DCA Aging Tests

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Introduction

Here is a summary of coatings to date:

1. First coating: August 1992- O.K.- Used in production

2. Second coating: November 1992- O.K.- Used in production

3. Third coating: May 1993- Rejected- Disposed of by OCLI

4. Fourth coating: Feb. 1994.

I report here results of age tests on the second and fourth coating. The second coating accounts for 2/3 of the concentrators already delivered, and has suffered some failures in previous age tests. The fourth coating was to be used in the last 10% of concentrators.

The Tests

The aging tests at UBC were carried out with a new Barnstead E-pure water system with N_2 and CO_2 bubbling to remove other dissolved gases. Other water tests (under air only) were performed by George Doucas at Oxford and by Michal Shatkay at CRPP, and were in broad agreement with my results.

"Petals" means strips machined for assembly in concentrators.

"Archaic" means $0.5mm$ one-sided DCA predating production for concentrators.

- "Archaic" DCA strips, 95°C, under air ($\sim$ 50% O_2), $C < 1\mu S/cm$, 500ml PP tub:

  Survived in pristine condition for 16 days. Hardly any smutting on uncoated back. Edges look frosty.

- Coating 2 petals, 95°C, under air ($\sim$ 100% O_2), $C < 12\mu S/cm$, $10l$ PP tub:

  After a day or two most petals showed signs of some failure, 50% along the stripes left by the glue of the protective plastic film. After 10 days this 50% figure stays fairly constant but all the rest suffered damage in spots. Edges look frosty.

  Petals in the vapour above the hot water survived well for at least 24 hours.

- Coating 2 petals, 95°C, bubbled with N_2 ($\sim$ 10-20% O_2), $10l$ PP tub:

  A total of fifteen petals survived with little visible aging (front and back) for more than 10 days. No stripes! Some slight local damage. Petals did not look as pristine as the "archaic" DCA.

The edges were uniformly frosty.

- Coating 2 petals, 95°C, bubbled with CO_2 ($\sim$ 15-30% O_2), $C < 32\mu S/cm$), 10l PP tub:

  Overnight aging of 12 petals showed uniform stripes on all front surfaces. No back or edge damage.

- Coating 2 petals, 95°C, bubbled with CO_2 ($\sim$ 15-30% O_2), $C < 22\mu S/cm$), 10l PP tub:

  After 6 days another set of 12 petals showed frosty stripes on all front surfaces, white blotches all over backs, and frosty edges.

  N.B. At some point in the aging, the bubbler failed.

- Coating 4 strips, 95°C, under air, 10l PP tub:

  Destruction of optical surface overnight.

- Coating 4 strips, 95°C, bubbled with N_2, 10l PP tub:

  Destruction of optical surface overnight.

- Coating 2 concentrators, 50°C, under air (100% O_2), 50l PP tub:

  After 5 and 7 weeks immersion for two concentrators, each had a contiguous set of five petals showing signs of failure along the stripes left by the glue of the protective plastic coating. Reflectivity here probably down to 70%.

  Previous tests with an old water system showed no failure on one concentrator after one month, prompting worries that we were sensitive to ppb water chemistry.

Assumed scaling of time: 6 weeks at 50°C $\approx$ 6 months at 8°C $\approx$ overnight at 95°C. The above tests under air seem broadly to confirm this scaling; this is the one advantage to having a consistent mode of failure!

The ranges I quote for oxygen levels reflect the difficulties in using my Corning DO meter with confidence.

Conclusions

Coating 4 is useless.

Coating 2 is by no means as hardy as earlier coatings, but will probably be fine in degassed water.

There is cause to suspect the CO_2 in the water used for most of these tests. The deionizer will only remove a the small fraction which is ionized. Once this occurs, equilibrium concentration of HCO_3^- ions is quickly re-established from the vast reservoir of dissolved gas. This is why the DI water system reads 18.3MΩcm but as soon as the water is delivered the resistance is down to about 2MΩcm and the pH has fallen to 5.5.

However, optical analysis of the "stripes" indicate oxidation of the specular aluminum layer beneath the dielectric layers. It would be nice to do a test under oxygen to unravel the relationship between failure, oxygen, CO_2, and pH. It is not clear at this instant how to do this.