Here’s why “baking” damaged reel-to-reel tapes renders them playable again



Enlarge / Audio buffs are rediscovering the sound quality of reel-to-reel tapes. Chemists at the Library of Congress are studying why the tapes tend to degrade over time and why baking them can often reverse the damage.

reader comments

16 with 13 posters participating

Share this story

Reel-to-reel tapes are experiencing a resurgence of interest among audio buffs, but they are prone to degradation, which has been a topic of active research for many years. It’s well known that applying heat can often reverse the damage

sufficiently to enable playback, usually by baking the tapes in an oven. Now scientists at the US Library of Congress have determined precisely why this method seems to work, presenting their findings earlier this month on the American Chemical Society's SciMeetings online platform.

Project leader Andrew Davis is a polymer chemist who works in the LOC's preservation research and testing division. The LOC's mission is to ensure its collections continue to be accessible to the public, either in their original or reformatted mediums. The R&D division is responsible for providing the scientific groundwork for that mission, similar to how the Smithsonian Institute employs research scientists to maintain its collections.

"We span everything from simple analytical tests, like determining the kind of ink used on paper, to testing all building and construction materials, and ensuring the stickers on the barcodes don't damage books," Davis told Ars.

Davis emphasizes that the audiotape collection is well-maintained and tapes are not literally decaying on the shelves as I type; he works to ensure that they remain in good condition. While the LOC continues to digitize its vast collection, there is still a large number of tapes in the archives that are still in their original format. They are simply obscure enough that they might only be digitized if the LOC receives a request to listen to them.

Even for those with a digital copy, preserving the originals as long as possible is still important. "It's not impossible that the digitized version might disappear, might get corrupted, or might become inaccessible 10 to 20 years from now," Davis said. "If you have that physical object, that's always something you can come back and re-listen to, or reprocess, if the need arises."

Baking

Davis was visiting one of the LOC's offsite facilities, the Audio Preservation Consideration Center in Culpeper, Virginia, when the issue of degraded reel-to-reel tapes came up in the discussion. The primary culprit for the degradation is known as "sticky shed syndrome," in which the binders used in a magnetic tape to hold the iron oxide casing to the plastic carrier deteriorate. They form a sticky residue that can damage both the tape and playback equipment.

He found that the LOC's audio curators had various methods on the best ways to bake a degraded reel-to-reel tape, and he also learned that heat-treated tapes will quickly revert back to their degraded condition if they aren't immediately processed.

"It became very clear that no one really understood the underlying mechanisms of how that thermal treatment worked," said Davis. Fortunately, his division has a collection of tapes set aside specifically for scientific research, making it possible to conduct even destructive scientific tests. He used small samples from those tapes for this particular project.

- The Library of Congress has a vast archive of reel-to-reel tapes it's responsible for conserving.
  Andrew R. Davis
- Polymer chemist Andrew Davis browses the archived tapes.
  Andrew R. Davis
- Davis and a colleague test an old reel-to-reel tape.
  Andrew R. Davis
- A reel-to-reel tape on deck.
  Andrew R. Davis
- A brown "sticky shed" residue on an unplayable reel-to-reel tape accumulates at a playback machine's contact points. The residue disappears upon heating.

Andrew R. Davis

- Looking at samples under an electron microscope reveals the difference between baked and unbaked.
  Andrew R. Davis
- Spectrocsopic analysis of a reel-to-reel tape.
  Andrew R. Davis

The first stage naturally involved baking the tape samples. While there is an obscure account from a 1990s audio magazine of a DIY hack using a hairdryer attached to a cardboard box to bake degraded reel-to-reel tapes, and Davis has been asked if a toaster over would suffice, he is skeptical that these were ever common methods. “I think most people use well-controlled laboratory-grade circulating convection ovens when they do this,” he said.

Davis also subjected the samples to other, more cutting-edge analysis techniques, such as scanning calorimetry to measure changes in temperature. (It’s a sophisticated version of the old chemistry-class trick of putting ice in a styrofoam cup and poking a thermometer through the top to make a calorimeter.) Samples were subjected to heat stage microscopy, which involves placing a hot plate under a microscope sample to monitor small microscopic changes in the material as it heats up over time. “We can’t do that in an oven because it’s dark and we can’t see anything,” he said.

He also artificially aged some of the samples in a special environmentally controlled chamber, ramping up the heat and humidity to accelerate the natural aging process. “A lot of degradation processes occur over decades or centuries, and we don’t always have that long to wait [to decide on a particular course of action],” said Davis. “This way we can mimic and predict what would happen over much longer time scales.”

Sweet spot

His experiments showed that, when a degraded reel-to-reel tape is heated, the sticky residues melt back onto the bulk polymer layer, rendering the tape playable once again. That's why 130°F is the sweet spot for baking degraded tapes; it's the melting point for the residues. "If you go any lower than that, nothing is going to happen," Davis said. However, he also found that there is no single component that accounts for tape degradation, and the sticky residues don't just form on the binder layer.

"This research also confirmed what we heard from audio technicians, that thermally treated tapes that were wound on reels reverted to a visibly deteriorated condition within a few weeks," said Davis. "Surprisingly, we found that when our small unwound test samples of tape were thermally treated, they appeared to be optically fine even after weeks. Clearly being wound has some effect on the tapes."

That is the next stage of research, and Davis actually set up a range of samples with different treatments that he was monitoring right up until shelter-at-home policies went into effect in the Washington, DC, area. He hasn't been able to return to his lab to check on them but is hopeful that, once the lockdowns lift, there will some intriguing experimental results on that score. Beyond that, Davis hopes to extend his experiments to enclosed magnetic media, such as cassette and VHS tapes.

https://arstechnica.com/?p=1669742