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Original article

An ATR-FTIR and ESEM study on magnetic tapes for the assessment of the degradation of historical audio recordings

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ABSTRACT

This article presents some approaches for chemical and physical characterization of materials (ATR-FTIR and ESEM) applied to a specific category of cultural material, magnetic tapes. Analogue recording on magnetic tape has been the main technique for capturing sound for about five decades in the past century. Most of our collective memory is therefore stored on this type of medium, which is unfortunately degrading very fast. The past twenty years have witnessed a true rush to digitization in order to save the information stored on tape, but many aspects of the physical recovery of damaged carriers are still performed without solid scientific knowledge, leaving space for improvised treatments with unexpected ill effects. The main motivations for this study are that the preservation of sound recordings is an urgent matter that belongs to the field of Intangible Cultural Heritage preservation, the scientific literature on the subject is scarce and little known by the non-scientific archival world, and the documented approaches to tapes recovery are currently fragmented and do not provide an exhaustive reference for the operators in this field. The analyses presented in this article aim at paving the way for the establishment of a scientific protocol for the safe recovery of damaged tapes.

1. Introduction

Magnetic tape is an important medium in the capturing of information and has had widespread use in audio, video, and computer applications over the past 60 years. Tape-based storage has been used both in analogue and digital systems, and despite being generally considered an obsolete medium, magnetic tape is still used for long-term storage purposes (with a digital encoding of the data) mainly due to its affordability and overall reliability compared to other storage systems [1–4]. Memorable music productions have been recorded on tape, including international pop/rock hits as well as erudite compositions of "tape music" (the name derives from the physical manipulation that composers performed on the tapes in order to achieve the desired effects). Today, re-mastered editions (Legacy, Ultimate, etc.) of the original tapes are all but uncommon (to name one of the biggest commercial success: "The Beatles Stereo Box Set" and "The Beatles Mono Box Set" issued in 2009). As years go by, the preservation of the information stored on tape is becoming of increasing concern to society, particularly as the carriers suffer from physical decay and they threaten the survival of recordings holding a great cultural and commercial value. Unfortunately, many tapes produced and recorded from the 1950s to the end of the 1980s often show serious damage due to ageing, inadequate storage, exposure to excessive heat, humidity or sunlight, absence of adequate box or container, and so forth. The reasons that cause a tape to degrade are many and different: some can be avoided, some cannot. The general process of degradation due to ageing can be slowed down but not stopped [5,6]. Moreover, it should be kept in mind that, on equal conditions, tapes of different brands will behave in significantly different ways – manufacture plays an important role in predicting the life-span of a tape. Fig. 1 shows a tape with a 27-cm reel on a stereo recorder, and a close-up of a tape showing visible signs of degradation. From this quick overview, it appears clear that when we speak about "audiotapes" we refer to a great variety of objects, all of them carrying precious information that we want to save, but that may present very different challenges. Yet, to give a general reference, audiotapes are generally believed to have a life expectancy of 30 to 60 years [7,8].

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Fig. 1. Left: open reel tape on a stereo recorder. The tape is 1/4 inch wide, and its average transfer speed is 9,5 cm/s or 19 cm/s. Tapes are usually wound on metal of plastic reels. Right: close-up on a damaged tape. Small portions of the magnetic side of the tape (light brown) came off and remained attached to the back of the tape (black).

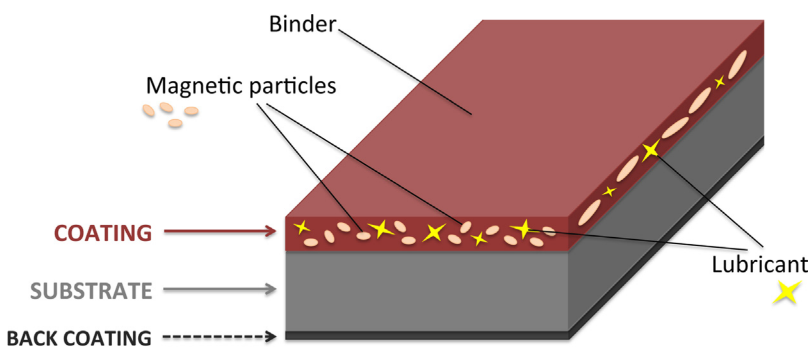

Fig. 2. Cross-section of a coated magnetic tape. The main elements are the substrate (or base) and the magnetic coating, containing the magnetic particles and the lubricant homogenised in a binder. The back coating is not always present (optional).

Fig. 2 shows a typical cross-section of a magnetic tape: the top coat (2–4-mm thick) is composed by a binder, usually poly(ester urethane) containing magnetic particles (iron oxide, Fe_2O_3, magnetite, Fe_3O_4, or chromium dioxide, CrO_2) together with additional materials such as lubricants, dispersants and stabilisers. The binder layer contains "hard" segments of polyurethane and "soft" ones of higher molecular weight polyester (variable in composition), responsible for the elastomeric properties of the layer [9]. The base film is often poly(ethylene terephthalate) (PET, 1953–present), but may be also cellulose acetate (1935–1973) or polyvinyl chloride (PVC, 1944–1972). The base film, usually contains carbon particles (for static dissipation) in the same polymer of the binder layer.

In order to attempt an assessment of the state of preservation of historical tapes, we considered 10 different samples coming from the audiovisual archive of the Arena Verona Foundation. This archive represents an emblematic example because it holds unique copies of unpublished recordings with a great value both historically and economically [10]. This category of archives cannot afford to take any risk when treating tapes, because any damage would cause the irreversible loss of its unique content.

On this basis the authors suggest that an identification of polymeric components of the tape would be useful before manipulation or baking, in particular for historical materials of which not much is known or that are visibly degraded. The first goal of this research is to evaluate the efficacy of some chemical and physical techniques into the assessment of the chemical nature and health state of historical audiotapes, for which also the storage conditions are unknown (i.e. where and how they were preserved).

1.1. Tape degradation

One of the challenges that archival institutions (such as IASA[1] [11]) and research centers (for example [12]) need to face is the identification of chemical components of the tape. Very often this information is not available, greatly increasing the difficulties surrounding a proper diagnosis of degradation and subsequent recovery [13,14]. Many types of degradation are possible: the base film can degrade due to poor winding and poor storage conditions. It becomes wavy, frill or brittle. Acetate tapes can become brittle and dry, showing shrinkage and the so-called *vinegar syndrome* (decomposition of acetate forming acetic acid). High temperature is also perilous for acetate tapes. In tapes with a PVC base film, iron oxide can fall out of the binder matrix, causing the tape to break. PET does not degrade under normal conditions and is a rather stable base film, even if it is hygroscopic reasonably affecting the binder degradation, which can lead to one of the most common syndromes for magnetic tapes, the SBS-SSS (sticky shed syndrome [SSS]) as a consequence of hydrolytic processes [9,15]. SBS-SSS is characterized by undesirable shed, stickiness or squeal, usually treated with prolonged exposure to heat. The authors embrace the terminology proposed by Hess in [8], where the broad term "soft binder syndrome" (SBS) is applied "to all tapes that show stickiness, shedding, and/or squealing, whether they respond to baking or not" ([8], p. 251). The authors also follow the additional subdivision proposed by Casey in ([16], p. 33), where tapes that squeal but do not

[1] IASA: International Association of Sound and Audiovisual Archives (http://www.iasa-web.org/).