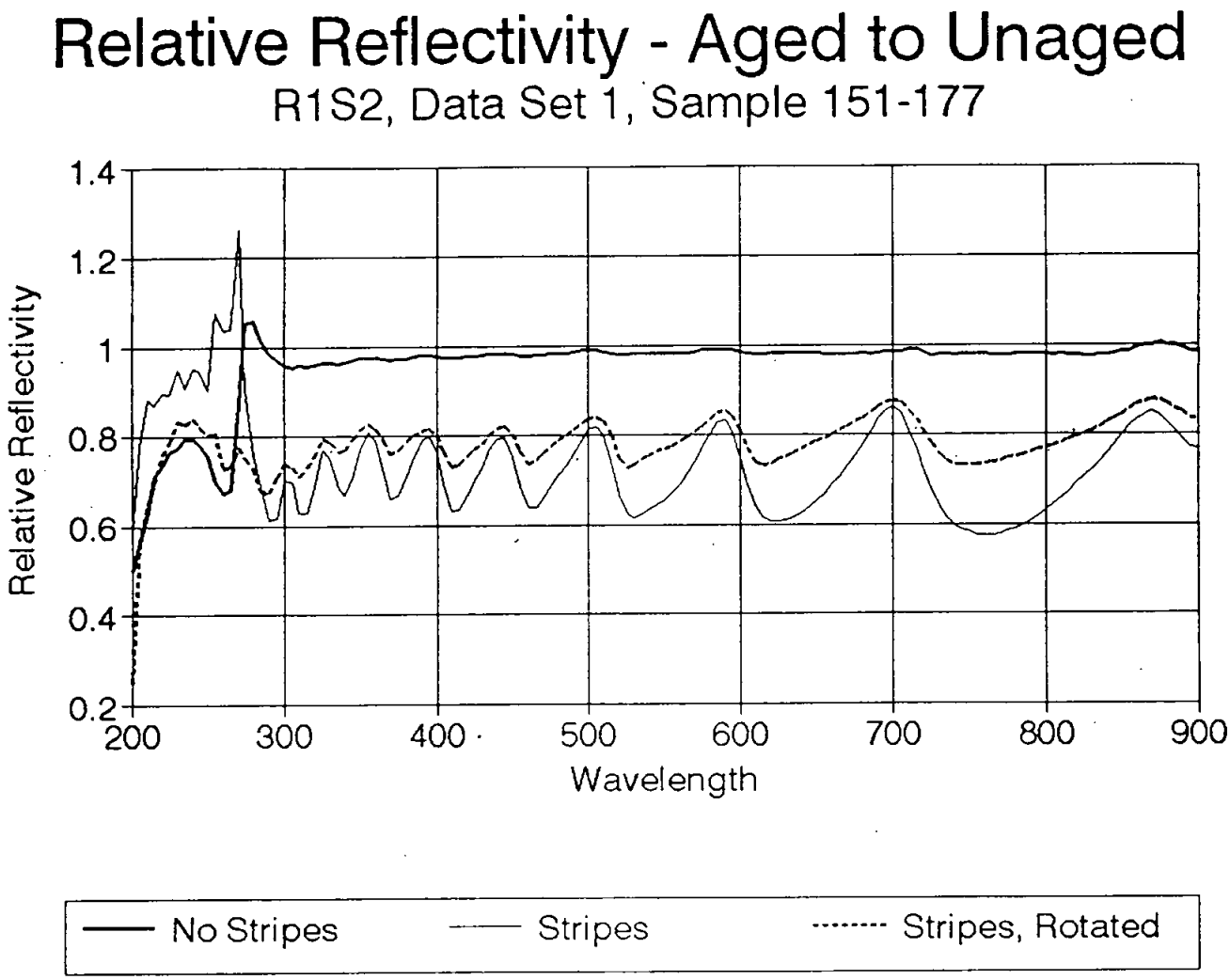

Relative Reflectivity - Aged to Unaged
R1S1, Data Set 1
Relative Reflectivity
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
200
300
400
500
600
700
800
900
Wavelength
234-806; Off Strip
234-806; On Strip
838-201

Figure 3


Relative Reflectivity - Aged to Unaged
R1S2, Data Set 1, Sample 151-177
Relative Reflectivity
1.4
1.2
1
0.8
0.6
0.4
0.2
200
300
400
500
600
700
800
900
Wavelength
No Stripes
Stripes
Stripes, Rotated