White Paper

Archival Media for the Masses

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January 2005
WP-120804-001, REV 1.1

Since the beginning of recorded history, humankind's attempts to keep records of social importance have been under the relentless assault of time and the elements. From the oldest of cave drawings and ancient tablets to the modern day magnetic and optical storage mediums, an archival media has yet to be discovered that will last forever. Whether the degradation stems from a lack of effective storage space, fragility of the media, physical degradation or the obsolescence of the technology used, eventually the information will need to be transferred to a newer medium or suffer the wrath of time and be forgotten.

When the decision to archive a given set of information arises, one needs to concern themselves with more than the longevity of the media. Although this is an extremely important factor, there are other aspects of the process that should not be ignored. Among these are the cost and availability of the media, the technology to be used and the media's volatility or susceptibility to external factors other than time.

Archival Media Comparison

Medium	Advantages	Disadvantages
Paper	Cheap and readily available, current and future technology	Short life span, requires the most storage space
Microfilm / Microfiche	Longest life span, current and future technology	High entry and media cost, low density
Magnetic Tapes	Readily available, high density	Volatile (erasable and EMI), aging technology, short life span.
Magnetic HDDs	Readily available, highest density, current technology	Volatile (erasable and EMI), short life span
Optical (Write Once Read Many, CDs only	Cheap and readily available, current and future technology, longest life span, high density	Light susceptible (some chemistries)
Optical (Write Once Read Many, DVDs only)	Readily available, current and future technology, long life span, highest density	Light susceptible (some chemistries), limited compatibility
Optical (Re-Writable, CD & DVD)	Readily available, current and future technology, long life span, high density	Expensive, light susceptible (some chemistries), erasable

TABLE 1-1

As can be seen in the Archival Media Comparison in Table 1-1, every archival media type has it's own set of advantages and disadvantages, but the media with the greatest ratio of advantages to disadvantages is the Optical WORM (Write Once Read Many) CD or CD-R. A CD-R made with the appropriate materials, manufacturing tolerances and storage conditions may have lifetimes of 300+ years according to standardized accelerated testing. With lifetimes three times that of a human, it may seem apparent that the longevity of the media is now dictated more by the lifetime of the technology rather than the media itself. This is true to some extent. However there are currently three dye chemistries in use (metal-Cyanine, metal-Azo and Phthalocyanine) that have varying degrees of susceptibility to light. Choosing the proper chemistry is the difference between archiving essential data and losing essential data.

Dye Chemistry Comparison

Dye Chemistry	Pronunciation	Color	Comments
Metal-Cyanine	Sy-a-neen	Blue	Original CD-R Dye, Least stable
Metal-Azo	Ay-zo	Very Deep Blue	Increased stability over Cyanine dyes
Phthalocyanine	Thalo-sy-a-neen	Very light Green	Most stable, transparent and durable

TABLE 1-2

Dye Layer

The list of dyes in Table 1-2 represents the three major dyes used in the production of CD-Rs. Through accelerated lifetime (ISO-18927) and direct light (including UV & IR) exposure testing, Phthalocyanine bases CD-Rs outperformed the other dyes by a factor of 3 to 1. Phthalocyanine dye is unique among CD-R dyes in that when burned it forms a bubble which scatters the light rather than darkening and absorbing the light to form the pits. This unique process which more closely reenacts the original land-pit structure of stamped CDs is partially responsible for the stability of the dye under proper storage and handling conditions.

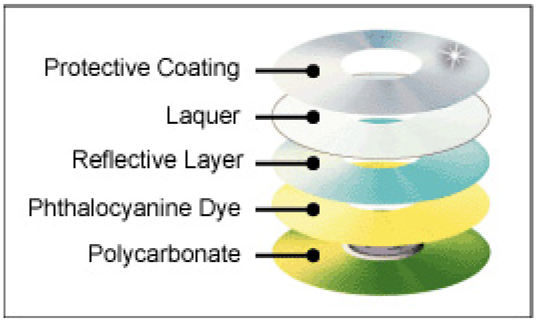

Fig 2 - 1

Phthalocyanine

- Phthalocyanine dye is more responsive to the writing laser so cleaner, better defined pits are created. The result is fewer errors when the CD is burned.
- Longest lifetime of any photosensitive dye.
- More transparent, contributing to a high reflectivity which results in better compatibility among readers.

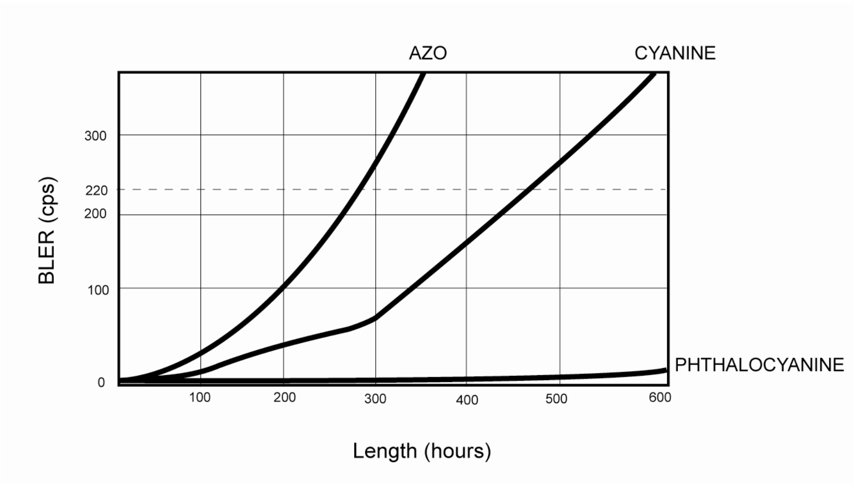

Fig 2 - 2

Fig. 2 - 2 shows the number of errors that develop after exposure to high humidity and high heat. Tests were performed by putting discs made with the three different dyes into an environmental chamber at 80 C degrees and 85% relative humidity.

Phthalocyanine dye reacts in a “burst” mode creating sharper pit edges. Sharper pit edges are easier for CD players to read, so cleaner sound reproduction and less read errors occur.

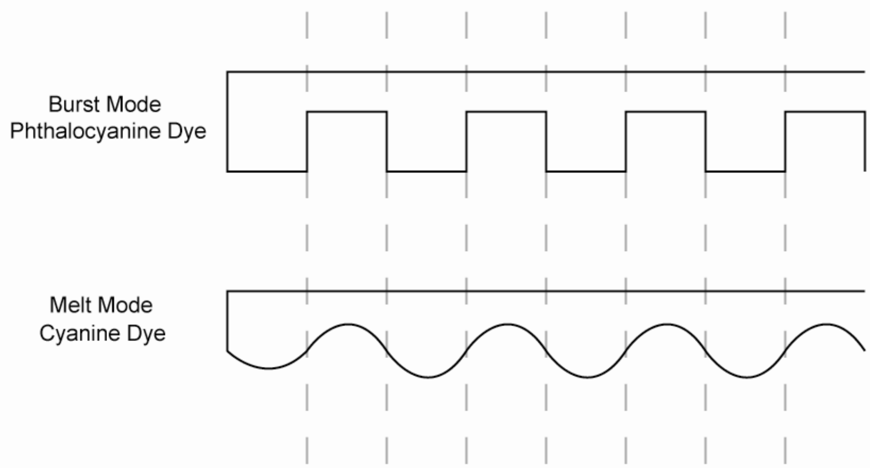

Fig 2 - 3

Phthalocyanine is naturally resistant to the harmful effects of UV light while cyanine and metal azo dyes are very reactive to UV light. Heat is another main cause of disc failure. The natural stability of the phthalocyanine dye makes it more resistant to damage from heat sources. Sources of heat not only come from where the discs are stored, but are also generated from the disc player which can cause read errors.

Cyanine

Discs incorporating a cyanine dye reflective layer have a shorter lifespan than CD-Rs using phthalocyanine-based dye and their quality is variable. Given the color of the dye, light reflection is lower resulting in less accurate burning.

Metal Azo

Typically CD-R’s made with metal azo are blue and use a silver reflective layer. However, like cyanine, the dye is less stable than phthalocyanine, has a higher BLER rate when recording, and has a shorter lifespan.

Reflective Layer

The physical degradation of the dye is a long term effect that when ignored will cause irreparable damage to the stored data. This degradation isn’t limited to the dye alone. If the reflective metal layer is made of silver, the most common reflective material, it may become oxidized over time, degrading the intensity of the reflected light and the readability of the media. To overcome the oxidation problem, the silver (Ag) is replaced with gold (Au), an inert metal which is immune to the diminishing effects of oxidation. A cheaper silver alloy is sometimes used instead of gold, but due to its similar appearance to silver, it is best to use gold as to avoid any intermixing of the media.

Storage and Handling

Damage to a CD-R is more than likely due to improper handling rather than inadequate environmental conditions. Improper handling includes labeling and physical storage as well as touching and cleaning. The most common forms of damage are scratches, smudges and dust particles. Figure 2-1 shows the layer structure of a CD-R disc. Although it's not apparent, the dye and reflective metal layers are close to the top surface of the disk making them more susceptible to external influences from the top side of the disk rather than the bottom recording side of the disk. Due to their proximity to the surface, labeling the CD-R becomes an issue. If the label adhesive or ink contains solvents, damage could occur to the protective and metal layer resulting in permanent data loss. Labels may also delaminate over the long term, more than 5 years and interfere with the disk drive operation. For archival purposes it is recommended to leave the media blank and write the media's serial number, located in the clear inner-hub and any relevant information on the protective cases inlay card. Media that is not serialized should be avoided for this purpose.

Protection of the media from physical damage and exposure to the elements is the sole responsibility of the user. NIST's "Special Publication 500-252: Care and Handling of CDs and DVDs – A Guide for Librarians and Archivists" recommends individual storage containers such as "jewel cases". The cases not only protect the media from airborne contaminants and foreign material, they also aid in buffering rapid environmental changes that can cause undue stresses to the disk. Protective cases are also designed to keep the surface of the disk from contacting the inside of the case and provide a convenient method for isolating the disks while in storage.

The vast majority of archived media's time is spent in storage, so the conditions of the surrounding environment have a potentially large effect on the archiving process. Recommended storage conditions are available from the manufacturer, but the typical recommended conditions are between 5°C and 30°C with a non-condensing relative humidity between 8% and 50%. As storage times increase, the storage temperature and relative humidity should migrate towards the lower end of the recommended spectrum.

With the use of current technologies in both recording equipment and media, the ability to store archival quality information is now available to the masses at reasonable costs. As long as quality media is used from the beginning of the archival process and proven, tested industry standards for handling and storage are implemented, archived data will last in excess of a lifetime.