DETECTION OF BPA AND OTHER ORGANIC CONTAMINENTS IN CANNED MUSHROOMS AND OLIVES

By

Mohammad Talha Mirza
Fatir Ijaz

DEPARTMENT OF EARTH AND ENVIRONMENTAL SCIENCES
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Mohammad Talha Mirza

Fatir Ijaz

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Committee Members	Name	Signature
Supervisor	Dr. Fiza Sarwar	Fiza Sarwar
Internal Examiner	Dr. Asma Jamil	
External Examiner	Ms. Nayyab Abeer	
Head of Department (E&ES)	Dr. Said Akbar Khan	10/10/23

ABSTRACT

Canning of food is a famous practice as they increase the shelf life of a food as compared to the food that is packed in other packing materials. The reason epoxy resin is used for inner coating of metal cans is because it gives flexibility to the metal cans; it adheres to the metal surface and is good corrosion resistant. It contains BPA, BADGE, BPS, and BPS. BPA is dangerous for human health. BPA exposure leads to endocrine disruption carcinogenicity (breast, prostate, testicular), hormonal and cognitive disorder. The objectives of this study were identification of the presence of BPA in canned mushrooms and canned olives and identification of the presence of other contaminants in samples. The samples were collected from major departmental stores in Islamabad, Pakistan. The FTIR analysis of canned mushroom supported the presence of BPA. However, the olive sample spectrum did not correspond with the BPA reference spectrum but showed a presence of Organophosphorus compound (P-C group). Its major source is pesticide that is used on crops in the agricultural sector from which Organophosphorus migrates in human body after consumption of contaminated vegetables. This study concludes the relationship of presence of BPA in canned food is highly dependent on the nature and physical structure of containing material. This study also pointed out that the migration of harmful chemicals that enter the human body and cause adverse health impacts. It is recommended that food and health regulatory authorities should carry out continuous monitoring and regulatory analysis of BPA and other chemicals regarding canned food and introduce safe alternative packaging materials. To prevent organophosphorus contamination of food stuff integrated pest management should be established to avoid use of harmful pesticide. It is recommended that further research in respective domain of Pakistan should be carried out to develop a proper and impactful understanding.

ACKNOWLDEGEMENTS

We extend our heartfelt gratitude to the Almighty Allah for granting us the strength and courage to successfully complete this research project. His blessings and guidance have greatly influenced our thoughts and allowed us to thrive. We praise Allah, the all-powerful, self-sufficient, and the one who answers prayers.

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LIST OF ABBREVIATIONS

BPA	Bisphenol A.
BPS	Bisphenol S.
BPF	Bisphenol F.
BADGE	Bisphenol A and Di Glycidyl Ethers
NIAS	Non intentionally added substance.
FCM	Food Contact Material.
ER	Epoxy resin.
PCP	Polycarbonate plastic.
PVC	Polyvinyl Chloride.
EDC	Endocrine Disrupter Chemicals.
USEPA	United States Environmental Protection Agency
EFSA	European Food Safety Authority.
U.S	United States of America.

CHAPTER 1

INTRODUCTION

1.1. Background

Food packaging that includes metals like cans, lids, and aerosols containers are used widely throughout the world. Out of which cans are the most prominent one that is being used for canning food and beverages (LaKind, 2013). The reason why canning of food is famous is because they increase the shelf like of a food as compared to the food that is packed in other packing materials. While a polymeric coating is used to coat the inner surface of metal cans that acts as a separator between food and metal of the can. Coating plays an important role in the preservation and maintaining the quality of the food and also protecting the can from corrosion (Driffield, Garcia-Lopez et al., 2018). But during the coating manufacture, due to incomplete polymerization process, residues of monomers and prepolymers can remain in the can and there is a potential danger of them ending up in the content of the can i.e., food. These substances of the metal can have the potential to enter the foodstuff, these substances are called migrants. These substances are called non-intentionally added substances (NIAS).

NIAS are impurities that can react, degrade the product and so on (Nerín, Bourdoux et al., 2022). Mainly epoxy resin is used for metal can inner lining/coating; some other kinds of resins are phenolic, polyesters, acrylic, vinyl, and oleoresins. The reason epoxy resin is used for inner coating of metal cans is that it gives flexibility to the can; it adheres to the metal surface and is good corrosion resistant. It contains BPA and BADGE (LaKind 2013, Geueke 2016, Tarafdar, Sirohi et al., 2022). Synthetic polymers known as epoxy resins consist of BPA and their derivatives. These chemicals are used to improve the quality and durability of the inner varnishing of the food cans and are also used in various kinds of food containers that are plastic for instance, baby bottles, plastic dairy containers etc. These are the specific cases in which BPA is used.

1.2. Introduction

Bisphenol A (BPA) is commonly a monomer that is used in the production of Polycarbonate plastics (PCP), epoxy resin (ER) as well as Polyvinyl chloride (PVC). Bisphenol A was first noticed by Alexander Dianin in 1891 as toxic chemical.

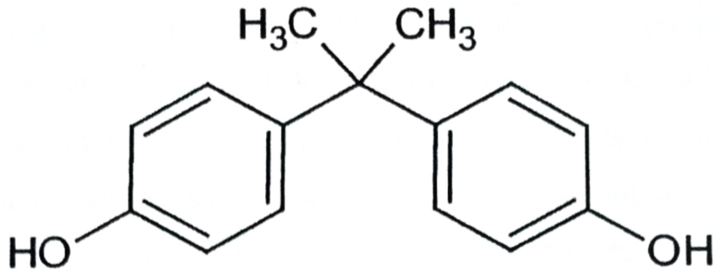


Figure 1.1 Structural formula of BPA

There has been sudden rise in polymer use in industrial sector that is observed with BPA. In addition to profound feature as flame retardant, industrial sector placed another function to epoxy resins and polymers that is food packaging (Wang, Nag et al., 2022). PCPs and ER as PVC are used in food storage containers and inside the coating of beverage and food cans and in glass jars to avoid contact between food and containing material walls (Cao, Perez-Locas et al., 2011).

Bisphenol A (BPA) is used in the production of many products such as health care equipment, dental composites, contact lenses, toys. BPA is one of food contact materials. Food contact material means that this chemical is used in many of the kitchenware like plastic storage containers, jars caps coating, mostly the walls of the metal can for sole purpose of acting as a barrier and prevent the contact of food with metal, therefore prevents corrosion (Konieczna, Rutkowska et al., 2015). This Polymeric coating which is mostly highly cross-linked thermoset resins which can withstand frequent processing conditions around 121°C for 1.5hr.

According to several studies that stated this certain migration occur during transportation and accidental storage in irregular positions. (Cao, Corriveau et al., 2009). There are also other factors that influence the migration of BPA from the lacquer to content present in the can. These factors are pH, salt, oil and glucose (Brotons, Olea-Serrano et al., 1995). Due to the close affinity of BPA with food containers it has been reported that it migrates to the food inside those containers which results in widespread effects of these chemicals in human dietary tract (Vandenberg et al., 2010). According to study conducted in New Zealand states that several factors such as pH, oil and salt that has been effective in influencing the BPA migration from lacquer to canned stuff (Thomson & Grounds 2005).

A study conducted associating with the application of BPA migration that involved canned food stimulants in compliance with council directive mentioning list of stimulants for migrating chemicals undergoing testing of plastic material that interact with food. According to a study, the food that was aqueous contained two stimulants: water and acetic acid. Respectively both stimulants undergone migration test. The experimental conditions were set that varied for food material and plastic material. The temperature that was set was 25°C and 80°C. The time duration was also set around 0-240h range. The results stated the level of bisphenol A, bisphenol S was at higher level when acetic acid was used with higher temperature and maximum contact time up to 240h while minimum on the other hand (Pinney, Mesaros et al., 2017).

In food toxicology the BPA migration has been an area of intense consideration. The potential migration of BPA into food, beverages, and other edibles as well as baby formulas has given rise to serious concerns (Carwile, Michels et al., 2011). The migration is also suggesting the BPA entering human body with dietary intake crossing the exposure intake (Liao, Liu et al., 2012). Since thermal processing such as microwaving canned food has been seen to be exacerbating the migration and ultimately potential exposure (Geens, Aerts et al., 2012).

1.3. BPA in food and their Effects

The general population is exposed to BPA from dietary (food and beverages) sources. Since exposure of BPA is considered primarily via ingestion, BPA migrates from metal and plastic can walls to food and beverages. There have been several evidential studies taken place across the world including U.K, New Zealand, Japan, and China. In domain of food safety, the increasing trend in BPA detection in packaged food has raised concerns. The detection of BPA across several food items has been done by several analytical studies (Kleywegt, Pileggi et al., 2011, Geens, Aerts et al., 2012).

The BPA presence in packaged food market has prompted research on impacts of BPA on human health. Many animal studies have been reported that points the influence and BPA fate in living things resulting in altering development in both animals and humans (Ho, Tang et al., 2006, Peretz, Vrooman et al., 2014). Such investigations have fueled the concern about public health and susceptibility of masses including children, pregnant women, and domestic animals as well.

BPA has been identified as EDC (Endocrine disrupter chemicals) and this chemical is categorized as of extreme concern by the USEPA (United States Environmental Protection Agency). This chemical has shown disruption/impairment of development and reproduction by studies carried out on animals (Sakhi, Lillegaard et al., 2014). Several evidential studies have shown the extreme susceptibility of the human reproductive system due to the presence of BPA. The reproductive system undergoes unsetting sex hormone activity. BPA is reported in studies as a direct link in increasing level of estradiol, progesterone and testosterone (Wisniewski, Romano et al., 2015). There have several studies been conducted that shown the relationship between numerous cancer types with BPA, that including breast cancer, ovary, uterus, prostate and testicular cancer as well (Maffini, Rubin et al., 2006, Doherty, Bromer et al., 2010, Song, Zhang et al., 2015). Various research studies have shown the effect of BPA since it acts as endocrine disruptor in human body by interacting with several biological receptors. This leads to harmful disorders in reproductive organ, nervous system, and immune system as well. Moreover, it disrupts the ability of the immune system to fight against infections.

According to result of several studies BPA has been degrading cellular systems moreover causing alteration in overall immune system of human body (Moon, Kim et al., 2012, Xu, Ai et al., 2016). This study was carried out on animals (Carlisle, Chan et al., 2009). BPA exposure has been associated with leading causing factor of growth disruption, halting natural development, endocrine system disruption, suppression of immune system and infertility. Moreover, it could lead to carcinogenicity (Gerona, Woodruff et al., 2013), (Manzoor, Tariq et al., 2022) BPA causes endocrine disruption. Moreover, it influences neuroendocrine function that leads to physiological interruption in organs. According to studies BPA presence caused increment in testosterone level in males while decrease in level of estradiol in females. This study was conducted on mice (Xi, Lee et al., 2011, Wisniewski, Romano et al., 2015) BPA also retards the development of offspring (Husøy, Beausoleil et al., 2015). BPA presence has resulted in tumor development including lung cancer, prostate, and breast cancer. (Leung, Govindarajah et al., 2017). Mothers with BPA exposure gave birth to offspring with low birth weight and height, the infants also showed retarded organ development (Pinney, Mesaros et al., 2017), (Mammadov, Uncu et al., 2018), (Perera, Vishnevetsky et al., 2012). These studies point at the adverse effects of BPA exposure during pregnancy period on the fetus. According to several studies BPA consumption has led to extreme influence on mental health, such as, sex specific neuron-impairment and changes associated with human behavior (Xin, Fischer et al., 2018).

1.4. Reported presence of BPA in canned food

In Japan, research concluded that no BPA was determined in canned fruits however in canned vegetables BPA was detected at a range from <10 ng/g – 95 ng/g in most of the canned vegetables samples. It concluded that concentrations of BPA were higher in solid portions than in aqueous portions (Yoshida, Horie et al., 2001).

In another study that was conducted in Japan to determine the presence of BPA in Japanese market reported the concentration of BPA levels in canned food. In canned fish concentration of BPA ranges from 0 – 30 ng/g, in canned vegetables it ranges from 0 – 25 ng/g (Yonekubo, Hayakawa et al., 2008).

In France, the study was conducted, and it revealed the character of BPA in food. About 85% of foods that were analyzed showed that the level of BPA was <5 µg/kg in foods that were in contact with BPA containing packaging (Krishnan, Stathis et al., 1993, Braunrath, Podlipna et al., 2005, Cunha, Almeida et al., 2011).

In Korea BPA range in canned food sample were ranging from < 1.41 - 278.5 µg/kg. Meanwhile in China the BPA content was around 0.20 – 106 µg/kg. According to several reports the BPA content in canned food in Egypt has been around 6.14 – 710.59 µg/kg. The BPA presence in canned food in Portuguese and Norwegian markets has been around <1 – 60 µg/kg and 0.11 – 5.8 µg/kg respectively. Such reports have been presented below in table.

Table 1.1 Description of Literature review

Country	**BPA**	**Types of food container**	**Types of food**	**Reference**
Japan	0 – 30 ng/g,	Canned	Fish and vegetables	(Yonekubo, Hayakawa et al., 2008).
France	<5 µg/kg	Canned	Food stuff	(Krishnan, Stathis et al., 1993, Braunrath, Podlipna et al., 2005, Cunha, Almeida et al., 2011).
Japan	3.4 µg/kg	Canned	Meat, vegetables, cooked food, fruits	(Kawamura, Etoh et al., 2014)
China	0.20 – 106 µg/kg	Canned	Meat, fish, vegetables, fruits	(Cao, Perez-Locas et al., 2011)
Egypt	6.14 – 710.59 µg/kg	Canned	Meat, vegetables, cooked food, fruits, milk	(Usman and Ahmad 2016)
Norway	0.11 – 5.8 µg/kg	Canned and non-Canned	Grain products, meat products,	(Sakhi, Lillegaard et al., 2014)

			fish, and dairy.	
Portugal	<1 – 60 µg/kg	Canned	Seafoods	(Cunha, Alves et al., 2017)

1.5. Study Focus

In recent years, due to an increase in commercial usage of mushrooms in food and pharmaceutical industries, there has been an increase in the import of mushrooms from all over the world mostly from China into Pakistan. Mushrooms in Pakistan are mostly used in foods commercially. However, they are also being used in home cooking. The type of mushroom that is commonly found in the market is Agaricus bisporus commonly known as Champignons mushroom.

On the other hand, olives are also used to make many products such as olive oil or in shampoos and many other hygienic and food products. These olives are mostly imported from Spain into Pakistan. The use of olive fruits in food got common in recent years with the increase popularity of fast food. In the market Olea europaea, also called olive fruits, are present in many forms but in two types i.e., black, and green olive fruits.

Over the course of 20 years, studies have shown a significant decrease in the presence of BPA in food and decrease in the usage of FCM containing BPA. The level of BPA is much lower than the acceptable limit of BPA/kg/bw/day in most parts of the world. The focus of our study is to see whether BPA in canned food is present or not.

1.6. Study Objectives

1. To identify the presence of BPA in canned mushrooms and canned olives.
2. To identify the presence of other organic contaminants in samples.

CHAPTER 2

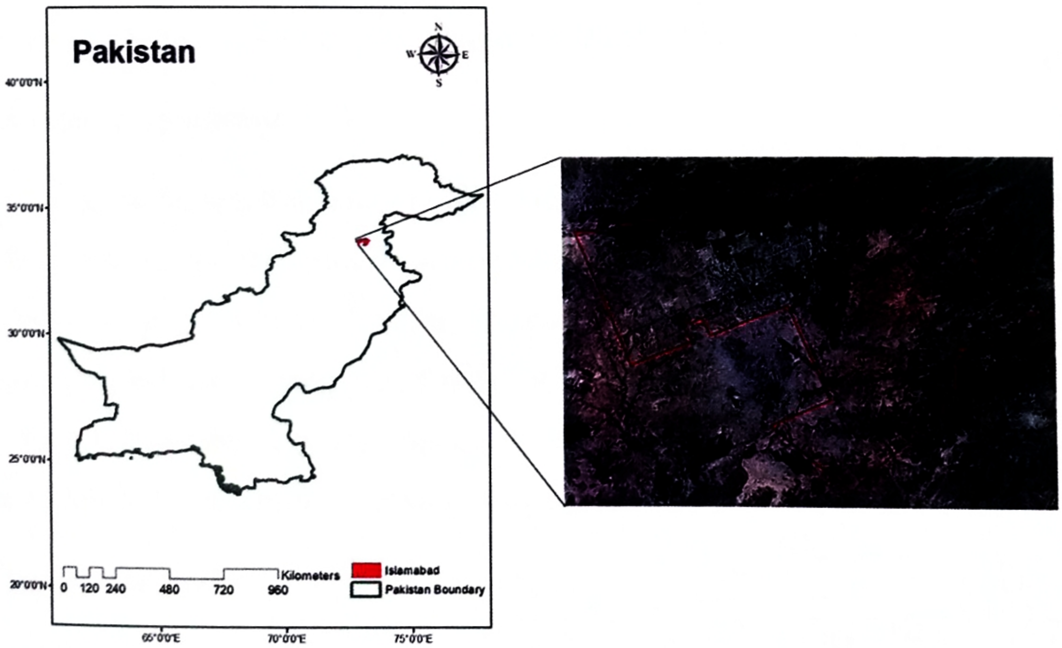
METHODOLOGY

2.1. Sample Area

All of mushrooms and olives that are being used by the people in Pakistan are imported from China and Spain, respectively. They can be found in supermarkets, marts and even in small grocery stores in and around Islamabad, Pakistan.

2.2. Sample collection

The samples in the undertaken study were collected from major departmental stores located in G-11 and F-10 Markaz Islamabad, Pakistan. The mushrooms that were collected for analysis were produced and imported from China. On the other hand, green and black olives were collected from Spain. Among 17 samples 9 were mushrooms and 8 were olives (4 each; green and black).



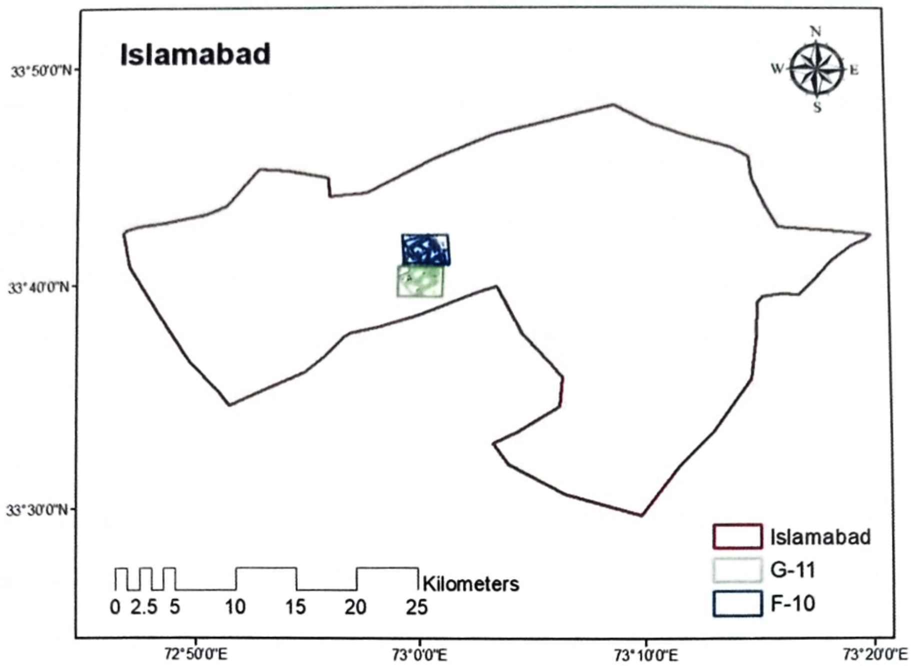


Figure 2.1: Study area map of G-11, F-10 sector Islamabad

The samples were labeled with serial numbers. "A" stands for mushroom sample and "G" for green olives meanwhile, "B" stands for Black olives.

2.3. Sample preparation

Initial steps included rinsing samples with distilled water over a mesh to wash them properly. After rinsing the samples were placed in oven for drying. The temperature of oven was set at 60°C for 24hr duration at constant weight. After the samples were dried, they were grinded and homogenized with the help of mortar and pestle (Yao, Li et al., 2019). Then the powdered mushroom and olives sample were stored in Ziploc bags each separately labeled and sent for analysis using FTIR.

2.4. Sample Analysis

2.4.1 Fourier Transform infrared spectroscopy (FTIR)

FTIR is a powerful analytical technique for qualitative and quantitative analysis of chemical compounds and attached groups in several samples.

2.4.2 FTIR principle

FTIR spectroscopy is based on interaction between Infrared (IR) radiations and sample material that is run under spectroscopy (Griffiths, 1983). FTIR spectroscopy is used to produce emission or absorption spectrum of solid, liquid or gas samples. FTIR spectrometer produces high resolution data information that ranges over a wide spectrum ($4000cm^{-1}$ & $400cm^{-1}$). It has a distinct advantage over other spectrometers. The purpose of spectroscopic technique focuses on quantifying the amount of light which is being absorbed by a sample of interest at specific frequency (Griffiths, 1983, Nandiyanto, Oktiani et al., 2019). It involves measurement of absorption of IR radiation by respective molecules in sample of interest When IR radiation passes through the corresponding sample some amount of it is absorbed at specific frequency with respect to vibration of certain chemical bonds in a sample molecule. The resulting spectrum provides data about chemical structure and composition of certain sample (Nandiyanto, Oktiani et al., 2019).

2.4.3 Basic Component of FTIR

The basic components include.

- Source of IR radiation
- Interferometer
- Detector
- Sample compartment

The interferometer is the crucial component that is responsible for generating the FTIR spectrum. It works. The data is analyzed by measuring the two beams of released IR. The first one passes through samples and the second pass through a reference material. The resulting mathematical spectrum is called interferogram which is used to interpret the results (Hsu, 1997, Chai, Zhang et al., 2020)

2.4.4 Common Application

- Compound identification by matching spectrum of unknown sample with standard spectrum that is used as reference.
- Identification of functional groups of substance that is unknown.
- Identification of plastic, resins, and polymers
- Analysis of insecticides and copolymers (Chai, Zhang et al., 2020)

2.4.5 Samples for FTIR Analysis

State:

All forms (Solid, liquid, gas) of sample can be run under FTIR.

- Solid, 50mg-200mg is preferable. However, 10μg grounded with transparent matrix is used for better qualitative analysis.
- Liquid, 0.5μL.
- Gases, 50ppb.

There are several advantages of using powdered samples for FTIR analysis, such as:

2.4.6 Improved spectral data and quality

Powdered samples give improved spectral quality since the light scattering is minimized.

2.4.7 Homogeneity

Powder sample is homogenous than the bulk which ensures that the powder sample that is analyzed can be considered representative of sample as whole.

2.4.8 Easy handling

Powdered samples are easier to prepare and run into FTIR spectrometer (Raposo 2016)

2.5 Method

The method of analysis for BPA detection in powdered samples of mushrooms and olives under FTIR spectroscopy is stated in a few steps.

Those key steps are:

2.6 Sample preparation

It involves grinding of sample into fine powder with the help of pestle and mortar to ensure homogeneity.

2.7 Sample presentation

Only specific amount of sample (powder) is placed inside of IR-sample holder that is transparent.

2.8 Baseline modification

Prior to analysis process, a baseline spectrum is collected from empty sample holder which later subtracted from the spectrum of sample to differentiate or eliminate the interference if present.

2.9 Spectral Acquisition

The FTIR spectroscopy is initiated to scan the sample in specific range ($4000cm^{-1}$ & $400cm^{-1}$). As the sample interacts with IR radiations FTIR gives an interferogram (Final spectrum).

1.10. Data Analysis

The acquired FTIR spectrum is processed and analyzed to identify the specific band absorption with desired target chemical (BPA). It is done by comparing sample absorption with peaks and curves that are generated in a matrix (Hsu, 1997).

CHAPTER 3

RESULTS AND DISCUSSION

3.1 Results

In this study, 17 samples were run under Fourier Transform Infrared Spectroscopy (FTIR) to investigate the presence of Bisphenol A (BPA) in canned mushrooms and canned olives. A total of 17 samples, comprising nine canned mushrooms of different brands and 8 brands of olives comprising 4 black and 4 green olives. All samples were analyzed to assess the presence of BPA in respective canned food samples.

3.2 Determination of BPA in foods

The presence of BPA was determined by comparing the interferogram peaks of both results of mushrooms and olives with BPA reference spectrum.

Respectively, Table 1 shows the number of attached groups that are only associated with BPA when run through FTIR analysis (Sigma-Aldrich, Long 2004).

Table 3.1 Showing the peak values of BPA.

Compound Class	Type of Bond	Appearance	Absorption	Comments
Phenols, Alcohols	O – H	Broad	3200 – 3400	High Conc.
Alkyl	Methyl	Medium to Strong	2960 & 2870	
Aromatic Compounds	C – H bending	Weak	1650 – 2000	Overtone
Cyclic Alkenes	C = C Stretching	3 – 4 weak to strong peaks	1450 – 1600	
Phenol	O – H Bending	Medium	1390 – 1310	
Secondary Alcohol	C – O	Strong	1124 – 1210	

Vinyl Ether	C – O	Strong	1075-1020	
Aromatic	C – H	Strong	750 – 850	Benzene

3.3 Interpretation of mushroom samples

The FTIR analysis of canned mushroom produced surprising evidence that strongly supports the presence of BPA in respective mushroom samples. Spectral data of all mushroom samples are demonstrated that reveal extremely distinct absorption peaks corresponding to BPA-specific attached functional groups that are shown in table 3.1.

The strongest peak 1 at 3200 cm^{-1}-2400 cm^{-1} in all mushroom samples (1A-8A) is associated with phenol and alcohol group which is also O-H attached group that is found in BPA spectrum. While the Alkyl group that is encountered is at 2960cm^{-1}-2870cm^{-1} on peak 2 was also framed on BPA spectrum. In addition to that peak 3 and peak 4 are respectively weaker than the rest. The spectral range of both are 1650 cm^{-1}-2000 cm^{-1} and 1450 cm^{-1}-1600 with C-H bending and C=C stretching. Out of all peaks 5,6,7 is the strong one possessing the C-O as ether, C-O as secondary alcohol and C-H in form of aromatic group which are highly associated with BPA. All of the BPA related attached groups could be noticed in all the mushroom sample spectrum (Ullah, Ahmad et al., 2016).

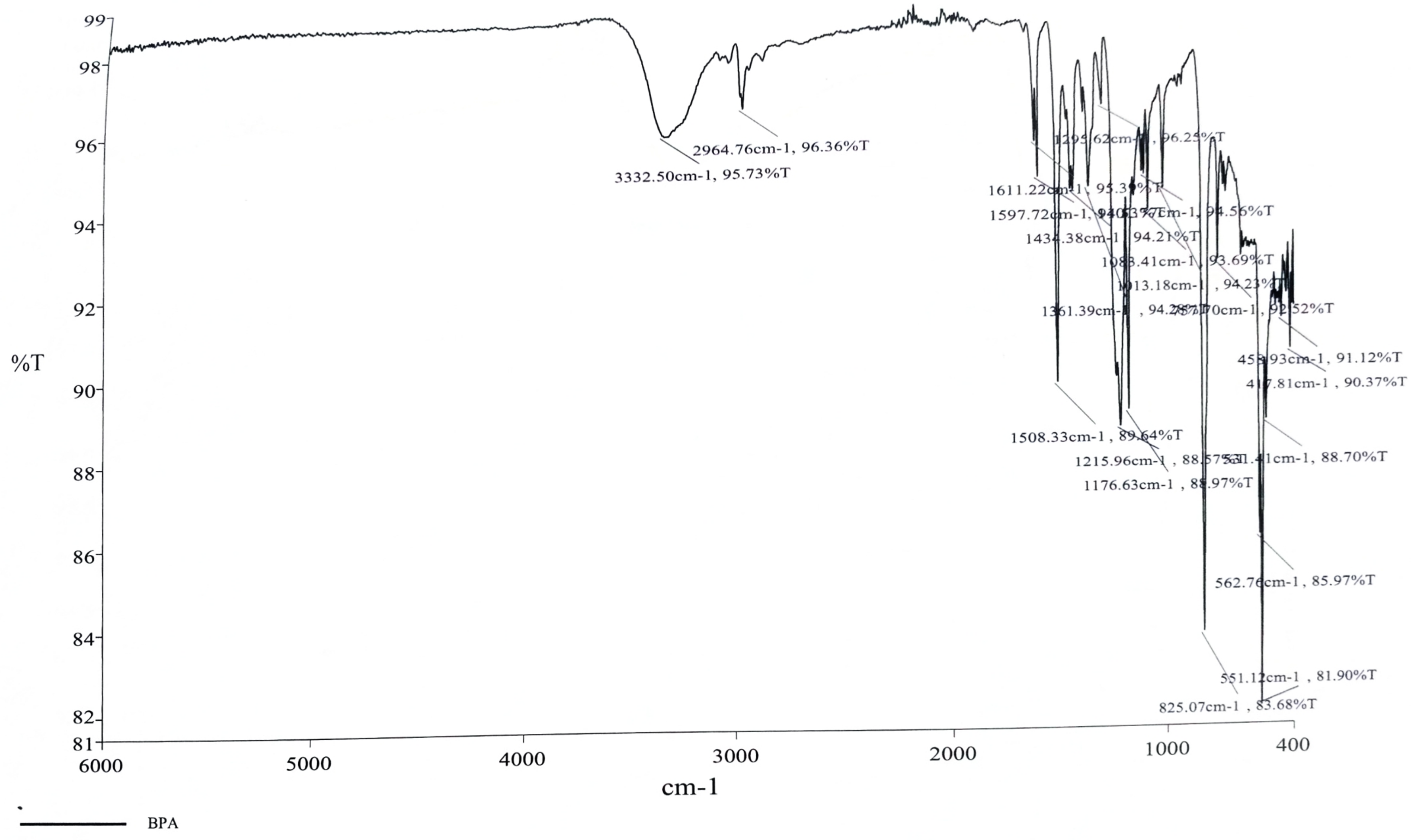


Figure: 3.1 BPA Standard FTIR

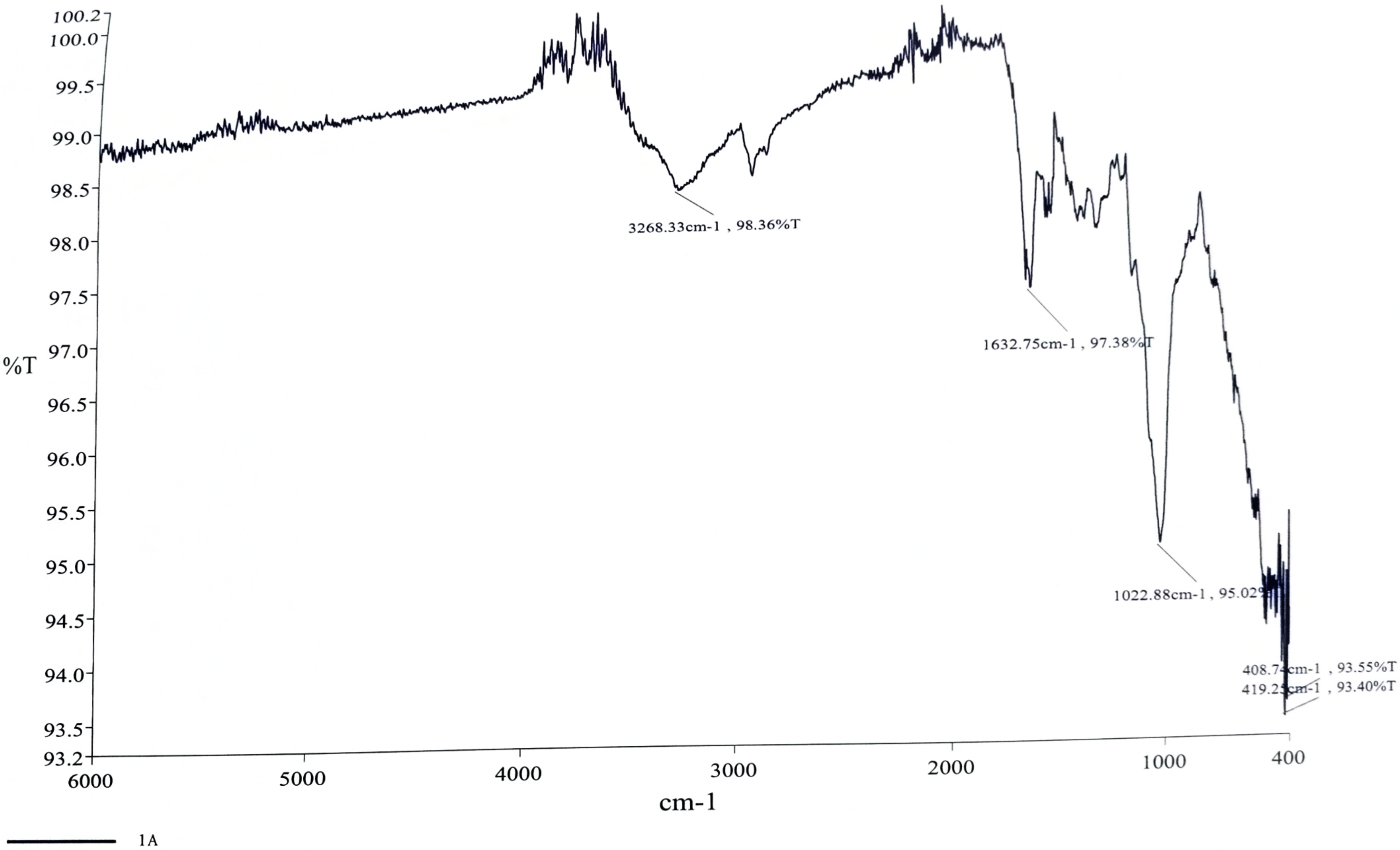


Figure: 3.2 Mushroom Sample 1A

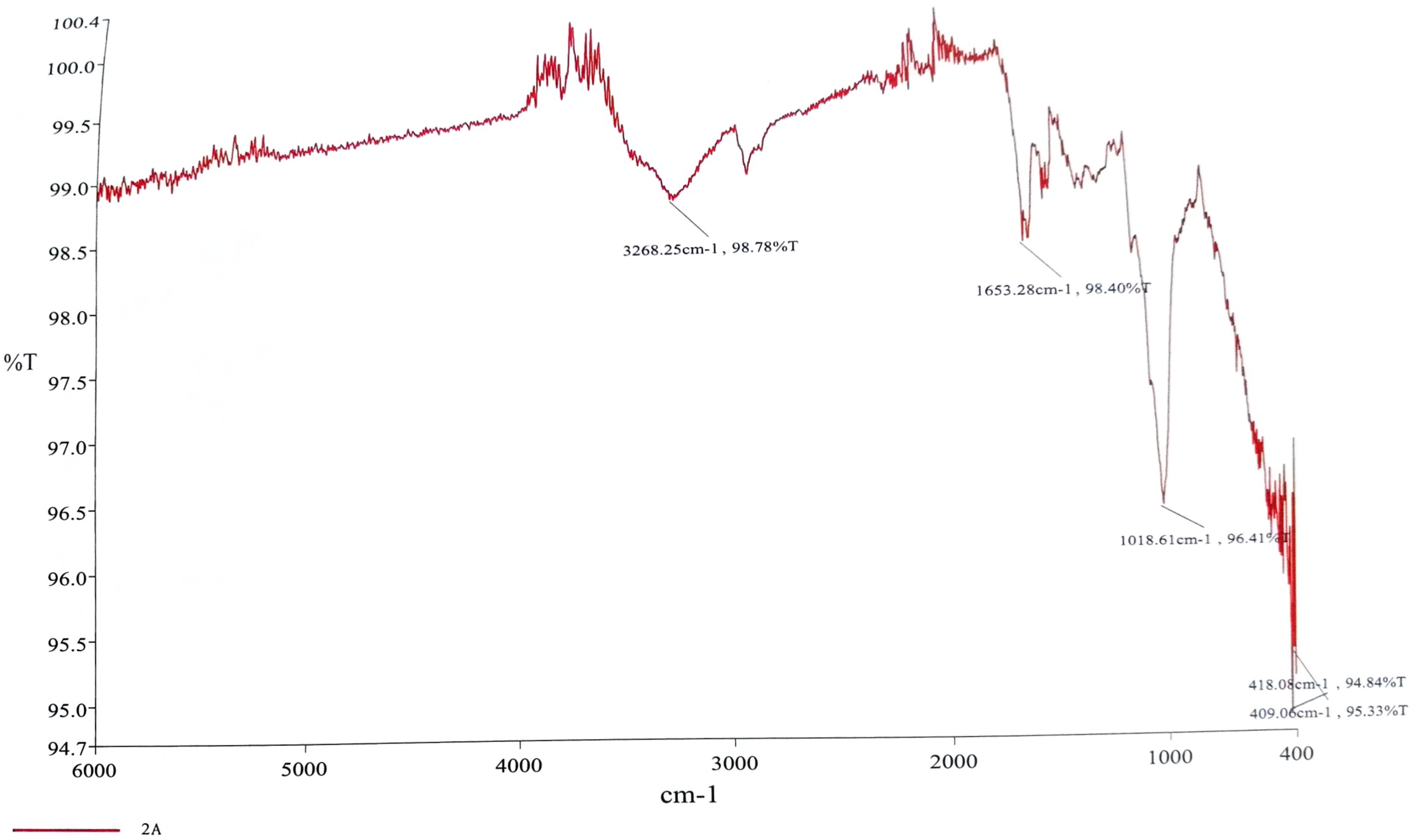


Figure: 3.3 Mushroom Sample 2A

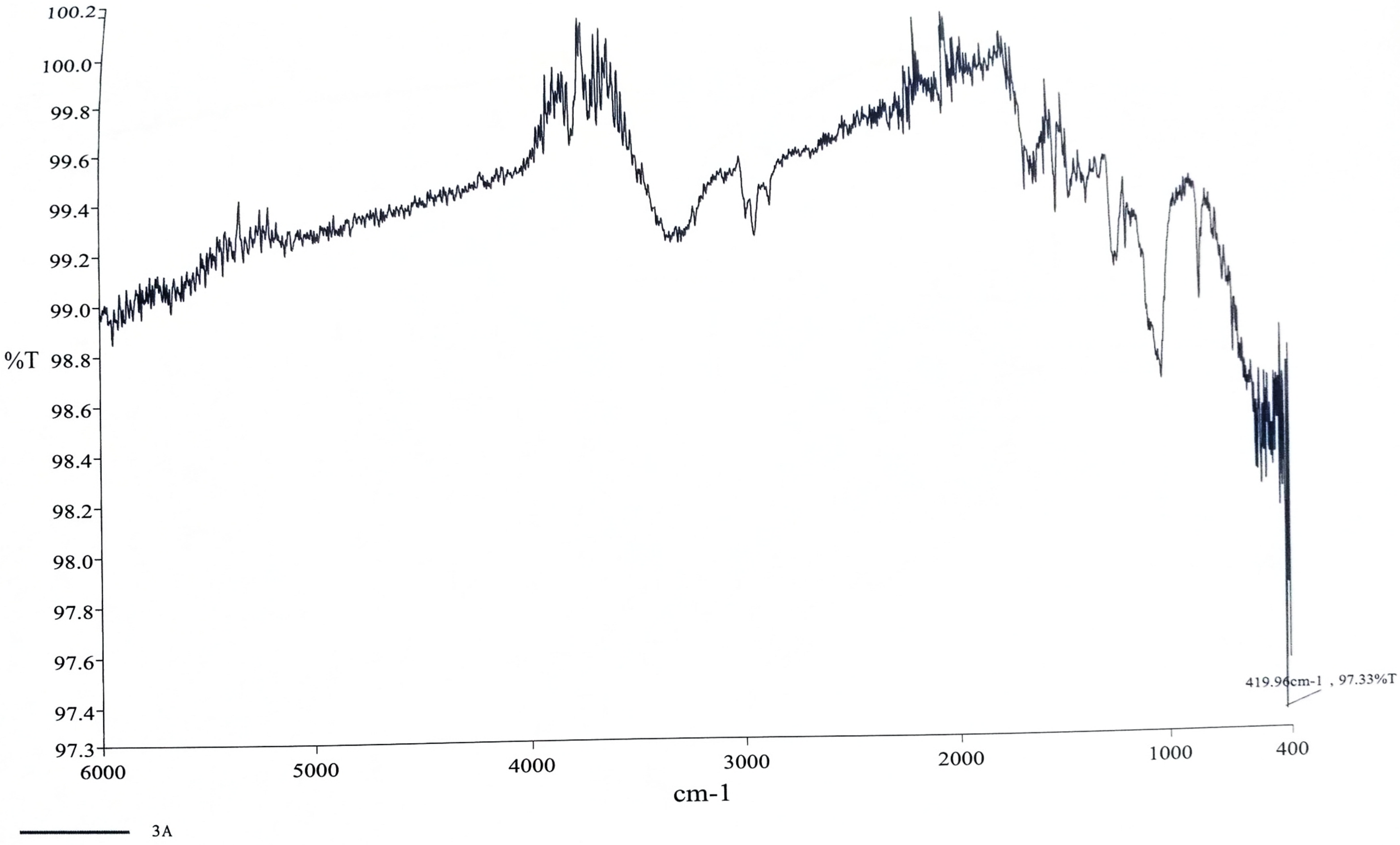


Figure: 3.4 Mushroom Sample 3A

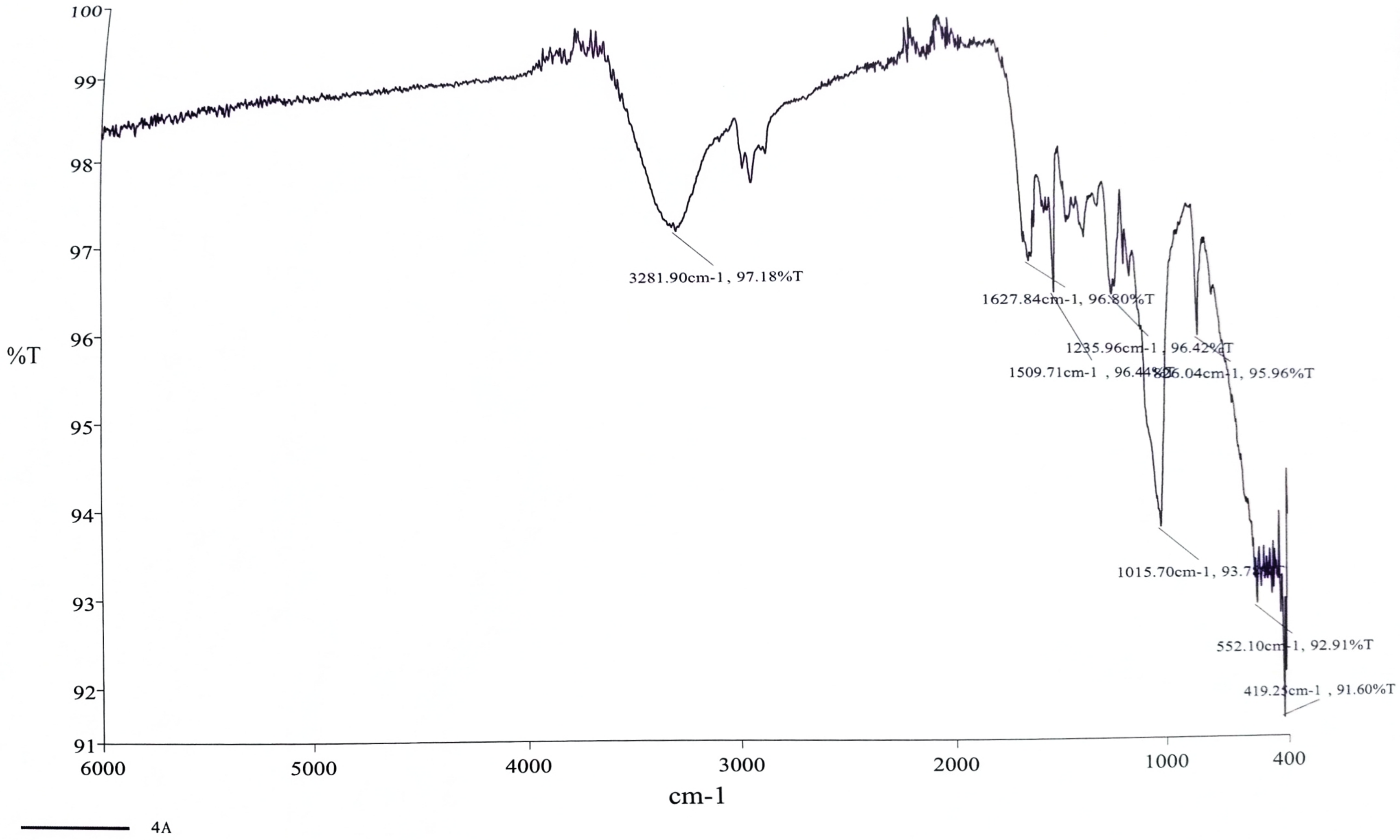


Figure: 3.5 Mushroom Sample 4A

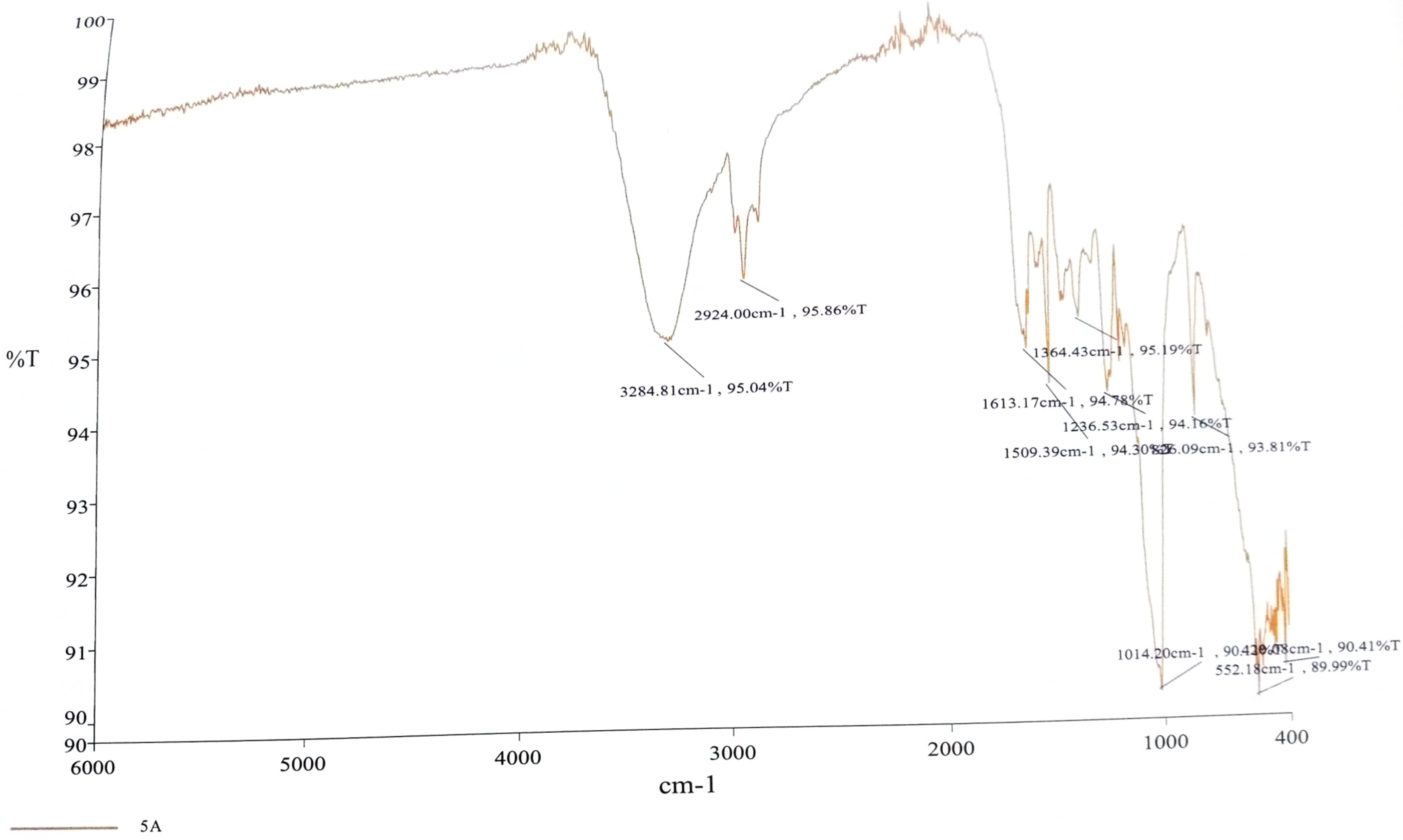


Figure: 3.6 Mushroom Sample 5A

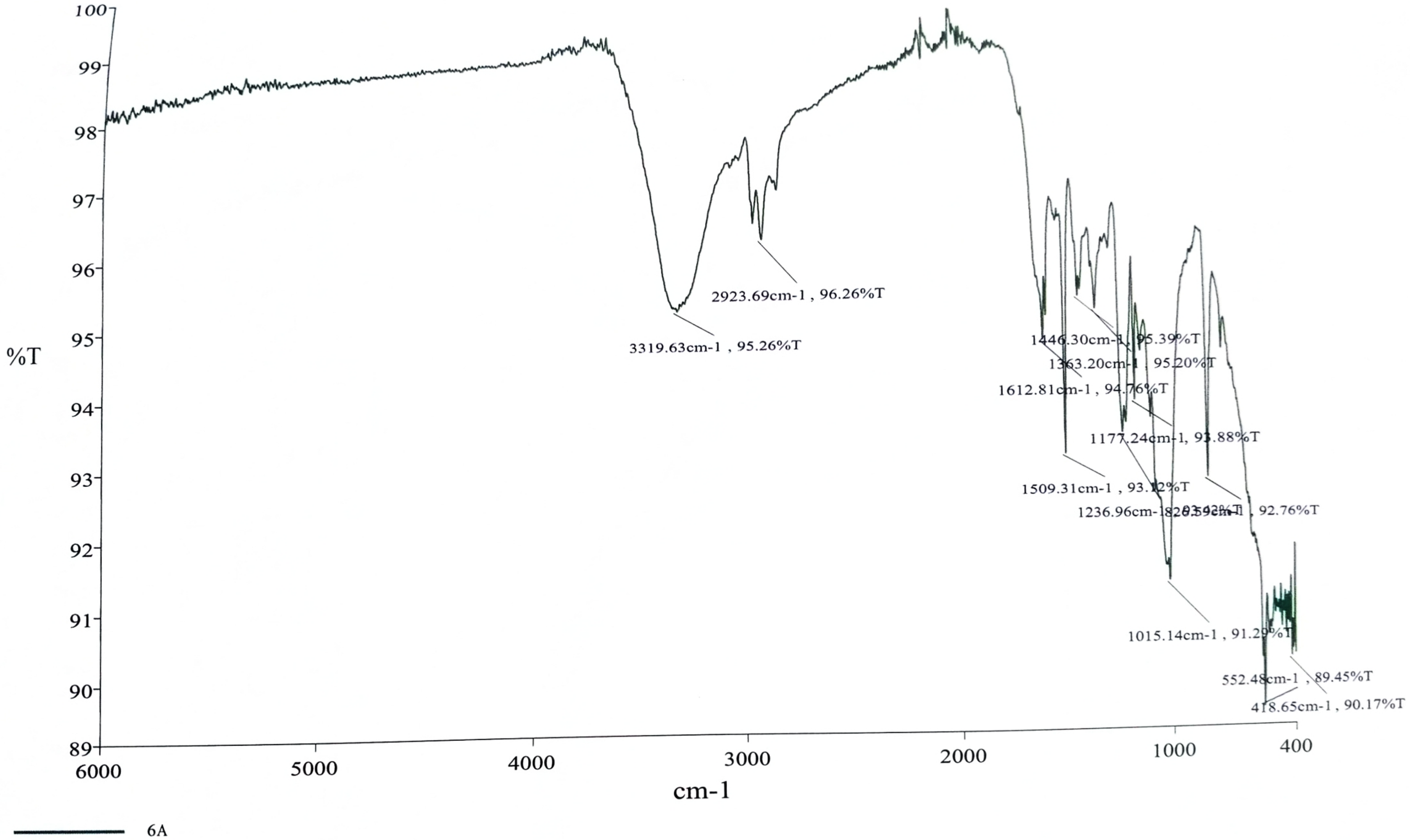


Figure: 3.7 Mushroom Sample 6A

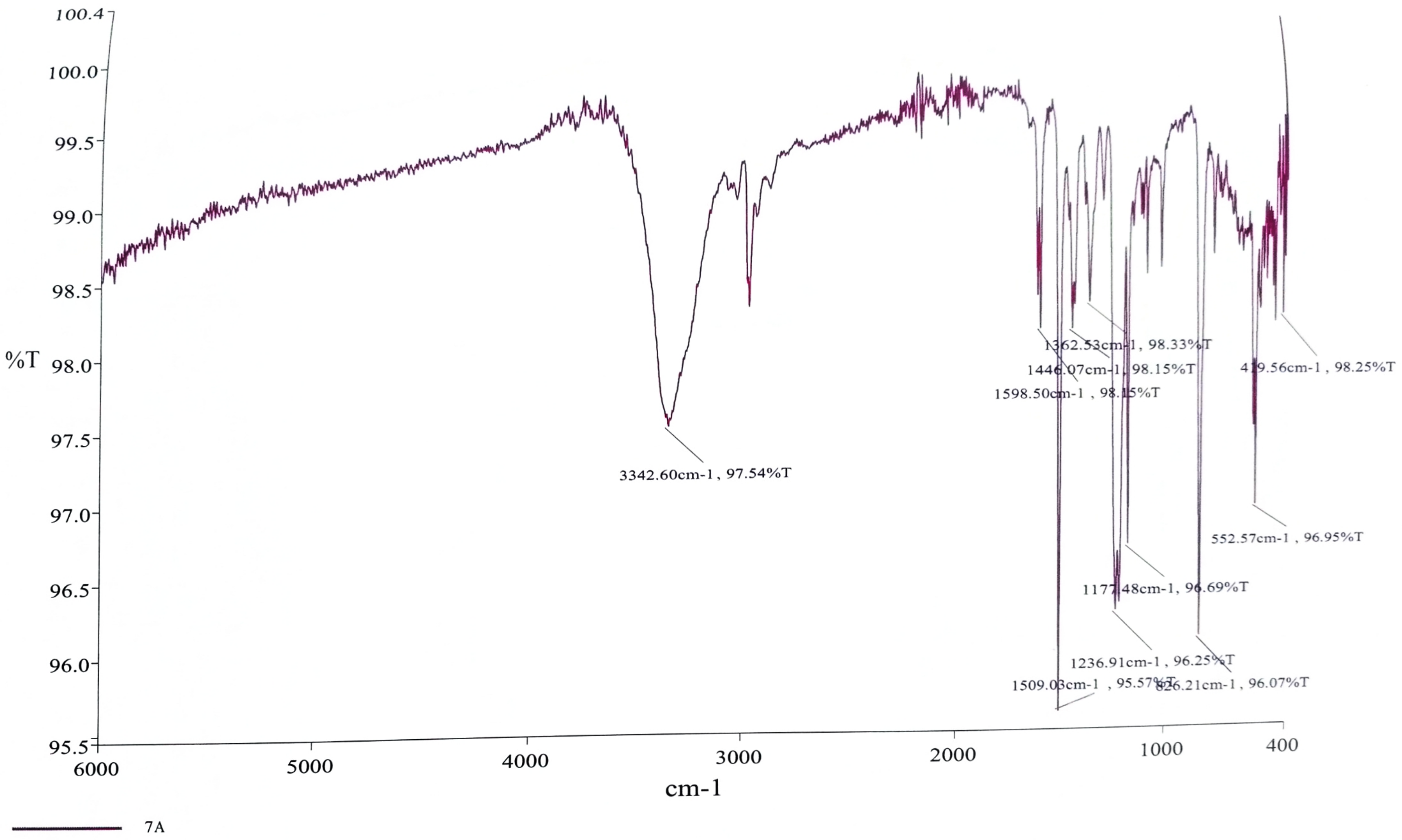


Figure: 3.8 Mushroom Sample 7A

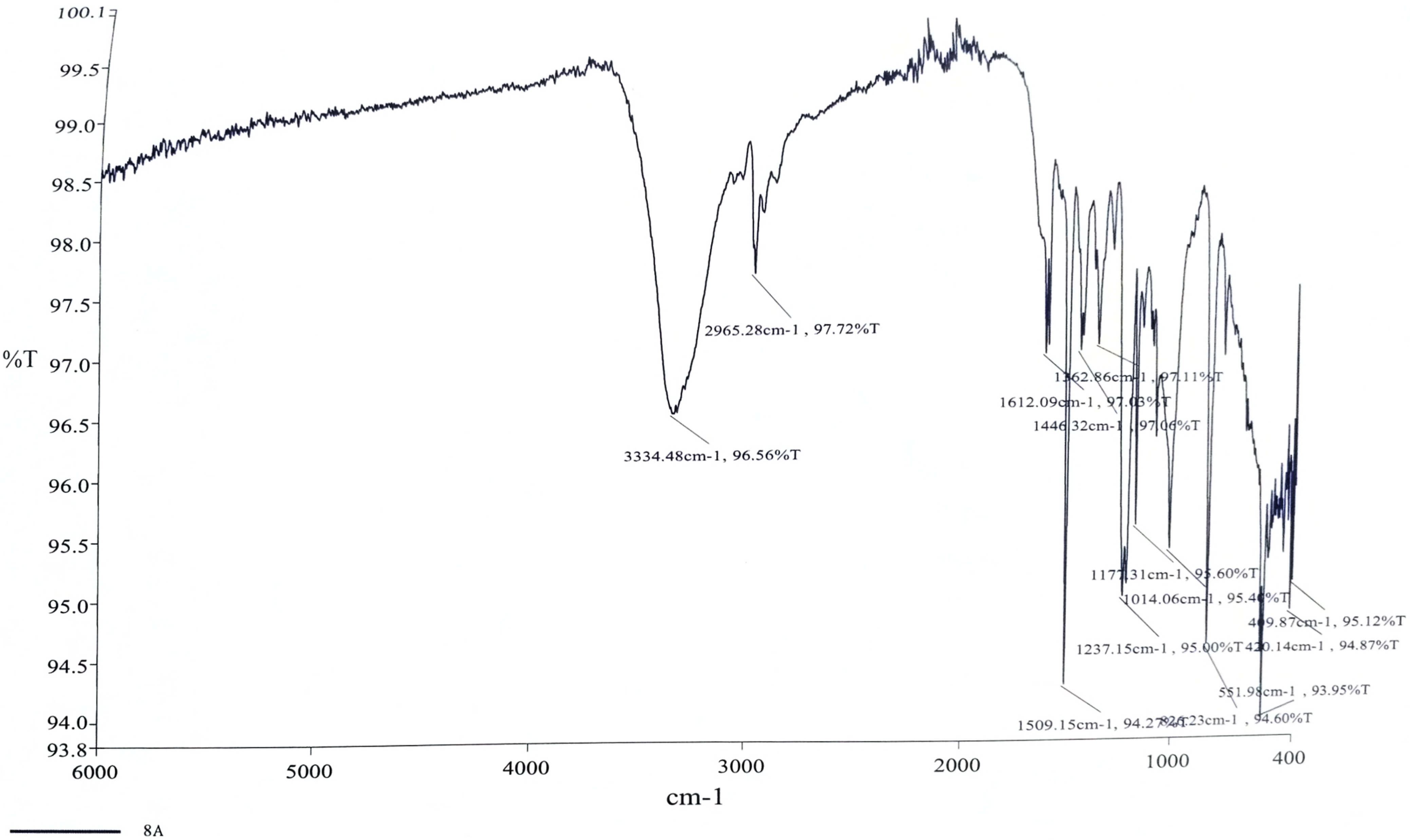


Figure: 3.9 Mushroom Sample 8A

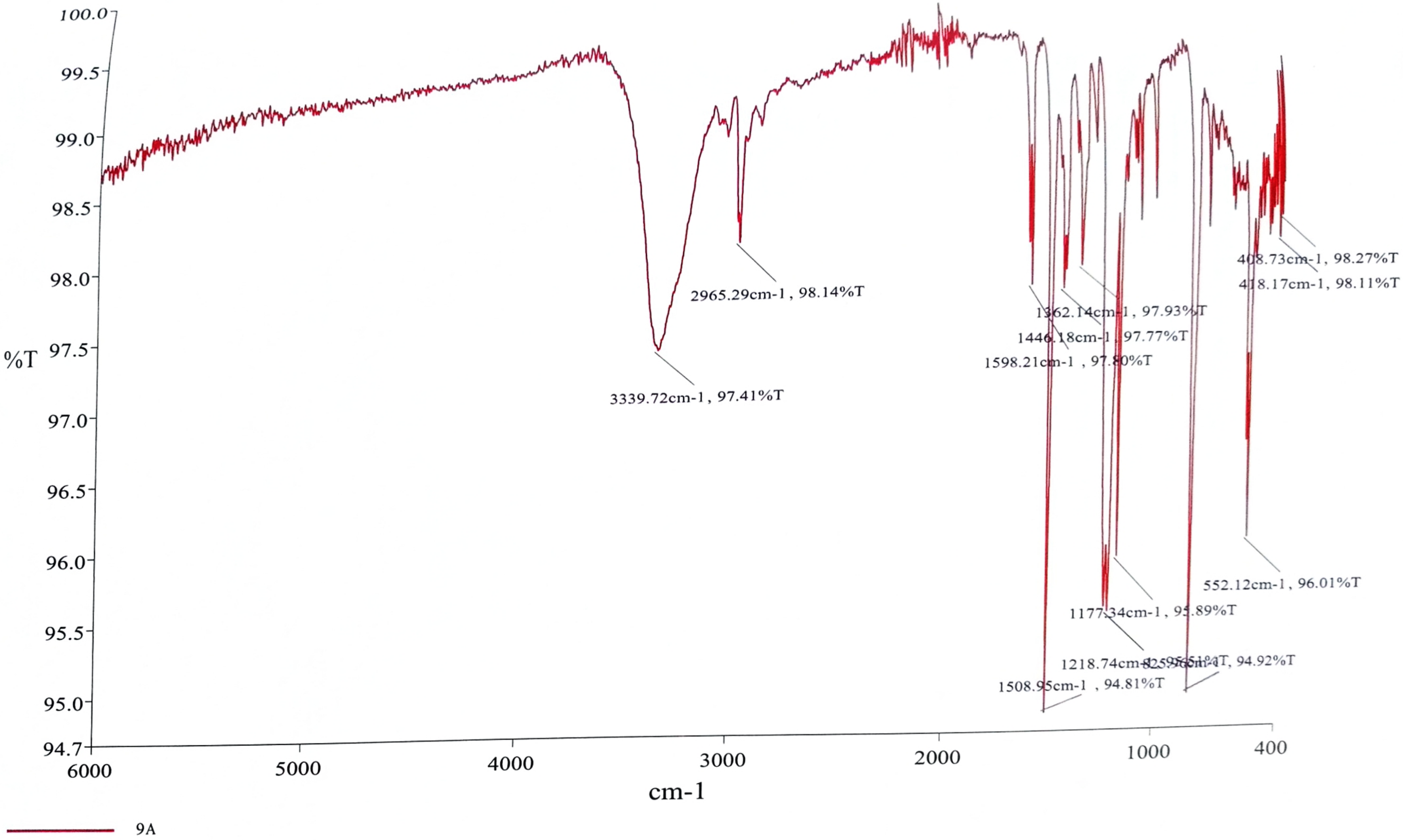


Figure: 3.10 Mushroom Sample 9A

3.4. Interpretation of olive samples

The FTIR analysis of canned olives produced remarkably contrasting and opposite results as compared to mushroom samples. The absorption spectrum of both BPA standard and olive samples was interpreted properly and the peaks of 1G-4G and 1B-4B spectrums were of totally different ranges. The olive sample spectrum did not correspond with the BPA reference spectrum. All the major peaks in the graphs are its natural peaks of olive (Mahesar, Lucarini et al., 2019) however, the sample shows an unnatural peak of organophosphorus compound (P-C group) which is noticed at a range of 1464 cm^{-1} (Long 2004).

Organophosphorus (O=P(OR)3) originated from chemical compounds which contain phosphorus and derived from phosphoric acid. The major reason for their development is agricultural purposes.

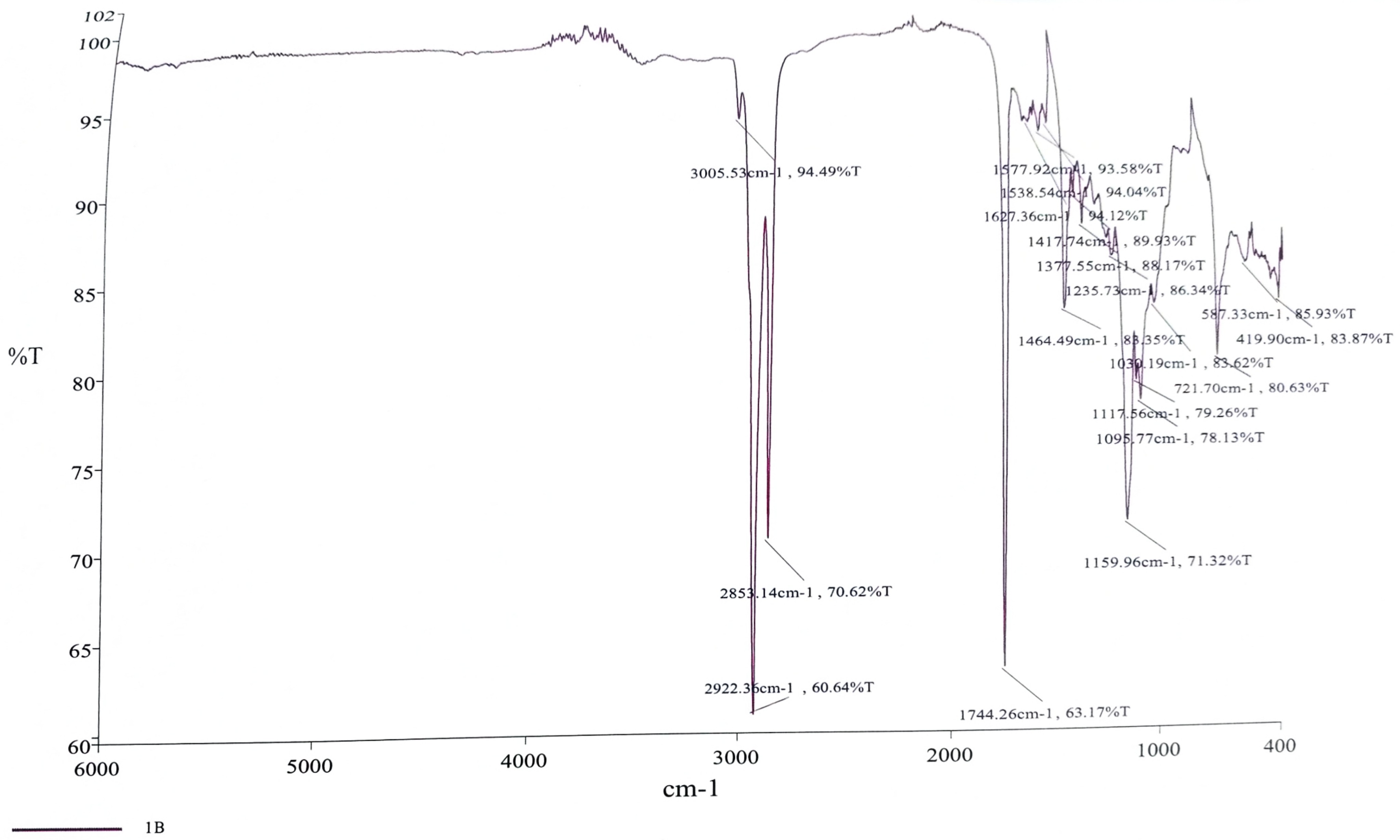


Figure: 3.11 Olive Sample 1B

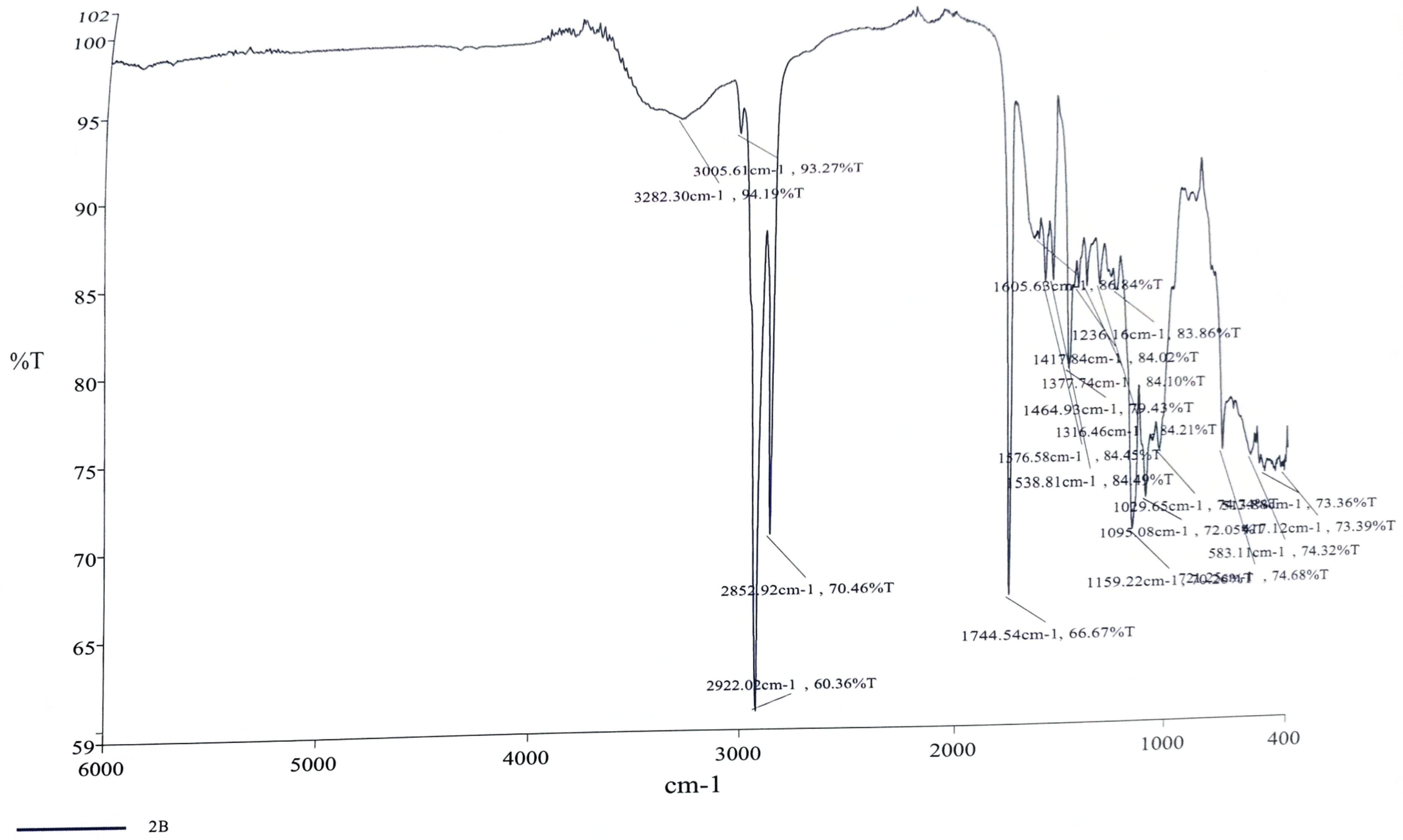


Figure: 3.12 Olive Sample 2B

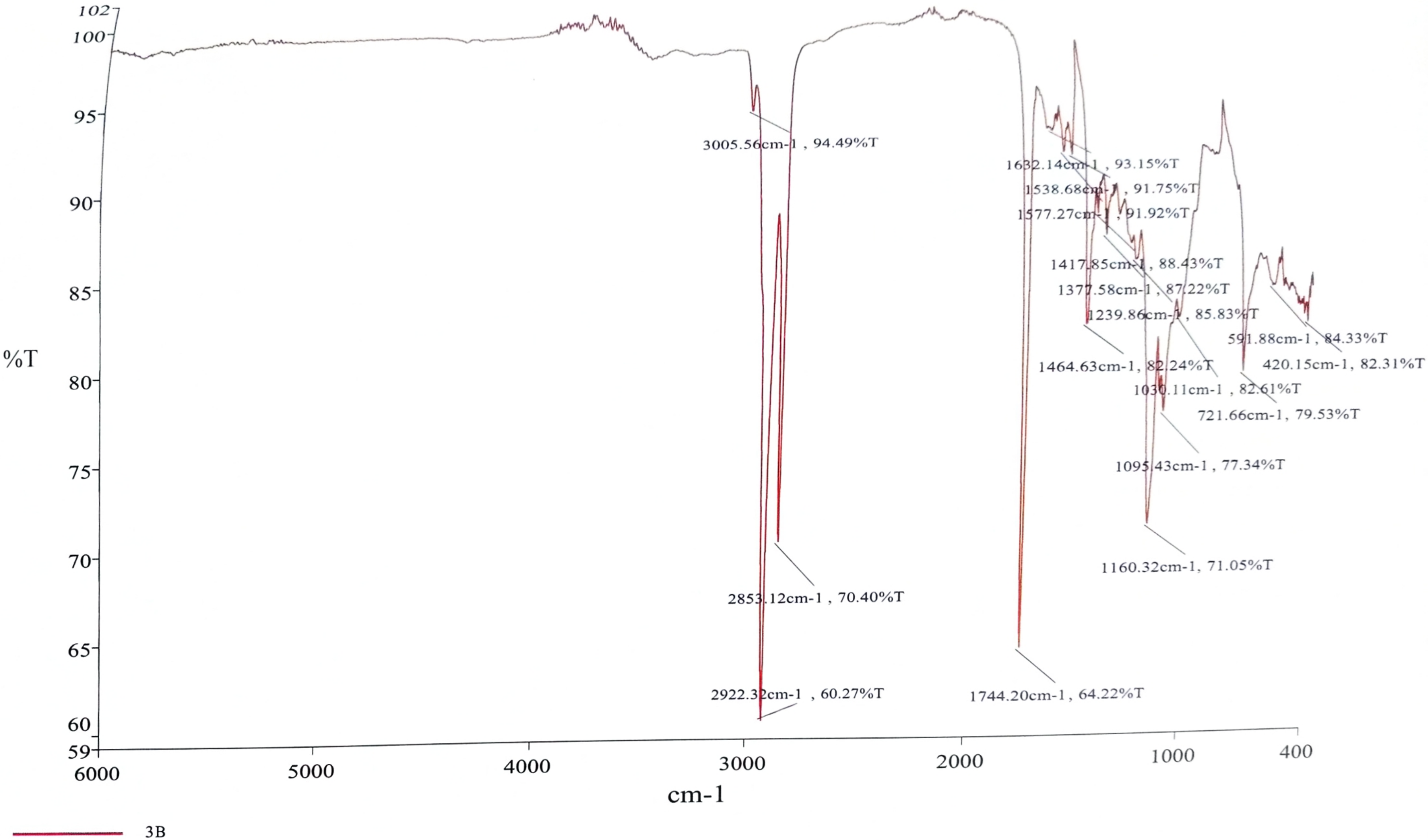


Figure: 3.13 Olive Sample 3B

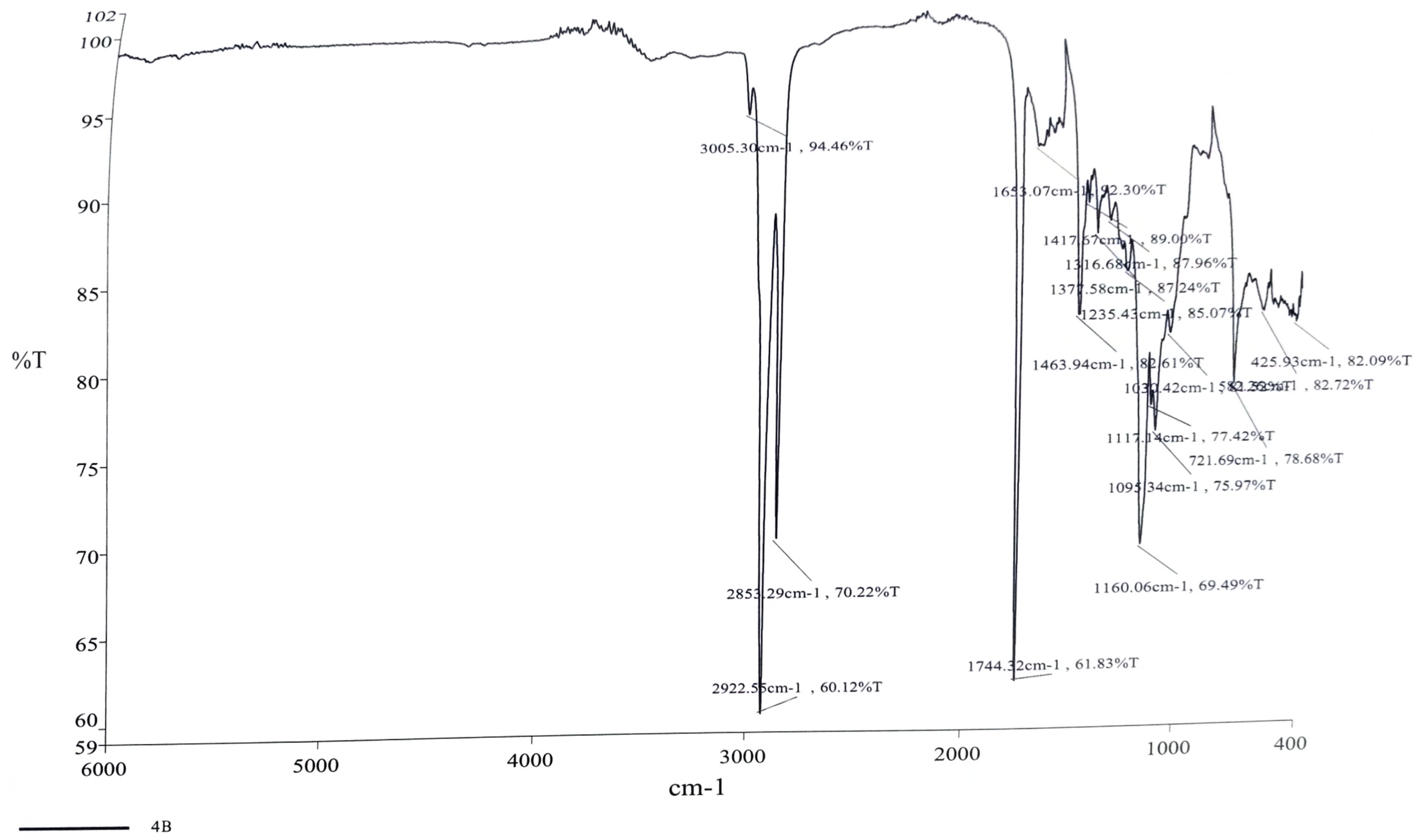


Figure: 3.14 Olive Sample 4B

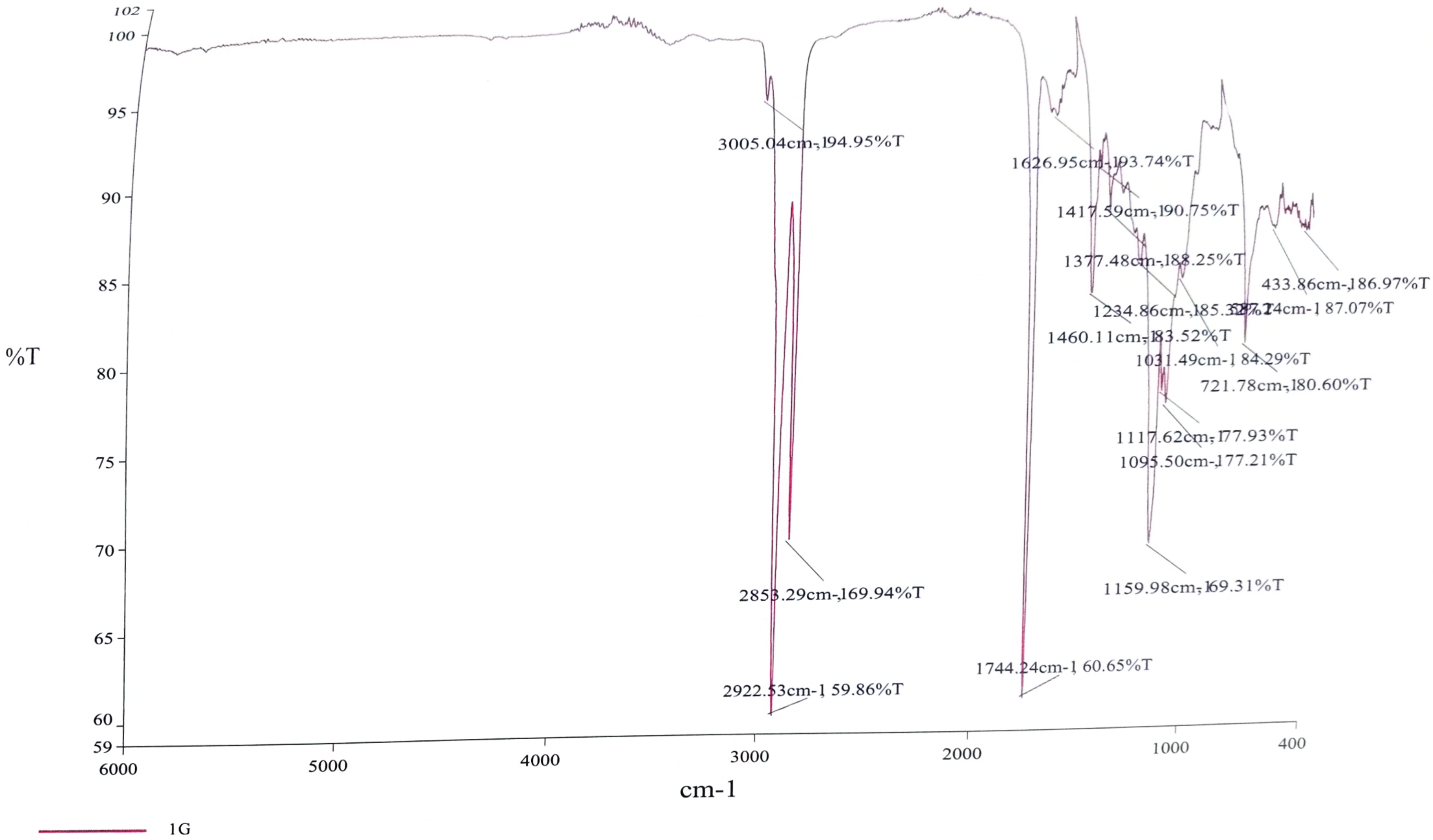
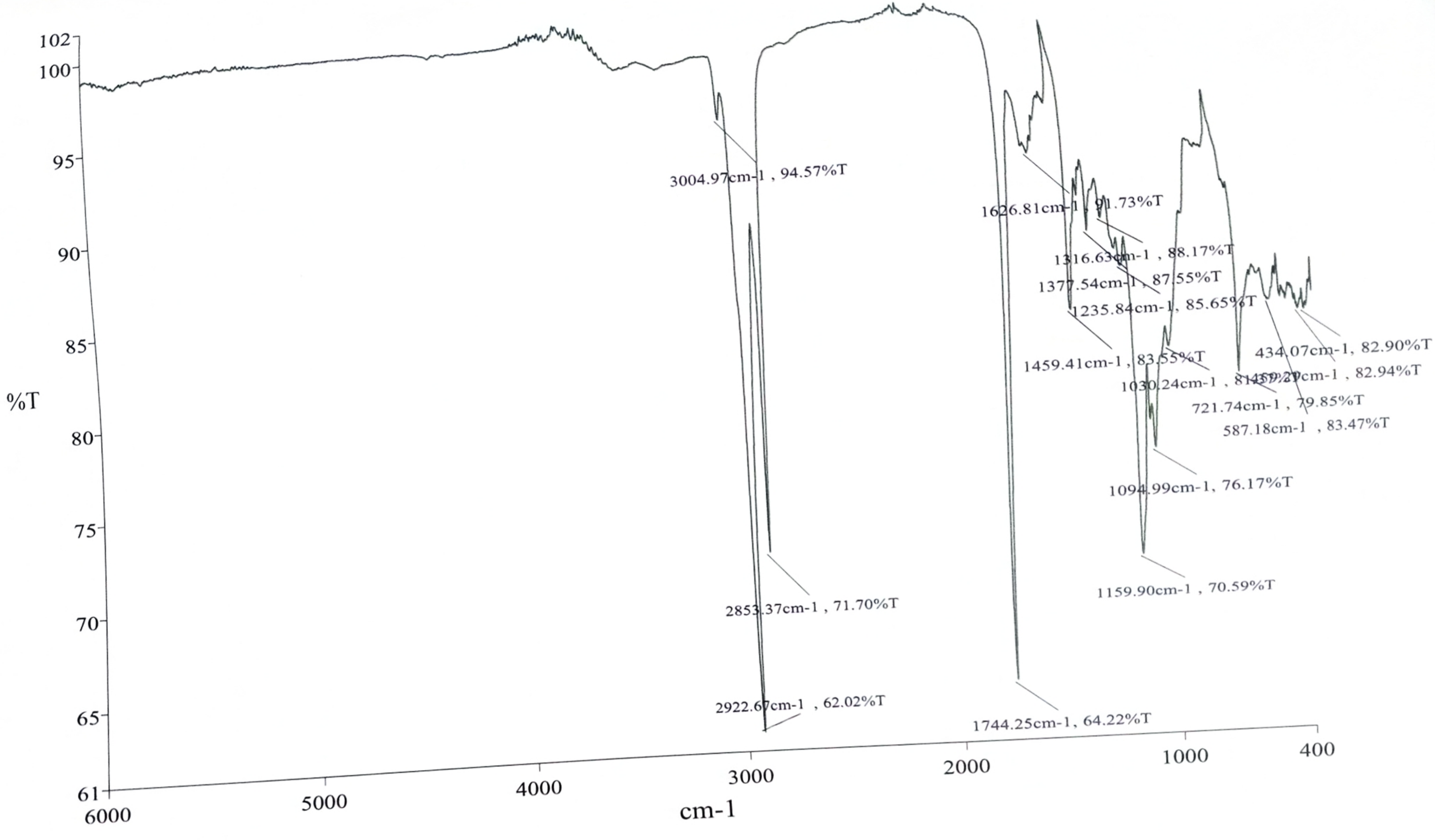


Figure: 3.15 Olive Sample 1G



2G

Figure: 3.16 Olive Sample 2G

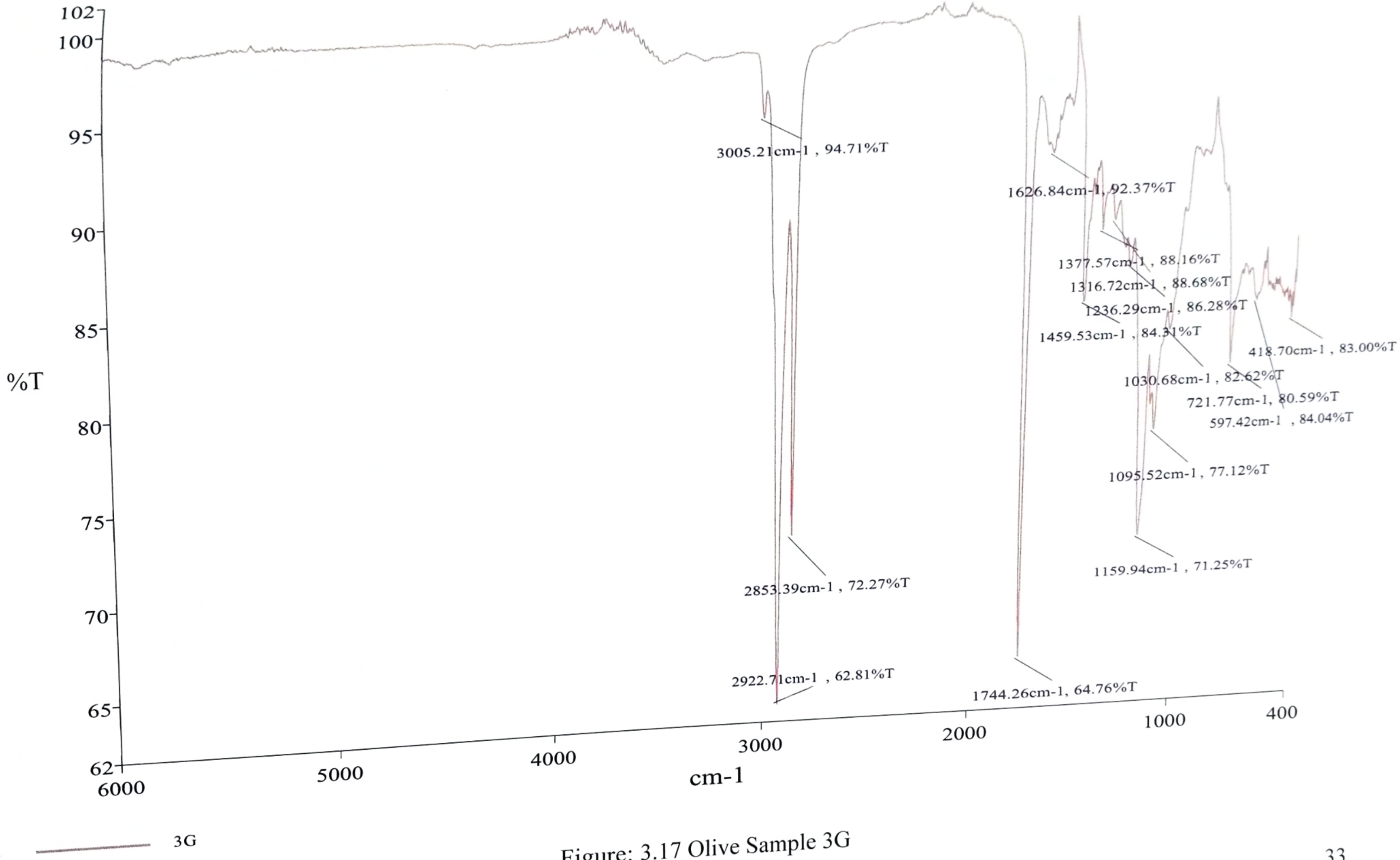


Figure: 3.17 Olive Sample 3G

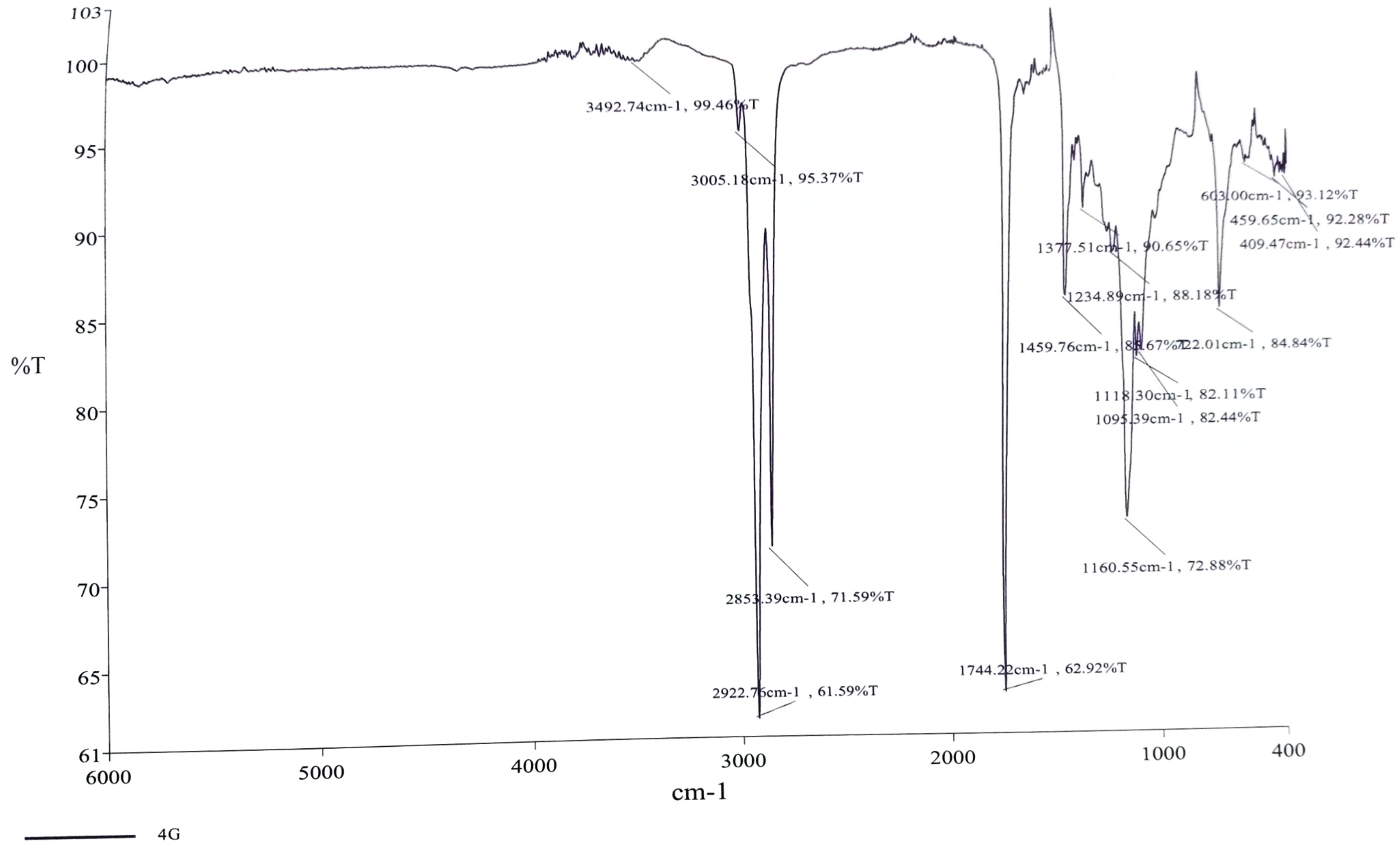


Figure: 3.18 Olive Sample 4G

3.5 New Findings

With respect to present prevailing trend in the research literature, our study supports the evidence for presence of BPA used inside of a can for coating whose purpose is to act as a barrier between food and metal can also providing improved shelf life of mushroom and to prevent corrosion. However, it has rejected the hypothesis of presence of BPA in olives. The major reason olive didn't provide any proof for presence of any Bisphenol or constituents is because they were packed in glass jars even having filled with acetic acid that triggers the leaching of BPA. There have been several studies that concluded the presence of BPA in metal canned food is extremely higher than the food packed in glass jars is due to material difference.

However, Organophosphorus, another contaminant was discovered in olive samples at the range of 1464cm^-1 which is used in the agriculture sector. It has plenty of applications including pesticides, insecticides, and several other industrial chemical formations.

Previous research on BPA detection in canned foods

Our study findings closely align with the studies that have been done in past for investigating Bisphenol and its types in canned food especially mushroom and olives. Since BPA is widely used coating chemical used in almost all the food and beverage containers numerous studies have been done to examine the BPA presence and concentration. Careful literature review was done on the respective research topic that is cited in many places. The food toxicology domain has raised many concerns regarding human health issues badly impacted by BPA in several studies.

There has been a brief analysis carried out on Bisphenol and its counter parts in canned food stuff and reported the presence of BPA in tested samples. Similarly, another study produced significant results about presence of BPA in canned vegetables and the leaching of BPA from container linings into food during transporting and storing processes (Bolognesi, Castle et al., 2015, Luo, Chen et al., 2019).

The important and crucial aspect of our research lies in the determination between these two types of canned foods with respect to presence of Bisphenol and its types.

Nevertheless, literature as well as our findings suggests that the BPA level in respective canned foods may be dependent and corresponding to certain factors such as pH, lining material quality, storage temperature, transportation manner, and manufacturing processes that were employed (Wilson, Chuang et al., 2007).

3.6 Sources

3.6.1 BPA

The most important and major source of BPA is often attributed to epoxy resins that are used to coat the inner walls of containers (Qu, Zhang et al., 2022). The purpose of these resins is to prevent corrosion and to improve storage life. Over time BPA leaches into food material causing adverse health impacts on human life (Cao, Perez-Locas et al., 2011).

In addition, can walls and linings, other source could which are pointed in literature are adhesives that are employed inside of lids and recycled chemical and material that is used in it (Krishnan, Stathis et al., 1993, Braunrath, Podlipna et al., 2005, Cunha and Fernandes 2013).

BPA exists exist in several forms that are already mentioned in the study those are Bisphenol A and Di glycidyl Ether (BADGE). BPA is a free compound that migrates into food while BADGE enters food in a result of reaction from fixing resins that are used in lids and linings (Wilson, Chuang et al., 2007). Apart from aforementioned chemicals it is extremely essential to acknowledge intense concerns with respect to micro-plastics. They can also act as BPA carriers in an environment that potentially introduces such micro plastics and chemicals in food chain.

3.6.2 Organophosphorus

In the case of Organophosphorus major source that has been identified in literature is pesticide that is used onto crops in agricultural sector from which Organophosphorus migrates into human body after consumption of contaminated vegetables (Jaga and Dharmani 2003, Luxton and Hart 2005, Darko and Akoto 2008).

3.7 Health impacts

3.7.1 BPA

According to United States Environmental Protection Agency (EPA) the reference dose of BPA is 50µg/Kg bodyweight/day. After a lot of risk assessment research of BPA and its health effects, the European Food Safety Authority (EFSA) has lessened the tolerable daily intake (TDI) to 4 µg/Kg bodyweight/day in 2015. (Husøy, Beausoleil et al., 2015). In April 2023, EFSA after further studying the effects of BPA have lowered the TDI of BPA from 4µg/Kg bodyweight/day to 0.2ng/Kg bodyweight/day. Since the impacts of BPA on human health depend on the concentration that is entering the human body, the consumption rate of canned foods would decide whether to accelerate or decelerate organ degradation or chronic impacts vice versa.

According to the study conducted in 2013, BPA has been proven as endocrine-disrupting agent and contributing to reproductive disorders and carcinogenicity (Rochester 2013). Moreover, BPA triggers the cardiovascular disorders in humans according to the study done by (Lang, Galloway et al., 2008) in U.S. In addition to that several health-related problems have been caused due to the influence of BPA and its intrusion in the human body system. Such as (Vandenberg, Hunt et al., 2019) has conducted a review study on adverse impacts of BPA on human health that states the BPA acts by disturbing reproductively, neurological balance and natural growth.

These aforementioned research studies highlight the widespread presence of bisphenol and other chemicals in canned food stuff that raise serious concerns regarding potential harmful health Impacts particularly chronic disorders,

3.7.2 Organophosphorus

The exposure of Organophosphorus leads to various health related issues including nausea, headaches, dizziness, muscle weakness and in some cases Organophosphorus poisoning that could be lethal. Respective chemical is also toxic to ecosystem and biodiversity that is exposed to it. There has been a study conducted in 2003 on environmental impacts of Organophosphorus that highlighted the harmful impacts of Organophosphorus in ecosystem and their persistence (Jaga and Dharmani 2003). In addition to that a study done in U.S on Organophosphorus pesticide exposure and its health impacts on human body in 2007 which stated the cognitive deficit linked with Ops exposure in young children (Eskenazi, Marks et al., 2007).

CONCLUSIONS

1. In mushroom samples the presence of BPA was detected and in olive samples the BPA was absent
    - ❖ Seven identified compound class present in BPA were present in the mushroom samples including O – H bending of phenol and Alcohols, Methyl, Phenols, cyclic Alkenes, Aromatic compound, Benzene. The relationship of presence of BPA in canned food might be highly dependent on the nature of FCM. The mushroom showed the presence of target chemical. It might be because of FCM that is particularly metal can, while the olives were packed in glass jars this could be a reason olive sample did not approve presence of BPA.
2. However, the presence of Organophosphorus an organic contaminant was detected olive samples.
    - ❖ This study also pointed out that the migration of harmful chemicals such as Organophosphorus from pesticides that are applied. We have concluded there might be many other pesticides and insecticides present in other vegetative food material as well and could be causing adverse health impacts.

RECOMMENDATIONS

1. It is recommended that food and health regulatory authorities should carry on continuous monitoring and regulatory analysis of BPA and other NIAS regarding canned food.

2. This study was qualitative, it is recommended that further quantitative studies should be carried out in this respective domain to investigate whether the presence of these organic chemicals fall in the safe limit for consumers.

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BPA in canned mushrooms and canned olives

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