

The Unusual Degradation of Recordable Compact Discs

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The recordable compact disc (CD-R) is a popular and inexpensive medium for storing and disseminating digital information, such as micrographs and scanned images. This technical note describes unusual degradation that rendered a group of discs unreadable. The discs were purchased as a set. Each disc was packaged in a jewel box and wrapped in clear plastic.¹ Several of the discs were used within weeks of purchase to store data, which included digital micrographs. These discs, and the unopened discs, were stored in the dark, in a climate-controlled room (Temperature: $\pm 20^{\circ}\text{C}$. Relative Humidity: $< 55\%$).

Degradation

Within two months of their use, feathery crystals² formed on the surface of the clear polycarbonate substrate (Figure 1). Crystals were subsequently found on several unopened discs. Solubility tests showed that the crystals could be reduced or removed using a soft tissue wetted with ethanol,³ but the discs remained unreadable and unwritable.

Analysis

Microgram surface scrapings of the crystals were analyzed using Fourier transform infrared microspectroscopy. Samples were flattened on diamond cells and analyzed in transmission using a Nicolet Continuum infrared microscope.⁴ Analysis showed that the crystals are bisphenol-A (BPA).⁵

Source

The probable source of the BPA is the polycarbonate substrate. Commercial polycarbonates are prepared using BPA. Bisphenol-A is not a component of other layers in a typical CD-R: an organic dye layer, a reflective metallic layer, or a protective lacquer layer.

The actual cause of degradation of the discs has not been established. Experts⁶ consulted for this technical note speculated that the observed degradation resulted from hydrolysis of the polycarbonate layer, which would produce BPA and carbon dioxide. Hydrolysis might occur at elevated temperature and relative humidity⁷ or through contact with a base.⁸ They also cited several co-factors that might contribute to degradation: (1) a high level of residual BPA in the original polymer, (2) impurities in the polycarbonate resin, and (3) improper processing of the disc.

Conclusion

This unusual form of degradation was unexpected and is, as yet, unexplained. The discs were not exposed to elevated temperature or relative humidity or a base, after purchase. The incident has caused the author to reconsider how and when CD-Rs are used to store digital information. In addition to changing the brand of CD-R, multiple copies are made using discs from different manufacturers.

1. The manufacturer will not be named. The color of the lacquered surface is silver.
2. The crystals appeared as dense radiates and arced clusters within the blue dye line and the stacking ring.
3. Alcohols dissolve bisphenol-A, but may induce cracking in the polycarbonate surface that could interfere with data retrieval.
4. Thirty-two sample and background scans were collected at 4 wavenumber resolution using Happ-Genzel apodization.
5. 2,2-bis (4-hydroxyphenol)-propane.
6. The author thanks Chad Mistele (Lexan QO Product Developer, GE Plastics, Mt. Vernon, IN) for sharing his expertise on polycarbonates.
7. Hydrolysis is produced experimentally using a standard hydrolytic test (80°C and 85% RH).
8. Two scenarios were described: (1) contact with a solvent that was slightly basic, such as softened tap water, and (2) in the case of spindled discs, contact with ink from a printed label that contained an organic base. ■



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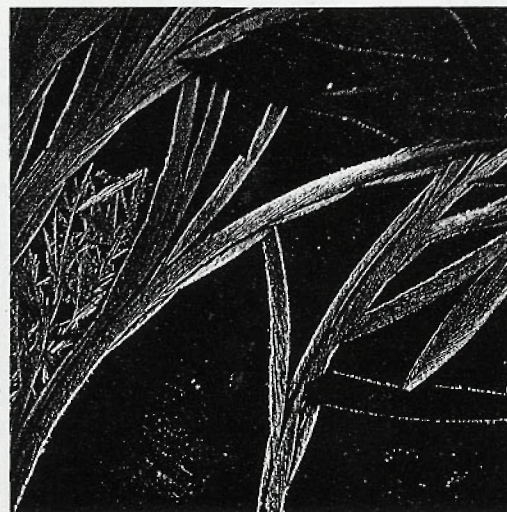
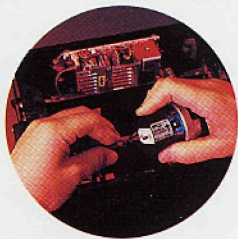


Figure 1: Visible light photomicrograph showing crystals in a 4 mm square area of a CD-R.

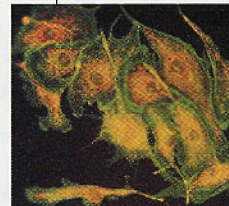


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