Backcoating vs. Coating in Binder Breakdown

Scott Dorsey

Preliminary as of May 2026

1 The Sticky Shed Problem

There have been some debates in the past about the origin of the sticky shed problem that appeared with the newer thermosetting magnetic tapes of the 1970s.

The first thermosetting urethane binders were developed for use with computer tapes and videotape where tape wear had become a severe problem. However, the demands of multitrack production for rock music, including going over the same bit of tape with multiple overdubs and repunches, caused Ampex to use these binders in their new audio tapes starting in 1972 with Ampex 406.

At the same time as the new binders came in, backcoating also appeared. The backcoating appeared to be the same formulation as the front coating, with the oxide pigment replaced with carbon black. This complicates determining the real origin of the problem. Is the issue only a poorly-crosslinked thermosetting urethane coating, or is it that the urethane crosslinks more poorly in the backcoating either because the carbon black impedes proper setting or because the iron oxide improves it?

Koester in [1] mentions that the backcoating of tapes frequently contains carbon black and silicic acid particles below a side of 0.1 um in diameter. Presumably this would be used along with the same binder and other additives used on the front coating.

This author is not positive what he means by “silicic acid” but it can be assumed that he means silica gel particles which would form silicic acid in solution. Presumably he is not adding an aqueous solution to a solvent-based slurry. Silica gel is exceptionally inert chemically.

Charles Richardson in [3] has made the claim that binder breakdown is solely the result of breakdown of the backcoating and that if the backcoating is mechanically removed that the tape remains stable. Many people in the industry are skeptical about this, but if it is true, and if the assumption above that the binder chemistry is the same between the front and back coating holds, then somehow either the iron oxide particles are improving the stability or the presence of the carbon black and silica particles in the backcoating are degrading the stability.

2 Basic Investigation

Therefore, we propose to determine long-term effects on thermosetting urethane compounds of iron oxide and carbon black. Note that the author is not a chemist but has spoken with dye and coating chemists and they cannot think of any reason why either iron oxide or carbon black pigment would affect the stability of the urethane binder. No actual research seems to exist on this, either in numerical simulations of the chemistry involved or in actual long term testing.

At this point it has been twenty years since Richardson’s paper and there is still debate about it and what it really means. Clearly there is a need to determine what the actual effects of the various pigments are with the binders. No one has done any actual testing of any sort.

With no real information to go on, therefore, all we can do is to attempt a long-term test using commercial urethane materials to see if their stability will be affected. Neither of the two commercial urethanes is necessarily identical to the formulations employed by tape manufacturers so two products with as different as possible formulations were used.

The plan, therefore, is to take commercial urethane coatings which are presumably stabile without pigment, add pigments to them, and see if the pigments either improve or reduce stability.

The coatings need not be identical to those used in original tapes as the goal is merely to find out if the pigment itself has any effect on the stability of typical thermosetting binders. It would be a good exercise to test a two-part mixture with Estane 5701-F9 and an isocyanate but this is not currently available to us. This would be typical of binders used. [16]

3 Procedure and Supplies

Two different binder materials were used to produce slurries for coating.

The first set of slurries were based on a commercial urethane compound intended for use as a conformal coating for printed circuit boards, MG Chemicals type 4223F. The exact configuration of this compound is unknown although the MSDS makes it clear that it does not use an isocyanate but some other crosslinking agent, and it includes TNPP (Tris(nonylphenyl) phosphite) as a stabilizer and secondary antioxidant. Long-term experience with this products has shown it to be extremely stable. [4,5]

According to the datasheet it can be heat-cured or can be cured at room temperature over a 30-day period. The 30-day room temperature curing procedure seems similar to that which was used with Ampex 406 in original production.

Note that the MG urethane was noticeably thicker than the Minwax coating described below, and unlike the Minwax coating it was strongly fluorescent with a blue tinge when viewed in bright sunlight. This may be due to a UV protectant not requiring mention in the MSDS.

The second set of slurries was based on a commercial urethane compound intended for use as a wood finish, Minwax “Warm Gloss Fast Drying Polyurethane Finish” model 23000444, batch number ”MWO206FQ09320 TRP JAS.” [6] The manufacturer’s datasheet describes this as a “Linseed Oil– Modified Urethane” finish although the odor and fast setting would indicate the level of linseed oil was fairly low.

Carbon black pigment was obtained from an artist’s supply, Vallejo Pigments part 73116.

Pigment-grade Iron oxide was obtained from Alpha Chemicals, as “Red Iron Oxide, Natural.” This is a gamma ferric oxide of moderate purity, likely chemically (although not mechanically) close to that used for magnetic tape manufacture. Microscopic inspection showed this to have a wide distribution of particle sizes with particles that were roughly potatoid rather than acicular.

Dry and Dry brand silica gel packets were obtained from amazon.com and the pellets from two 5g packets were pulverized by hand with a mortar and pestle. The resulting powder was uneven and coarse compared with anything that would be used in a tape slurry but should be sufficient for the purpose.

A base material similar to that of magnetic tape was simulated by sheets of mylar intended for use for image transparencies (3M Transparency Film CG3460). These appear to have a texured side with a coating so the test sample slurries were applied to the base side. This material is considerably thicker than used for tape making it more convenient for testing.

The mixtures for all slurries were hand-stirred with a rod for one minute. Consequently, there is much clumping and dispersion is far poorer than that of production magnetic media. This was not seen as a problem for test purposes.

4 Slurries and Coating

Eight different slurries were produced:

1. 10ml MG Type 4223F and nothing else
2. 10ml MG Type 4223F and 5.0g gamma ferric oxide
3. 10ml MG Type 4223F and 5.0g carbon black
4. 10ml MG Type 4223F and 2.5g carbon black with 2.5g silica gel
5. 10ml Minwax 230004444 and nothing else
6. 10ml Minwax 230004444 and 5.0g gamma ferric oxide
7. 10ml Minwax 230004444 and 5.0g carbon black
8. 10cc Minwax 230004444 and 2.5g carbon black with 2.5g silica gel

These slurries were applied onto sheets of mylar intended for use for image transparencies (3M Transparency Film CG3460). These appear to have a texured side with a coating so the test sample slurries were applied to the base side.

The application was performed outdoors in April of 2026, allowing plenty of opportunities for environmental contamination by pollen and molds.

Since excess slurry was available, about ten feet of quarter-inch tape leader was brush-coated with the Minwax+ferric oxide mixture and immediately run over a strong permanent magnet to align particles before it set. This test tape was found to have much lower coercivity than typical audio tapes but could be biased properly and could record a voice. We consider this verification that our basic formula is accurate.

5 Long Term Testing

A period of thirty days at room temperature to allow for basic setting, and then a conventional water drop test [8] to verify that the coatings have completely set. At this point sets of one stripe of each of the combinations (making up two mylar sheets each) were sent to the Library of Congress in Washington DC, the Paul Scherrer Institut in Switzerland, the NASA Marshall library in Alabama, and the author's home in Williamsburg, Virginia.

The contact person at the LoC was Andrew Davis, at the Paul Scherrer Institut it was Sebastian Gliga. At the NASA library it was Paula Laurita.

6 Breaking News

As this paper was being prepared, Andrew Davis from the Library of Congress, along with Gary Louie of the AES Historical Committee gave news of finding a reel of Ampex 291 tape without backcoating but with stickyshed. This gives great evidence to the theory that the backcoating is not implicated in the binder breakdown. It may completely obviate the need for this experiment.

Ampex 291 was a “nonconforming tape” product, like the later Ampex 031 and Ampex 041 tapes. Tape of any sort that did not pass quality assurance testing but seemed to be vaguely usable for basic audio recording would be slit down to quarter-inch and sold as 291. All different kinds of tape from videotape, computer tape, and instrumentation tape as well as audio tape would turn up under the 291 label.

The reel of tape that was tested had a reddish coating and under microscopic inspection was found to have particle grain parallel to the direction of tape travel. This would indicate it was not originally a videotape. It does not match the description of any tape Ampex has ever sold for audio, which would indicate it was not originally an audio tape. It may be a low band instrumentation tape or more likely a computer tape reslit down to quarter inch. This author suspects an 800-series computer tape since the original patent for the thermosetting binder suggests it for use for that application and it would be reasonable for the thermosetting binder to be used there first as computer operations like sorting and searching can place a lot of wear on small parts of a tape.

7 Results

At this point there are no results yet and the author is waiting for the materials to age.

8 References

This list of references may be incomplete.

[1] Eberhard Koester: Particulate Media, chapter 3 of Mee and Daniels, Magnetic Recording Technology, pp. 3.49-3.53, ISBN 0-07-041276-6, Second Edition, McGraw-Hill: 1980.

[2] Bauer, H., Magnetic Recording Element Having Diisocyanate-based Elastomer Binder and Method for Preparing Same, US Patent 3,150,995.

[3] Richardson, Charles A., Solving the Sticky Shed Problem in Magnetic Recording Tapes: New Laboratory Research and Analysis Provides A Safe and Effective Remedy, Audio Engineering Society Convention 121, Oct 2006. AES Convention Paper 6969.

[5] Material Safety Data Sheet for MG Chemicals 4223F Liquid as retrieved from https://mgchemicals.com/downloads/msd
English Can-USA SDS/sds-4224-part%2520a.pdf on April 3, 2026.

[6] Data Sheet for MG Chemicals 4223F Liquid as retrieved from https://mgchemicals.com/downloads/tds/tds-4223f-l.pdf on April 3, 2026.

[7] Material Safety Data Sheet for Minwax part number 230004444 as retrieved from https://assets.unilogcorp.com/187/ITE
on April 3, 2026.

[8] R. Davis, ”Rapid Prediction of Polyester Magnetic Tape Playability Using Water Contact Angles” J. Audio Eng. Soc., vol. 67, no. 12, pp. 953-960, (2019 December.).

[9] Williams, J.L. and Markusch, P.H., ”The chemistry of isocyanates and polyurethanes,” also titled ”Polyurethane Coatings,” Symp. Magn. Media Mfg. Meth., Honolulu, Hawaii, 1983.

[10] Milhalek, R.S. ”The Relationship between polyurethane binders and various binder additives and modifiers,” Symp. Magn. Media Mfg. Meth., Honolulu, Hawaii, 1983.