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Technology of the Gramophone Records of the Music Museum by Fourier Transform Infrared Spectrometry (FTIR) Method

Seyedeh Zeinab Afzali¹, Seyed Abdulhossein Mokhtabad²

Abstract

Music is one of the branches of the art whose helpful role and usefulness in the human's mind and soul is undeniable. It is the only art which in the philosophers' divisions is directly linked with the human spirit and immediate overflows the ears of his soul. The sound, as a psychological phenomenon is associated with the emotion and excitement so that sometimes calms and sometimes confuses the human. This study aims to examine the technology of the gramophone records in the Music Museum by Fourier transform infrared spectrometry (FTIR). The method of this research is experimental and the data are collected by documentation, library, and using FTIR tests. Some records of the Music Museum were studied including four samples of 78 rpm platter (stone platter), one sample of 45 rpm, and one sample of 33 rpm (vinyl platter). The results of the FTIR test indicated that the materials of the records were vinyl and shellac and in their raw material, some of the softening additives (phthalates) and fillers (silica and calcium carbonate compounds) had been used.

Keywords: Audio archives, Gramophone records, Stone platter, Vinyl platter, FTIR, 45 rpm Record, 78 Rpm Record.

¹ MA, Restoration of Historic Monuments, Central Tehran Branch, Faculty of Architecture and Urban Development, Islamic Azad University, Tehran, Iran. Email: z.afzali66@gmail.com

² PhD, Faculty Member of Arts and Architecture, Central Tehran Branch, Islamic Azad University, Tehran, Iran.

Introduction

The audio archives are the realities deemed as the main anchor and pillar of the most of the institutions' activities. In the era when the media play a significant role in all social events, the audio archives construct the main infrastructures of their activities, and they also invest enormous costs. Obviously, these archives are the result of the experts' effort to collect during a long time and are collected with huge costs, therefore, these archives must be maintained properly in a way that to be usable for now and future. On the other hand, most of the audio works are the national heritage of each country and should be preserved appropriately. In most of the countries, this type of audios is kept in the specialized museums and make up the valuable documents of the political, social, cultural, or art history of that country. The mentioned audios in both sections of audio archives and specialized museums are maintained in various formats such as digital files, CD-ROM, magnetic cassettes or rails, platters (vinyl – stone), and recordable and cylindrical wires of the phonograph.

As Sepanta specifies, "Iranian music like other arts and languages, in any period of its history has not been stagnant and continuously more or less has evolved. In some periods, this development had been slower and in some others, like a recent century, its evolution and diversity has been more" (Sepanta, 2004, 11). Iranian melodies are transmitted over the years from the art students to others. In the Western countries, music evolution has had a certain procedure and with reaching the abundant documents kept in the survived archives, its trajectory can be determined for the investigations; however, in the East, and especially Iran cannot. Destruction of historical documents and works of arts through myriad events has plunged some periods of art history of this land into the darkness forever and has made the investigating not only difficult but also impossible. Most of the researchers could achieve some understandable and relatively acceptable results by means of analogy and logical methods of analysis and research (Mir Alinaghi, 1998). Along with the emergence of the gramophone in Iran, many more people were interested in music and its flourish causes, and the musician's relative welfare, respect, and fame were provided. Moreover, some musicians gradually tried to attract the people by executing more popular programs, and later this procedure was accelerated with the opening of radio. The gramophone affects the playing style including removing some of the delicate parts and playing some parts stronger in order for better hearing during the playback, and playing faster and shortening the parts due to the time constraints of platters (Khezraei, 2008).

Various sectors and displacement of archive

- *The sector of services offered to the public:* for security reasons, visiting all parts of the archive is not open to the public. Visiting the reservoirs (place of documents maintenance) is allowed only for the staff of the institute.

- *Salon of visiting and studying the documents:* Because of the uniqueness of this document and intense passion for knowing and studying them, anyone can use these records and archives by following some safety aspects to be familiar with the audio archive.

Generally, people have a major impact on the documents; sometimes displacements and unprincipled manipulations destroy the archive. The damages to archives are various and often occur due to the carelessness of people including breaking, cracking, damage to the grooves, fingerprints, tearing the protector cover, dirt, pucker, and etc. these happen due to the improper use of people or lack of training the archive cleaners. The incorrect management of the archives makes the works to be stored in inappropriate places leading to incorrect displacements and repairs. Therefore, it is necessary to train the archive staff regularly (Taraj, 1998).

Technology of the records

Technology in restoration knowledge refers to the activity which leads to identifying the materials, methods, and techniques used in constructing a work. The quality and quantity of the applied materials are examined to know the materials and for identifying the methods and techniques, the mechanisms, tricks and technical knowledge applied in a work are investigated. This section has always been difficult because just the final historical product or work is available and the experiences of the manufacturer and techniques are forgotten. Hence, their recognition simply cannot be achieved.

Technology of the records production

In the summer of 1877, Edison was working on the telegraph and brought the idea of sound recording to the realization. He found out that the sounds can be recorded on a flat plate or cylinder and just a device was needed to revive these sounds. John Cruz, assistant and mechanic of Edison in November of that year built a test model in which a metal cylinder with groove was used that was rotating around a horizontal axis by hand. This model was successful and apparently it should be called the first sound machine (Kasnezhad, 2007, 11).

Berliner was very keen interest in the phonographic industry and just one year later, in 1888 created the first circular plates or discs that the sounds were recorded on its grooves. Emile Berliner's platters were very important.

Berliner within the experiencing the production of the record, manufactured the platters from "zinc". He coated the zinc layer with a layer of wax and immersed it in a chromic acid laver in order to the waveform lines and recorded grooves be corroded by acid to the optimum depth. The audio broadcast volume of these platters was good but along with the original sound, a "hiss" sound was heard. The reason was that the acid not only corroded the groove surface and deepened it, but also corroded the groove surrounding and affected it (Sepanta,

1998, 91). The records are divided into vinyl and stone based on their material and their manufacture procedure will be explained in the next parts. In most countries, dimensions of a platter are 300 mm, 250 mm, and 175 mm (Kasnezhad, 2007, 32).

Platter stone: the constituent formula of the gramophone platters, as well as their coating material, is much discussed, but the shellac is the most common material used in the stone platter production. Shellac is the most important natural resin which has insect source and considerable economic importance for Iran. Shellac is provided and supplied in the different form of cube, pill, sheet, and etc. (Bahadori, 2007, 149).

Older models of 78 rpm records or shellac are made of a molding material which today is called thermoplastic (melting temperature) and in which shellac is largely combined with suitable neutral material that carbon is among them which begrimes the platter and strengthens the shellac's brittle and very thin glass. The material applied in stone platters must be hard and flat in cold condition and be able to melt or soften at the appropriate temperature (Canby, 1952).

In the World War II and after that the shellac sources were limited, some 78 rpm records instead of shellac were provided from the compact vinyl, especially 6-minute and 12-inch platters (Yale University Irving S. Gilmore Music Library, retrieved on 01.01.2017; in addition to see Mudger and Hoek 2001 for detailed information regarding the history and archive of 78 rpm sound recordings). The stone platters have been a very noble and expensive good in Qajar era. Industrial development and progress in gramophone production had led to a significant price reduction of this product after the World War I. After the Second World War and expanding the use of radio, the market of platter had found a new move and prosperity with Indian made Iranian platters (labels Bang-e Iran, Delbar, Navay-e Iran, and Tehran). For the sake of following reasons, the Iranian stone platters are very important.

1. Persian stone platters are historical documents with unique features belonging to the course of over half a century ago that trying to maintain them is a national and cultural task. The path of industrial production and supply of these platters from the record to distribution has caused the provision of some documentation confirming the reliability and authenticity of the stone platters in comparison with other historical documents and even phonograph pipes (available in Iran).
2. Stone platters are the major audio sources for the studies of linguistics and dialects in various regions; for example, the recorder works suggest that the dialect of the artists resident in Tehran has undergone dramatic changes between the years 1912 till 1942.
3. The stone platters are the most valuable documents for Iranian ancient music recognition. Because they are the starting point of industrial protection and transfer of the music and lyrics which are transferred from the master to the student of art and are kept in this way.

4. They are an important research source on the folklore and popular culture. Many of the remained minstrels, imitations, blackface-show or Siah-Bazi, Takht-e Hozi shows, and Koocheh-Bazari or popular music contains unmatched information of this arena.
5. The stone platters are an untouched document of the acting and show history in Iran. Some parts of the first operators and musical shows with the act of prominent artists of the early decades of the fourteenth century to the Pardeh-Khani shows of the twentieth century are preserved on these platters.
6. These platters contain considerable notes for scientific writing about the contemporary history of the music and artists' biography, autobiography, and memoirs.
7. They also are a special source of research on political history. Do the remaining three samples of Mozaffar ad-Din Shah's voice are not deemed historical documents? Is not the system of regulations about the sound recording on the platters approved in 1929 by the Cabinet or preliminary to the act the political issues?
8. They compared with other historical documents such as manuscripts and old photographs, in terms of number and access are very limited and scarce. The number of books, manuscripts and handwritten historical documents is in excess of hundreds of thousands of sheets. They are considered by relevant government agencies, researchers, and collectors as artistic books and manuscripts, rules, documents, letters, government documents, politicians' portrays, business documents and letters, the records of the telegrams among the masses of people as settlements and contracts.

The gramophone platters are capable of recording all types of sounds and during the recorded history, from Edison's famous sentence to the most modern available music are recorded on these platters. Regarding the music's diversity and passion of all to it, it seems that the invention of the gramophone records has been an important step to surviving the music and accurate record and maintenance of this valuable legacy for posterity. Therefore, its manufacture and sound record procedures may be interesting for people as much as listening to it. Hence, the technology of the platter (manufacture mode, material, and playback time) and the damages and harmful factors will be investigated.

Vinyl platters: since 1948, fine-groove platters were produced gradually. New unbreakable plastic platters are made of vinyl. Despite the natural lacquer, this new plastic is flexible and while is hard enough to be used as a material for recording (Canby, 1952). The platters made of vinyl or flexible firm plastic is known as a vinyl platter.

The fine groove platters are made of vinyl and are lighter, flatter, and subtler for fine grooves rather than the older platters made of shellac, and as result the scratches on surface of these platters has been reduced to the minimum and fragility is also lower than the old shellac platters (BNB-Beatles, 2006). Some platters are pressed on colorful vinyl or different pictures are set on them. These types of platters, in some cases, are collectible items and have a high price. Sometimes, the platter is produced by the customer's order and its color and picture are

completely private (Kasnezhad, 2007, 26). In order to attain the original platter that the music would record on it, the manufacturing process starts with an aluminum sheet in the center of the platter. The aluminum sheet at first has some roughness which smoothens with polish. The sheet is placed on the conveyor; at this stage, there is a thin layer of cellulose nitrate on it, and this is done during the insertion of the disc inside the device (the wheels on the device move the sheet and remaining chemical enter the recycle process). This layer immediately dries and cellulose solvent quickly evaporates and consequently vinyl remains on the platter. In the control station, the platters are examined in terms of dust, scratches, dirt, and corrosion. Then, the edges of the platter are coated with plastic to prevent abrasion in the next steps. After that, a hydraulic punching device creates a hole in the middle of the platter and then the platter is placed on a bar. A robotic arm inserts the plastic rings into the bar. These rings are placed on the central hole of the platters to like plastic edges prevent the abrasion with each other.

Research method

In this study, four methods are applied to collect the data; 1) documentary: recording the status and characteristics of the platters, 2) field study: presence in the Music Museum and visiting the private archives can lead to the information about the maintenance problems, damages, etc. directly, 3) library, and 4) photography: using the photography in platters' pathology and repair departments, visual observance of the existent stages, changes, and damages is possible. The data are analyzed by following stages: The first step in maintenance and repair is its documentary. The second step is recognizing the technology of that work. Technology includes manufacture procedure, knowing the history of music, sound record, etc. The third step is pathology and recognizing the damages. Recognition of damages, their division, and accurate record guarantees a good repair in which using the tools, software, and global capabilities can be very useful. The last step is the mending measures. This step is conducted after the complete recognition of the work and right understanding of the damage and technology of that thing. Extensive knowledge of materials (particularly chemicals) is required for the reparation and how to consume considering the repair theoretical foundations and the amount of manipulation of the object.

Sample preparation for FTIR test

In order to obtain the red spectrum of an organic liquid compound, the compound should be placed in a sample conservator or cell. The common cells contain potassium bromide sheets (scope of performing $400\text{-}4000\text{ cm}^{-1}$) and sodium chloride (scope of performing $650\text{-}4000\text{ cm}^{-1}$). About the solid samples, there are different methods of specimen preparation. A frequently used method which requires minimal sample preparation is KBr tablets method and is placed inside the device by a conservator.

FTIR tests

Since the samples were historical and the least damage should be exerted, this method was used. In addition, coatings and polymer samples all are organic materials and identifiable by this device. A little amount of 0.5 g sample is enough to achieve the acceptable result.

6 samples of the platters in the Music Museum were studied including four samples of 78 rpm platter (stone platter), one sample of 45 rpm, and one sample of 33 rpm (vinyl platter). The structure of the samples was various that mean some had integrated structure and others steel core with the coating. The sampling was performed by two ways.

1. About the samples with integrated structure, sampling was carried out using a scalpel and under the microscope and by scratching a part of the sample in a way that the least damage exerts to the sample.
2. Those with the steel core and coating were sampled using the scalpel and creating the scratches on their coating. They were combined with KBr powder which has no absorption in the IR region at a ratio of 1 to 100. The compound was pulverized in an agate mortar and a transparent pill with a thickness of one millimeter was provided using the special press device. The spectrum of the obtained samples was measured in the form of a pill and using FTIR device model Nicolet 510p in the range of 450-4000 cm^{-1} with 64 scans and resolution of 4.

Results

Sample 1 (78 rpm platter):



Figure (1): 78 rpm platter which is filled for private (Tehran Music Museum, 2016).

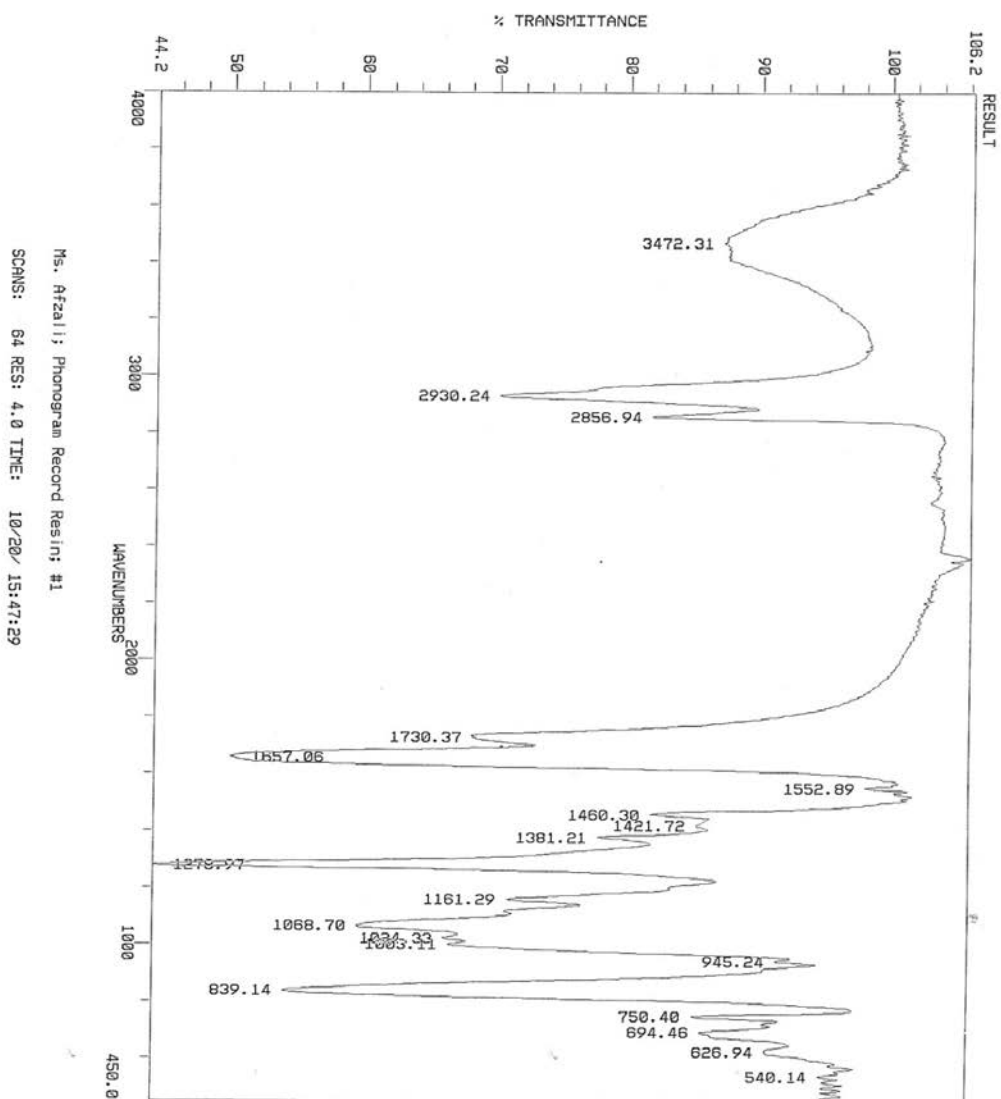


Figure (2): sample spectrum 1 which is obtained by FTIR method.

According to the absorption tapes in the spectrum of sample 1, it was detected that:

Table (1): analysis of the sample 1 spectrum (78 rpm platter)

Assignment	Wavenumber cm^{-1}
CH ₂ and CH	2930
CH ₂ and CH	2856
C = O	1730
C = O	1657
C = O	1552

CH	1460
CH ₂	1421
CH	1381
C _ O	1278
C _ O	1161
C _ O	1068
C _ O	1024
C _ O	1003
C _ C	945
CH ₂	839
CH	750
CH	694
C - Cl	626
C - Cl	540

The comparison of the attained spectrum of the sample and the appeared absorption tapes with the control spectrum it was concluded that the material of this sample is polyvinyl chloride and there is no softening and filling material inside it.

Sample 2 (45 rpm platter):



Figure (3): 45 rpm platter in the 1950s (Tehran Music Museum, 2016)

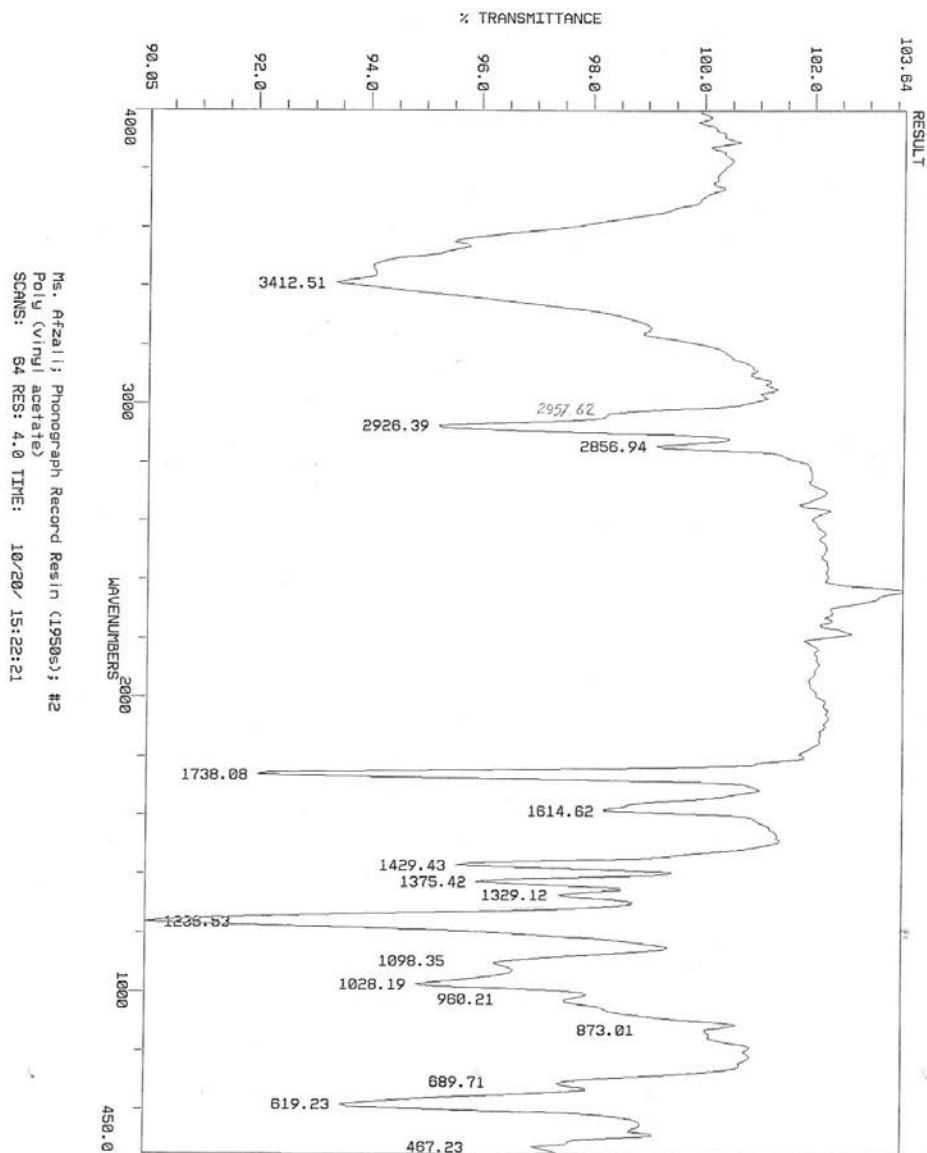


Figure (4): sample spectrum 2 which is obtained by FTIR method.

Table (2): the analysis of the sample spectrum 2 (45 rpm platter)

Assignment	Wavenumber cm^{-1}
CH_2 and CH	2926
CH_2 and CH	2856
C = O	1738

C = O	1614
CH ₂	1429
CH	1375
CH	1329
C _ O	1286
C _ O	1098
C _ O	1028
C _ C	960
CH ₂	837
CH	689
C – Cl	619
C – Cl	647

The control spectrum showed that sample 2 is made of vinyl and observing the absorption tape in the region of 873 and 1429 cm^{-1} related to the carbonyl base O _ C _ O and CO₃ it was concluded that the filling material of calcium carbonate is used in this type of platters. Moreover, the regions of 467 and 1098 cm^{-1} show the presence of the silicate compounds.

Sample 3 (78 rpm platter):



Figure (5): 78 rpm platter attributed to 1920s (Tehran Music Museum, 2016)

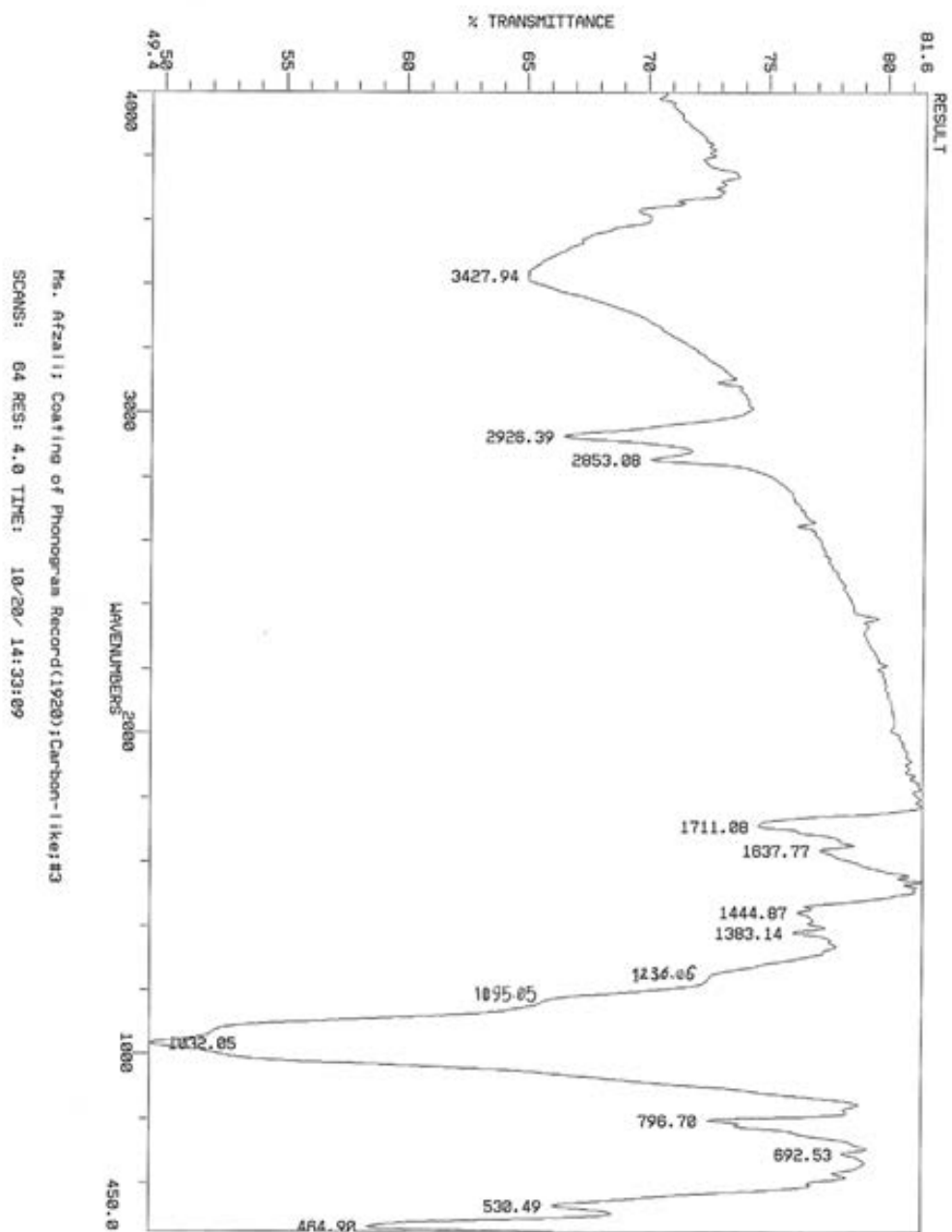


Figure (6): the obtained spectrum of sample 3 by FTIR method.

Table (3): the analysis of sample 3 (78 rpm platter)

Assignment	Wavenumber cm^{-1}
O _ H	3427
C _ H	2926
C _ H	2853
C = O	1711
C _ C	1637

C _ H	1444
C _ H	1383
C _ O	1236
C _ O	1095
C _ O	1032
C _ O	796
Si _ O _ Si	464

According to the comparison of the control spectrum and absorption tapes of shellac, and considering the existent 464 and 1032 cm^{-1} absorption tape, silicate compounds are used in this platter as the filling material.

Sample 4 (78rpm platter):

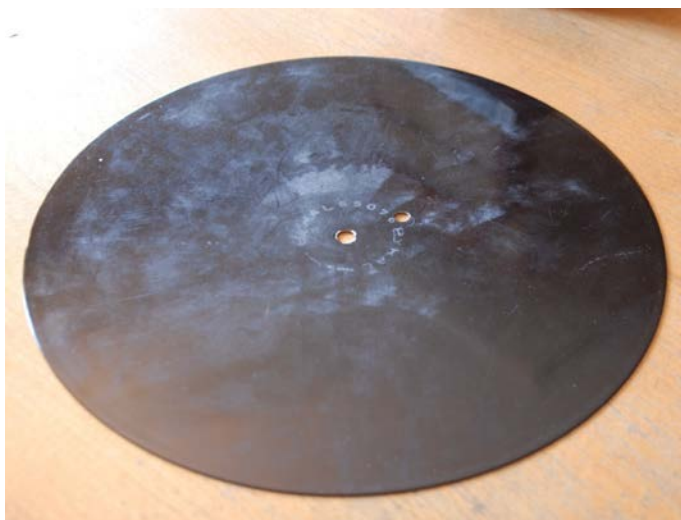


Figure (7): 78 rpm platter attributed to 1940s (Tehran Music Museum, 2016)

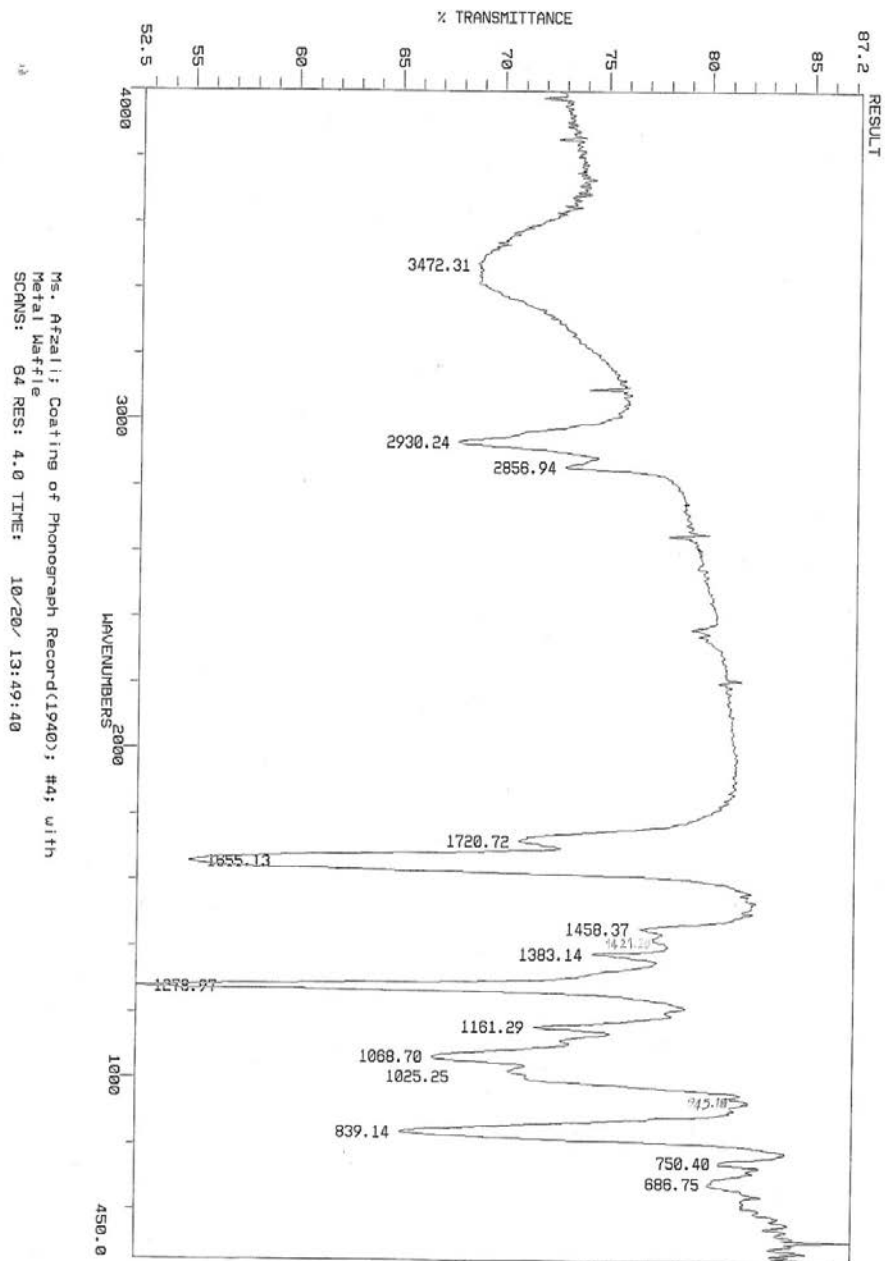


Figure (8): the obtained spectrum of sample 4 by FTIR method.

Table (4): the analysis of sample 4 (78 rpm platter)

Assignment	Wavenumber cm^{-1}
CH ₂ and CH	2930
CH ₂ and CH	2856

C = O	1720
C = O	1655
CH	1458
CH	1383
C _ O	1278
C _ O	1161
C _ O	1068
C _ O	1025
CH ₂	839
CH	750
C _ Cl	686

By comparing the control spectrum, it resulted that it is made of polyvinyl chloride and no filling material is applied.

Sample 5 (78 rpm platter):



Figure (9): 78 rpm platter attributed to 1940s (Tehran Music Museum, 2016).

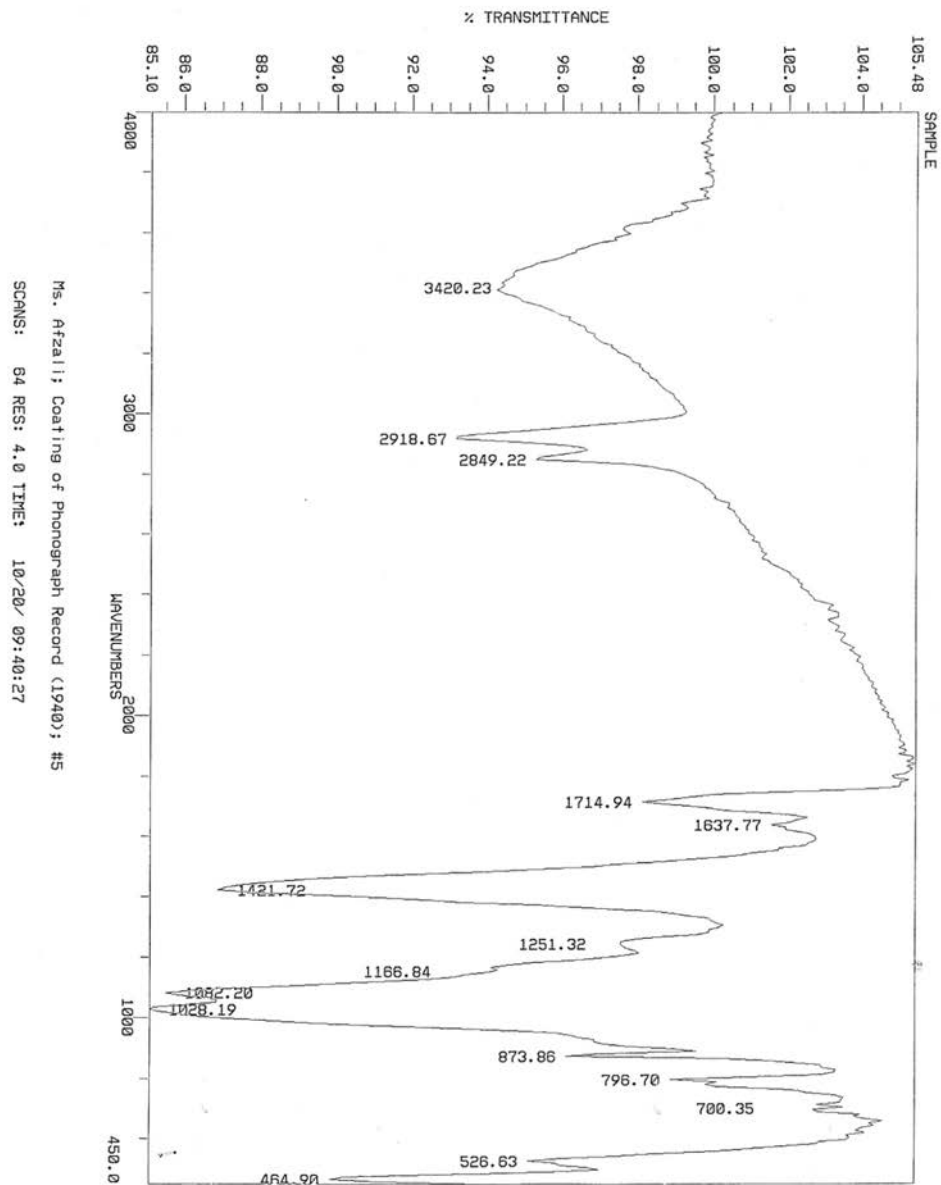


Figure (9): the obtained spectrum of sample 5 by FTIR method.

Table (5): the analysis of sample 5 (78 rpm platter)

Assignment	Wavenumber cm^{-1}
O _ H	3420
C _ H	2918
C _ H	2489
C = O	1714

C _ C	1637
C _ H	1421
C _ O	1251
C _ O	1166
C _ O	1082
C _ O	1082
C _ O	873
Si _ O _ Si	464

Sample 6 (33 rpm platter):



Figure (11): 33 rpm platter attributed to 1965 (Tehran Music Museum, 2016).

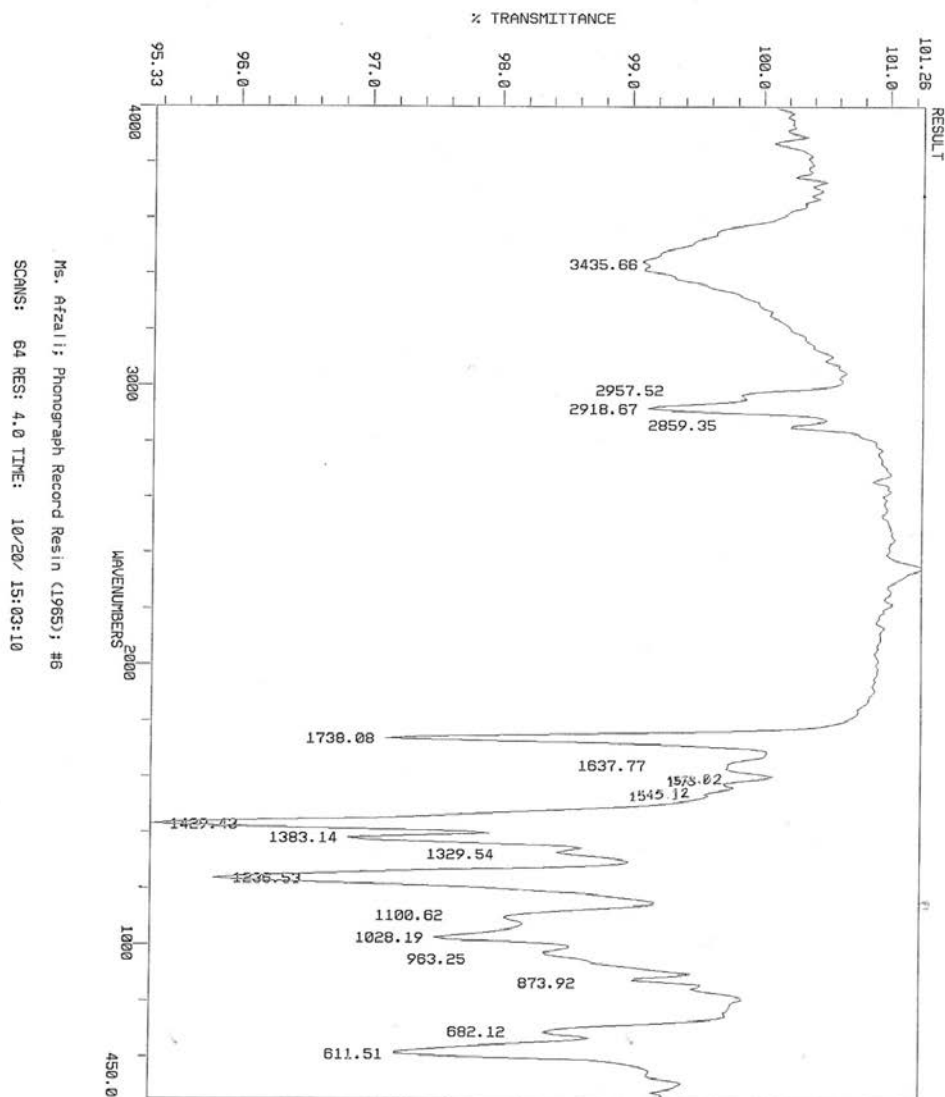


Figure (12): obtained spectrum of sample 6 by FTIR method.

Table (6): the analysis of sample 6 (33 rpm platter)

Assignment	Wavenumber cm^{-1}
CH ₂ and CH	2957
CH ₂ and CH	2918
CH ₂ and CH	2859
C = O	1738
C = O	1637
CH	1578

CH	1545
CH ₂	1429
CH	1383
CH	1329
CH	1236
C _ O	1100
C _ O	1028
C _ C	963
CH ₂	873
CH	682
C _ Cl	611

This platter is made of natural resin of polyvinyl chloride and on the basis of the absorption tapes of 1429 cm^{-1} in the region of CO_2^3 in $\text{O}_2\text{C}_2\text{O}$, the filling material of calcium carbonate is used.

Conclusion

The beginning of the sound record is a great evolution in music art. The audio documents have been able to record about 120 years of Iran's music history. Although it is a short period of the whole history of this art, its maintenance, record, and research on it can be a heritage for the posterity. In this study, the experiments by FTIR method due to high speed and accuracy on six samples of the platters in Tehran Music Museum attributed to 1920 to 1960 indicated that the platters had made of shellac and vinyl and in their raw material some additives such as softening (phthalates) and filling (compounds of silica and calcium carbonate) had been used. In addition, it makes it clear that in a period of World War II because of shellac unavailability, vinyl has been used to produce these platters.

The gramophone platters of the Music Museum due to their being unique cannot be tested one by one for repair, knowing their technology, and pathology. For this reason, it is suggested to classify the platters which belong to the same historical period and are from the same material, and the platters which cannot be played and applied anymore for the sake of severe damage can be used for the required tests; perhaps the damaged platters can be repaired in this way and the proper protection solutions can be proposed.

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