PRESERVATION TREATMENT OF MODERN STORAGE MEDIA

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Abstract: The effect of anoxia on magnetic tape used for storage of archival material has been investigated using non-invasive spectroscopic techniques, namely Fourier-transform infrared spectroscopy and X-ray fluorescence spectroscopy. The results showed that anoxia could be the method of choice for decontaminating magnetic tapes which might have accidentally been exposed to biological contamination, as no significant changes in the molecular and physico-chemical properties of the magnetic tape have been evidenced.

Keywords: magnetic tape, anoxia, X-ray fluorescence, Fourier-transform infrared spectroscopy, optical microscopy

1. INTRODUCTION

Archival storage units include several types of supports, such as wax cylinders, magnetic recording tape. Along with the continuous technical development, magnetic recording tape was outdated by some more recent storage facilities. However, at the moment, much of the audio inventory in museums is placed on such magnetic tapes, which are no longer being produced and whose' lifetime is decreasing. Archivists are concerned with the complex mechanisms of degradation of the tapes. Addressing this need to identify the risks associated with the magnetic recording tape, several studies have focused on identifying the proper storage conditions for this type of audio storage category.

The present study emerged from the collaboration between the National Institute of R&D for Optoelectronics with the Romanian Academy of Sciences' Folklore Institute. Like many other similar facilities, the Folklore Institute has much information stored on magnetic tape and is searching for the optimal storage conditions. Unfortunately, some of the inventory was affected by various threats, such as biological contamination of the collections. During this partnership, new ways of treating magnetic recording tape affected by biological contamination were investigated. One such method was decontamination through anoxia. Anoxia implies placing the contaminated object in a sealed custom-made plastic bag, in an oxygen-deprived medium. Anoxia has started to be used in museums since the late 1980s and represents a much cleaner, more environmentally friendly method, safer for the objects, as compared to traditional methods of removing unwanted aerobic organisms, such as fumigation or extreme temperatures [Maekawa and Elert, 2003]. Several research studies have addressed the question of whether anoxia is appropriate for cultural heritage objects, leading to the conclusion that the technique is safe for the investigated type of objects, but no studies have been found regarding the consequences of treating magnetic recording band through anoxia.

The structure of a typical audio magnetic tape includes multiple layers, of varying thickness: the back coating, the base film and a binder containing the magnetic particles [Hobaica, 2013]. The back coating is made of carbon particles dispersed in a binder and was not found in all types of magnetic band. The base film was made from acetate, PVC, paper or PET. PVC in

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particular, stands for polyvinylchloride and was the material of choice for BASF producer between 1945 and 1972 [Hess, 2008].
Magnetic audio tape was introduced in the early 1930s [Gómez-Sánchez et al., 2011] and quickly gained the trust of those working in the audio industry, for being a high-quality storage unit. As such, in many countries, including Romania, part of the national cultural legacy and history is currently being stored on audio magnetic tape. Unfortunately, this type of storage does not represent a permanent option, as the average life expectancy is around 30-60 years [Hess, 2008] and the quality of the recorded data is known to degrade in time [Bressan et al., 2016]. It is important to preserve and prolong the life of such storage units for as much time as possible.
The aim of the study was to investigate if anoxia treatment affects in any way the properties of the magnetic tape.

2. MATERIALS AND METHODS

For this purpose, a sample of magnetic tape (BASF-25, Typ L, dated between 1945-1972) was chosen. The tape had been stored in museal conditions. Two 5 cm long samples were cut from the original tape. One of the samples (denoted by A) was subjected to anoxia treatment for 21 days and the other (denoted by R) was kept as reference, being stored in the dark, at room temperature. The climate inside the anoxia bag is controlled and the object is kept under constant parameters. After 21 days, both samples were analyzed using Fourier-transform infrared spectroscopy (FTIR), X-ray fluorescence spectroscopy (XRF) and optical microscopy. The two faces of the magnetic tape were denoted by F1 – the face with the recoding on it (the part with the magnetic particles) and F2 – the face without recoding. XRF was performed with TRACER III-SD energy-dispersive portable X-ray fluorescence equipment (Bruker Elemental), with Rh anticathode. The system was operated at 40 kV voltage, 11 μA current intensity, 60 s analysis time, without filtering, in air atmosphere. Using this experimental setup all elements from Na to U can be detected. Spectra were acquired with S1PXRF software from Bruker and elemental identification was achieved using standard Bayesian deconvolution with Spectra version 7.4.
FTIR investigation was carried out with Perkin Elmer Spectrum Two equipment with PIKE GladiATR accessory (fig. 1). The spectra were acquired in Attenuated Total Reflection mode, between 4000 – 400 cm^{-1}, by averaging 8 accumulations, with baseline correction and a smoothing factor applied. Spectral processing and peak identification were performed in Essential FTIR Spectroscopy Toolbox, version 3.5. Identification of molecular components was performed using existing literature [Engel, 1988; Feller, 1994; Hess, 2008; Gómez-Sánchez et al., 2011; Hobaica, 2013].

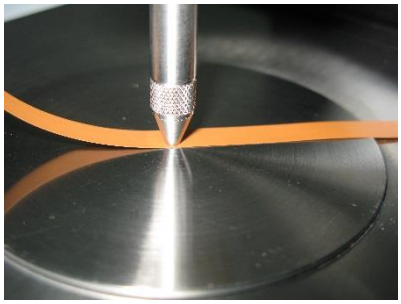


Figure 1. Image from the FTIR aquisition

Optical microscopy images were obtained using a Leica M205FA with Leica LED 5000 illumination system, in partial illumination at 10.610 lux, 321x zoom.

3. RESULTS AND DISCUSSION

The optical microscopy images are shown in fig. 2. By comparing the reference and the anoxia samples, no obvious change in the stoichiometry of the two faces can be seen. Both sides of the tapes appear to be slightly inhomogeneous, which indicated the need to perform FTIR and XRF analyses on several points along the samples.

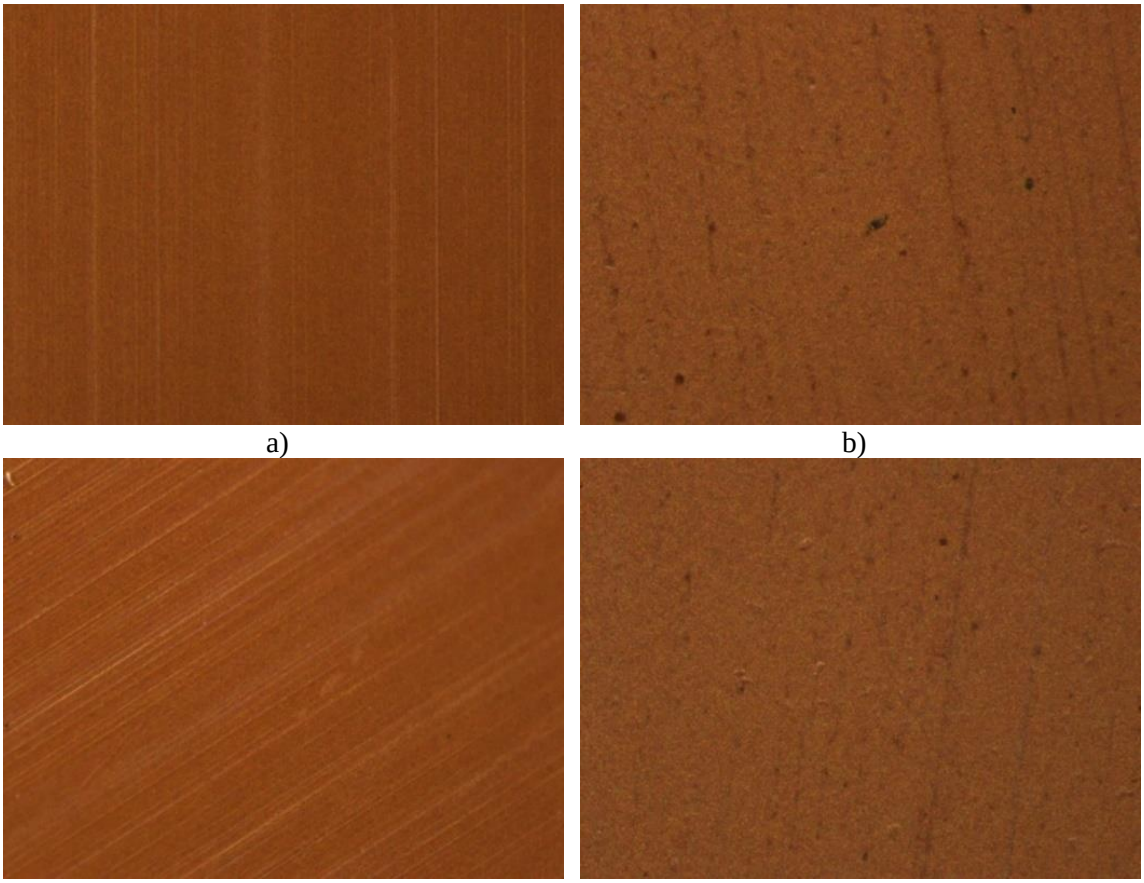
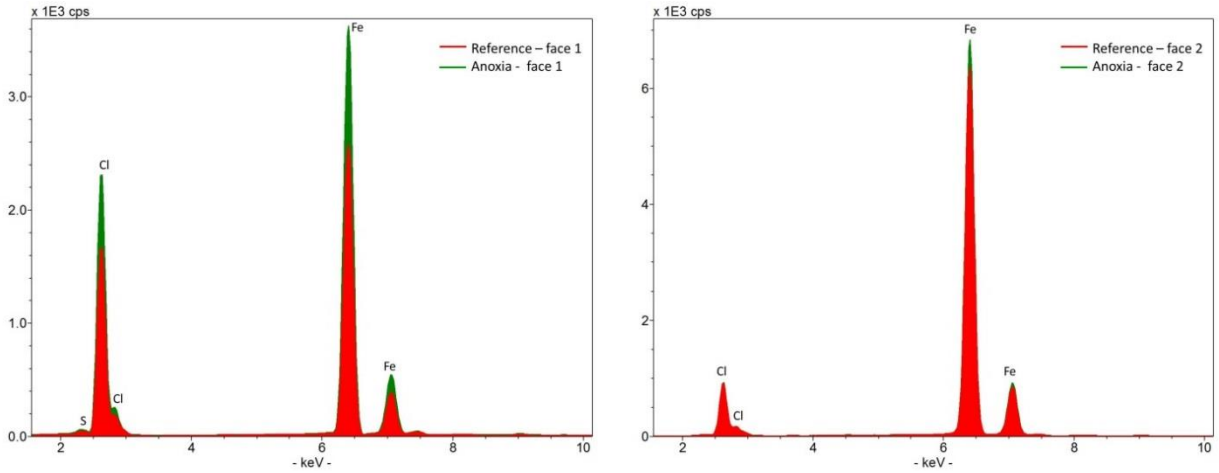


Figure 2. Optical microscopy images: a) Reference-F1; b) Reference-F2; c) Anoxia-F1; d) Anoxia-F2

The FTIR and XRF analyses were performed on three different points along the samples, and the presented values are the mean of the recorded values.

As can be seen in Fig. 3, the main elements identified by XRF are Fe and Cl, along with some other elements, such as S (minor concentration), Ca, Ti and Cu (trace elements). By comparing the two faces of the reference sample it can be seen that face 1 has higher intensities of the Cl, S and Br lines, consequent of the fact that chlorine comes from the PVC base film of the tape. Sulfur is a low-energy element, which can be detected by XRF only if it is in the upper layers of the investigated object. That is why sulfur lines are only visible on face 1 and not on face 2. Face 2 showed more intense lines of Fe, Cu, Ti and Ca. The presence of higher iron on face 2 is easy to understand given the fact that Fe is part of the binder of the tape.



a) b)

Figure 3. Comparison between a) face 1 of the reference and anoxia-treated samples; b) face 2 of the reference and anoxia-treated sample

The distribution plots of the main elements of interest found in the magnetic recording tape are presented in Figure 4. The anoxia-treated sample shows higher net count rates of the main elements, iron, chlorine and sulfur. A possible explanation could be the fact that the surface depositions are acting like a filter and slightly attenuate the XRF signal. After anoxia treatment the signals coming from the main constituents of the sample are better evidenced, hence the increased net count rates detected for iron, chlorine and sulfur.

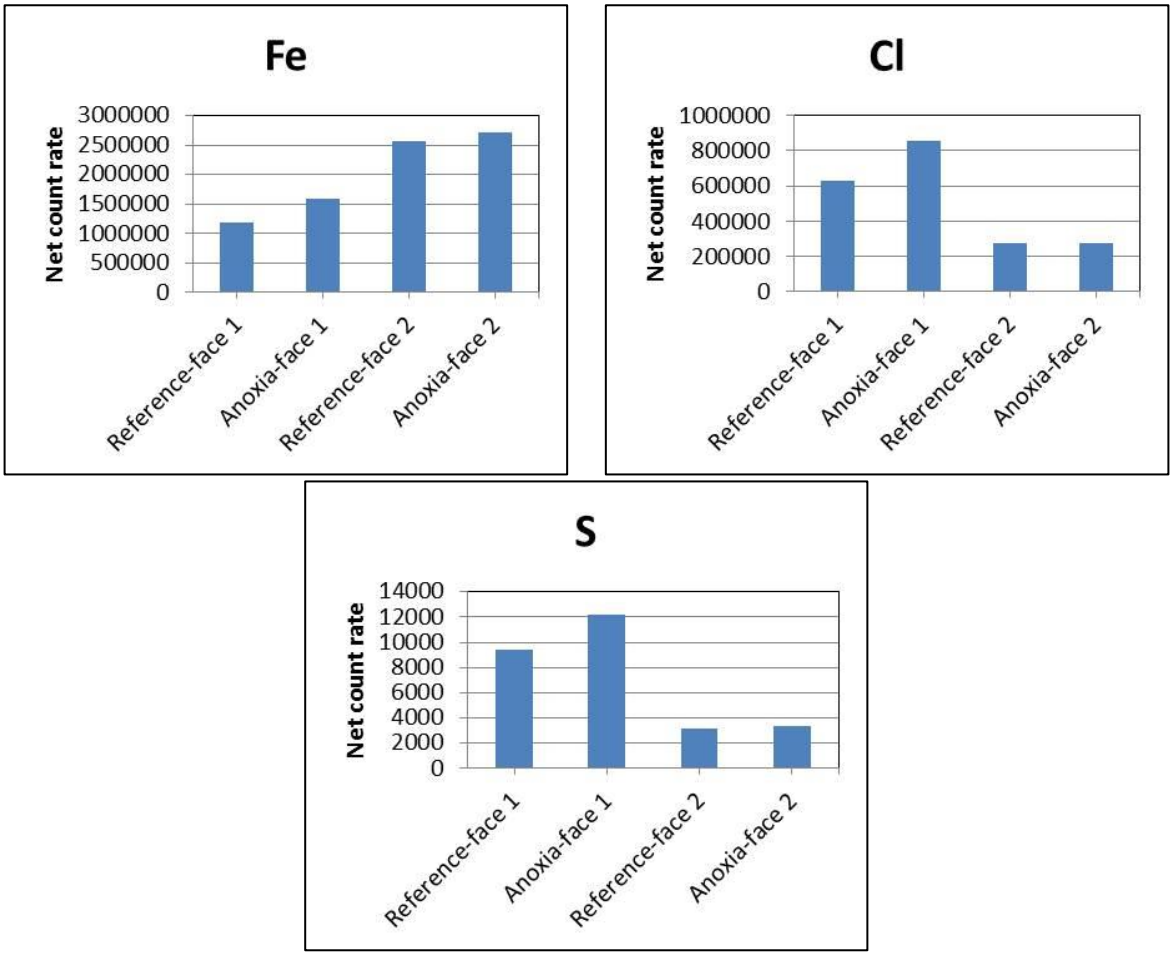


Figure 4. Elemental distribution plots of the main elements of interest

FTIR data (Fig. 5) showed that for the substrate (F2) there are specific bands of PVC due to (ν) CH, CH_2 stretching vibrations at 2964, 2915, 2851 cm^{-1}, (δ) CH2, CH deformation vibrations at 1427, 1330, 1245 cm^{-1}, ν C-C at 1095 cm^{-1}, δ CH2 at 962 cm^{-1}, and ν C-Cl at 679, 630, 610 cm^{-1}.

Both sides of the magnetic tape showed absorption bands characteristic to vinyl chloride copolymers, from the binder: 1738 cm^{-1} (ν C = O), 1435 cm^{-1} (δ CH), 1248 cm^{-1} (δ CO), respectively bands in the region 700-615 cm^{-1} attributed to the stretching vibrations C-Cl.

As indicated by XRF, IR absorption bands attributed to iron (III) oxide were found on the face containing information, at lower wavenumbers, below 600 cm^{-1}.

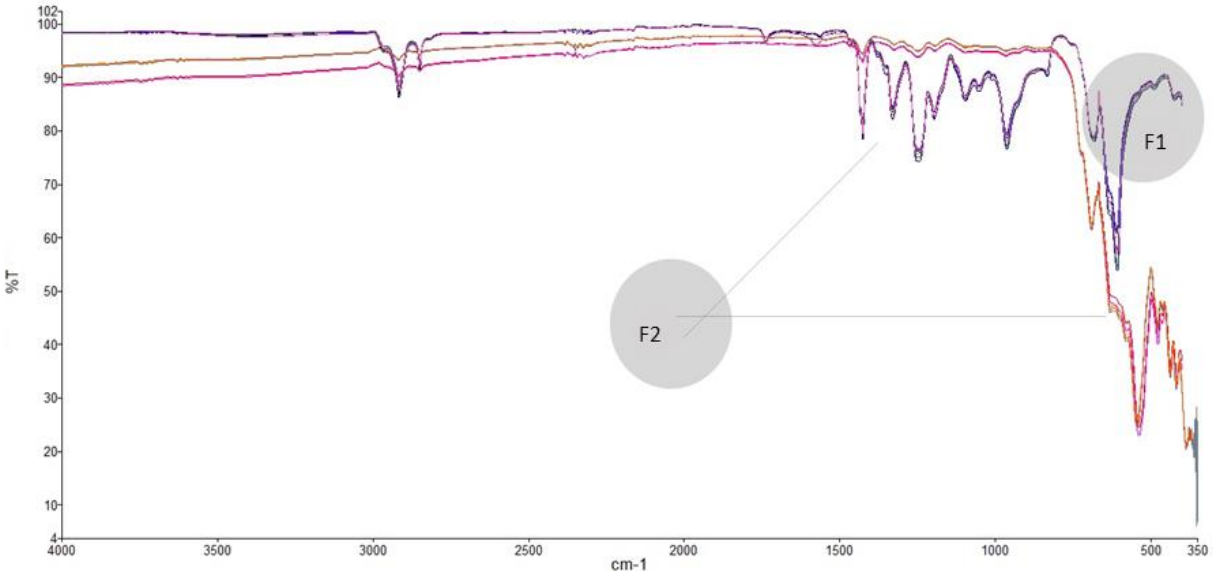


Figure 5. Overlap of FTIR spectra recorded on the two analyzed samples; there is a clear distinction between the two sides of the magnetic tape

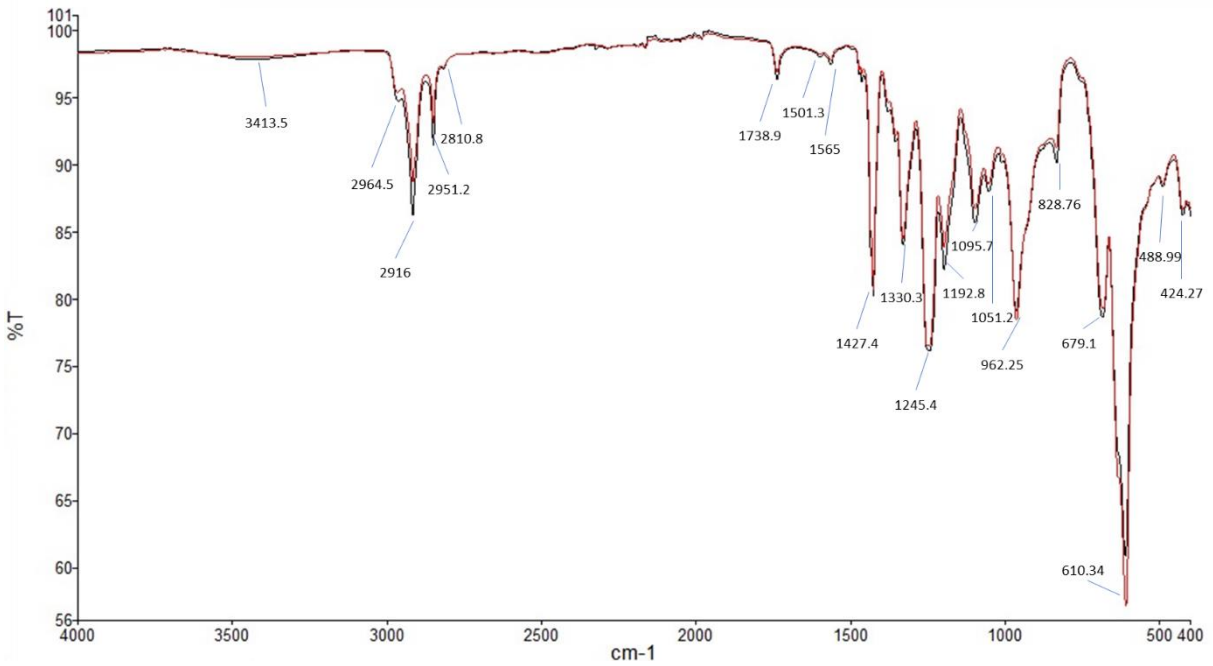


Figure 6. Comparison between the back of the treated (red) and untreated (black) samples

Figure 6 shows the comparison between the back of the untreated and treated magnetic tape samples. Small variations can be seen in the absorption bands' intensities, which can be explained based on the local inhomogeneities and/or based on experimental data acquisition

factors – the spectral response is directly related to the quality of the optical contact between the ATR crystal and the sample, the penetration depth (d_p) of the evanescent wave in the analyzed sample depends on the following formula: $\boldsymbol{d_p = \frac{\lambda}{2\pi(n_1^2 sin^2\theta - n_2^2)^{1/2}}}$.

The comparison between the face of the treated and untreated magnetic tape samples is illustrated in Figure 7. Slight changes can be noticed at the absorption bands around 691, and, respectively, 545 cm^{-1}, changes which might indicate a thermal relaxation of the polymeric chain in the binder.

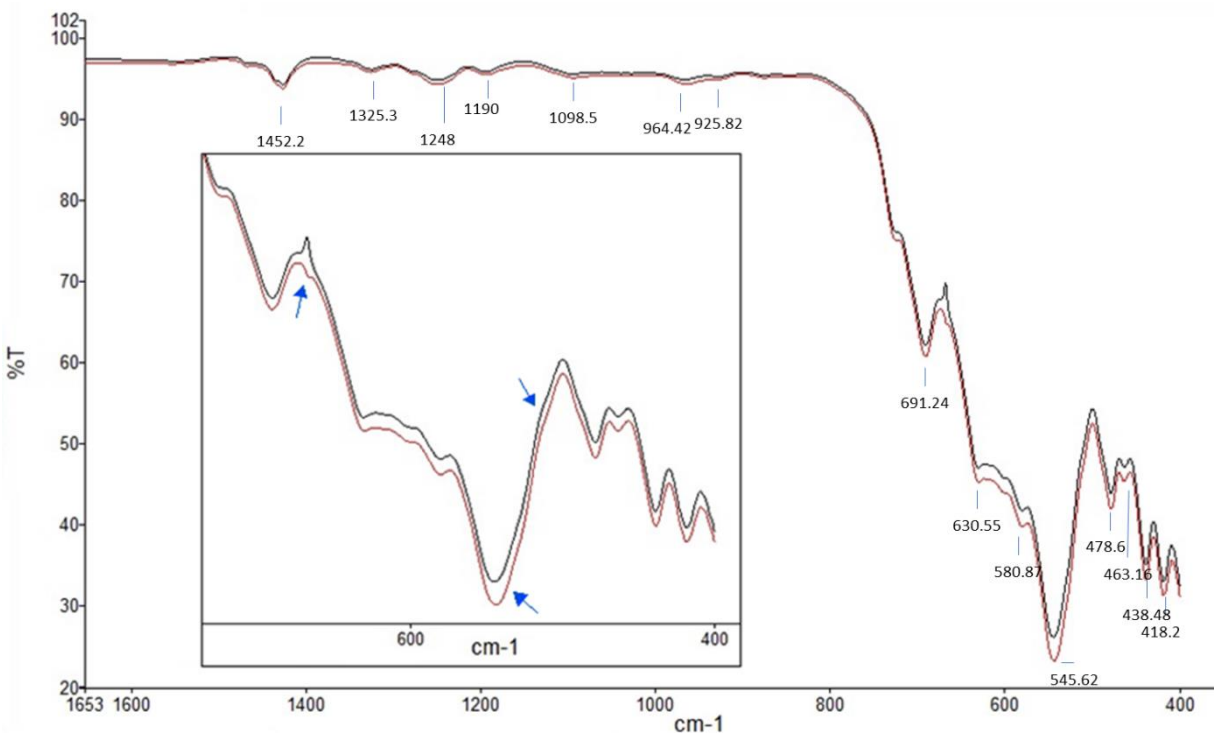


Figure 7. Comparison between the face of the treated (red) and untreated (black) samples

Overall, the FTIR data point to very fine variations with molecular changes in the binder (thermal relaxation of the polymer chain segments) in both samples analyzed; however, an objective assessment of these changes must be made in comparison with an outdated sample; the reference test with which the comparison was made in this case is itself naturally aged, the analysis in several points indicating fine variations in structure at its level.

4. CONCLUSIONS

Samples of magnetic tape type BASF-25, Typ L, commonly manufactured and used between 1945-1972, and currently the storage medium of many museum archives, have been used in order to assess how anoxia treatment might affect their physical properties. To this aim, optical microscopy, X-ray fluorescence spectroscopy and Fourier-transform infrared spectroscopy have been employed. Microscopy images revealed a slightly inhomogeneous surface. XRF showed that

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Luminita Ghervase studied at the University of Bucharest, where she also got her PhD degree, in 2011. Since 2014 she has joined the CERTO (Centre of excellence for restoration by optoelectronic techniques) team within the National Institute of Research and Development for Optoelectronics INOE 2000. Her work is primarily focused on non-invasive spectroscopic characterization methods for cultural heritage objects.

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