This is to certify that the
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THE CHARACTERIZATION OF AUTOMOBILE BODY FILLERS

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SARA CHRISTINE MCNORTON

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of the requirements for the

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Major Professor's Signature

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Date

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THE CHARACTERIZATION OF AUTOMOBILE BODY FILLERS

By

Sara Christine McNorton

A THESIS

Submitted to
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ABSTRACT

THE CHARACTERIZATION OF AUTOMOBILE BODY FILLERS

By

Sara Christine McNorton

Body fillers and spot putties are sometimes encountered with paint evidence from hit-and-run accidents in forensic casework. It is a challenge for the forensic scientist to attempt to classify and compare the body fillers since no research has been published on the subject since 1986 when Walsh, *et al.* compared body fillers in New Zealand.

The objective of this study was to determine if chemical and physical differences in body fillers from various manufacturers existed and could be identified. A Perkin-Elmer Spectrum One FTIR Spectrometer, a stereoscope and a Hewlett Packard 5890 Series II Gas Chromatograph were used to analyze the body filler and spot putty samples. The results of this study are of significant value because they will provide useful data for trace evidence examiners when examining body fillers.

Extensive research was done to obtain a complete sample of light-weight automobile body fillers and spot putties used in the United States. After all the samples were identified, thirty-three were obtained. Twenty-four of the samples were body fillers and nine were spot putties. Nine different companies were identified as the manufacturers of these 33 samples.

ACKNOWLEDGMENTS

I would first like to acknowledge Guy Nutter for your interest, enthusiasm and support for this project. You have been a great source of knowledge and help! Thanks also to Cheryl Lozen and Guy Nutter for making my internship with the Michigan State Police a valuable learning experience and fun too! Additional thanks goes to Dr. Siegel, for your ongoing support, encouragement and care.

A final thanks to my family, friends and to Phil, who have provided ongoing love and support. I appreciate you putting up with me, especially during my trying times! I could have not done as well with my Master's and this project without you!

Lastly, thank you to the Midwest Association of Forensic Science (MAFS) for generously providing the funding for this project.

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INTRODUCTION

Interest in the field of forensic science is becoming more popular and scientists are constantly looking for new types of evidence to characterize from scenes of crimes. Since criminals are becoming more aware of the presence and use of fingerprints and DNA as individual evidence, they are becoming more conscientious about not leaving that type of evidence behind. Thus, trace evidence is becoming more and more important as it is this evidence that is left behind that may seem insignificant to the criminal, but may eventually lead to circumstantial proof that she or he could have committed the crime in question.

Automobile body fillers have been used extensively in repair shops and by individuals to aid in fixing minor body damage that may have occurred as a result of an accident. Since the bond between the filler and the metal pieces of the car is relatively weak, pieces of filler are usually removed along with adhering paint chips in traffic accidents (Home *et.al*, 1980).

Through multiple conversations with body repair shop mechanics, it was determined that the light-weight brands of body fillers are used most commonly due to their prevalent use in repairing damage to the metal in automobiles. Other degrees of fillers are commercially available (heavy-weight), but were not studied here due to the fact that they are mostly used to repair damaged plastic parts. In addition, a new trend was learned from the body repair shops, which is to replace a damaged part with a plastic one, rather than fixing the damage to the metal with automobile body filler. This information is relevant to the trace evidence examiner as the prevalence of automobile body filler encountered in casework

will be less, however, if it is encountered, it could be considered as unique evidence.

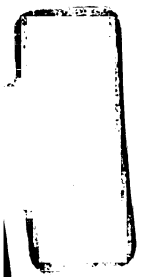
Purpose of this Research

The purpose of this project was to propose an analysis scheme for analyzing an unknown body filler or spot putty sample. Since this type of evidence is considered class evidence, the best way to classify it into the smallest group as possible is to use an analysis scheme comprising multiple analysis tools, since an individualization will never be possible. The idea for this project originated from examining cases involving automotive paint with body filler attached to it. In the past 15 years with advances in technology, product compositions have changed greatly. Since no studies have been done in the United States on attempting to characterize body fillers and spot putties, the author wanted to start a new study which incorporated as many different body fillers and spot putties that currently existed on the market today.

Review of the Literature

An extensive search of the literature for recent articles that have attempted to characterize vehicle body fillers was done and only 3 articles dating back to 1980's were found. First of all, Cleverley in New Zealand proved that by examining the color and infrared spectrum of 12 body fillers, the brand of the filler could be identified (Cleverley, 1970).

In 1980, Home *et.al.* studied automobile body fillers from Britain by comparing the results obtained through color, pyrolysis gas chromatography (pyGC) and X-ray fluorescence analysis in order to provide a systematic scheme



for their analysis. This study found that their 18 manufacturers' samples could be split into 5 smaller groups by examining their color variation. Analysis using pyGC showed that they all produced different pyrograms. In addition, the use of X-ray fluorescence gave an indication of the heavier inorganic elements, which could be used as an additional discrimination technique (Home *et.al*, 1980).

Lastly, Walsh *et.al.* looked at 37 different formulations of body filler available in New Zealand from 12 different manufacturers and surveyed them using SEM-EDAX, visible microspectrophotometry, infrared spectrometry (IR) and density. Nearly all of the samples of the different formulations could be discriminated using this analysis scheme. This study found that SEM-EDAX was the most powerful, single analysis tool. Density and visible microspectrophotometry showed good discrimination with IR having the least discriminatory ability (Walsh *et al*, 1986).

Body Filler and Spot Putty Composition

The majority of body fillers that were used in this study were comprised of 5 main components; polyester resin, talc, styrene, titanium dioxide and glass/silica bubbles. The polyester resin is a proprietary formulation determined by the manufacturer. It comprises the majority of the filler. Talc is used primarily as filler, which aids in the sanding down process. Upon addition of the hardener (comprised mainly of benzoyl peroxide), cross-linkage occurs between the styrene and polyester resin, producing a 3-dimensional polymer. Titanium dioxide is present in order to increase the opacity of the hardener and to give an indication of the uniformity achieved when the hardener and filler are being mixed

(Home *et.al*, 1980). Finally, lighteners may be added which serve to decrease the density of the final product. Examples of these low weight, high volume lighteners are quartz, silica and glass bubbles (Walsh *et al*, 1986).

The spot putties that were examined were comprised of a variety of different components. However, there were two main components that were seen in all of the spot putties; talc and xylene. The purpose of the talc, as mentioned above, is used as a filler to aid in the sanding process. Xylene is used as a solvent to help keep the spot putty in its liquid-like form inside of the tube until it is ready to be used.

Introduction to the Techniques

Three different analysis techniques were chosen based on their usefulness for analyzing body filler and spot putty samples. These techniques chosen are also commonly used in crime laboratories.

Fourier Transform Infrared Spectroscopy (FTIR) is employed in the analysis of small paint samples, textile fibers, particulate explosive material and low dosage drugs by identifying the class of compounds present within a specimen. By exposing the sample to light in the infrared region (4000-500cm^{-1}), the interaction of the light with the bonds between the atoms in a specimen can be measured. The bonds in the sample attain a higher state of vibrational energy by absorbing this radiation. The absorbances are detected by an infrared spectrophotometer, which produces a spectrum showing the intensity of the absorption of the infrared light at each wavelength. One limitation of FTIR is that is has a limit of detection of 5%. This means that substances that are present in

the specimen of less than 5% of its total weight may not be detected, if this substance is not totally miscible in the rest of the specimen mixture. Since automobile body fillers and spot putties contain several organic components, FTIR was chosen because it can distinguish between the organic components in each of the samples (Saferstein, 1993 & Kirkbride, 2000).

Visible microscopy was also chosen for this study because it is a simple, non-destructive technique, which yields discriminating results for many trace evidence samples. All forensic science laboratories have stereoscopes, making it very useful as part of the protocol in the body filler and spot putty analysis.

Pyrolysis Gas Chromatography is useful for analyzing substances that do not have sufficient vapour pressure at the normal operating temperature of the gas chromatograph (300°C) such as hairs, fibres, paints and adhesives. Due to their polymeric nature, automobile body fillers and spot putties are prime candidates for analysis by pyGC. In pyGC analysis, the sample is heated under controlled conditions to temperatures around 1000°C, causing the sample to break apart into its smaller, constituent molecules. These molecules elute from the column at characteristic times and amounts. PyGC was chosen for this research project due to its sensitivity in detecting small changes in polymer composition, which may differ between samples from different manufacturers (Cirimele, 2000).

MATERIALS & METHODS

Sample preparation

A standard protocol was used for the preparation of the body filler and spot putty samples for all of the studies that were performed on all of the instruments. Manufacturer's instructions were followed in preparation for the 24 body filler samples, which were the same for all of the samples; 2% hardener by weight added to every sample of body filler.

The can containing the body filler was opened and the filler was stirred. Approximately 1.00g of body filler was weighed out along with approximately 0.02g of red hardener (see results from hardener study). The filler and hardener were mixed together and spread as a thin layer onto a microscope slide. The slide was placed in a fume hood and allowed to dry for at least 30 minutes.

For the 9 spot putty samples, a small amount of the spot putty was placed on a wooden stick and spread onto a microscope slide in a thin layer. The prepared slide was then placed in a fume hood and allowed to dry for at least 30 minutes at room temperature.

Table 1: The body fillers and spot putties used for the analysis

BODY FILLER #	MANUFACTURER	PRODUCT NAME
1	U.S.C.	QUALITY LIGHT-WEIGHT FEATHER-RITE
2	U.S.C.	PREMIERE LIGHT-WEIGHT
3	U.S.C.	BASECOAT/CLEARCOAT EXTRA
4	U.S.C.	LIGHTWEIGHT KROMATE LIGHT
5	3M	LIGHT-WEIGHT
6	MARSON	BODY LIGHT
7	BONDO	BODY FILLER
8	MARSON	WHITE FILL
9	MARSON	PLATINUM PREMIUM LIGHT-WEIGHT
10	MARSON	GOLDEN EXTRA
11	EVERCOAT	RAGE GOLD
12	EVERCOAT	LIGHT-WEIGHT
13	EVERCOAT	CHROME-A-LITE
14	EVERCOAT	RAGE
15	EVERCOAT	Z-GRIP
16	EVERCOAT	TACK FREE
23	DUPONT	FINAL FIL
24	DYNATRON	ULTIMATE PREMIUM LIGHT-WEIGHT
25	DYNATRON	ULTRAGRIP
26	U.S.C.	EASYWHITE LITE
27	U.S.C.	BLUE ICE
28	3M	PREMIUM BODY FILLER GOLD QBA
32	3M	ZEBRA TACK FREE LIGHT-WEIGHT
33	3M	PREMIUM LIGHT-WEIGHT
SPOT PUTTY #	**MANUFACTURER**	**PRODUCT NAME**
17	PPG	RED OXIDE
18	EVERCOAT	EVER-GLAZE AND SPOT PUTTY
19	BONDO	GLAZING & SPOT PUTTY
20	NITROSTAN	RED SPOT & GLAYZE PUTTY
21	DYNATRON	GLAZING & SPOT PUTTY
22	3M	ACRYL GREEN SPOT PUTTY
29	MARSON	SPOT & GLAZING PUTTY
30	NITROSTAN	GREEN SPOT PUTTY
31	NITROSTAN	GREY SPOT PUTTY

Fourier Transform Infrared Spectroscopy

The Perkin-Elmer Spotlight Fourier Transform Infrared Spectrophotometer (FTIR) was used for a number of preliminary studies as well as to compare the chemical compositions of all of the body fillers and spot putties.

Aging Study- FTIR Microscope

The purpose of this study was to determine if the chemical composition of the body fillers and spot putties changed over specific time intervals. The results of this study are used to determine how long a sample would produce reliable results, after it had been prepared.

In order to perform this study, one type of body filler was chosen; Bondo. The Bondo sample was prepared according to manufacturers' directions (as mentioned above). After specific time increments had passed, a small amount of the body filler was scraped off the slide, flattened and placed onto the FTIR salt plate, for analysis. This method was conducted on samples at the following intervals:

30 minutes (estimated drying time as suggested by the manufacturer)

60 minutes

24 hours

5 weeks

The spectra were analyzed to compare peaks and determine if any of the spectra changed over time. The sample of Bondo was stored at room temperature, on an analysis bench in between the time intervals.

Hardener Study- FTIR Microscope

The purpose of this study was to determine if differences existed between the different colors and manufacturers of the various hardeners used in body filler preparation. All 19 hardeners were prepared by putting a small amount on a wooden stick and spreading a thin layer onto a microscope slide. The hardeners

were allowed to dry by placing them in the fume hood at room temperature for 24 hours. To prepare the hardener for analysis, a small amount was scraped off the slide, flattened and placed on the FTIR salt plate. Three different locations were scanned on each hardener sample and the spectra obtained were compared.

Comparing the spectra from all of the hardeners and determining similarities and differences, separated the hardeners into 7 groups. Next, one hardener from each group was mixed with Bondo body filler (as per procedures mentioned above), and allowed to dry in the fume hood. Once dry, a small amount was scraped off, flattened, placed on the salt plate and analyzed with the FTIR microscope.

FTIR Bench Spectra v. FTIR Microscope Spectra

All 33 samples (prepared as mentioned above) were initially run using the FTIR microscope. The spectra were examined and were found to be too concentrated. The peaks were too broad and not well resolved. It was then decided that the 33 samples would be run again on the FTIR, but this time using the main bench and having the samples prepared as potassium bromide (KBr) pellets. The spectra obtained from both analysis techniques were compared.

Sample Analysis- FTIR Bench

Each of the 33 body filler and spot putty samples were made into KBr pellets and run on the FTIR bench. The samples were prepared for analysis as follows: a square of size 0.5 cm x 0.5 cm was cut out of the sample from the microscope slide and placed into a mortar. Three scoops of KBr was added and ground in with the sample using a pestle. A small amount was placed into a

press and a pellet was made. The pellet was placed into the FTIR holder and placed into the instrument. Five scans of each sample were done from 4000cm^{-1} to 450cm^{-1}.

The spectra from the 33 samples analyzed on the FTIR bench were collected, compiled and put into a database so a library could be created. Future samples could then be run and compared against these standards, producing a list of either exact matches or similar body fillers and spot putties.

Blind Study- FTIR Bench

A blind study was conducted in order to evaluate the protocol used in this research for accuracy in comparing and attempting to distinguish and characterize the 33 body filler and spot putty samples. A Forensic Scientist at the Michigan State Police Crime Laboratory prepared thirteen samples. The unknown samples were chosen at random, so the author was unaware of what was being tested. Once the author received the samples, the same protocol was followed as for the sample analysis in order to obtain reliable spectra of each of the unknowns. Once a sample had been analyzed on the FTIR bench, it was searched against the spectra library and the results were recorded in terms of their percent match to the sample in question.

Visible Microscopy

Each sample was selected and examined on the microscope slide on which it had been prepared using a Leica MZ7 stereoscope under 20X magnification. The color that was observed by the author was recorded for each of the 33 samples.

Pyrolysis Gas Chromatography

A Hewlett Packard 5890 Series II Gas Chromatograph was used for comparing the organic components of each of the 33 body filler and spot putty samples. A method was created on the pyrolysis gas chromatograph, which resembled that of what is used to analyze paint samples. Each of the samples was run twice through this method. The samples were prepared by scraping off a small amount from the microscope slide and placing it in a glass tube. In order to make sure that the pyGC was free of contamination, blank runs were performed after every 8 samples and the method was designed to have long holds at the final temperature before the next sample was run. The spectra obtained were compared by checking for reproducibility and similarities and/or differences amongst the samples.

RESULTS

Fourier Transform Infrared Spectroscopy

Aging Study

There was no continuous trend of change in chemical composition detected by the FTIR as the samples aged at room temperature. The spectra for all of the samples did not differ significantly from each other (see Figure 1). This suggests that drying time does not affect IR spectra, as the body fillers and spot putties maintain their chemical composition over an extended period of time. This is useful information for a forensic scientist since body filler and/or spot putty samples may come into the crime lab for analysis after a hit-and-run accident, and would have been on the car for an unknown period of time. If one assumes that body filler and spot putty samples maintain their chemical composition over time, one can be sure that the spectra being produced resemble that of the filler's original condition.

Hardener Study

Nineteen different hardeners were received along with all of the body filler samples. The problem that existed here was to establish how similar or different each of the hardeners were in order to determine the number of hardeners that were needed to make up the body filler samples. Before running the hardeners, they were divided into three groups according to their color (pink, blue or red), as determined by visual examination. After running all of the hardeners on the FTIR microscope, it was determined that the hardeners of the same color could still be considered members of their original group. However, smaller groups could now

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be created, based on the similarities and/or differences to other members within their color group. All of the pink hardeners could be considered one group, with similar spectra. The blue hardeners were further sub-divided into 4 groups and the red hardeners into 2 groups. This hardener study resulted in the creation of 7 different groups of hardeners based on their FTIR spectra (see Figures 2, 3, 4).

In order to determine how each hardener group would interact with a body filler sample, one type of body filler; Bondo was chosen as the test filler. As previously mentioned, Bondo was mixed with one hardener from each of the 7 groups. It was allowed to dry at room temperature and analyzed on the FTIR microscope. Results from this study indicated that there was no change in chemical composition observed when the Bondo was mixed with any of the 7 different hardeners (see Figures 5 & 6). This result was advantageous because it allowed the author to choose one hardener (red) to prepare all of the body filler samples for analysis. This would ensure that the results obtained from the FTIR analysis would only be due to the filler composition and not be affected by the composition of the hardener. When the hardener is mixed in with the filler, polymerization occurs, which allows the filler and hardener to form bonds with each other. This polymerization causes the hardener to be evenly dispersed throughout the mixture, thus proving that the existence of the hardener has not effect on the final FTIR spectra result.

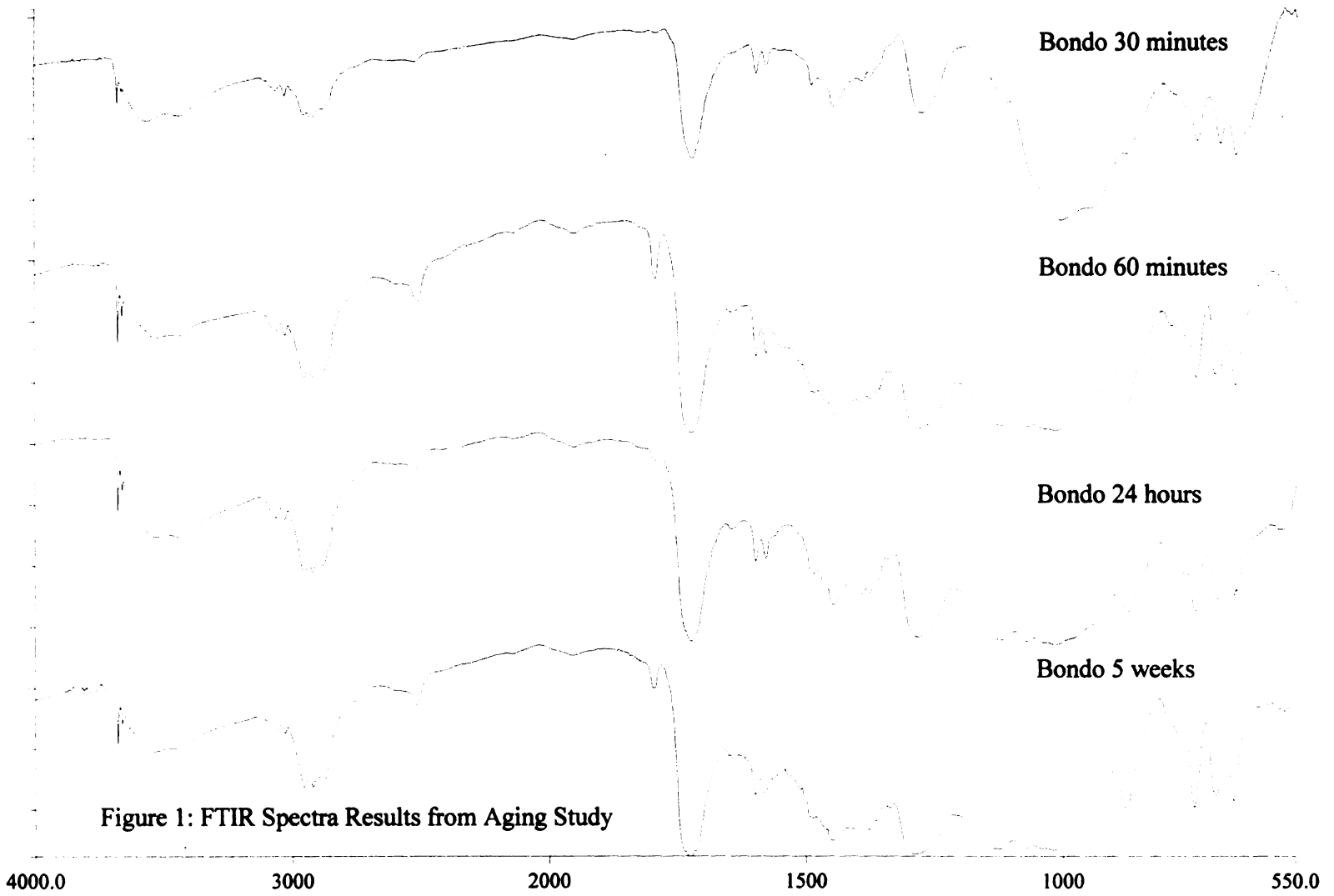

Figure 1: FTIR Spectra Results from Aging Study

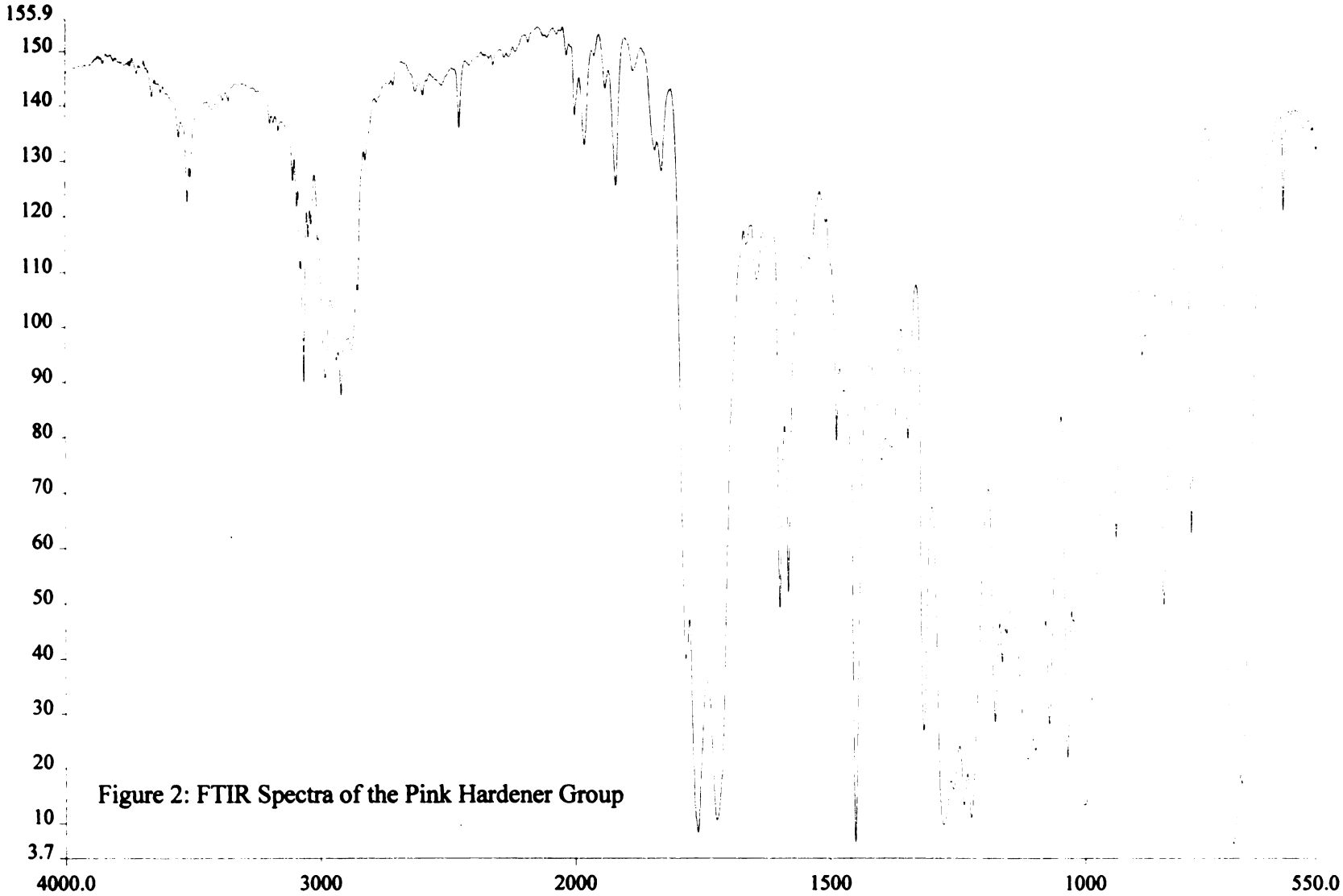

Figure 2: FTIR Spectra of the Pink Hardener Group

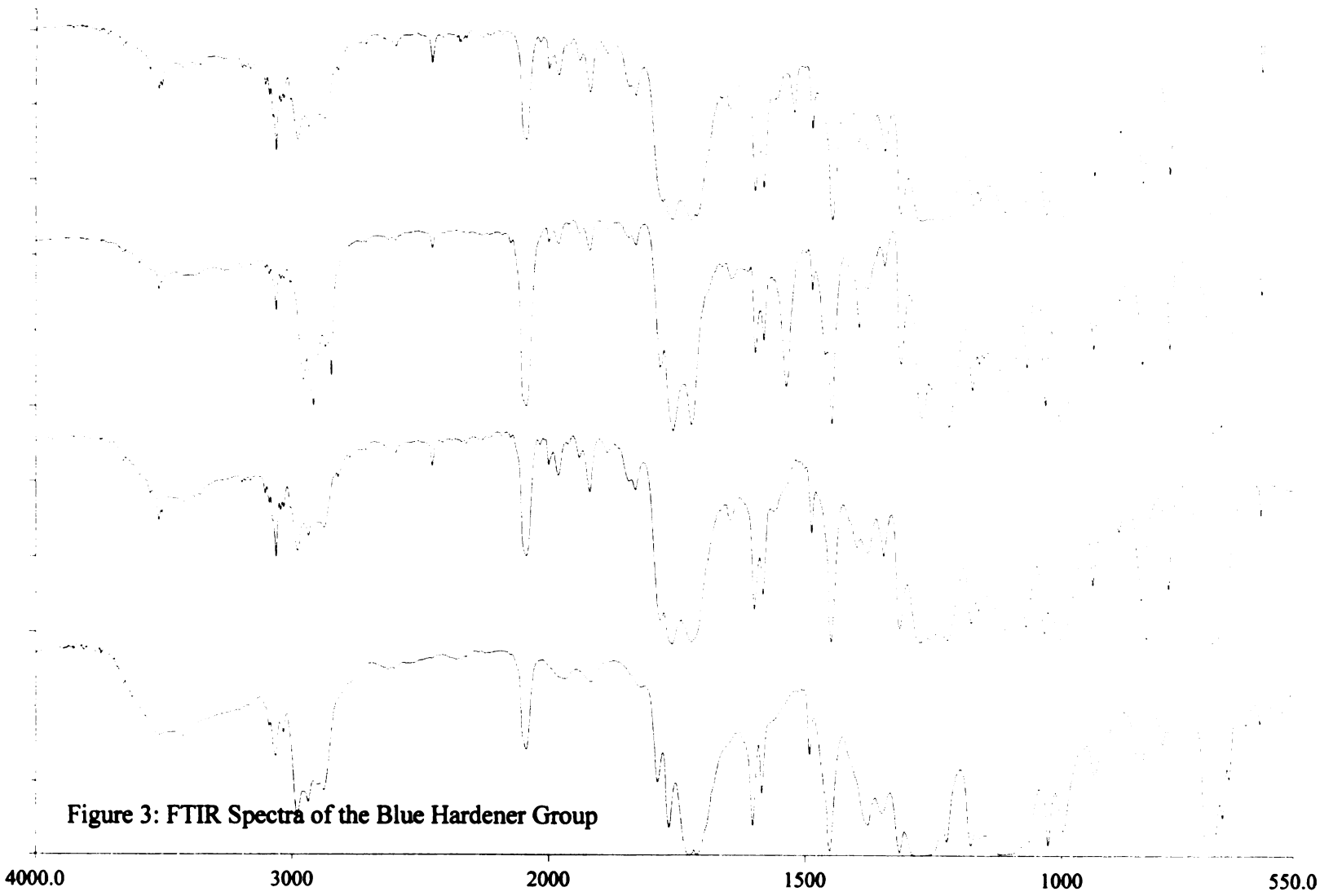

Figure 3: FTIR Spectra of the Blue Hardener Group

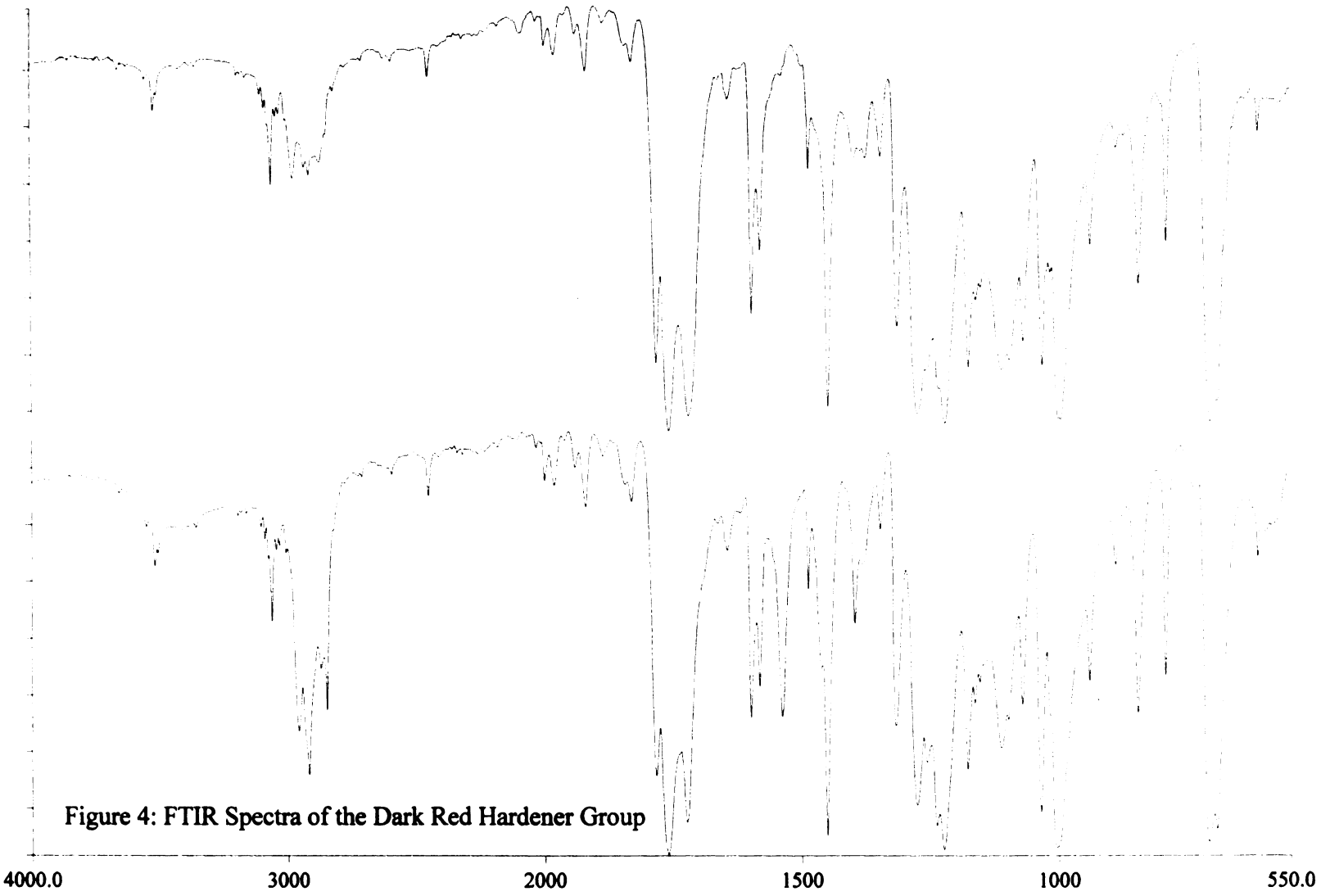

Figure 4: FTIR Spectra of the Dark Red Hardener Group

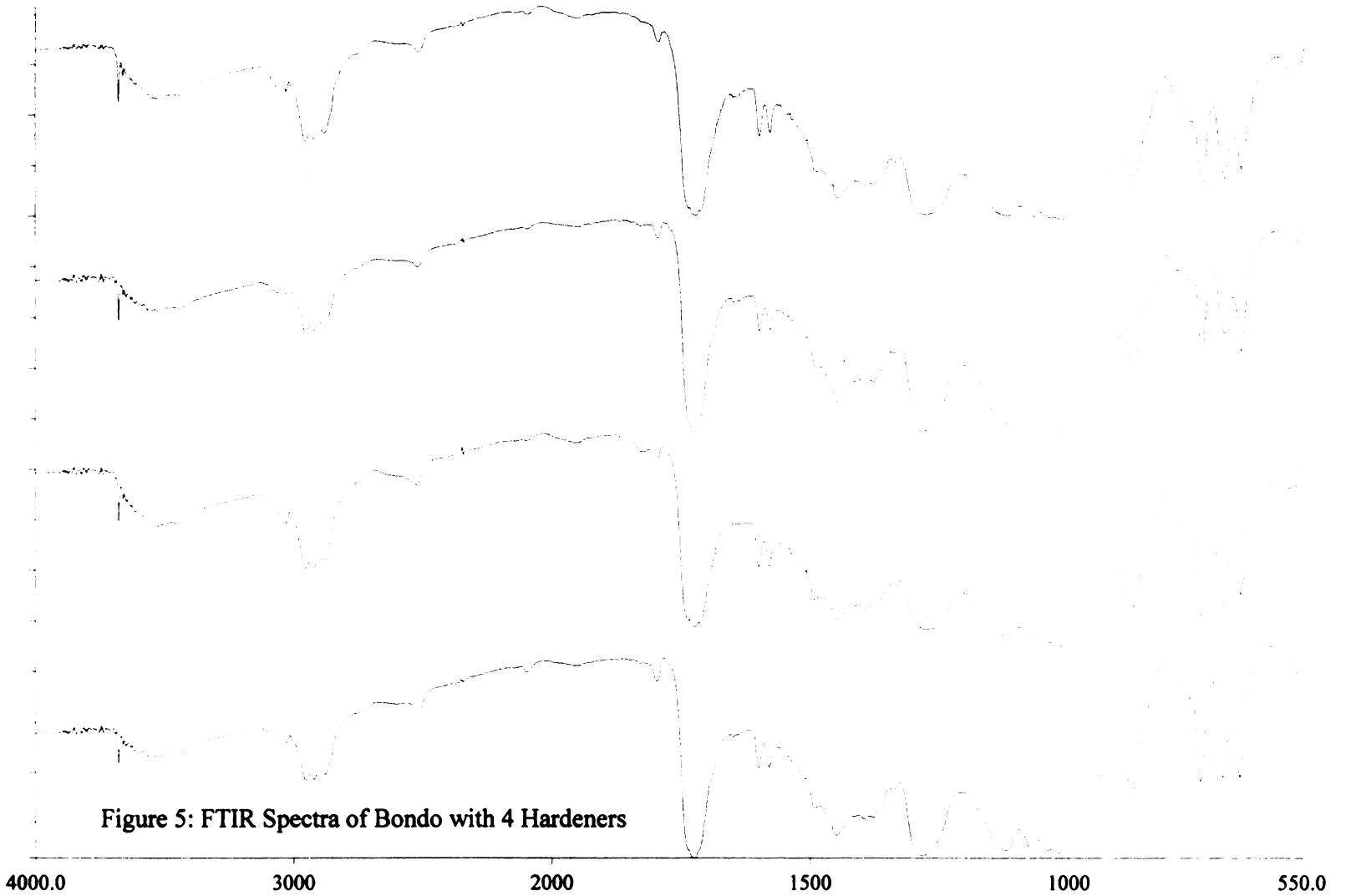

Figure 5: FTIR Spectra of Bondo with 4 Hardeners

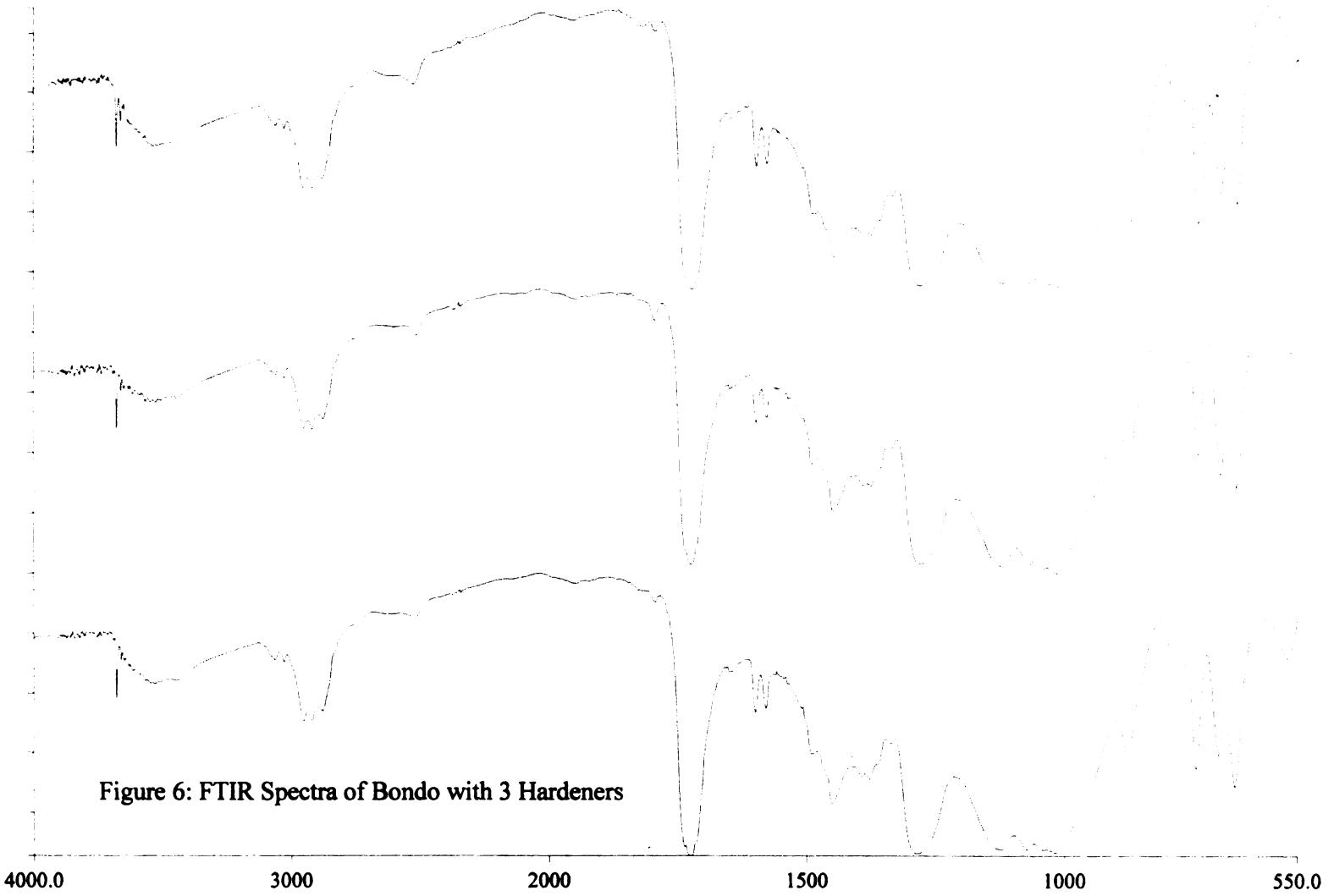

Figure 6: FTIR Spectra of Bondo with 3 Hardeners

FTIR Bench Spectra v. FTIR Microscope Spectra

Various samples were chosen for the purpose of comparison of the spectra obtained from the FTIR microscope and the FTIR bench analysis. Upon examination of the spectra, it was concluded that there was no difference in peak location or general shape between the spectra acquired from both analysis techniques (see Figure 7). The main difference that was found, however, was that the spectra from the FTIR bench were less concentrated, making the peaks look sharper and more resolved. Since the spectra that were acquired from the FTIR bench were a better representation of the chemical composition of the body fillers and spot putties, that analysis technique was then chosen as the one to use for the rest of the analyses.

Sample Analysis

The results from the FTIR bench analysis of the body fillers and spot putties, resulted in the author being able to group the 24 body fillers into 6 groups and the 9 spot putties into 6 groups; for a total of 12 individual groups comprised of anywhere from 1 to 9 members (see Figures 8-19). The way in which each of the samples was grouped was by examining peak shapes and locations found in the fingerprint region. More specifically, the most pronounced differences that were observed between the groups were from $1700cm^{-1}$ to $1200cm^{-1}$, with smaller, but still significant differences from $750cm^{-1}$ to $500cm^{-1}$. This was a very successful analysis tool as it provided straightforward criteria for separating out the samples.

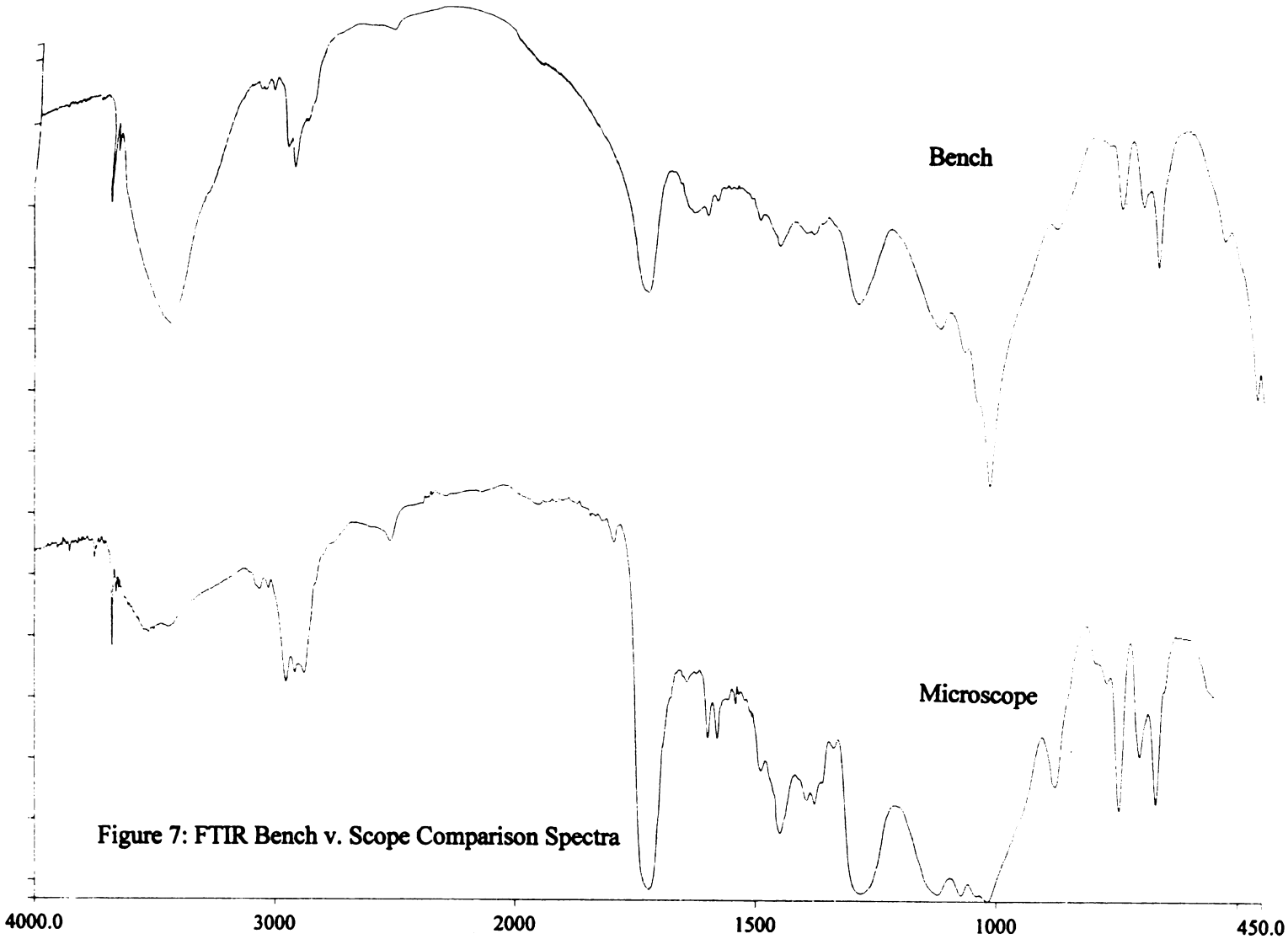

Figure 7: FTIR Bench v. Scope Comparison Spectra

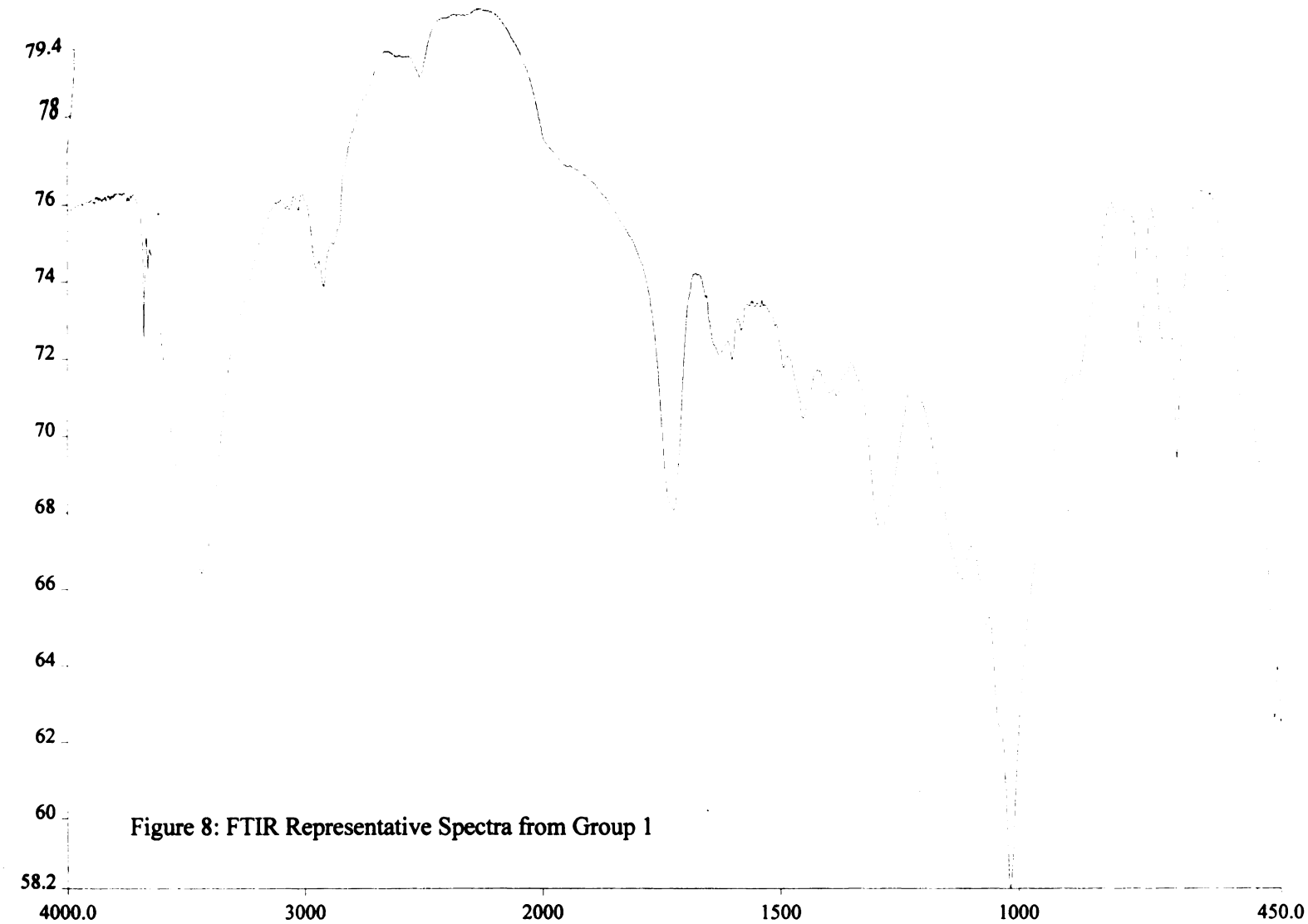

Figure 8: FTIR Representative Spectra from Group 1

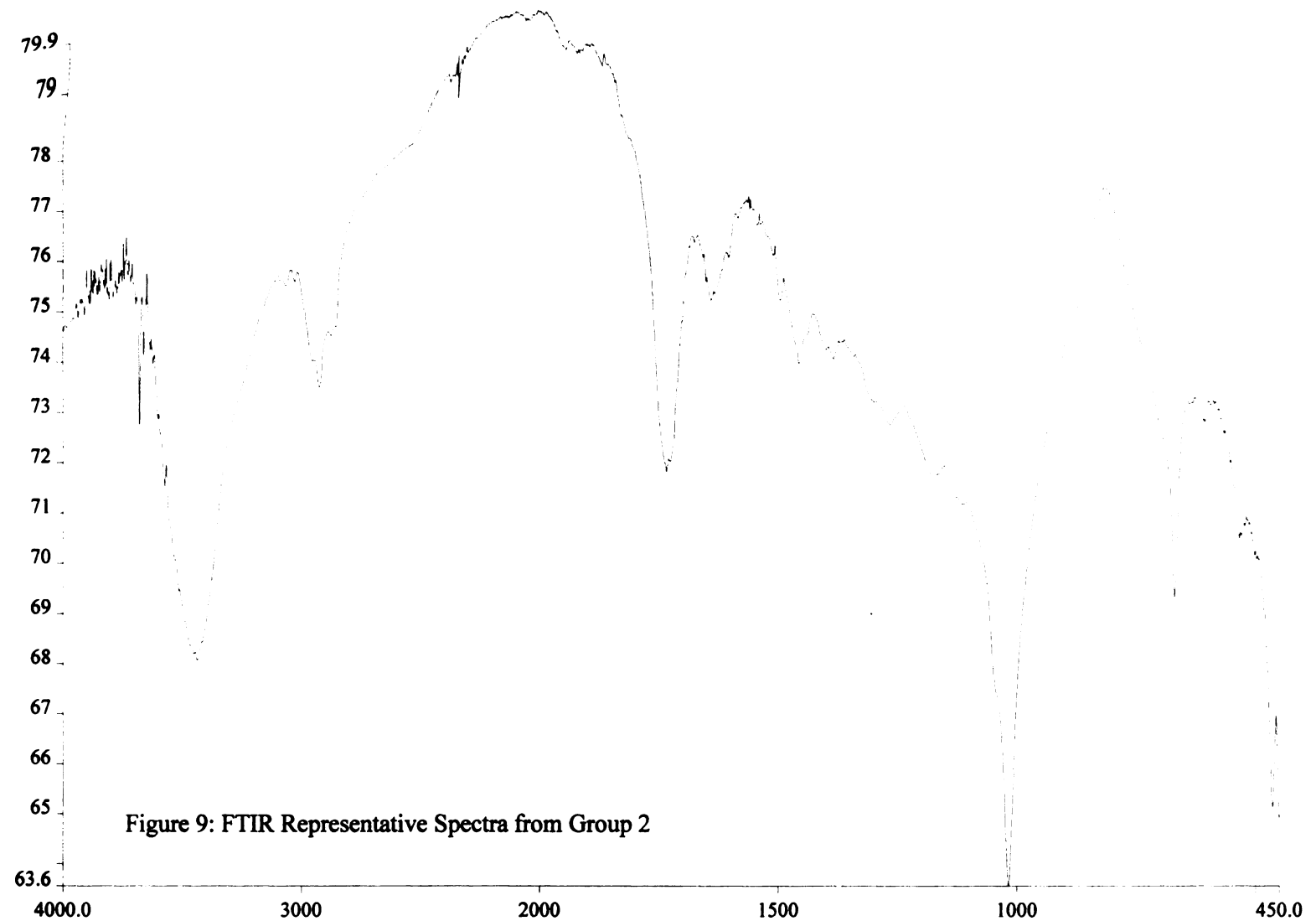

Figure 9: FTIR Representative Spectra from Group 2

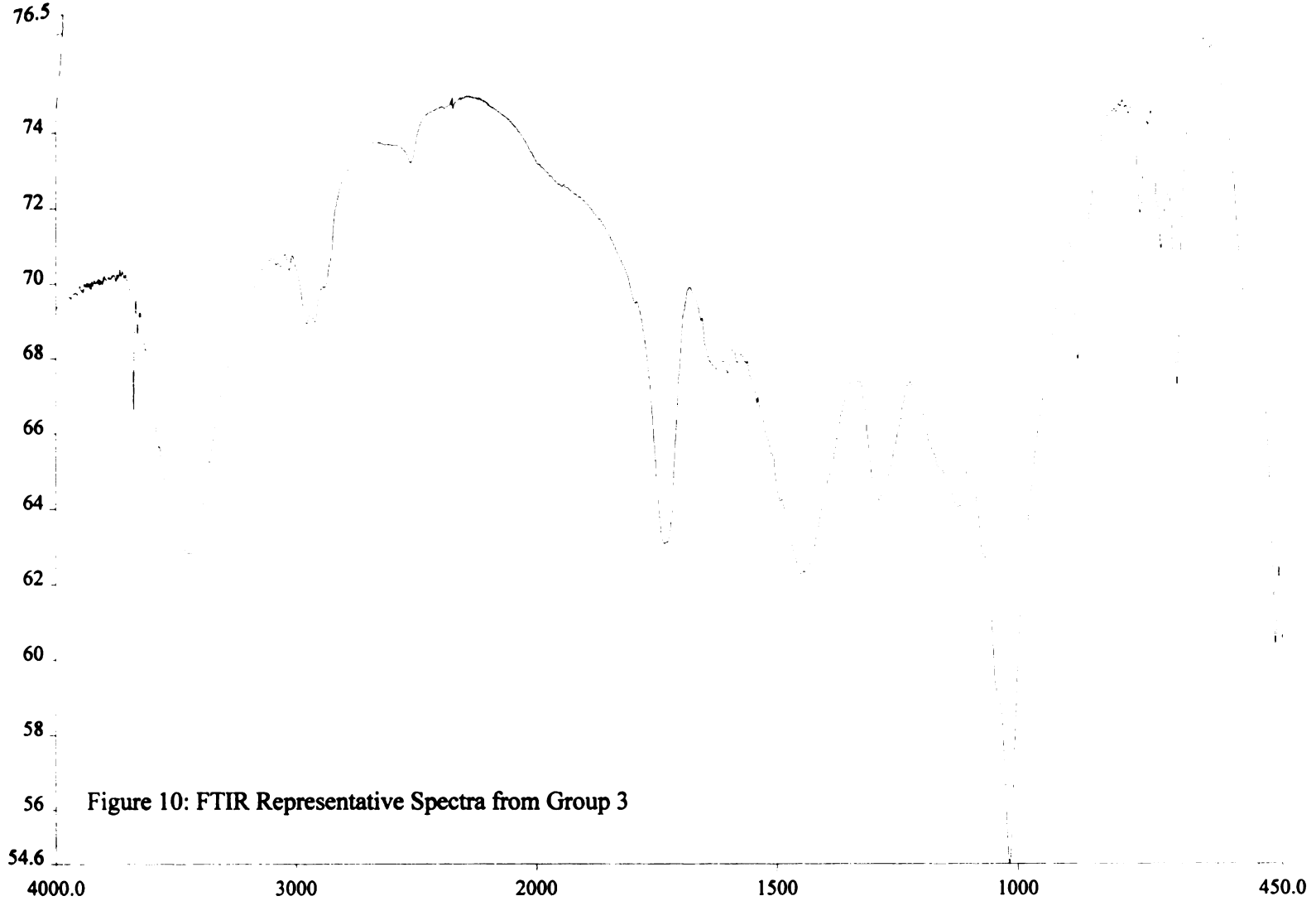

Figure 10: FTIR Representative Spectra from Group 3

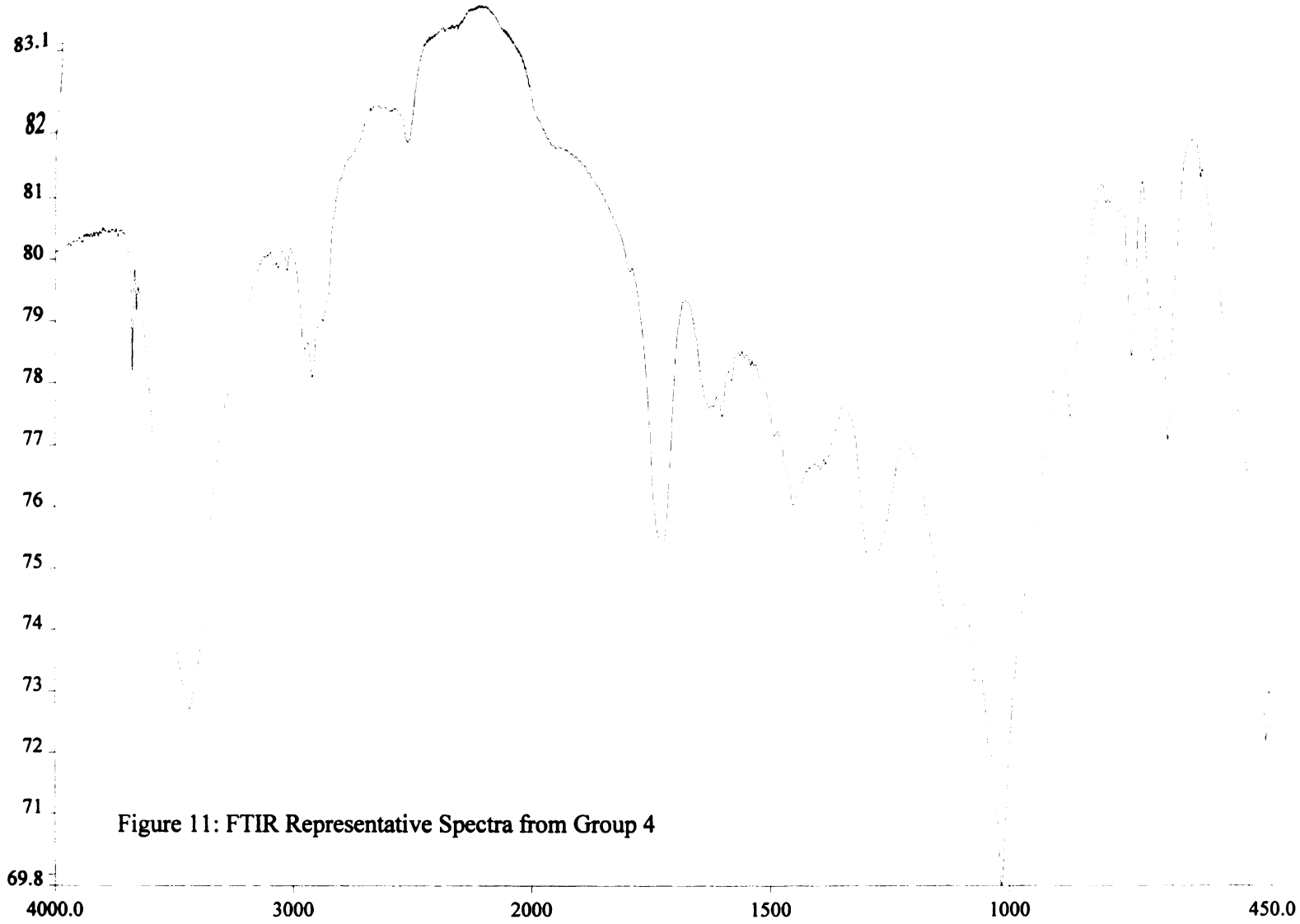

Figure 11: FTIR Representative Spectra from Group 4

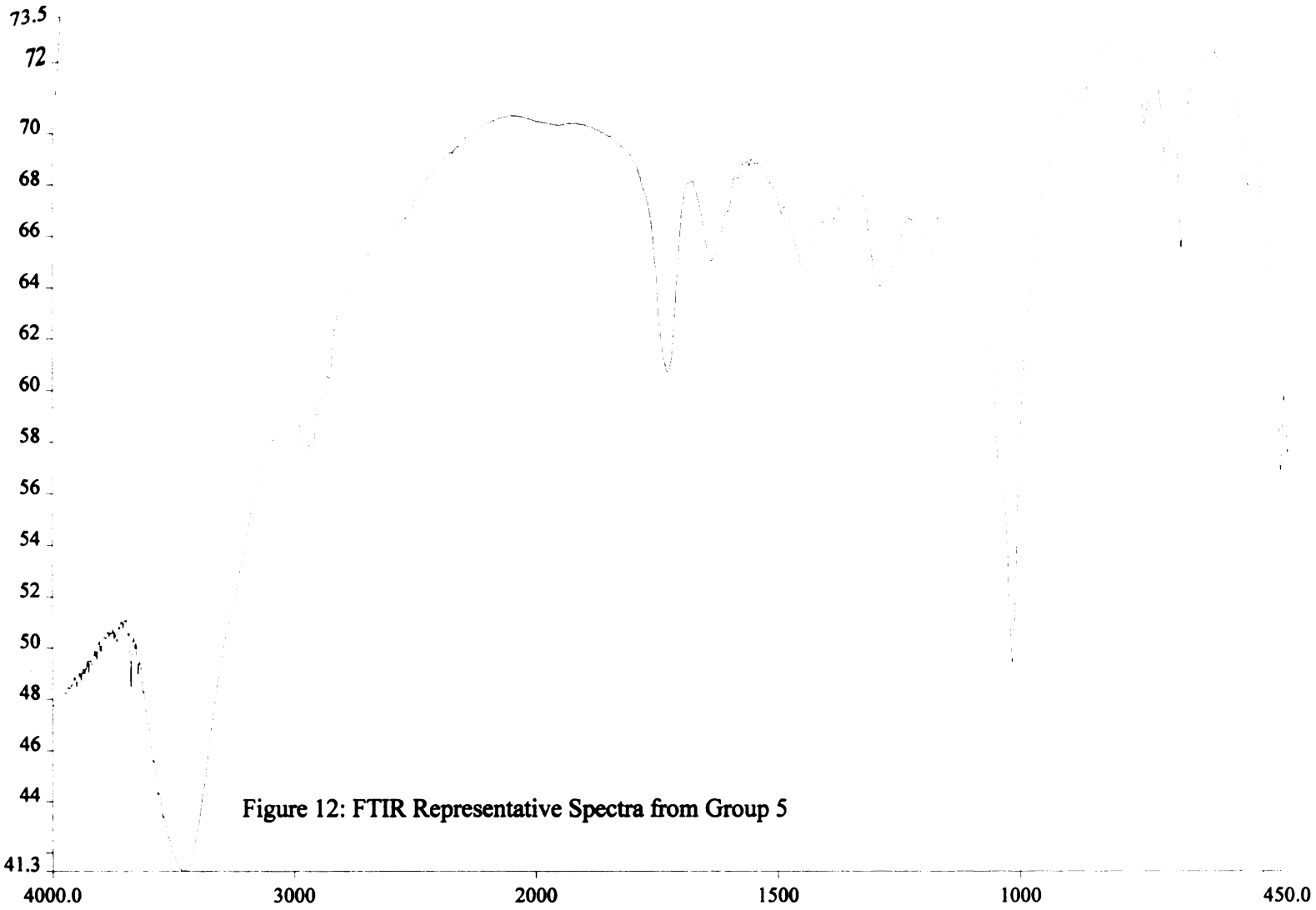

Figure 12: FTIR Representative Spectra from Group 5

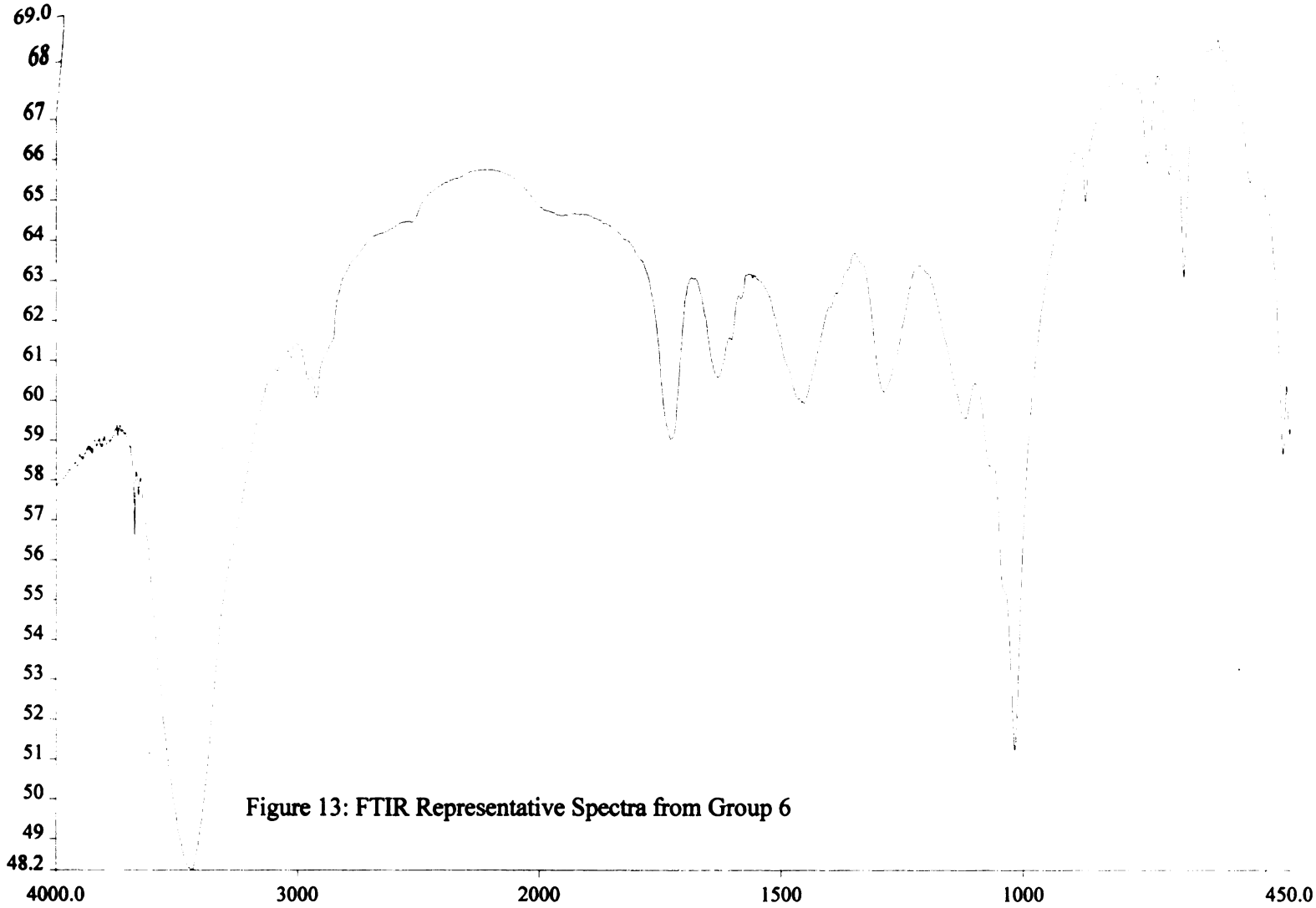

Figure 13: FTIR Representative Spectra from Group 6

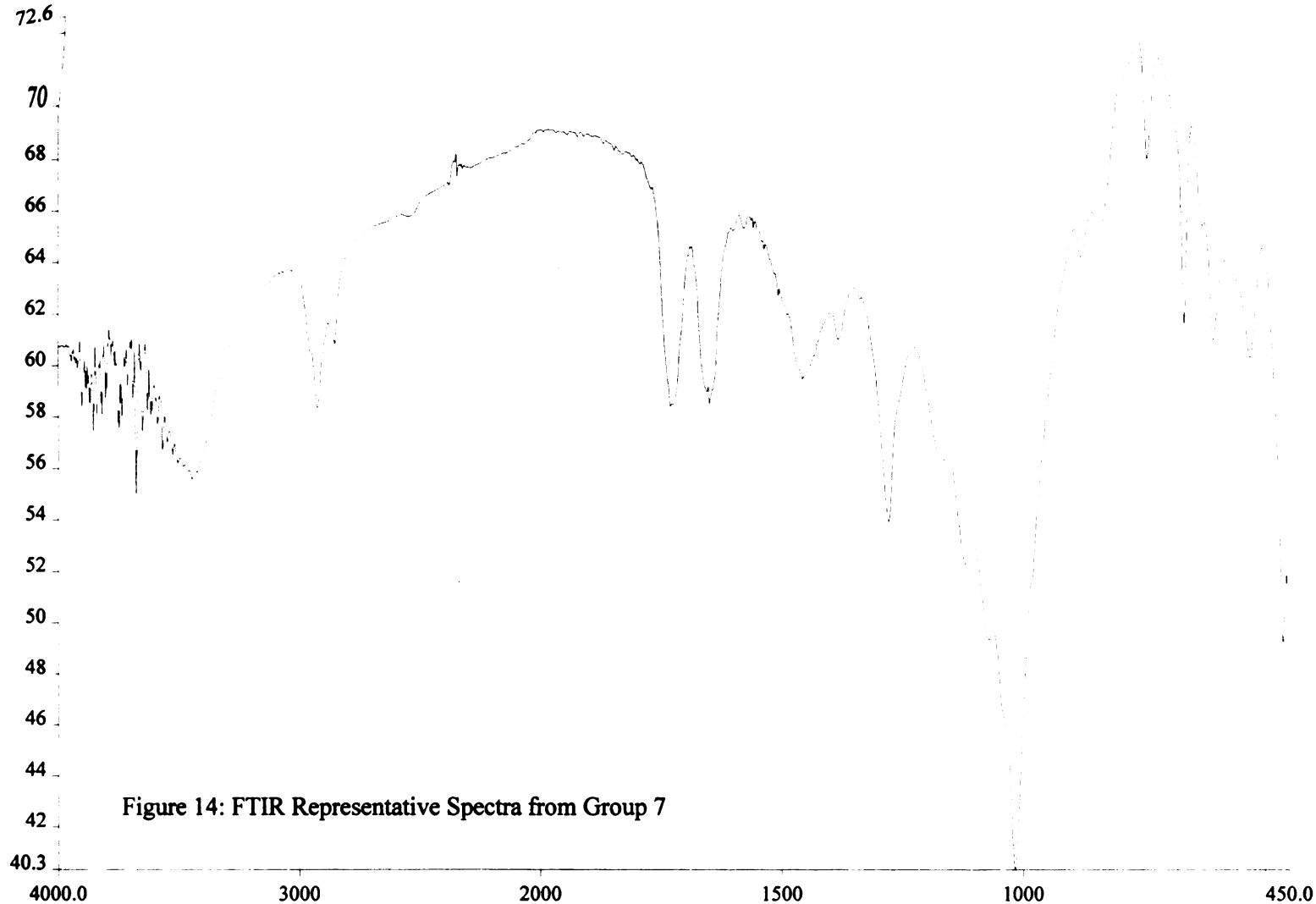

Figure 14: FTIR Representative Spectra from Group 7

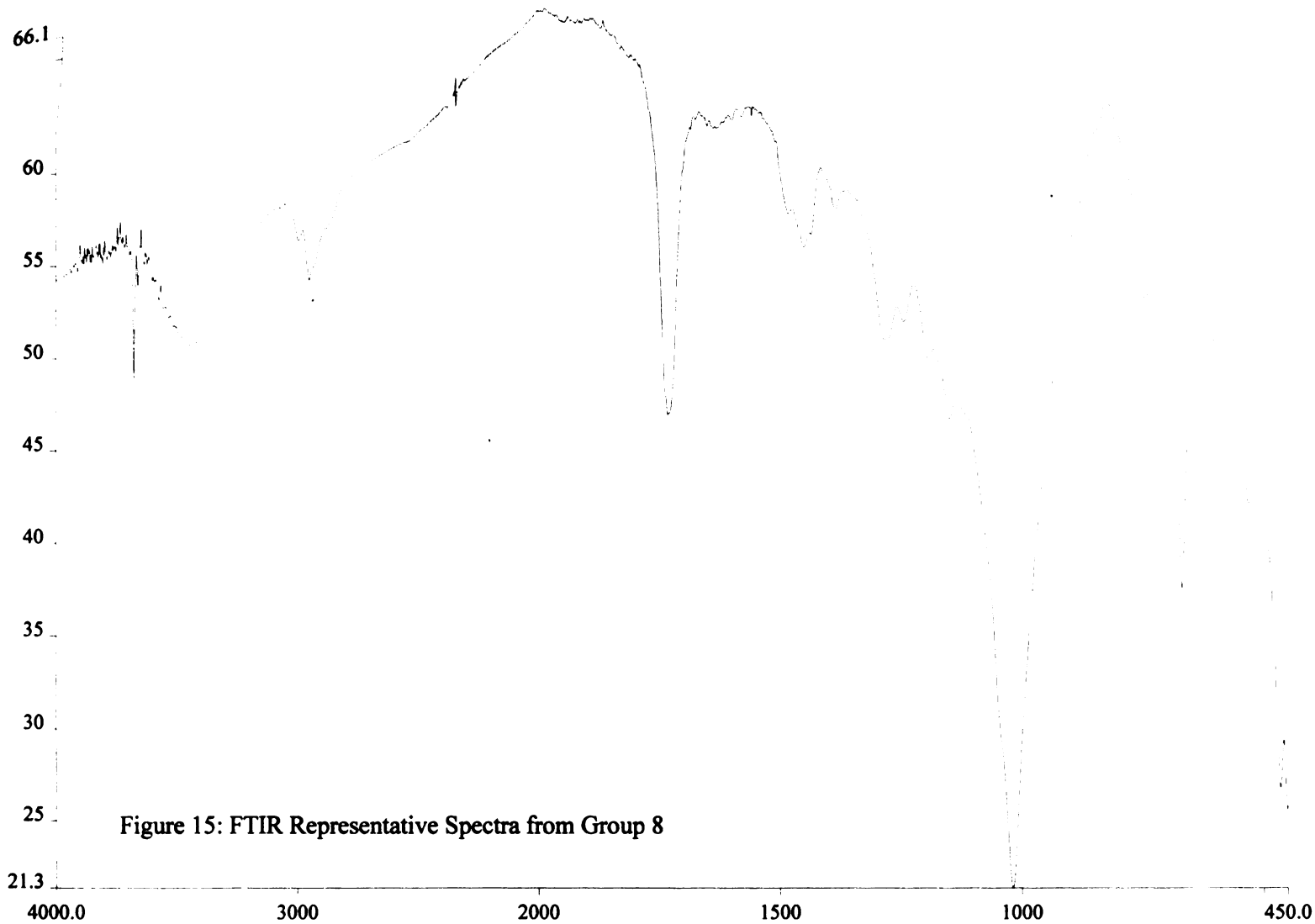

Figure 15: FTIR Representative Spectra from Group 8

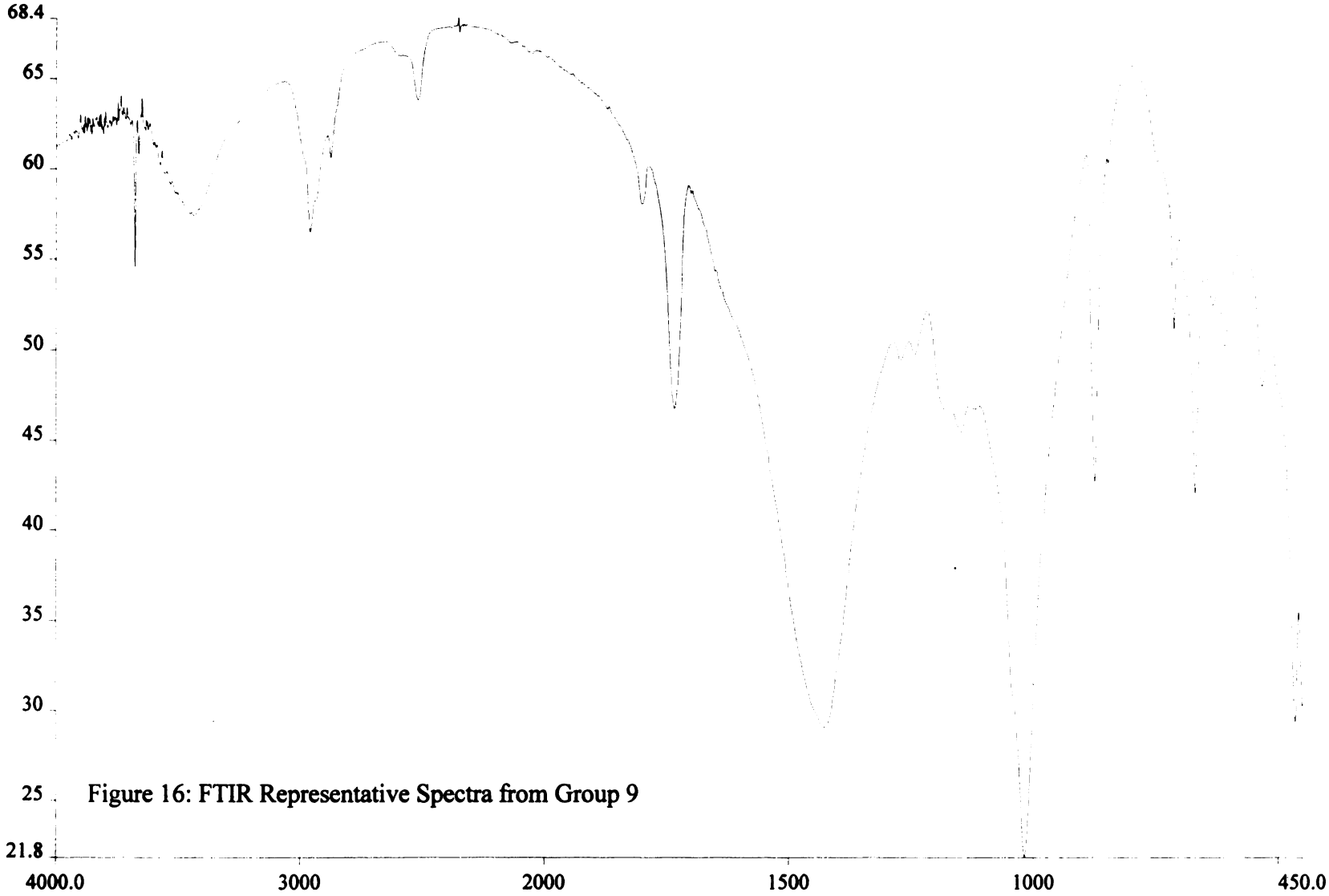

Figure 16: FTIR Representative Spectra from Group 9

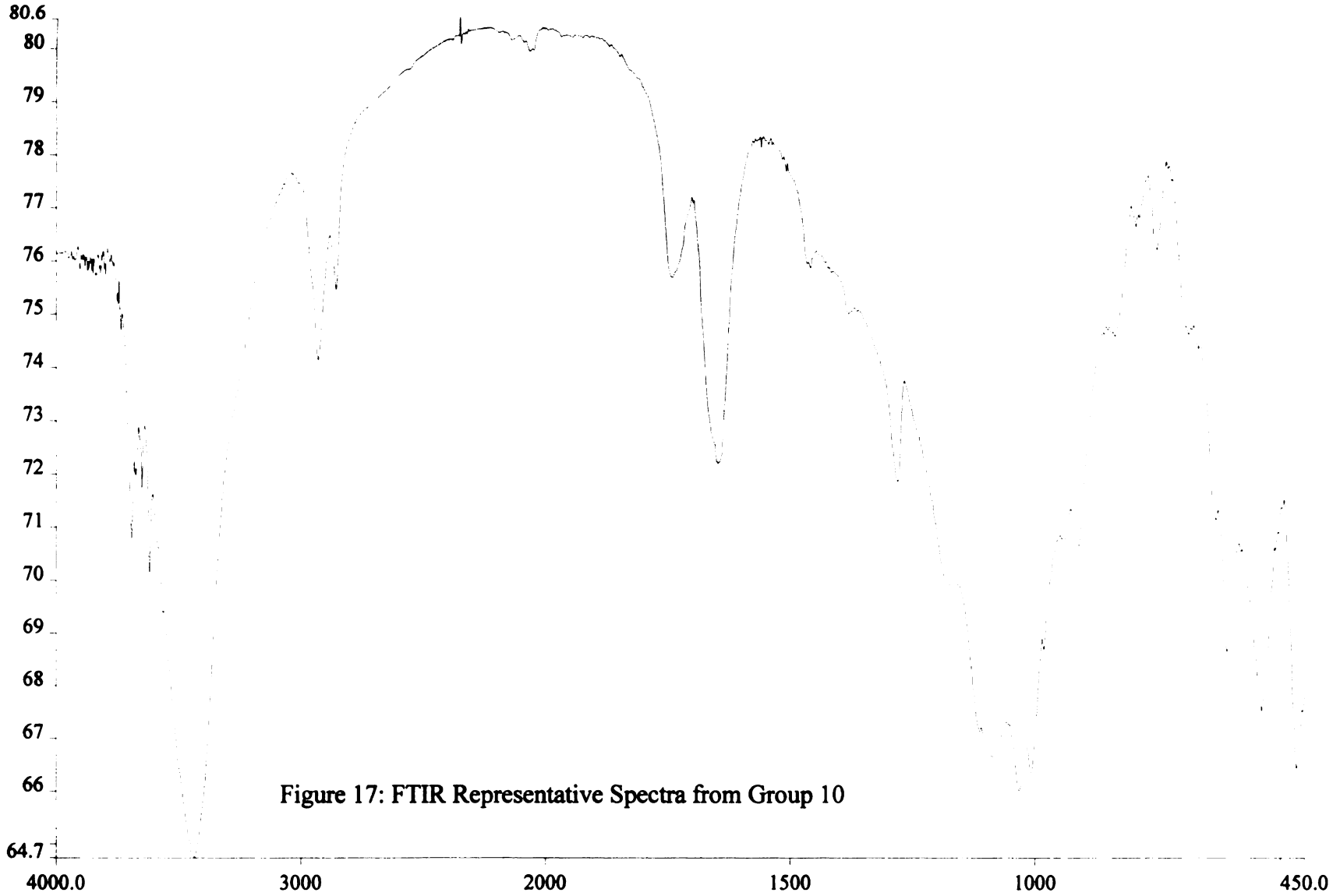

Figure 17: FTIR Representative Spectra from Group 10

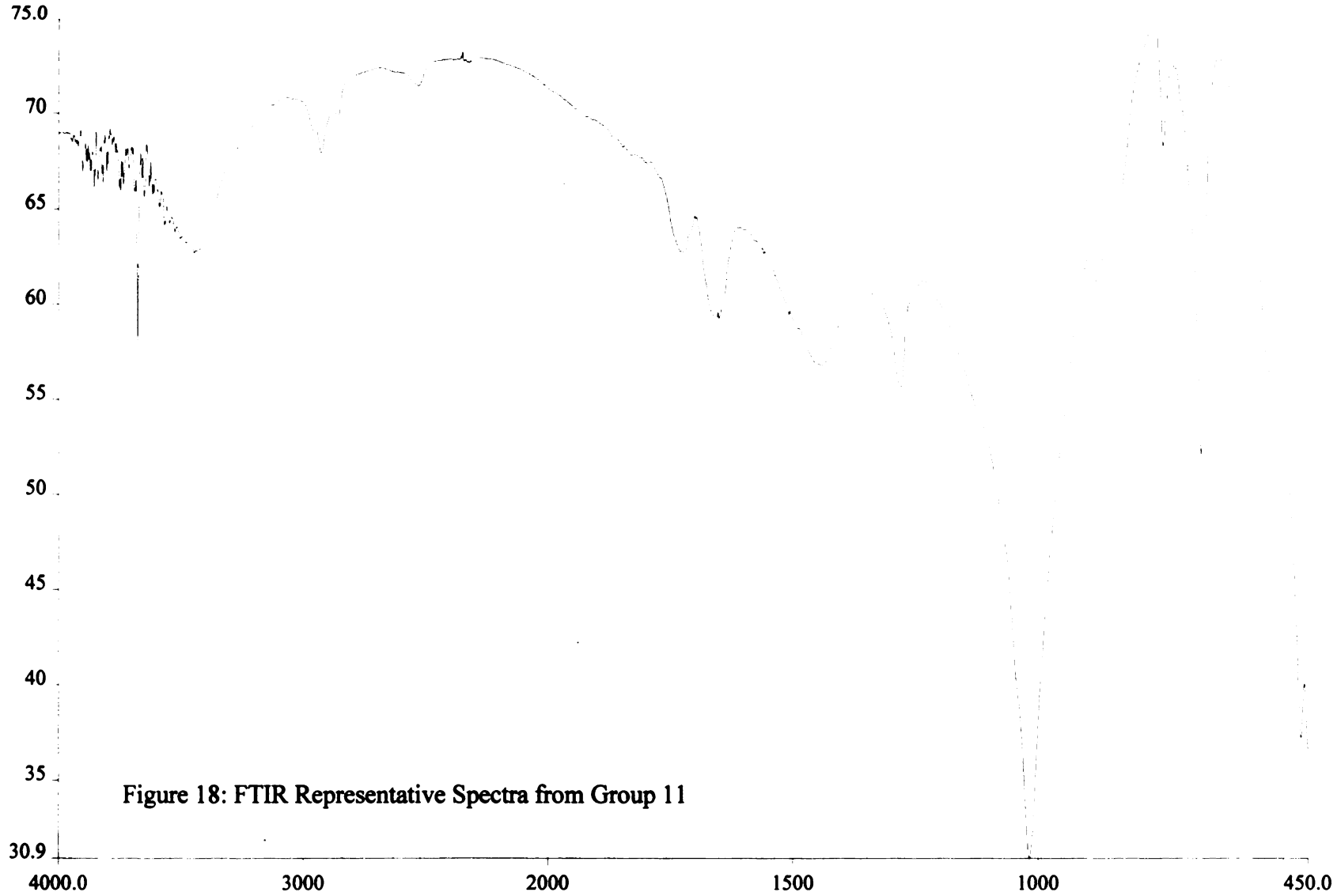

Figure 18: FTIR Representative Spectra from Group 11

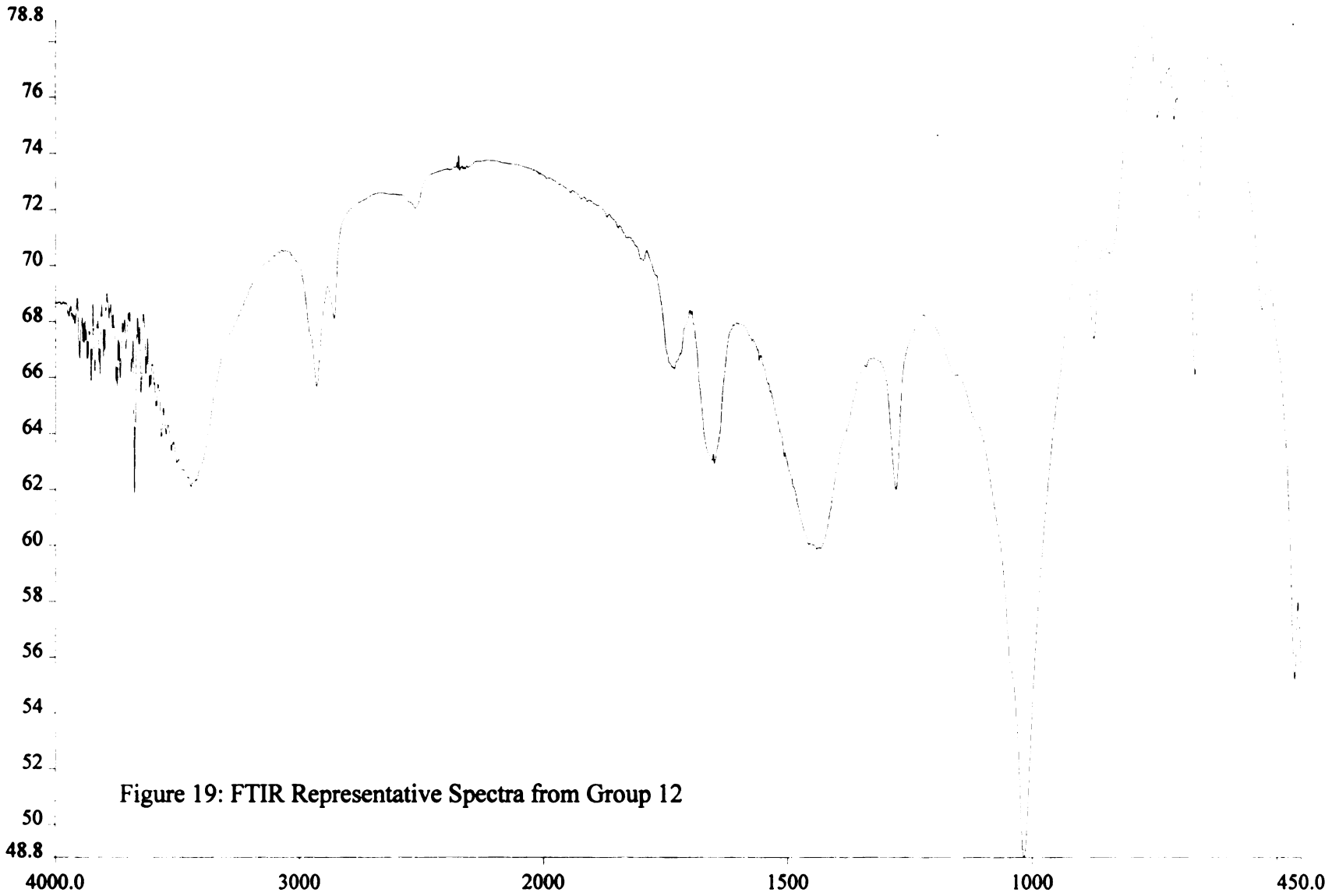

Figure 19: FTIR Representative Spectra from Group 12

Blind Study

After analyzing the 13 unknown samples using the FTIR bench, each was searched against the library of body filler and spot putty results from the sample analysis portion of this study. The spectra from blind samples 1, 3, 5, 6, 8, 9, 11 and 12 all matched with what they actually were, whereas blind samples 2, 4, 7, 10 and 13 when searched against the library came up with spectra that were different to what they actually were.

Table 2: Results from the blind study

UNKNOWN #	ACTUAL PRODUCT	PRODUCT FROM LIBRARY SEARCH	CHOICE # AND PERCENT	CORRECT/ INCORRECT MATCH
1	USC Premiere LW Body Filler	USC Premiere LW Body Filler	1, 96%	CORRECT
2	Bondo Body Filler	Zebra Tack Free LW Body Filler	16, 91%	INCORRECT
3	Bondo Glazing & Spot Putty	Bondo Glazing & Spot Putty	1, 99%	CORRECT
4	Zebra Tack Free LW Body Filler	3M Premium Gold QBA Body Filler	4, 97%	INCORRECT
5	Nitrostan Grey Spot Putty	Nitrostan Grey/Red Spot Putty (indistinguishable)	1/2, 91%	CORRECT
6	Evercoat Ever-glaze & Spot Putty	Evercoat Ever-glaze & Spot Putty	1, 99%	CORRECT
7	3M LW Body Filler	Marson Body Light Body Filler	9, 95%	INCORRECT
8	Nitrostan Green Spot Putty	Nitrostan Green Spot Putty	1, 98%	CORRECT
9	Marson Body Light Body Filler	Marson Body Light Body Filler	1, 99%	CORRECT
10	Marson Golden Extra Body Filler	USC Easywhite Lite Body Filler	3, 94%	INCORRECT
11	Marson Spot & Glaze Spot Putty	Marson Spot & Glaze Spot Putty	1, 98%	CORRECT
12	3M Acryl Green Spot Putty	3M Acryl Green Spot Putty	1, 99%	CORRECT
13	DuPont Final Fil Body Filler	Dynatron Ultimate Premium LW Body Filler	16, 81%	INCORRECT

All of the spot putties were found to match with the correct sample, while only 29% of the body fillers matched and 71% did not. With the exception of the last

sample, all of the samples that were considered incorrect, were within the top 10% (90% or higher match rate) of the library search results. Since the library is attempting to choose between very similar spectra, and rank them according to their similarity to the questioned sample, it is entirely possible that if the blind samples were run again, the library may choose another sample within the top 10% as correct. A general practice in forensic science is to use 90% as a means of possible inclusion. That is, all of the samples with the exception of one would still be included as a possible match to the unknown sample. One would then have to examine the spectra obtained from the unknown sample and compare it visually to the standard samples that resulted in 90% or greater match from the library search in order to determine inclusion or exclusion.

Visible Microscopy

A stereoscopic examination was done in order to see if the body filler and spot putty samples could be distinguished by their color alone. Body fillers and spot putties look very different from each other. Obvious differences are observed in terms of texture and lustre, thus making it very easy to separate the body fillers from the spot putties upon initial examination. After examining each of the samples under the stereoscope, the body fillers were placed into one of two groups (peach or gold) and the spot putties were placed into one of three groups (red, green or grey). The author, in consultation with another forensic scientist, categorized the samples into these color groups, so to attempt to eliminate examiner subjectivity.

Pyrolysis Gas Chromatography

Pyrolysis Gas Chromatography also proved to be a useful tool in helping to place the body filler and spot putty samples into 4 groups. One unique result was observed using the pyGC: some of the spot putties fell into the same groups as the body fillers, which is different from the groups formed from FTIR and microscopy analysis in that all of the body fillers fell into different groups than the spot putties. Additionally, the first group had to be further divided into 2 subgroups because subtle differences existed in the chromatograms. These slight differences were not significant enough to create separate groups.

The way in which the samples were separated out into different groups depended on the presence/absence of a peak at 2 minutes as well as the sizes and shapes of peaks that were present around 6 minutes. Although many other peaks were present, these peaks were chosen because they represented the most significant differences between the pyrolysis groups as seen on the programs. Group 1A had similar chromatograms to group 1B except for the presence of a really tall peak at 2 minutes (around 1 500 000 abundance), whereas group 1B had virtually no or a very small peak (less than 500 000) for the same time interval. Members of group 3 stood out due to the absence of any significant peak at 2 or 6 minutes, while group 2 was characterized due to the presence of a doublet peak between 6-8 minutes and a small peak at 2 minutes, and group 4 showed multiple peaks at 2 minutes and a small, single peak around 6 minutes (see Figures 20-24).

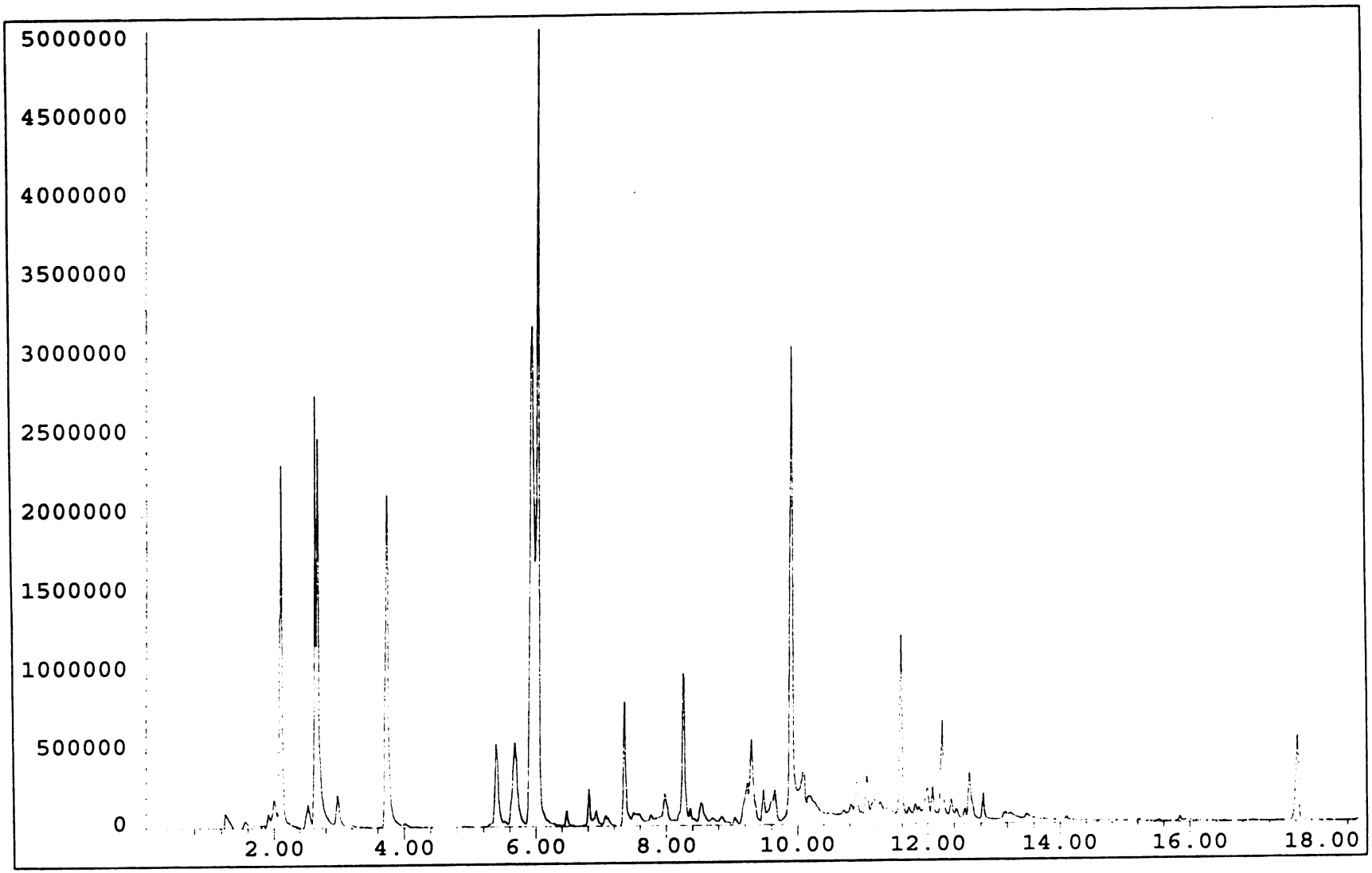

Figure 20: pyGC Representative Chromatograph from Group 1A

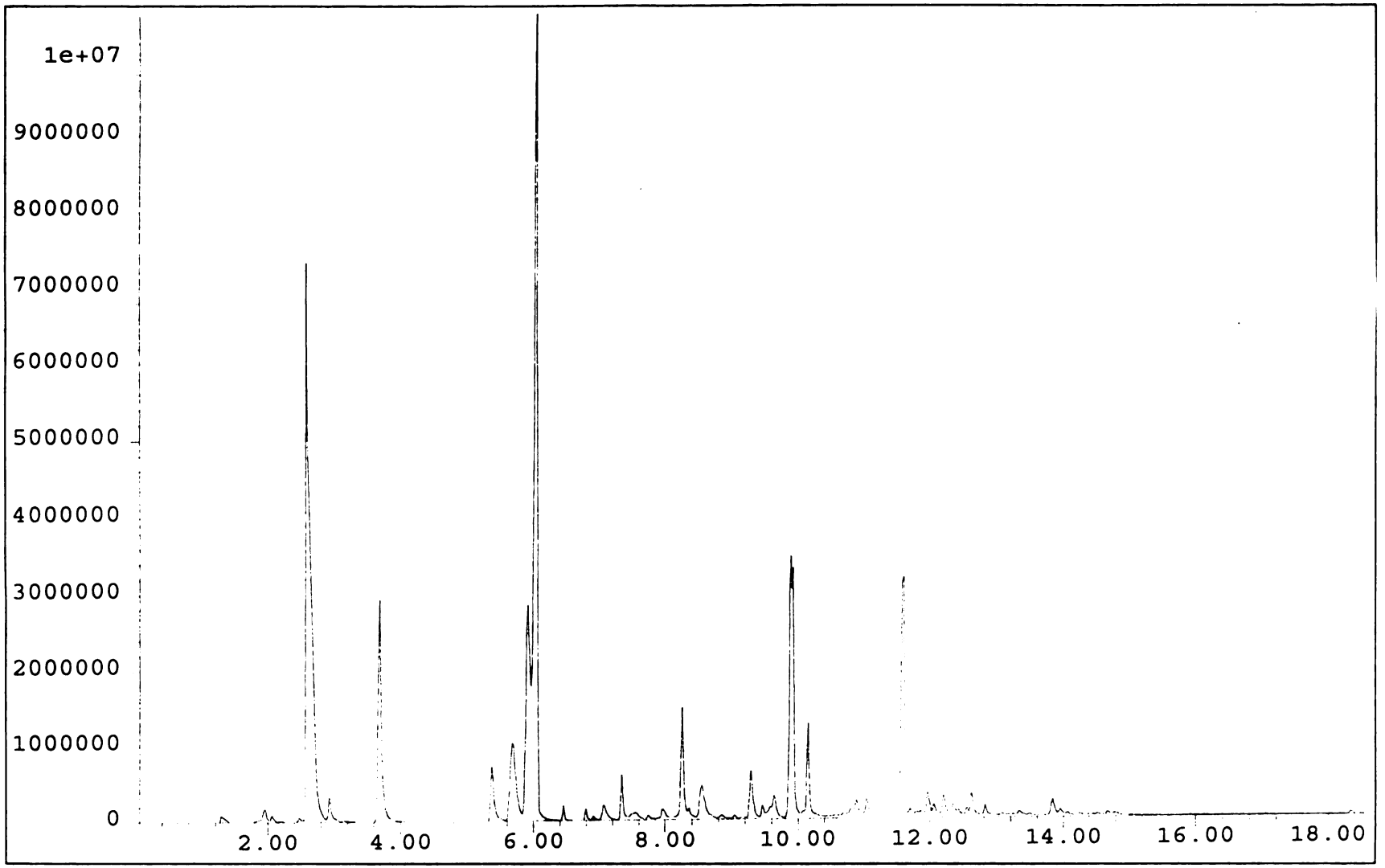

Figure 21: pyGC Representative Chromatograph from Group 1B

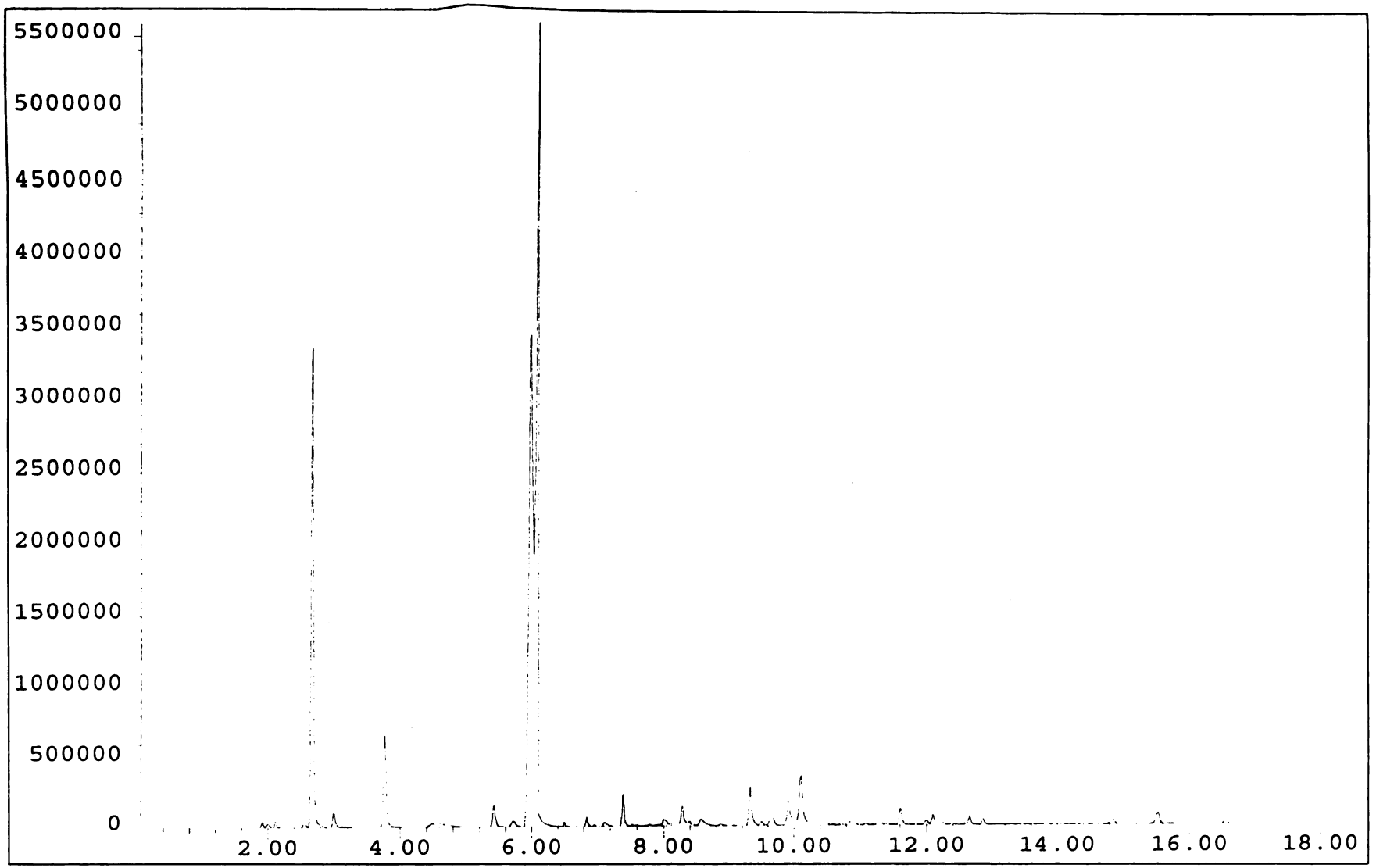

Figure 22: pyGC Representative Chromatograph from Group 2

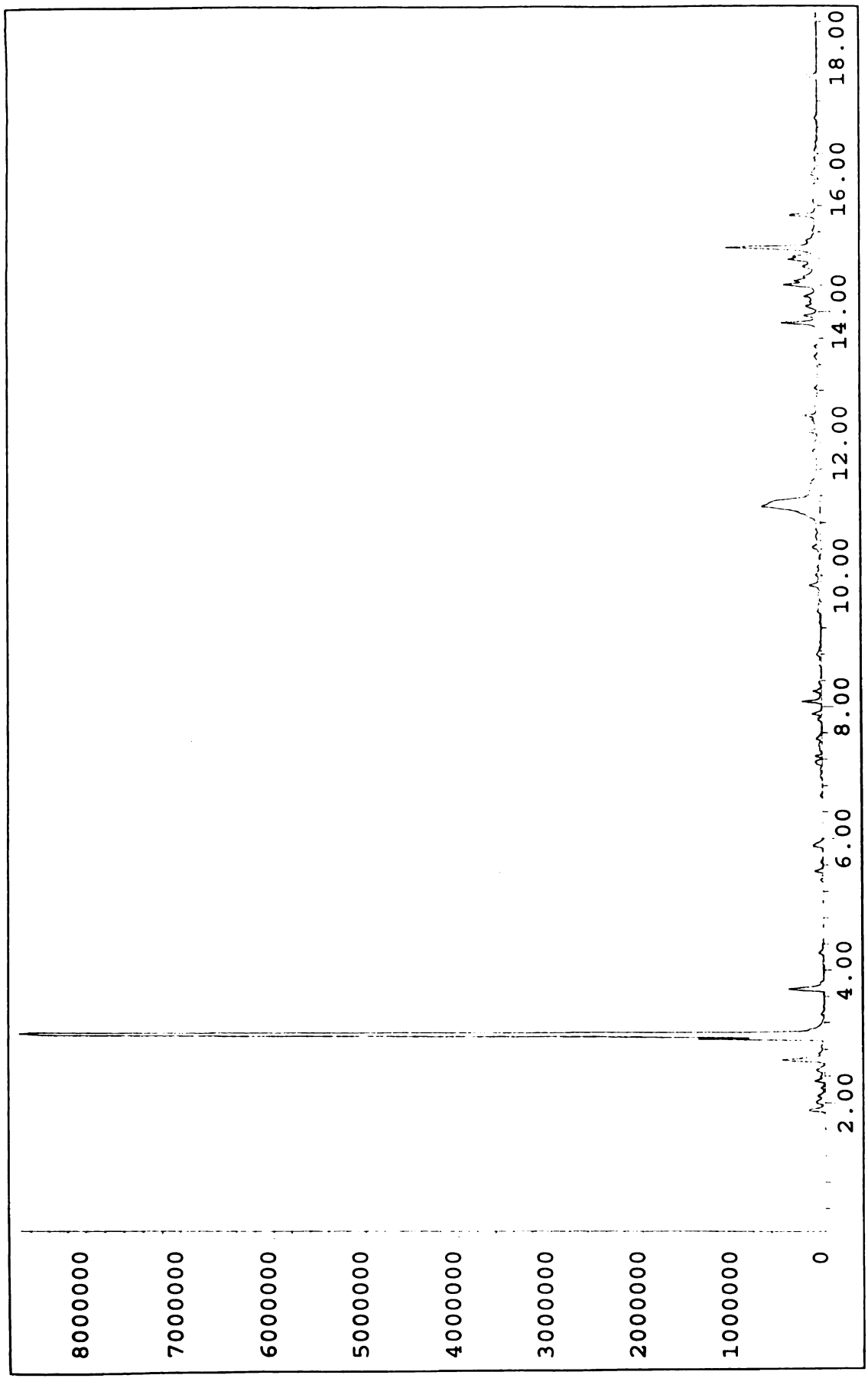

Figure 23: pyGC Representative Chromatograph from Group 3

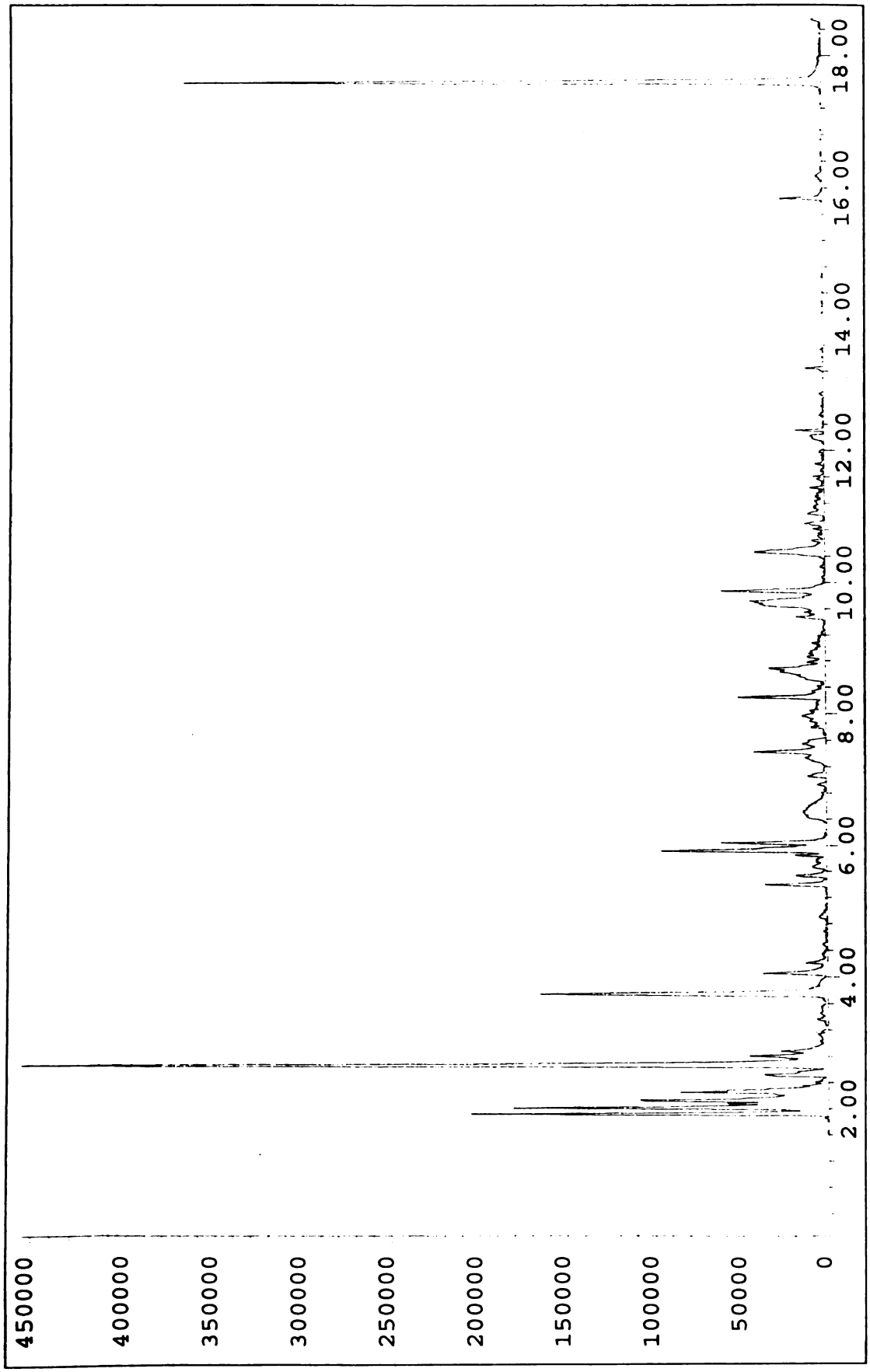

Figure 24: pyGC Representative Chromatograph from Group 4

Overall summary

Table 3: The results from all 3 analysis techniques, showing the groupings for each sample

GROUP #	FILLER #	STEREOSCOPE	PYGC	FTIR BENCH
Individual	1	Peach	2	4
	2	Peach	1A	5
	4	Gold	1B	4
	10	Gold	1B	1
	12	Peach	1B	6
	13	Gold	1B	3
	23	Peach	1A	2
	32	Peach	1B	3
I	3	Gold	1A	3
	11	Gold	1A	3
	28	Gold	1A	3
II	5	Peach	1B	4
	7	Peach	1B	4
	15	Peach	1B	4
III	6	Peach	1B	1
	8	Peach	1B	1
	16	Peach	1B	1
	26	Peach	1B	1
IV	27	Peach	1A	3
	33	Peach	1A	3
V	9	Peach	1A	1
	14	Peach	1A	1
	24	Peach	1A	1
	25	Peach	1A	1
	SPOT PUTTY #	STEREOSCOPE	PYGC	FTIR BENCH
Individual	17	Red	4	7
	20	Red	4	10
	22	Green	3	8
	30	Green	2	9
	31	Grey	4	10
VI	18	Red	4	12
	29	Red	4	12
VII	19	Red	1B	11
	21	Red	1B	11

DISCUSSION

The purpose of this research project was to perform multiple analysis techniques in order to attempt to characterize different types of body fillers and spot putties. The primary goal of this study was to create a scheme by which every sample that may be encountered in a crime laboratory could be differentiated using 3 different analysis techniques. Upon examining the results, it can be concluded that 13 of the 33 body filler and spot putty samples could be individualized, while the rest of the samples, could be put into smaller groups of 2-4 samples.

The first conclusion that can be drawn is that all of the spot putties could be differentiated from the body fillers based on color alone. The spot putties tend to be comprised of more vibrant, unique colours such as green and red, whereas the body fillers tend to resemble dull colors like peach and gold. Since an attempt was made to find a representative sample of all of the body fillers and spot putties currently on the market, it would be likely that the samples that were tested in this study would be similar to what a forensic scientist would encounter during his or her casework.

When referring to Table 3, some additional conclusions can be reached with respect to the spot putties. Five out of nine spot putties can be individualized using visible microscopy, pyGC and FTIR together (17, 20, 22, 30, 31). The remaining 4 can be grouped into 2 groups: 18 & 29 could not be differentiated from each other and 19 & 21 could not be differentiated from each other.

Additionally, when referring to Table 3, it can be concluded that 8 out of 24 body filler samples can be individualized using the 3 analysis tools from this study (1, 2, 4, 10, 12, 13, 23, 32). The remaining 16 samples were further divided into 5 smaller groups: 3, 11, 28 could not be differentiated from each other; 5, 7, 15 could not be differentiated from each other; 6, 8, 16, 26 could not be differentiated from each other; 27, 33 could not be differentiated from each other; and 9, 14, 24, 25 could not be differentiated from each other.

CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

The protocol that was created for characterizing body filler and spot putty samples proved to be a straightforward, easy and a relatively quick procedure. The combination of three different techniques helped to individualize 13 out of 33 samples, while placing the remainder of the samples into smaller groups. However, this analysis scheme can only be successful if a crime laboratory has access to all three of the instruments used in this study.

The analysis techniques that were used in this study primarily focussed on the organic components of the body filler and spot putty samples. Since these samples are largely made up of inorganic elements, it would be extremely useful to test all of these samples using Scanning Electron Microscopy (SEM-EDX), which would help in identifying some of the major inorganic components. The author believes that the use of SEM-EDX would help to further individualize the remaining samples and/or place them into even smaller groups. In addition, these samples were run as they came from the manufacturer, straight from the can and not taken from paint chips or an automobile. It would be interesting to see if the results would change when a sample was taken from an automotive shop floor or from a car itself that has been repaired and its filler painted over. The author feels that there would not be much seen by way of changes in chemical composition. The body filler/spot putty would be protected from weathering and destruction by the application of paint over top of it when placed on a car, or by being protected in the shop by storing and capping it properly.

SUGGESTED PROTOCOL

Before attempting to analyze this type of forensic evidence, there are a number of factors that a scientist must keep in mind. First of all, the scientist must decide how much weight to place on a specific type of evidence. This will help to determine the analysis protocol the scientist will follow. Also, the scientist must be aware of the quantity of the sample, because some tests are destructive. Keeping all of this in mind, a protocol is suggested for the analysis and comparison of forensic body filler and spot putty samples.

Since pyGC is a destructive test, the scientist should first attempt to examine any known and questioned samples under the stereoscope so they could make a good observation of the color. Next, the scientist should attempt to scrape away as much of the sample as possible from the paint or metal it's attached to, keeping in mind that if the sample is being removed from adhering paint, contamination may result from the bottom layer of paint interacting with the top layer of sample. Thus, the scientist should attempt to obtain the best representative sample as possible, by sampling from the middle of the body filler or spot putty layer and not from either end. With the remaining sample, the scientist should then try to perform FTIR by preparing the sample as a KBr pellet. If the sample is limited, FTIR should be done before pyrolysis since it is not a destructive test. If the sample needs to be recovered after FTIR, one could dissolve the KBr into water, evaporate the water and recover the sample. Lastly, pyrolysis should be performed since it is destructive and does not require a very large amount of sample. Hopefully, if all 3 analysis techniques are available and

used, the scientist will get a really good idea of whether these two samples are alike or not.

Finally, the results of all 3 of the analysis techniques should be taken into account and given equal weight when drawing any conclusion as to whether the questioned body filler/spot putty sample could or could not have originated from the same source as the known body filler/spot putty sample.

APPENDICES

APPENDIX A

Fourier Transform Infrared Spectra from Sample Analysis

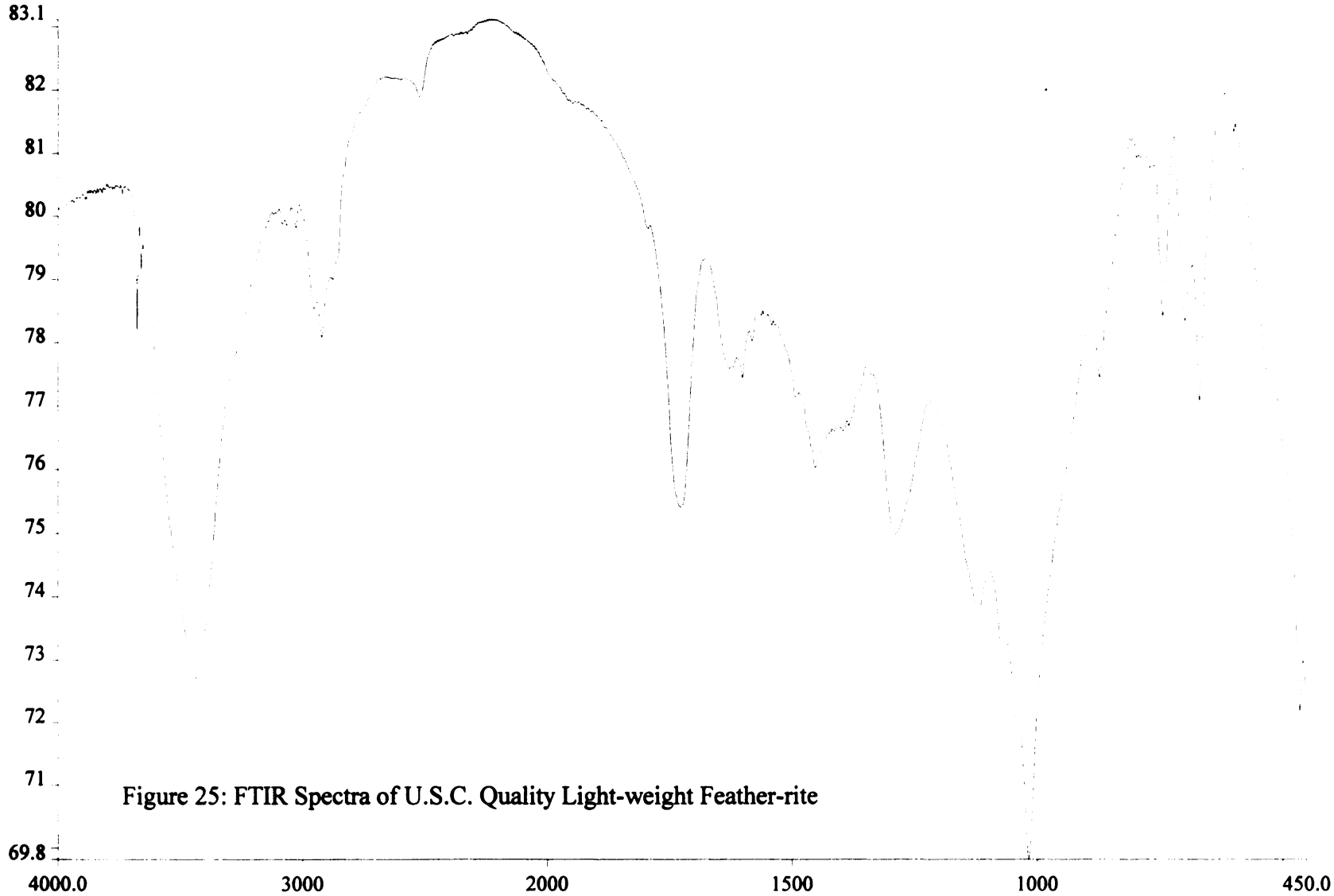

Figure 25: FTIR Spectra of U.S.C. Quality Light-weight Feather-rite

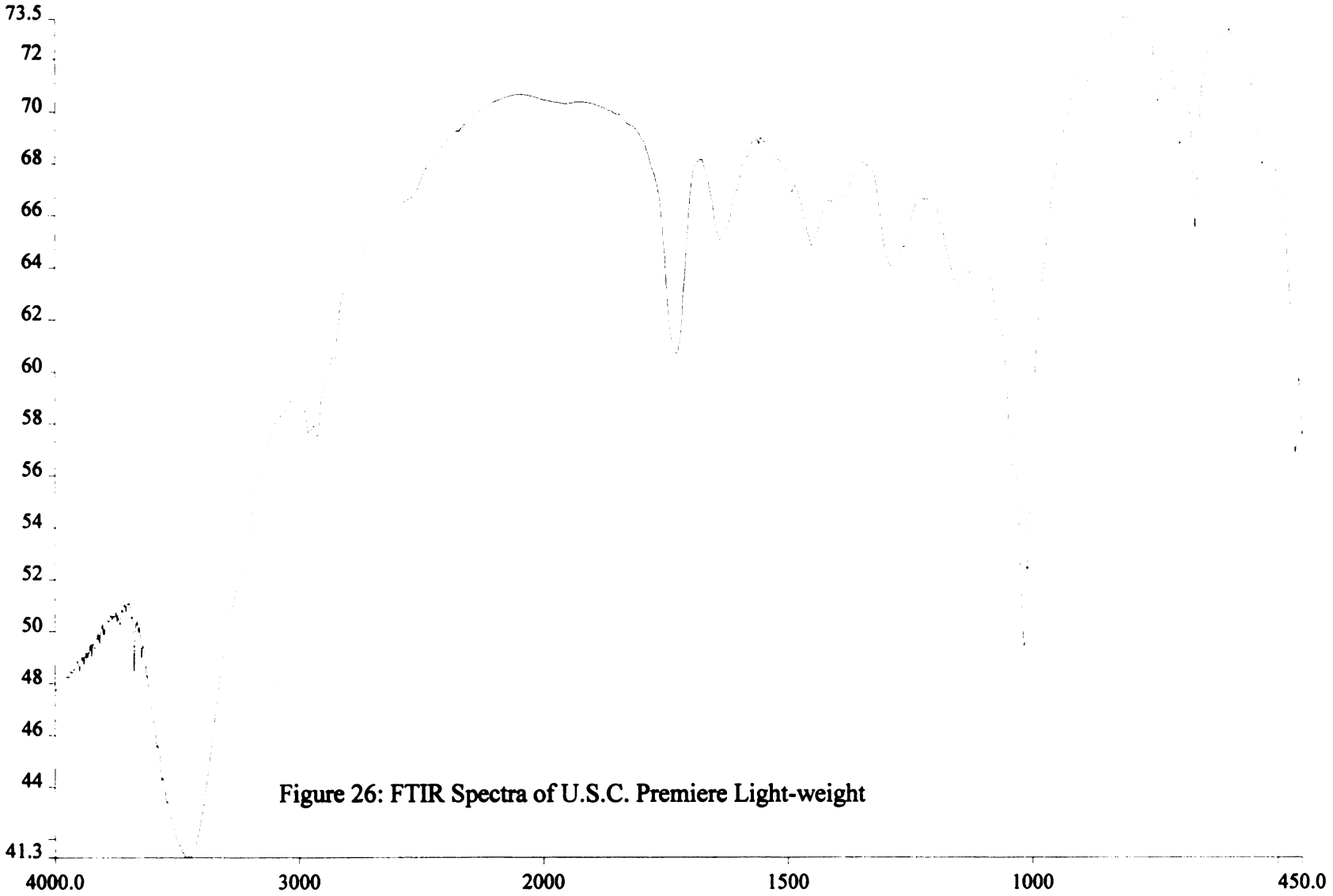

Figure 26: FTIR Spectra of U.S.C. Premiere Light-weight

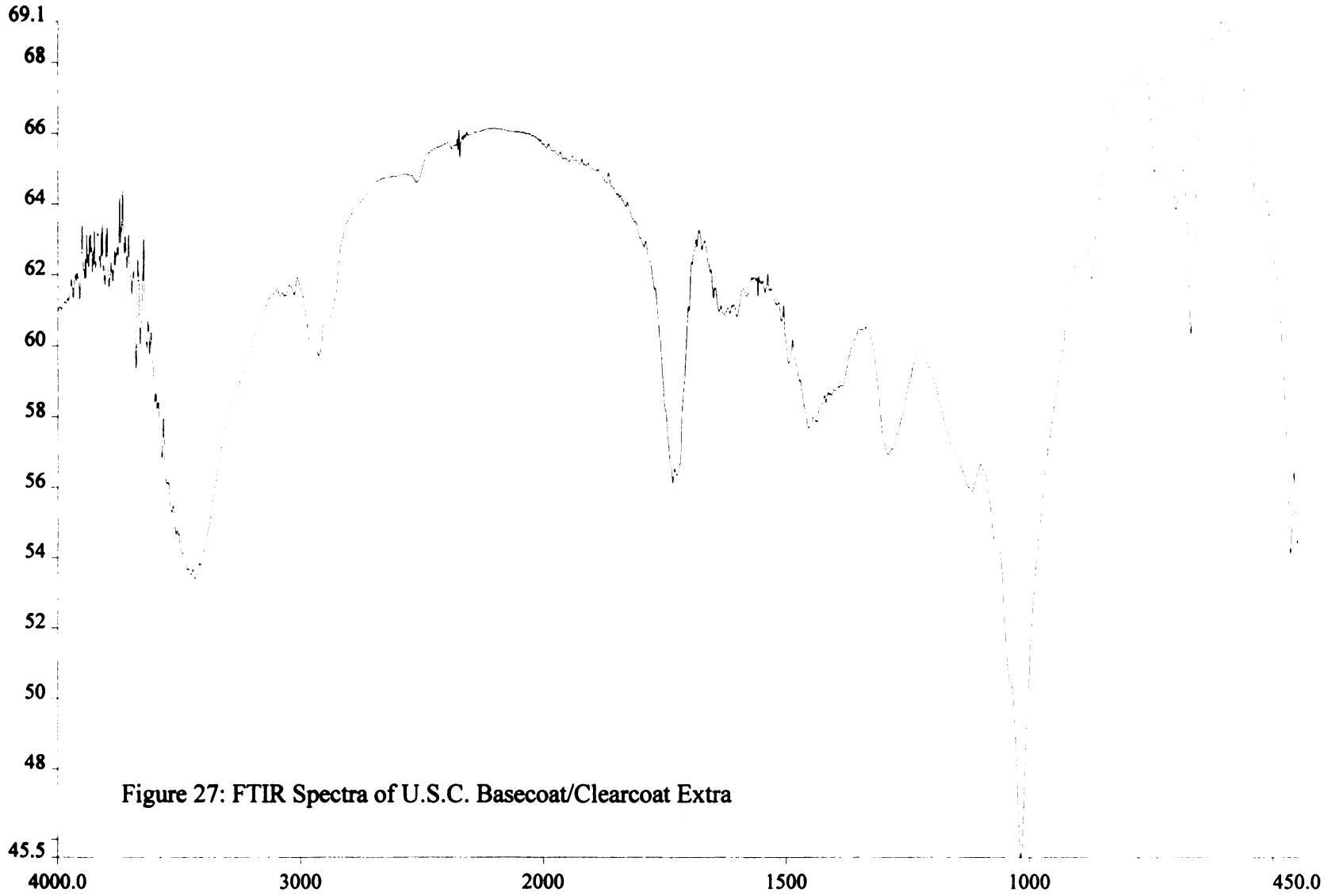

Figure 27: FTIR Spectra of U.S.C. Basecoat/Clearcoat Extra

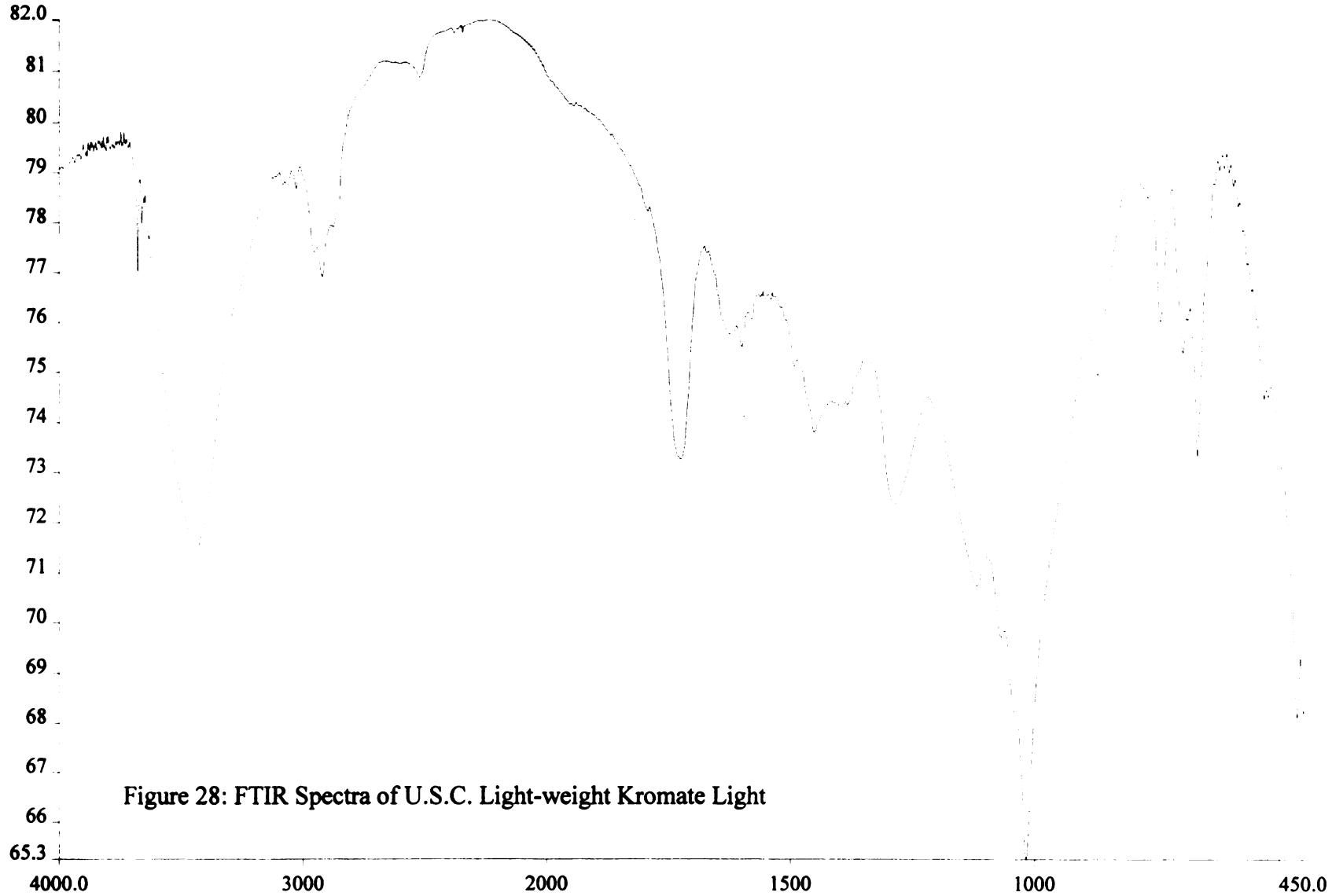

Figure 28: FTIR Spectra of U.S.C. Light-weight Kromate Light

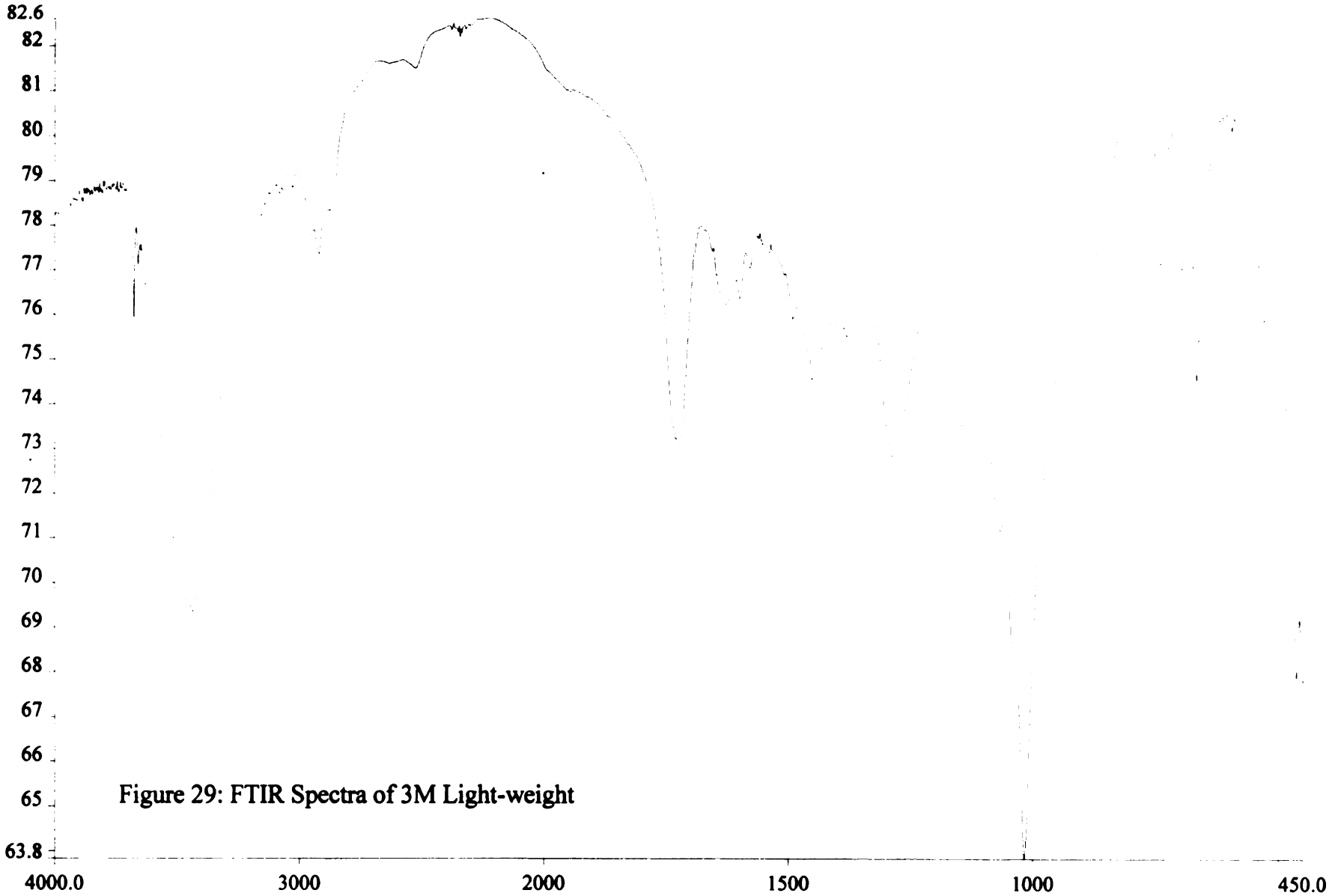

Figure 29: FTIR Spectra of 3M Light-weight

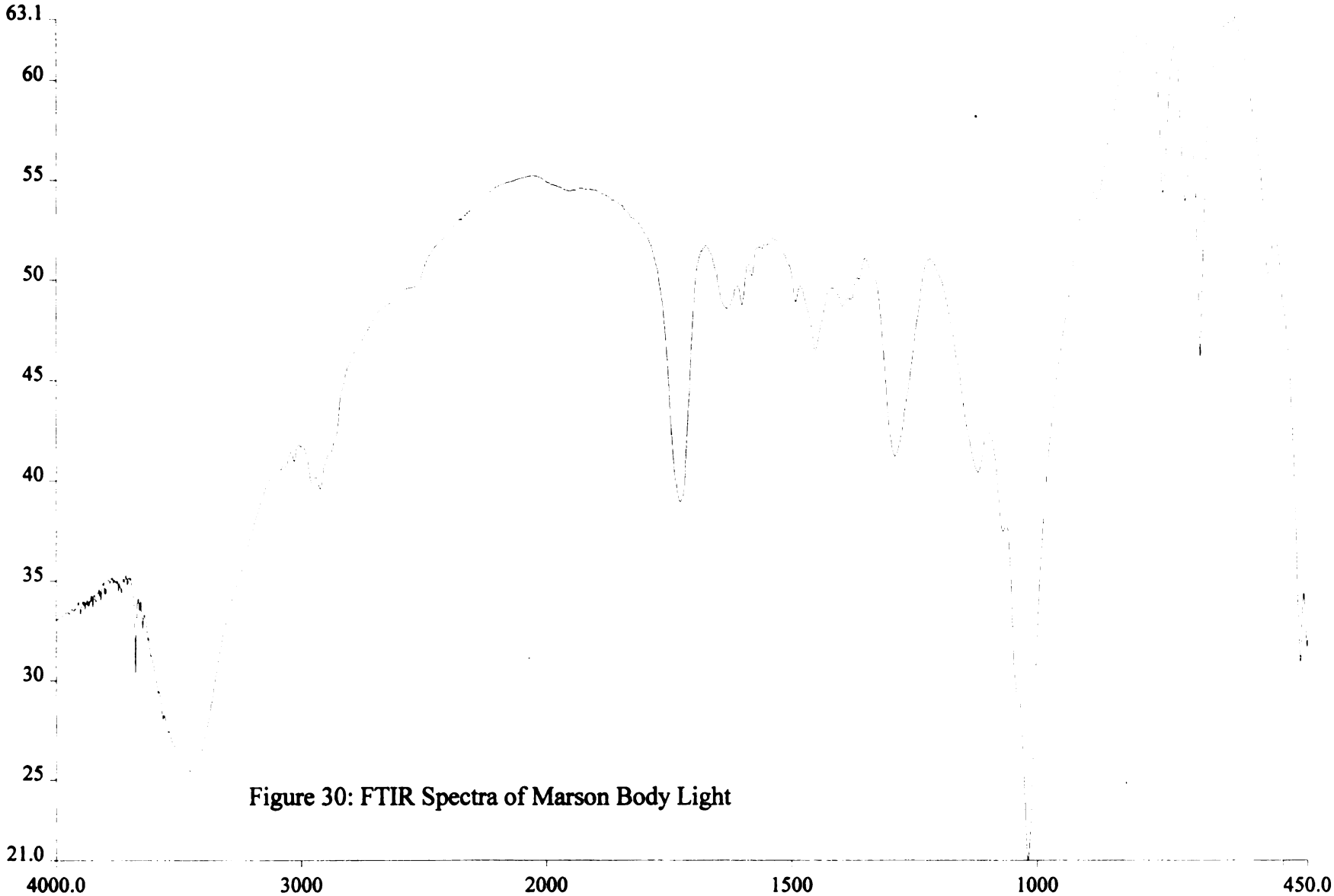

Figure 30: FTIR Spectra of Marson Body Light

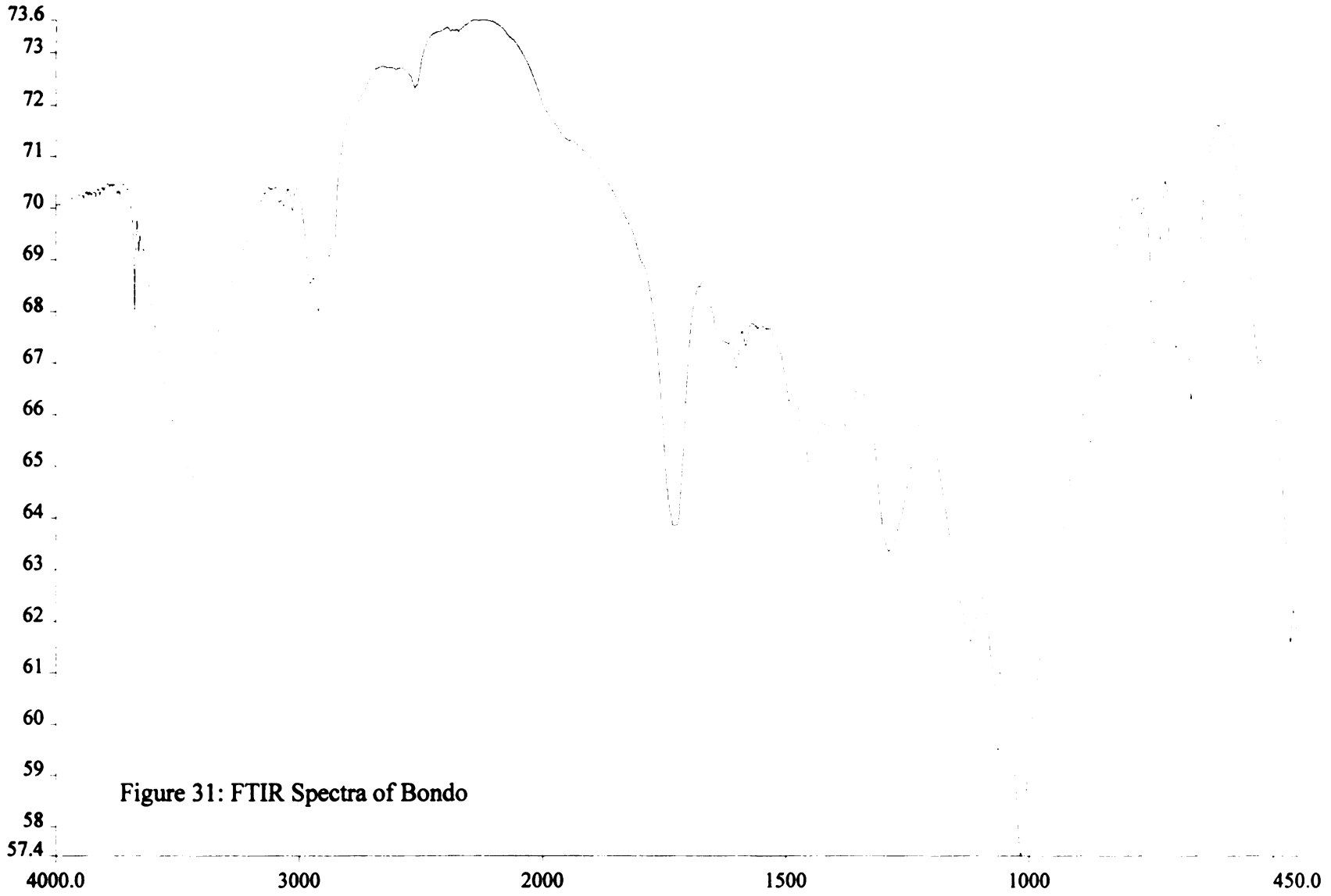

Figure 31: FTIR Spectra of Bondo

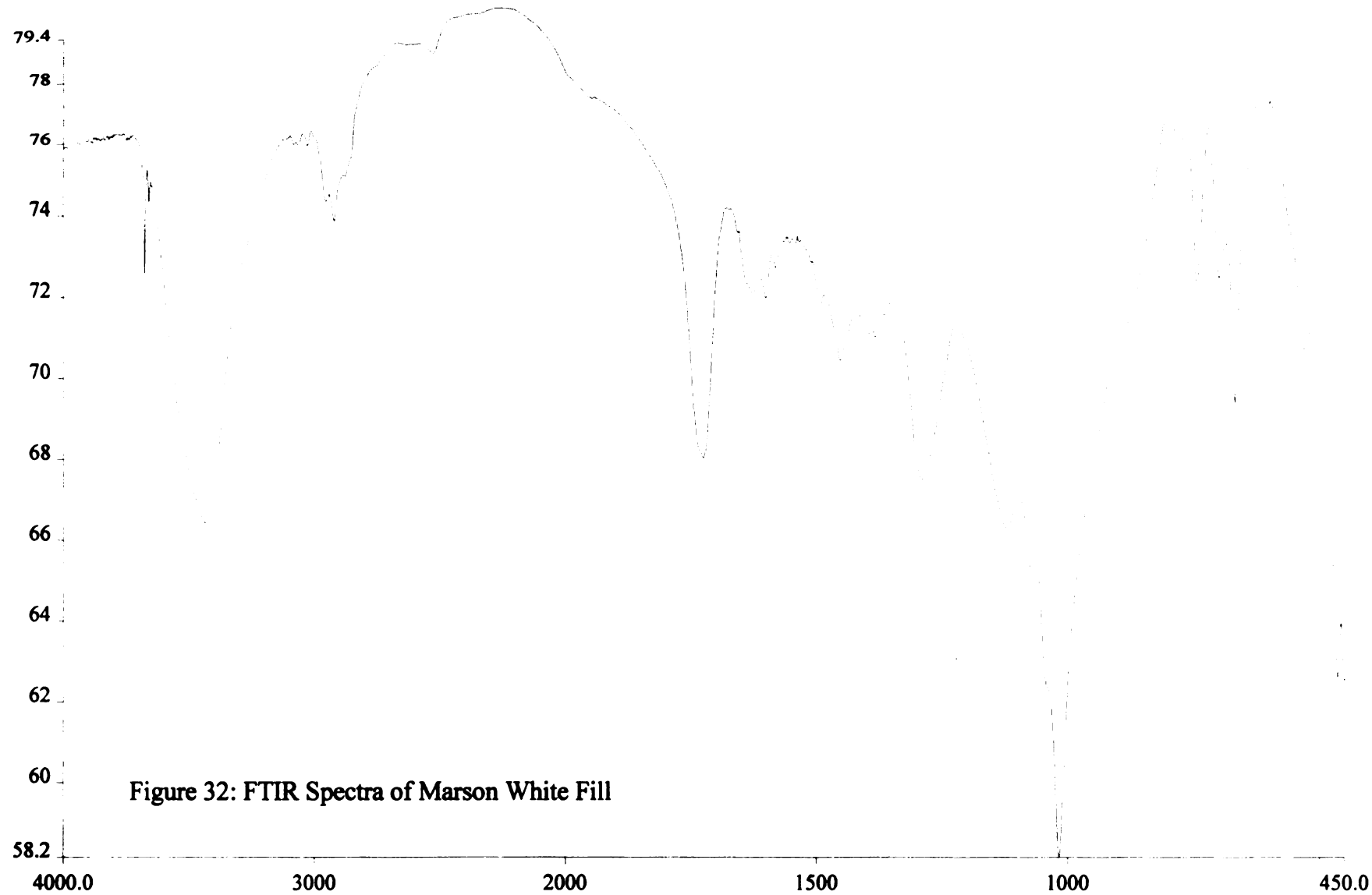

Figure 32: FTIR Spectra of Marson White Fill

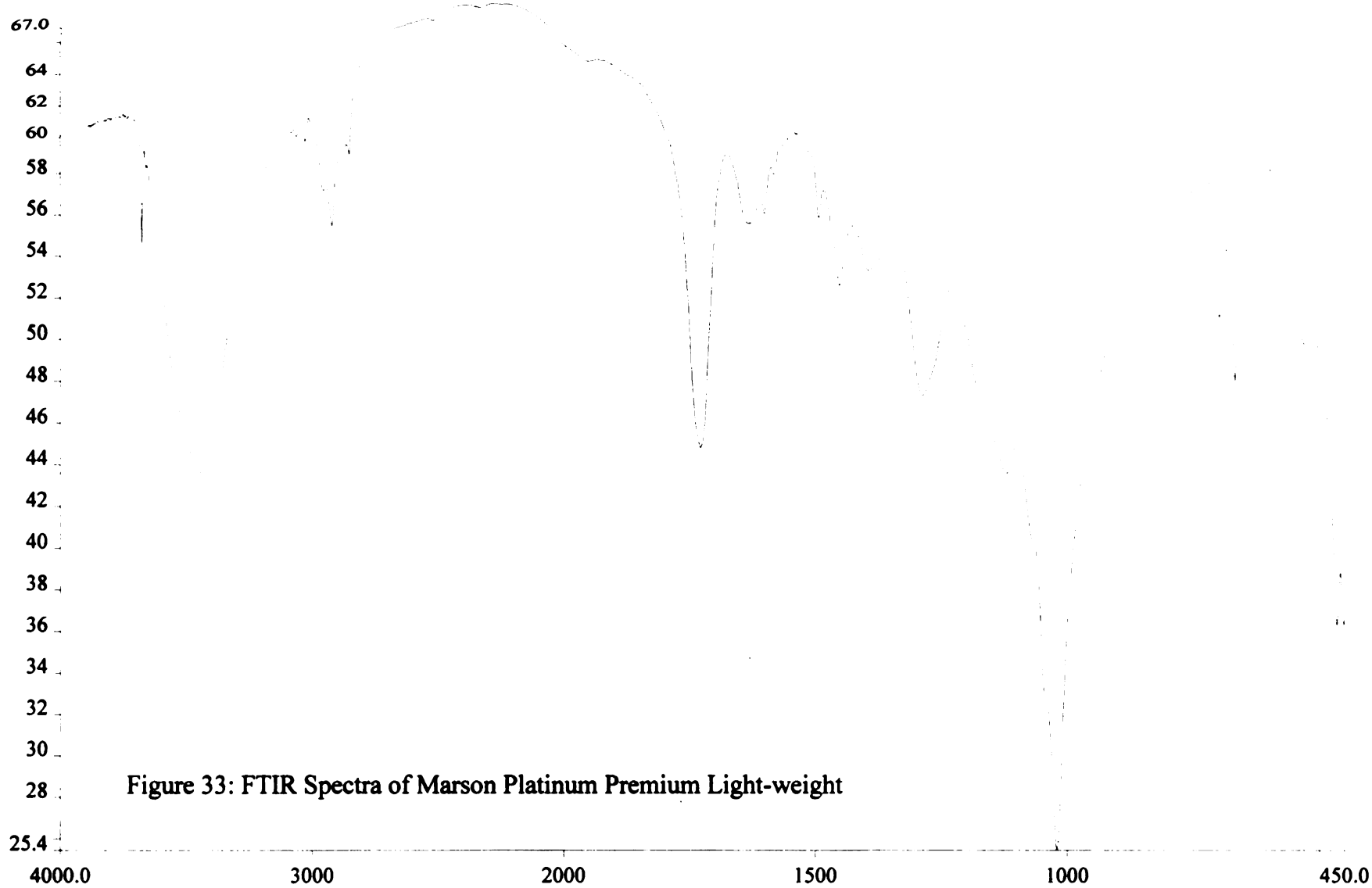

Figure 33: FTIR Spectra of Marson Platinum Premium Light-weight

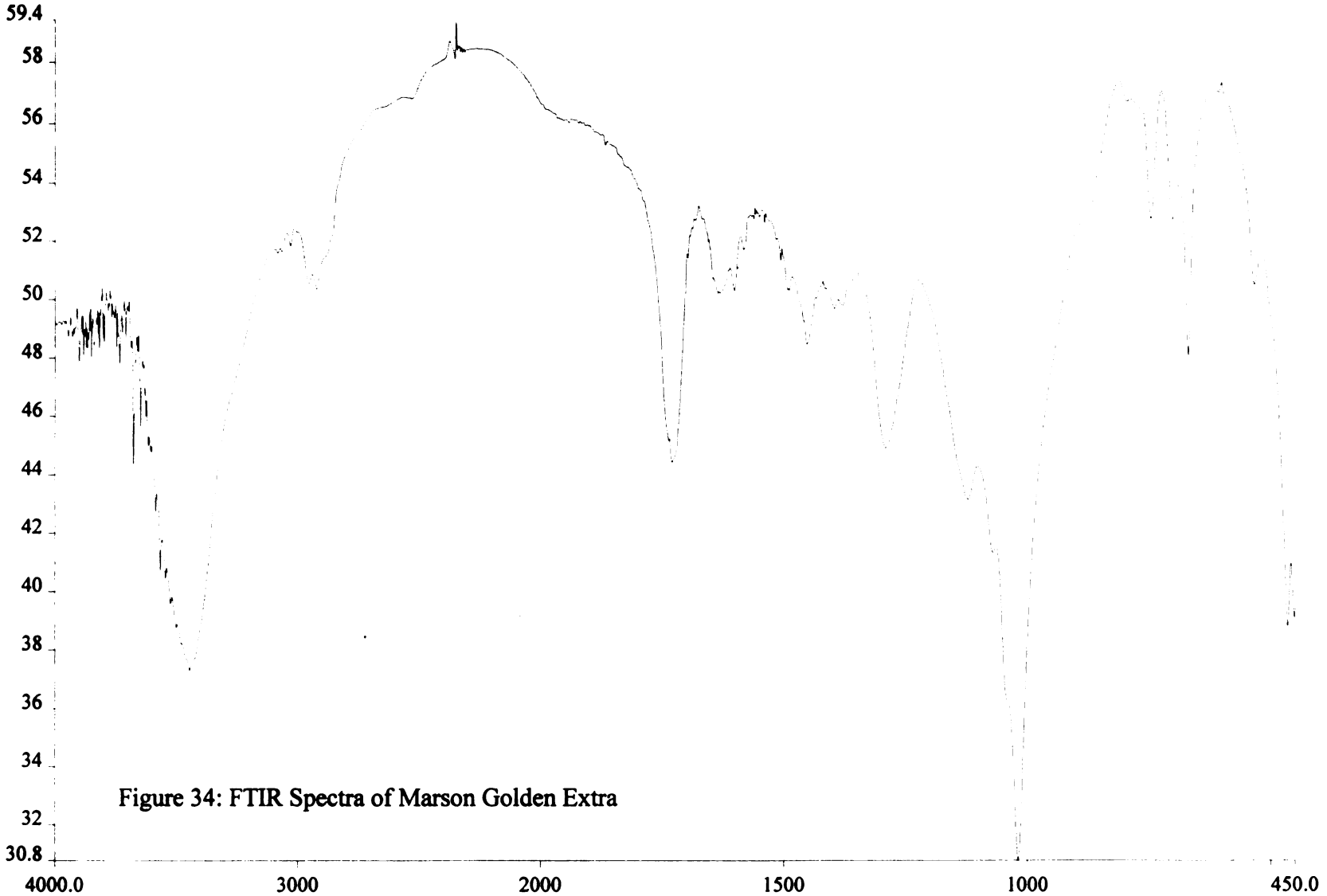

Figure 34: FTIR Spectra of Marson Golden Extra

Figure 35: FTIR Spectra of Evercoat Rage Gold

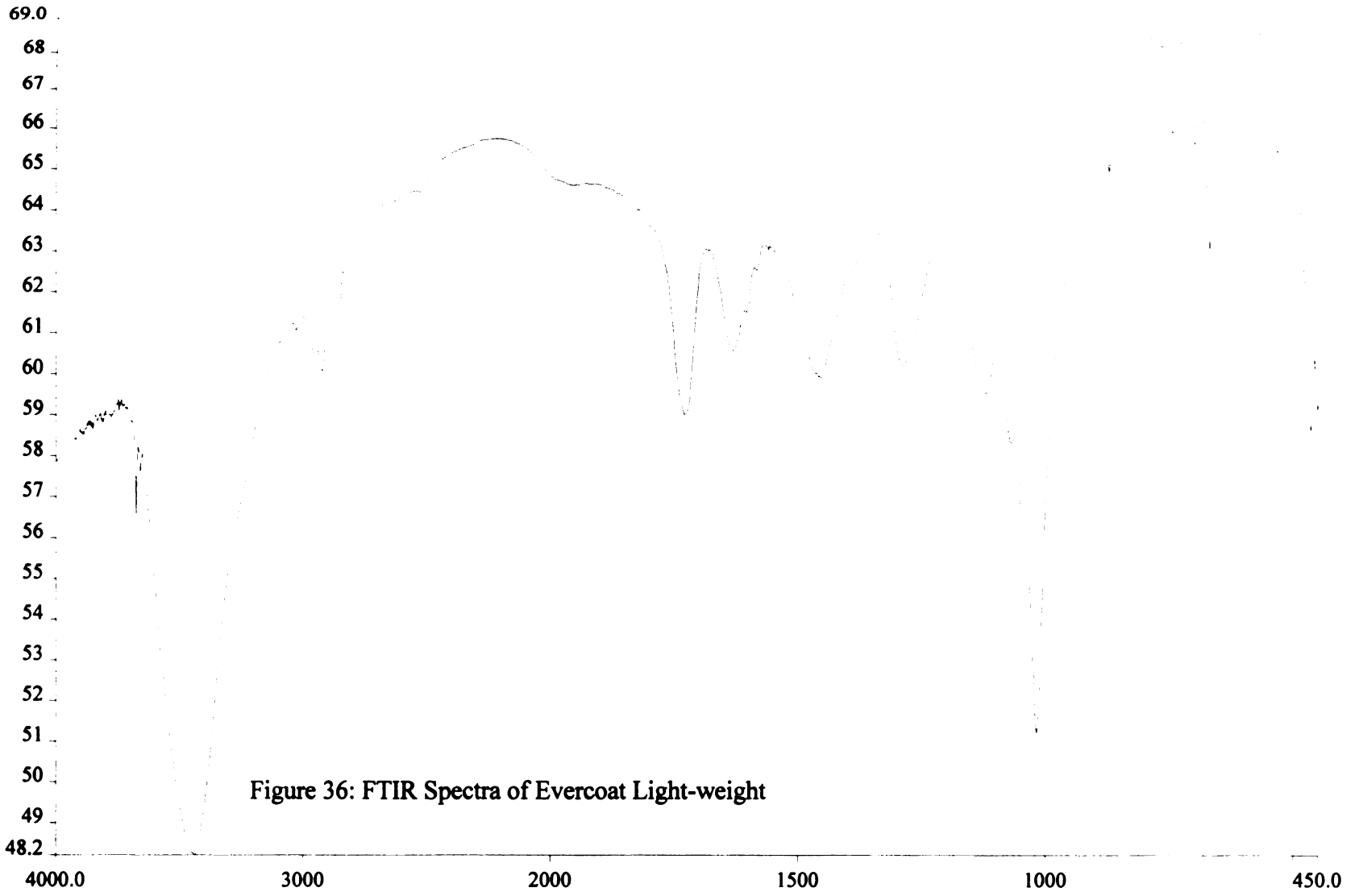

Figure 36: FTIR Spectra of Evercoat Light-weight

Figure 37: FTIR Spectra of Evercoat Chrome-a-Lite

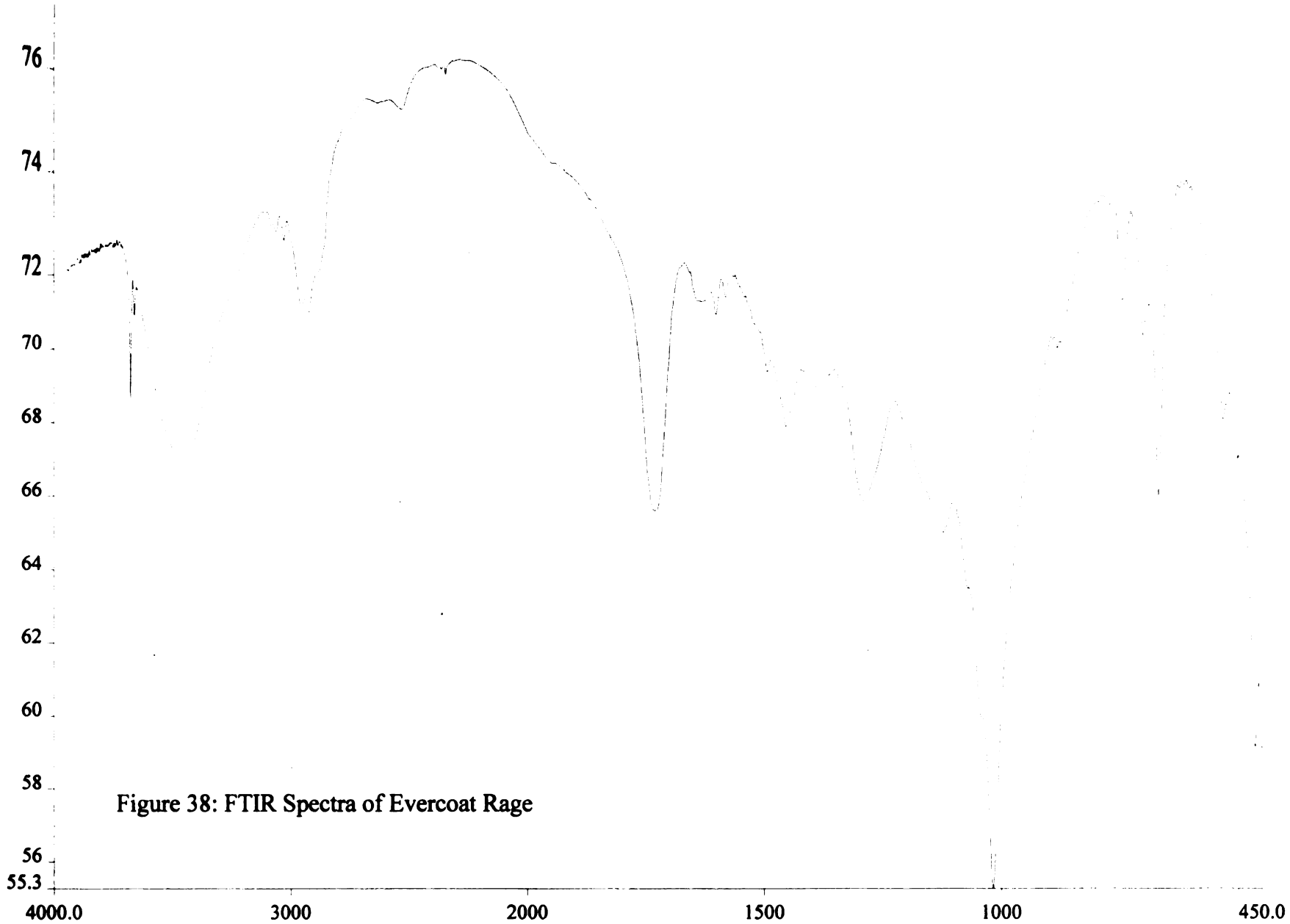

Figure 38: FTIR Spectra of Evercoat Rage

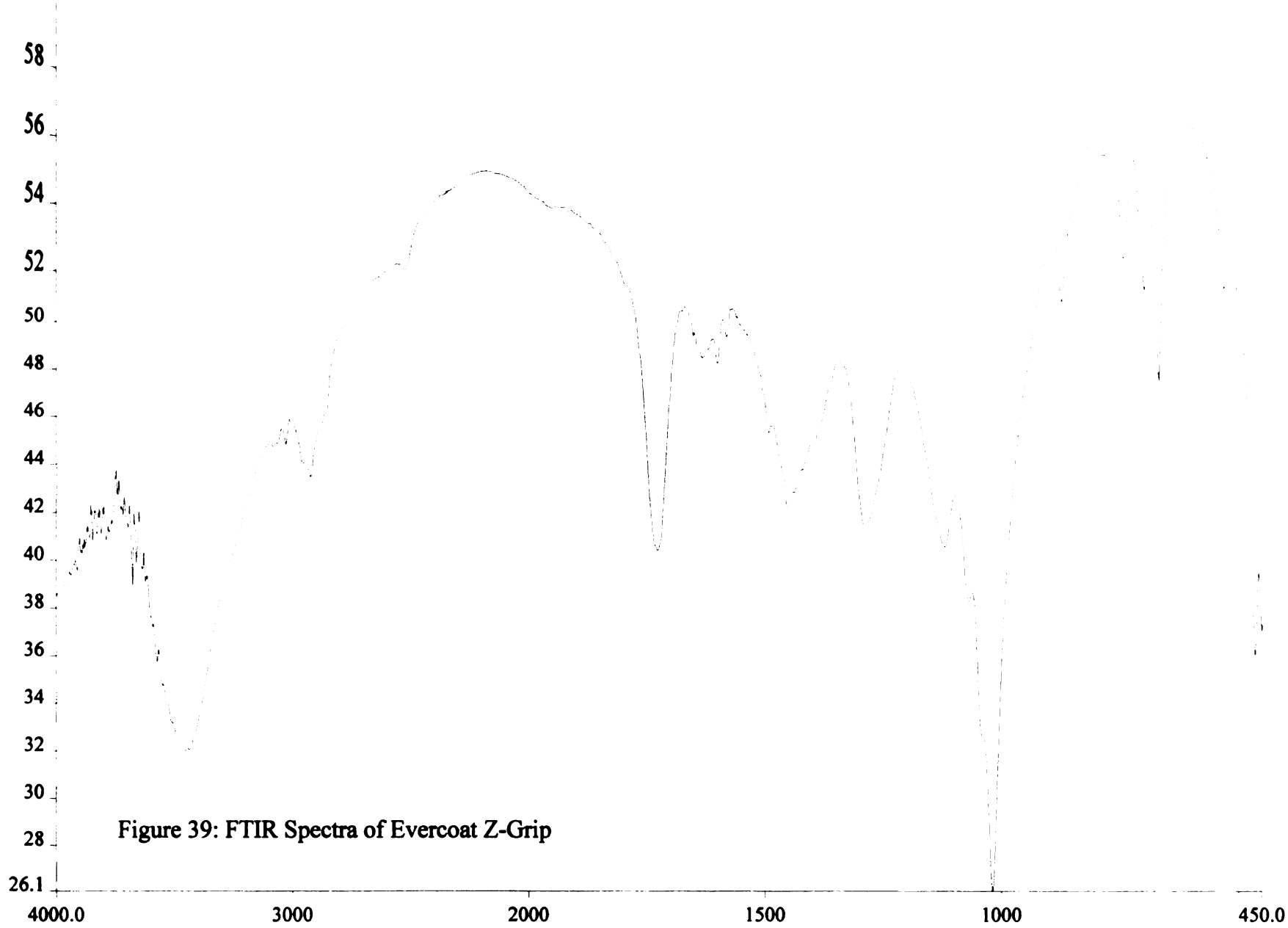

Figure 39: FTIR Spectra of Evercoat Z-Grip

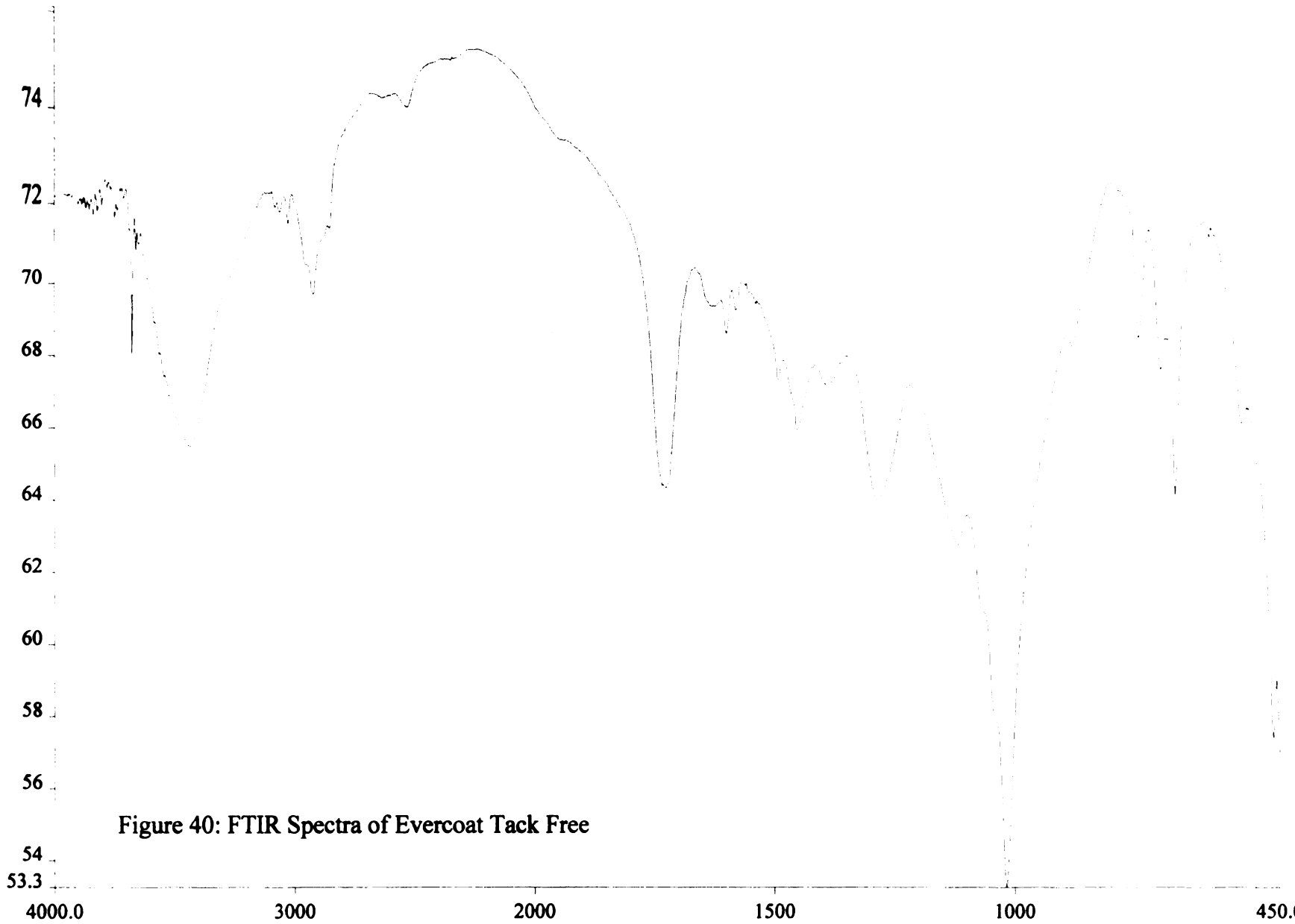

Figure 40: FTIR Spectra of Evercoat Tack Free

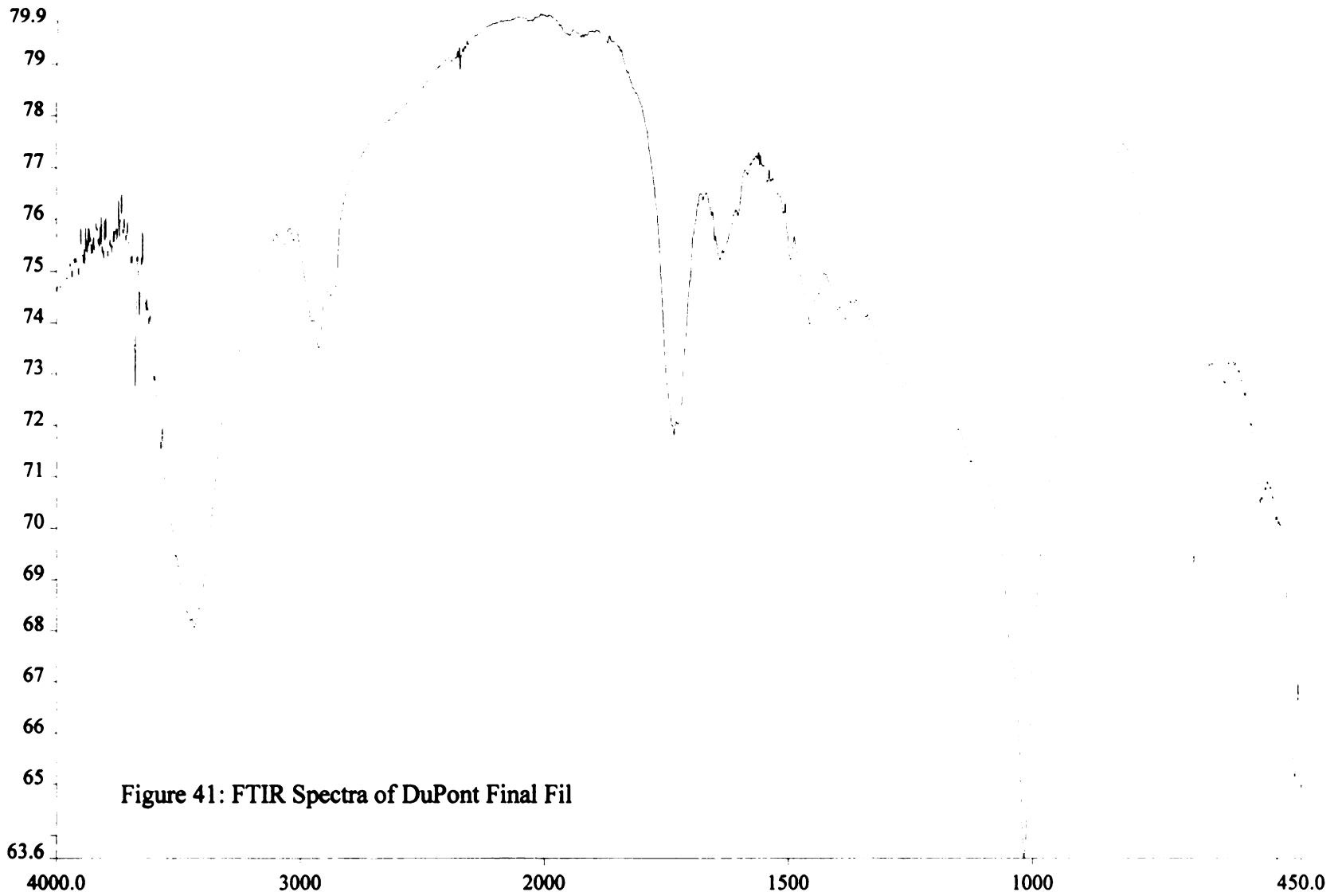

Figure 41: FTIR Spectra of DuPont Final Fil

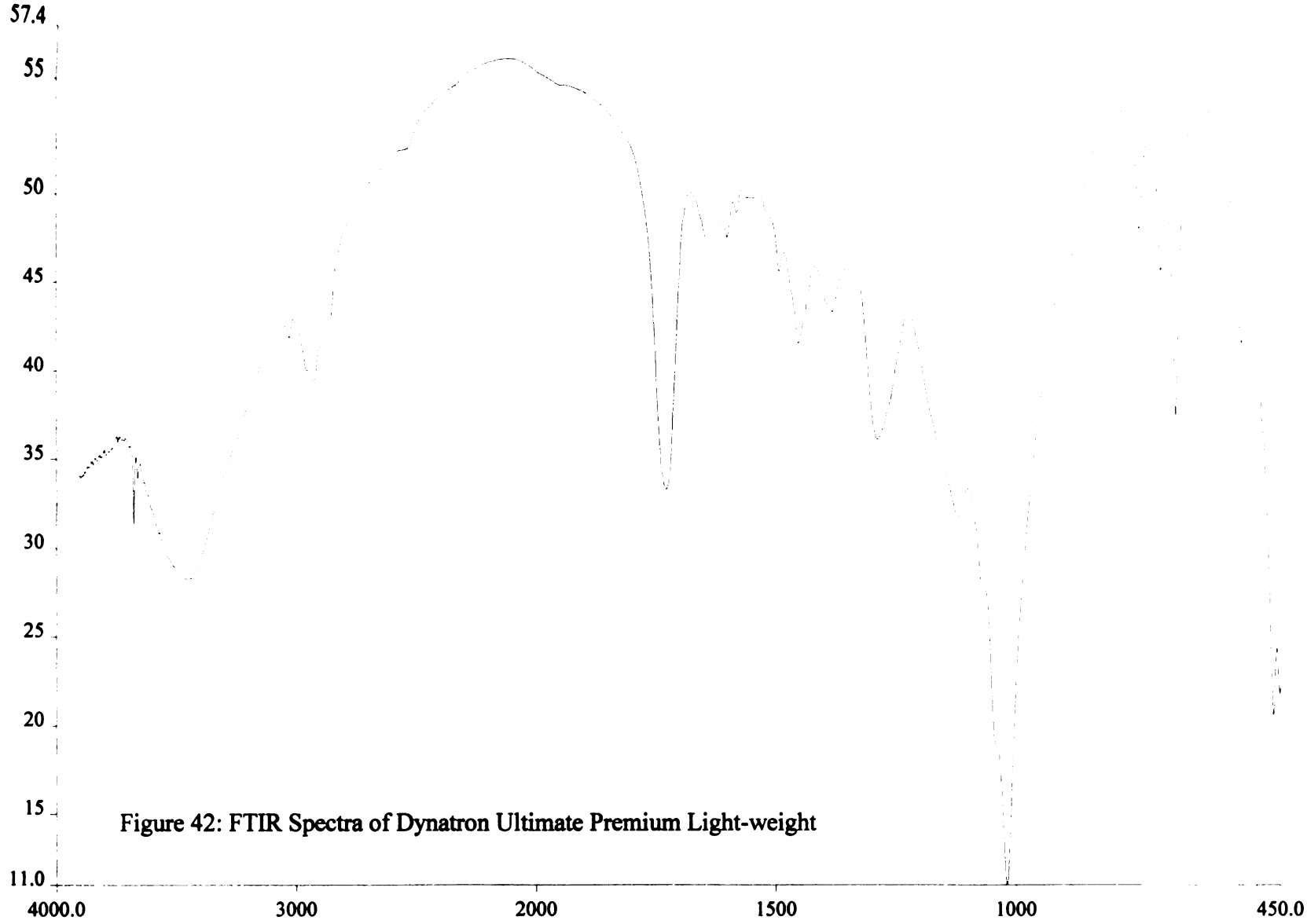

Figure 42: FTIR Spectra of Dynatron Ultimate Premium Light-weight

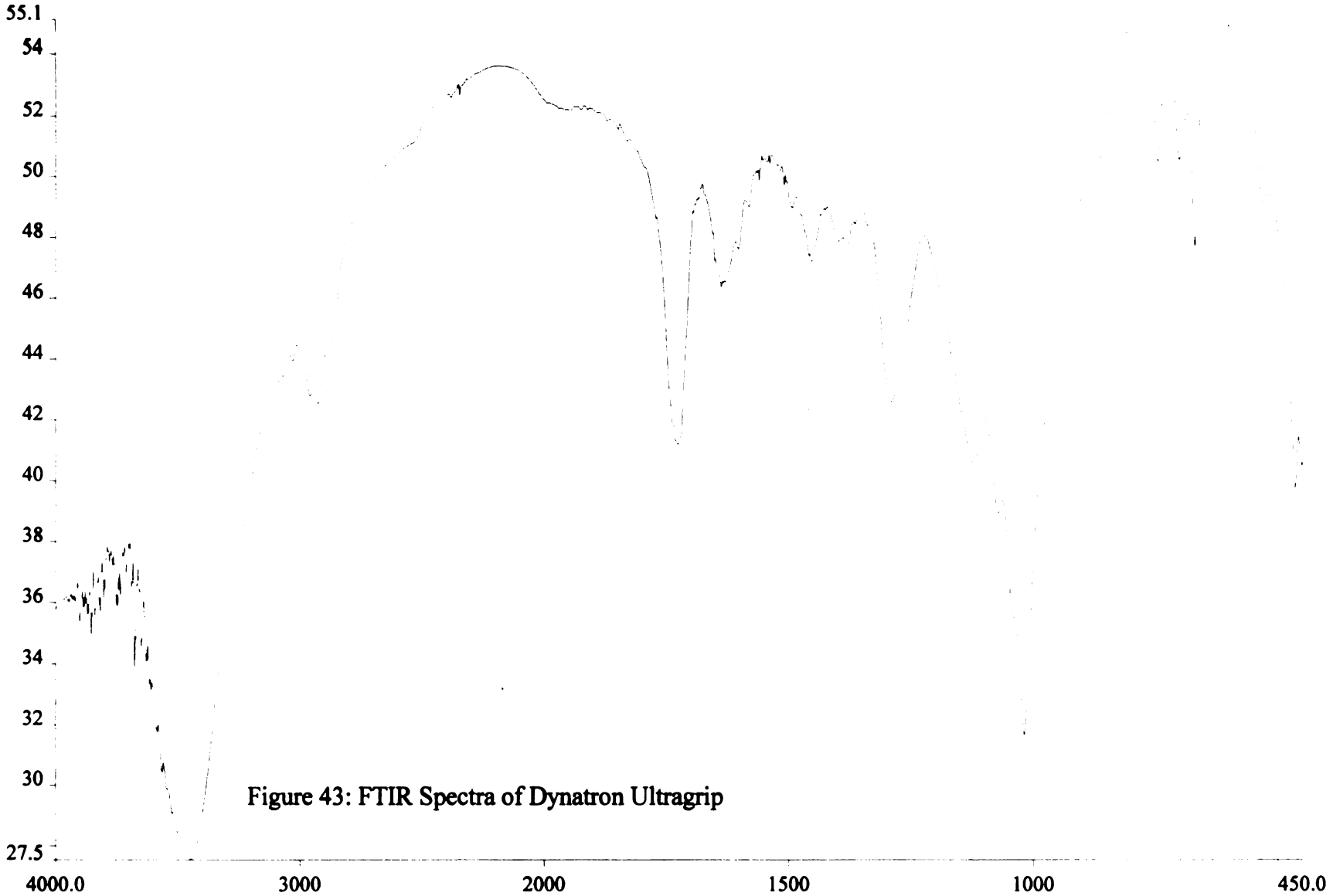

Figure 43: FTIR Spectra of Dynatron Ultragrip

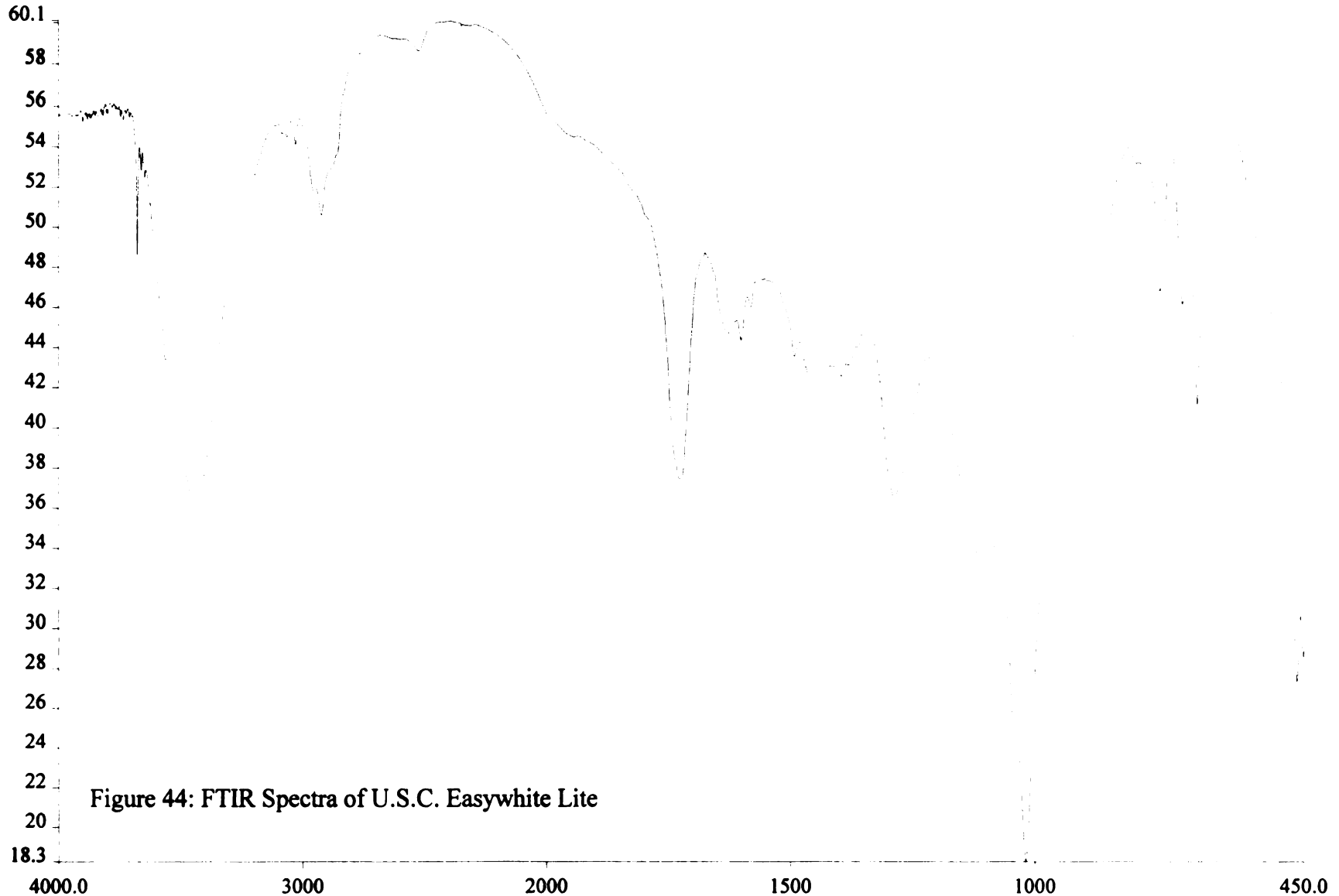

Figure 44: FTIR Spectra of U.S.C. Easywhite Lite

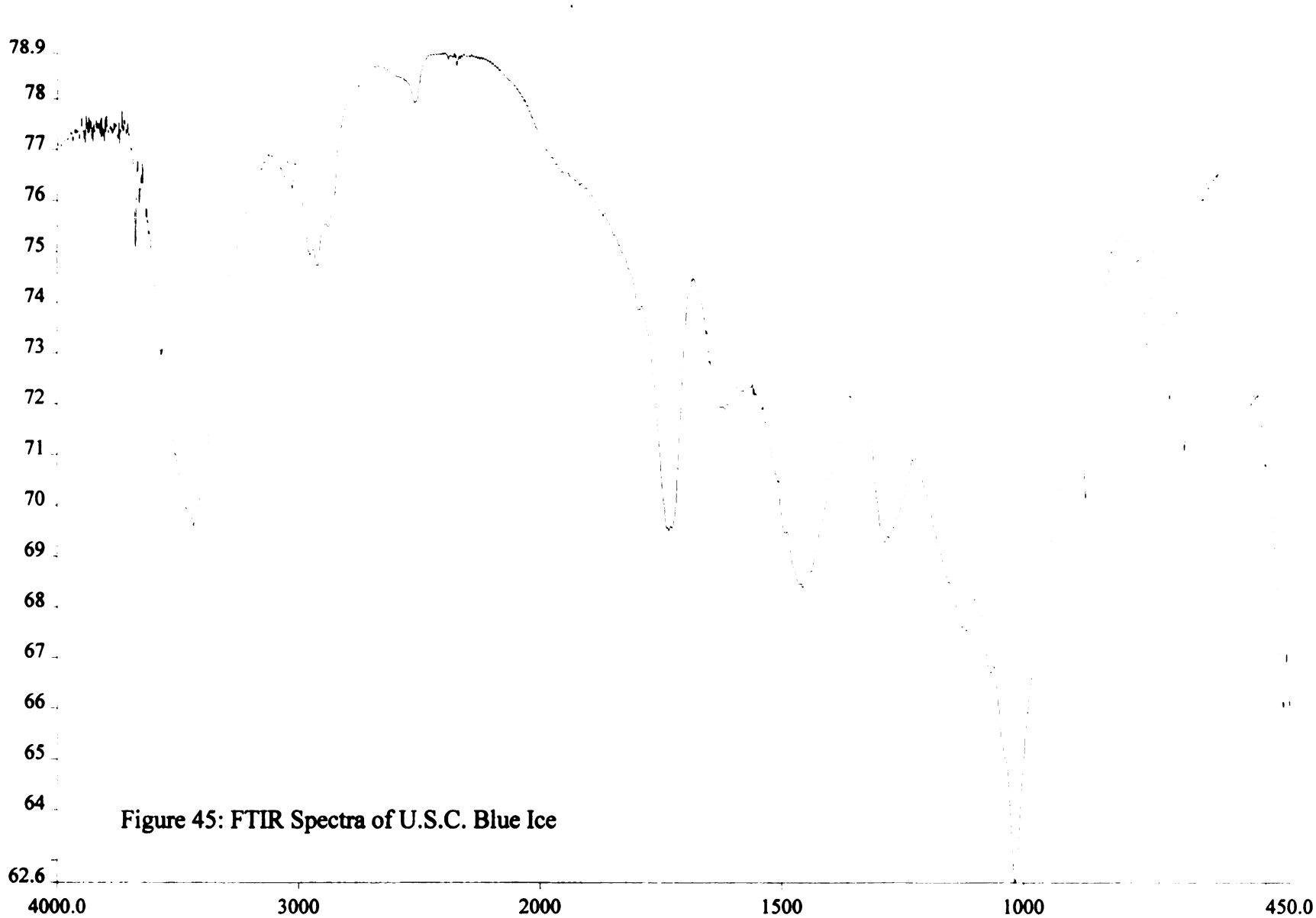

Figure 45: FTIR Spectra of U.S.C. Blue Ice

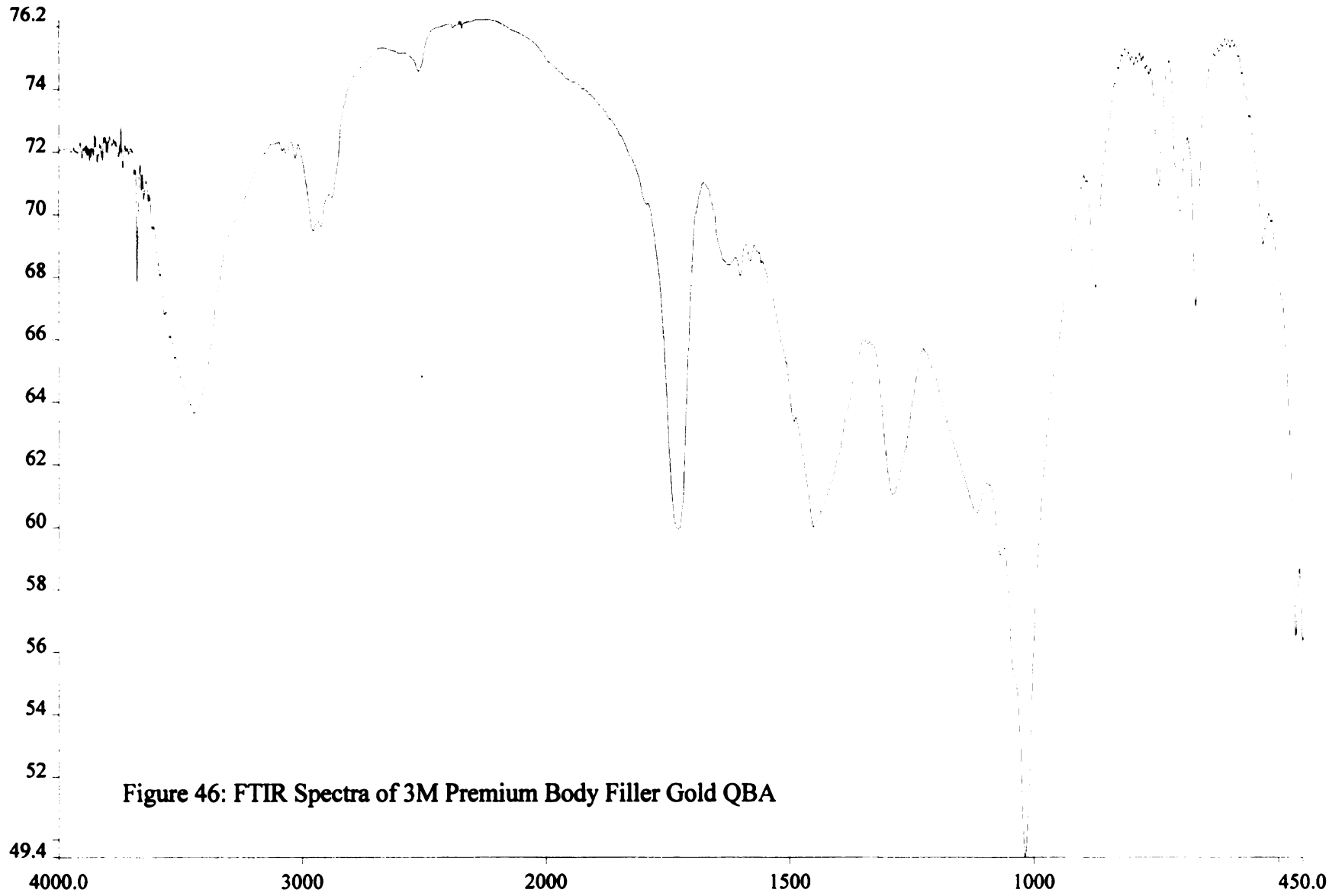

Figure 46: FTIR Spectra of 3M Premium Body Filler Gold QBA

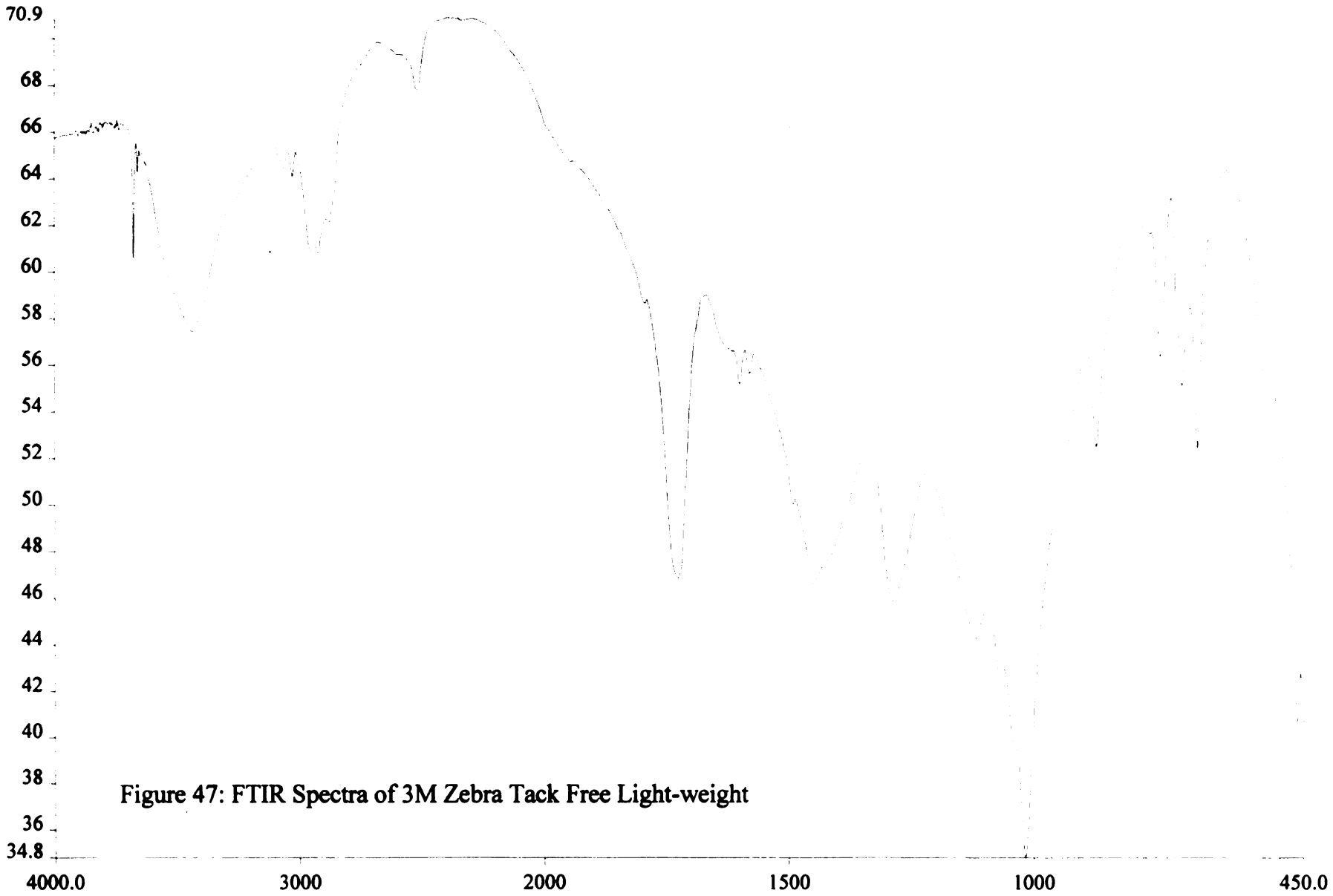

Figure 47: FTIR Spectra of 3M Zebra Tack Free Light-weight

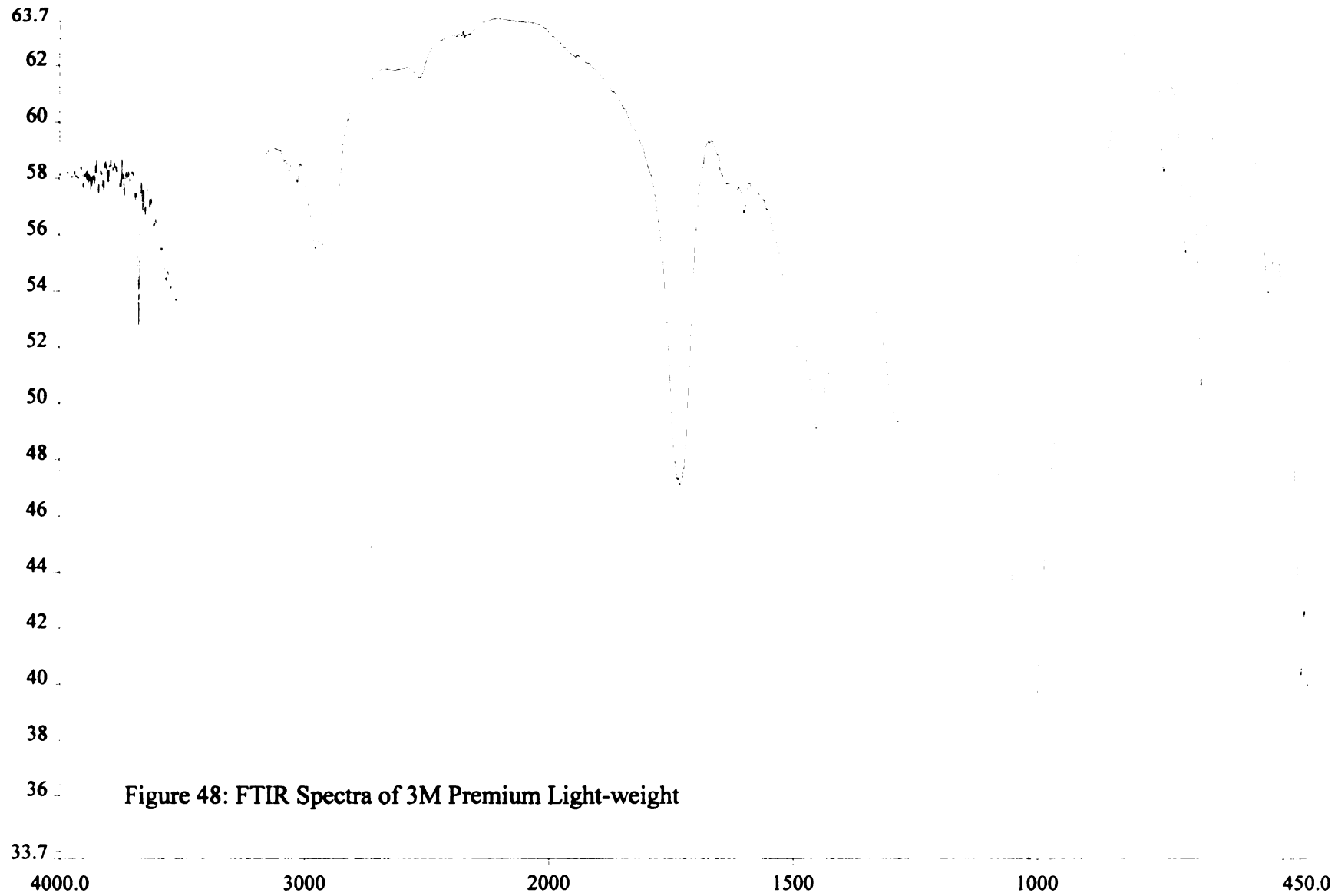

Figure 48: FTIR Spectra of 3M Premium Light-weight

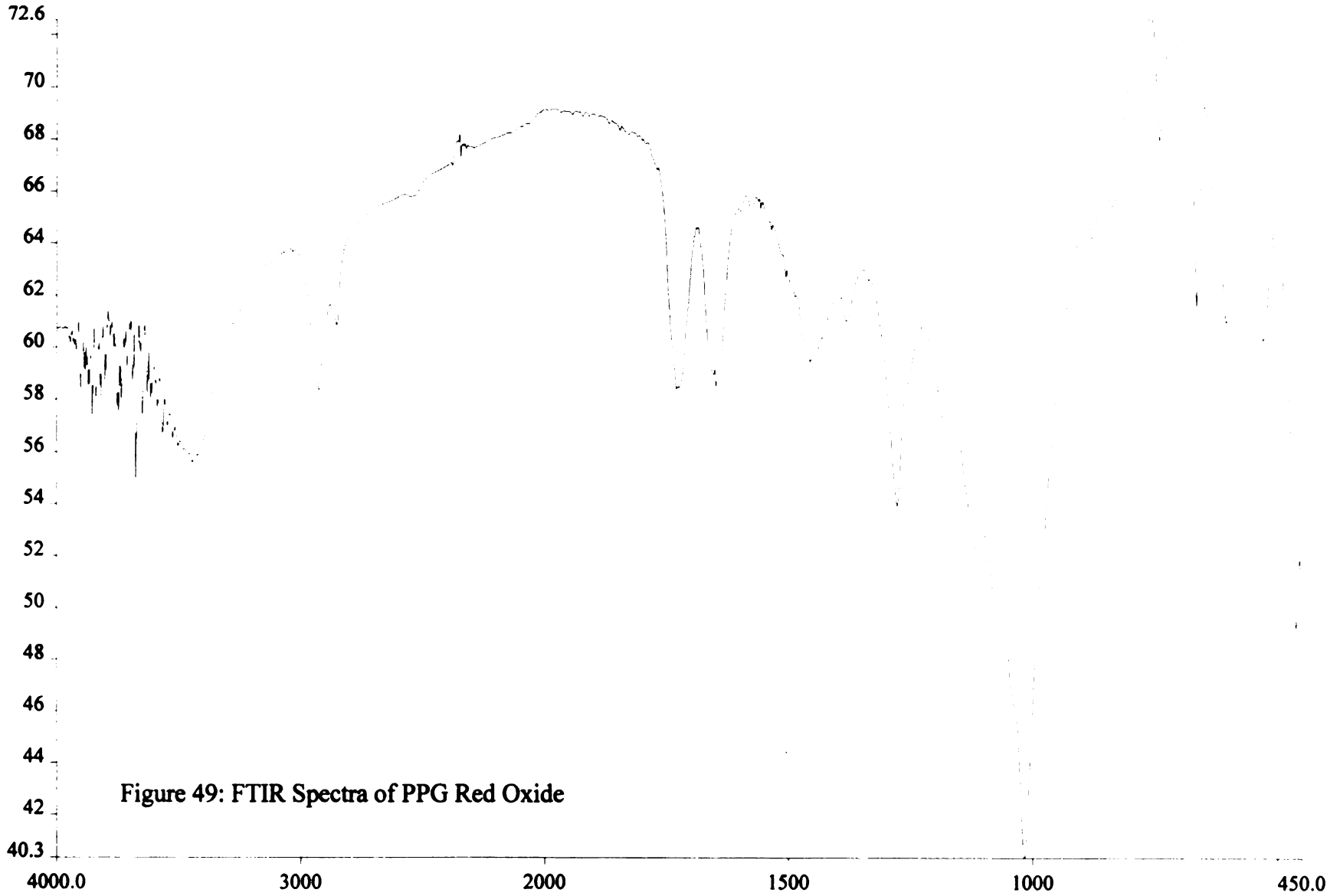

Figure 49: FTIR Spectra of PPG Red Oxide

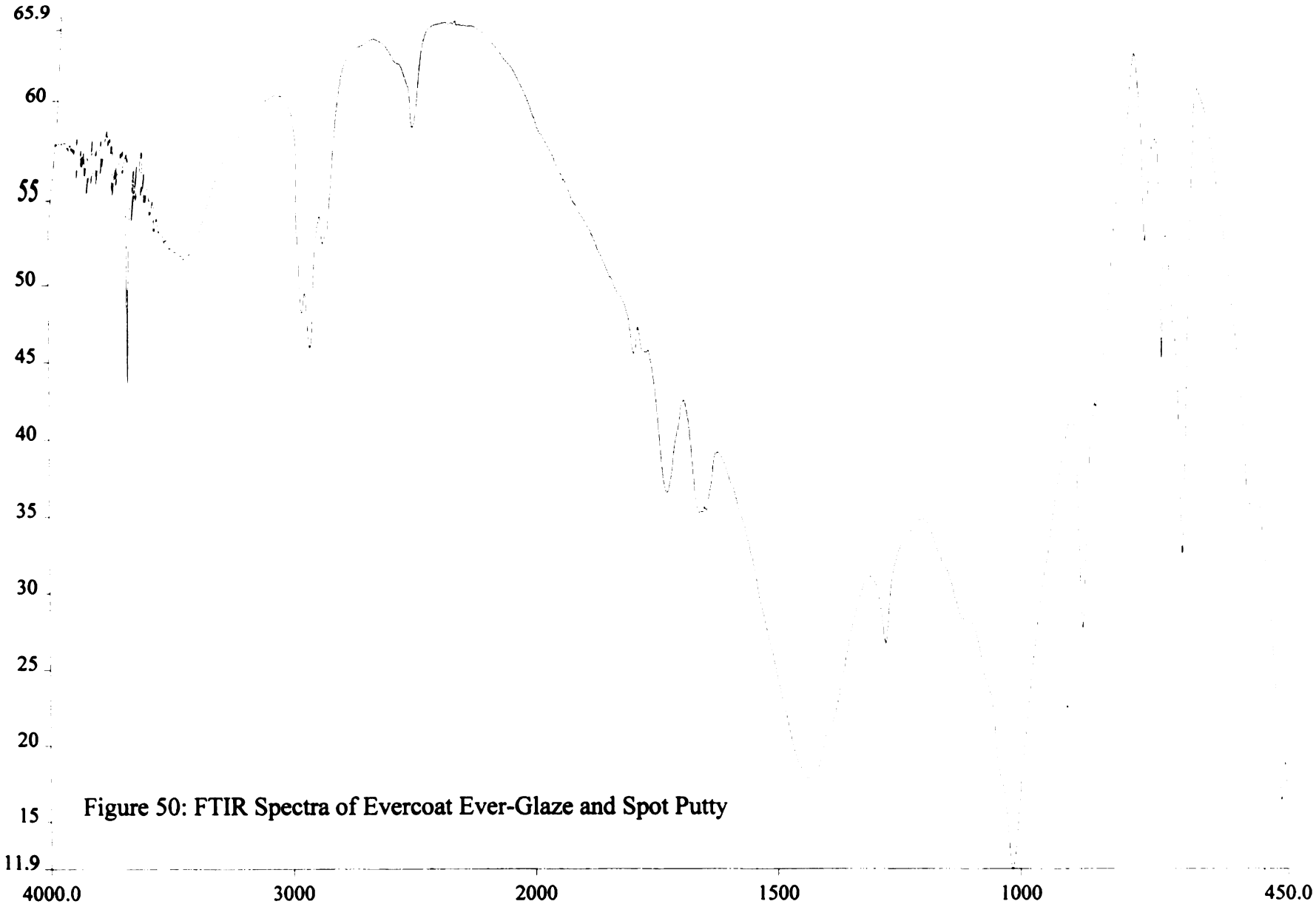

Figure 50: FTIR Spectra of Evercoat Ever-Glaze and Spot Putty

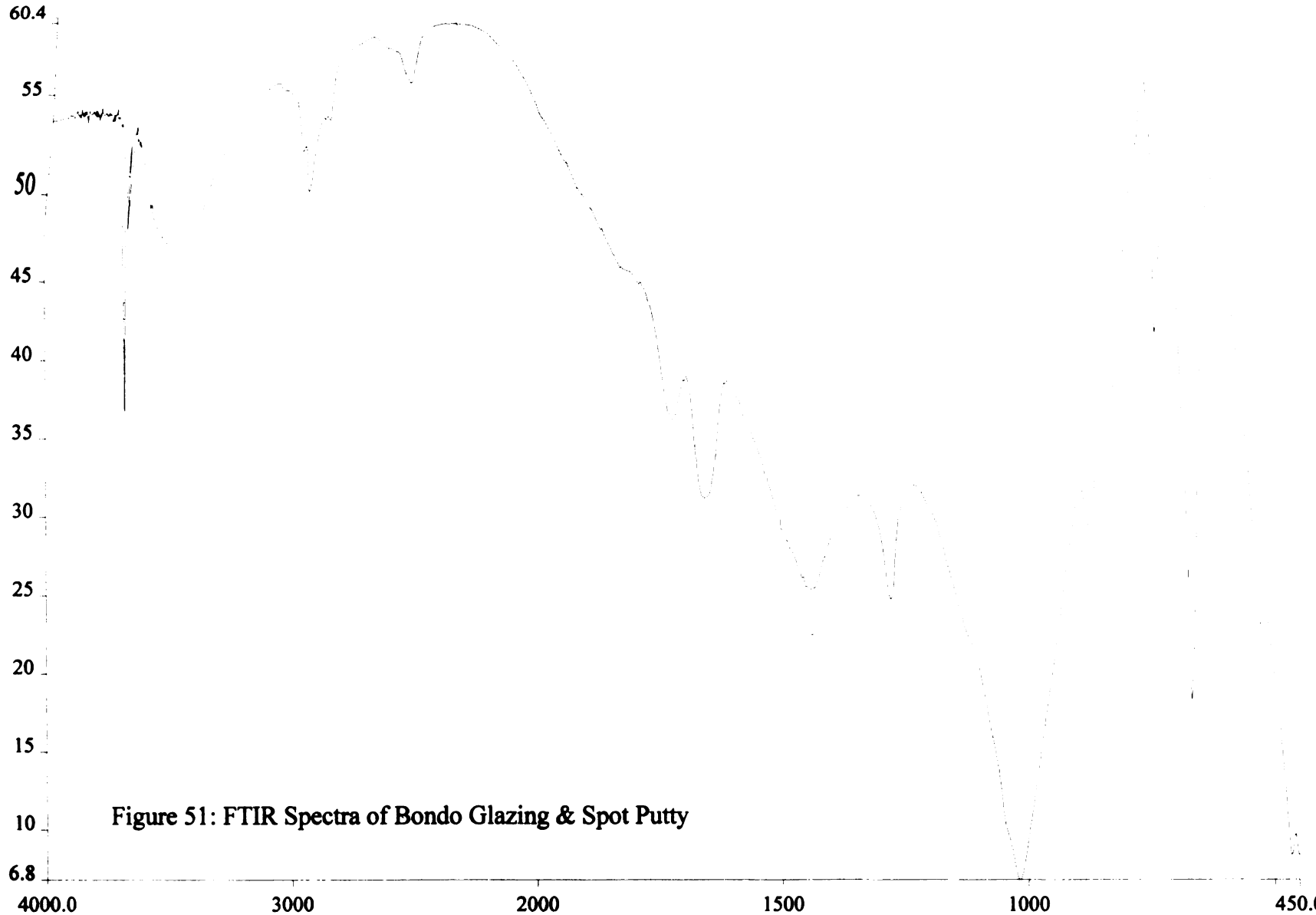

Figure 51: FTIR Spectra of Bondo Glazing & Spot Putty

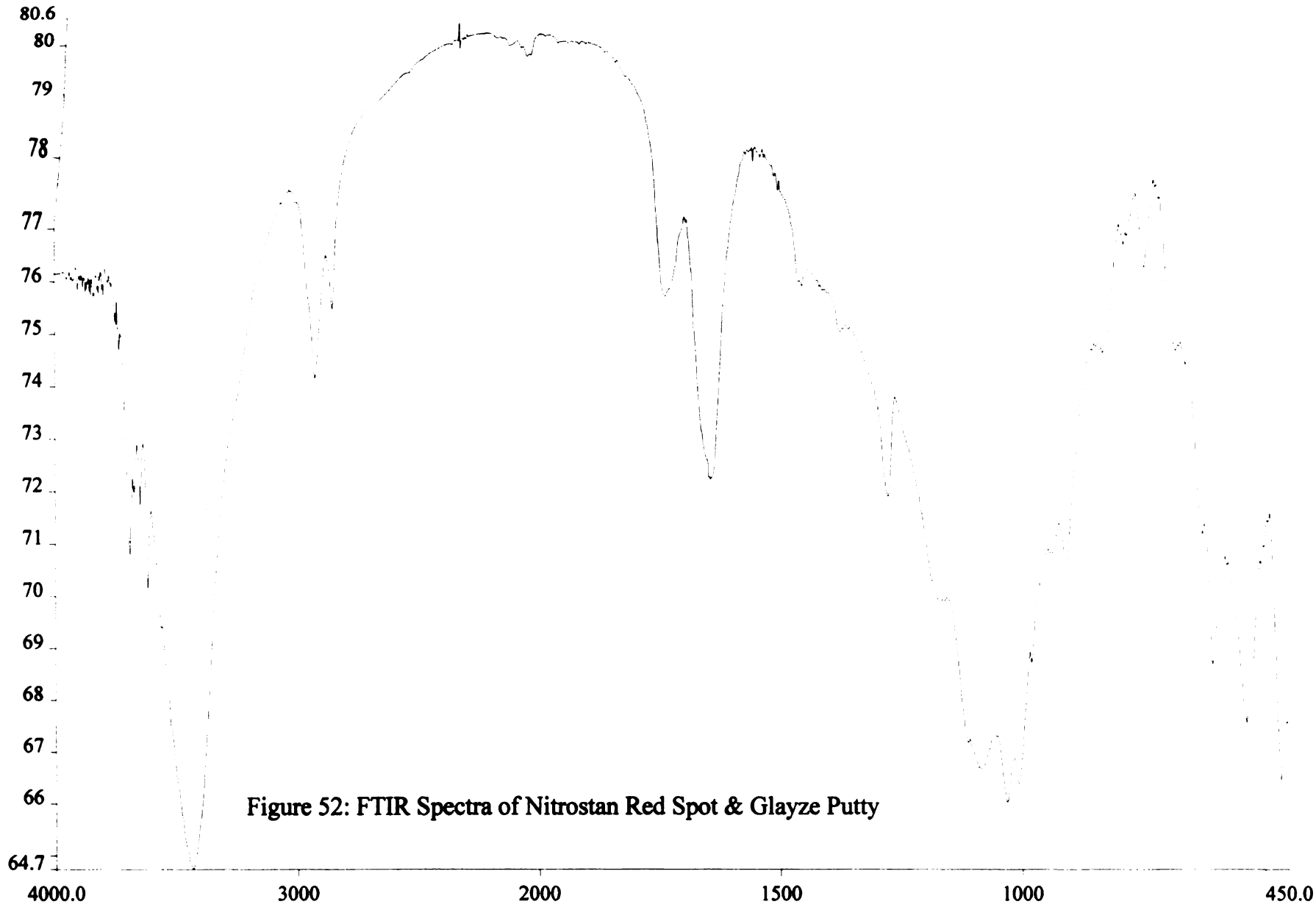

Figure 52: FTIR Spectra of Nitrostan Red Spot & Glayze Putty

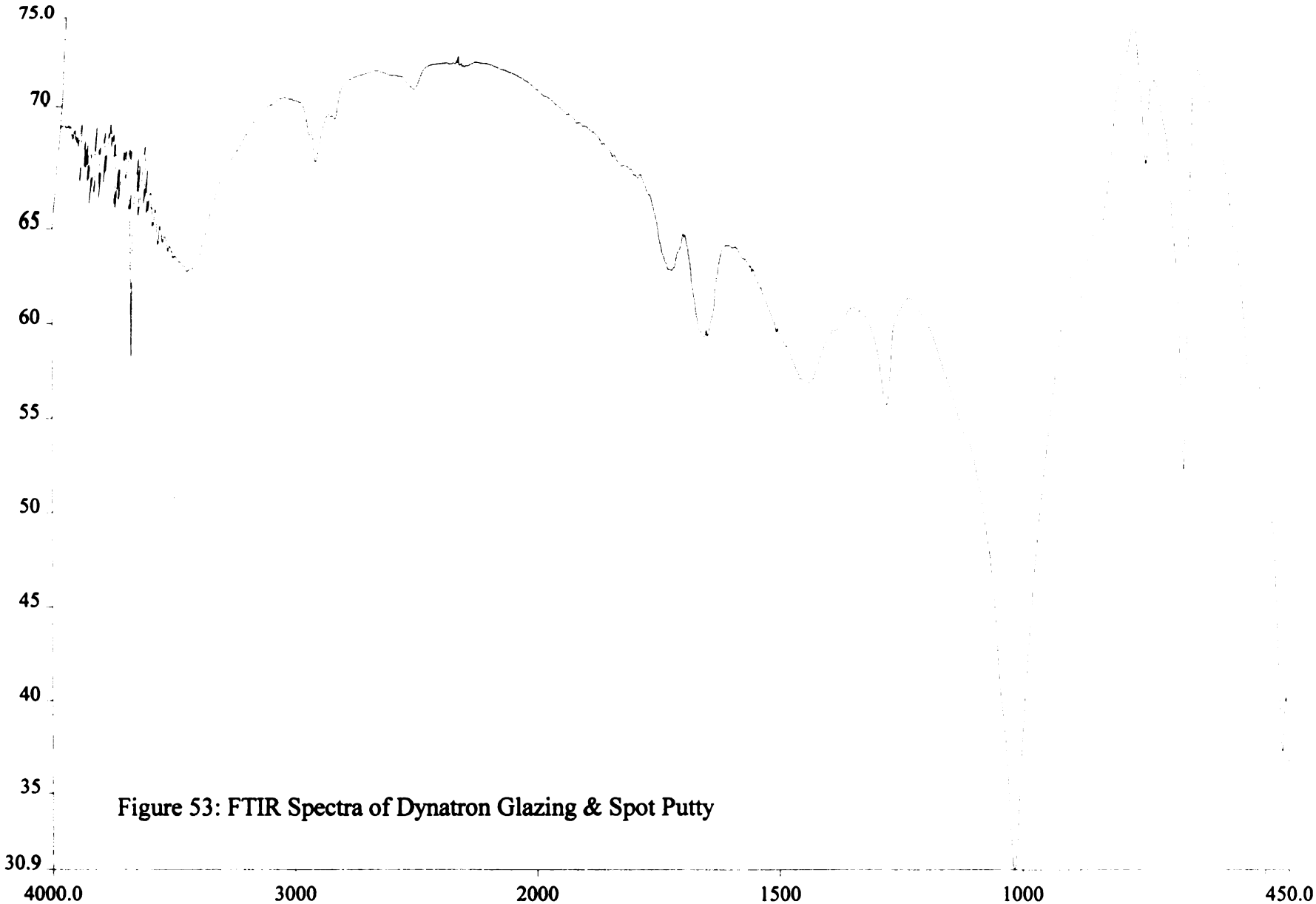

Figure 53: FTIR Spectra of Dynatron Glazing & Spot Putty

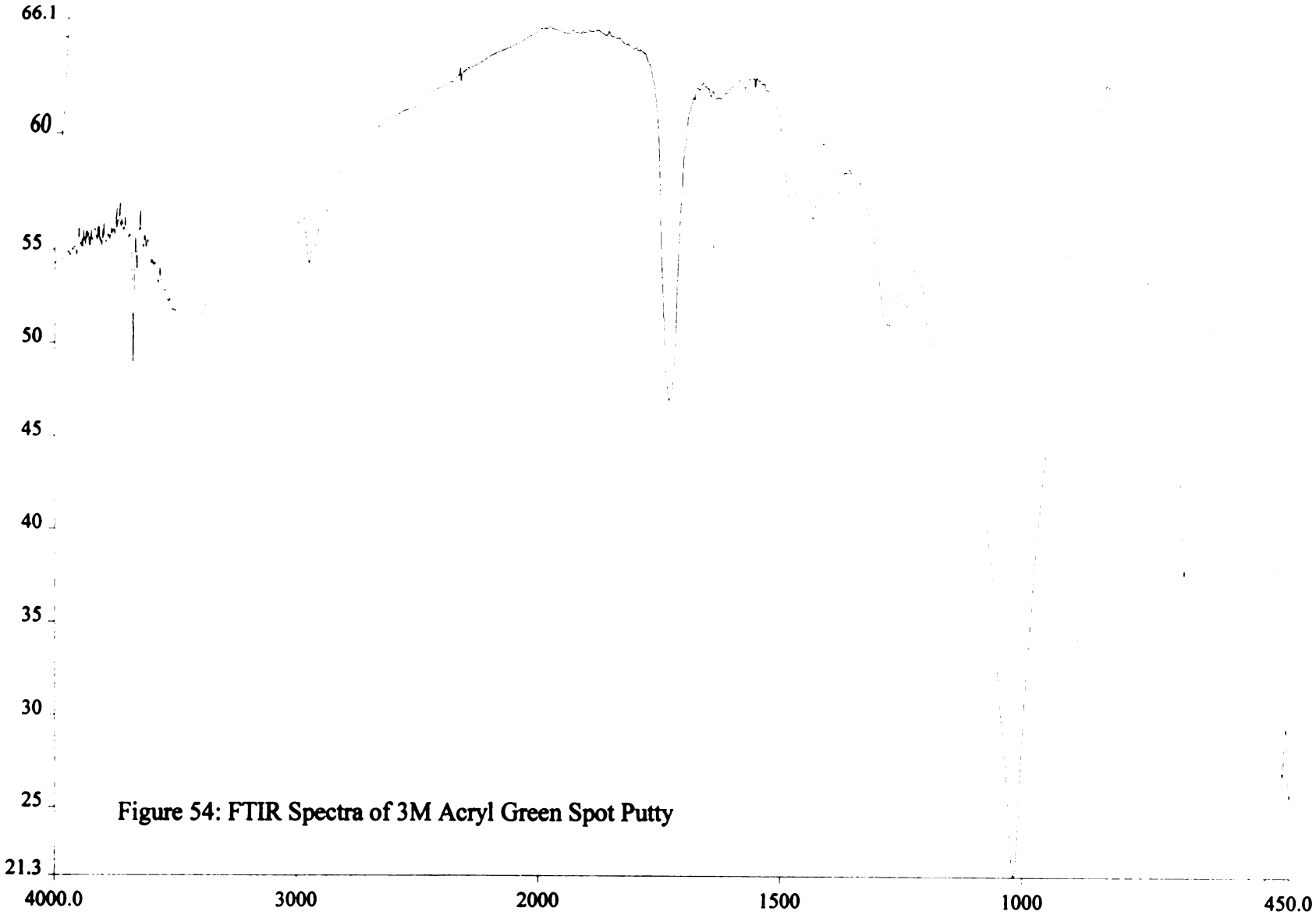

Figure 54: FTIR Spectra of 3M Acryl Green Spot Putty

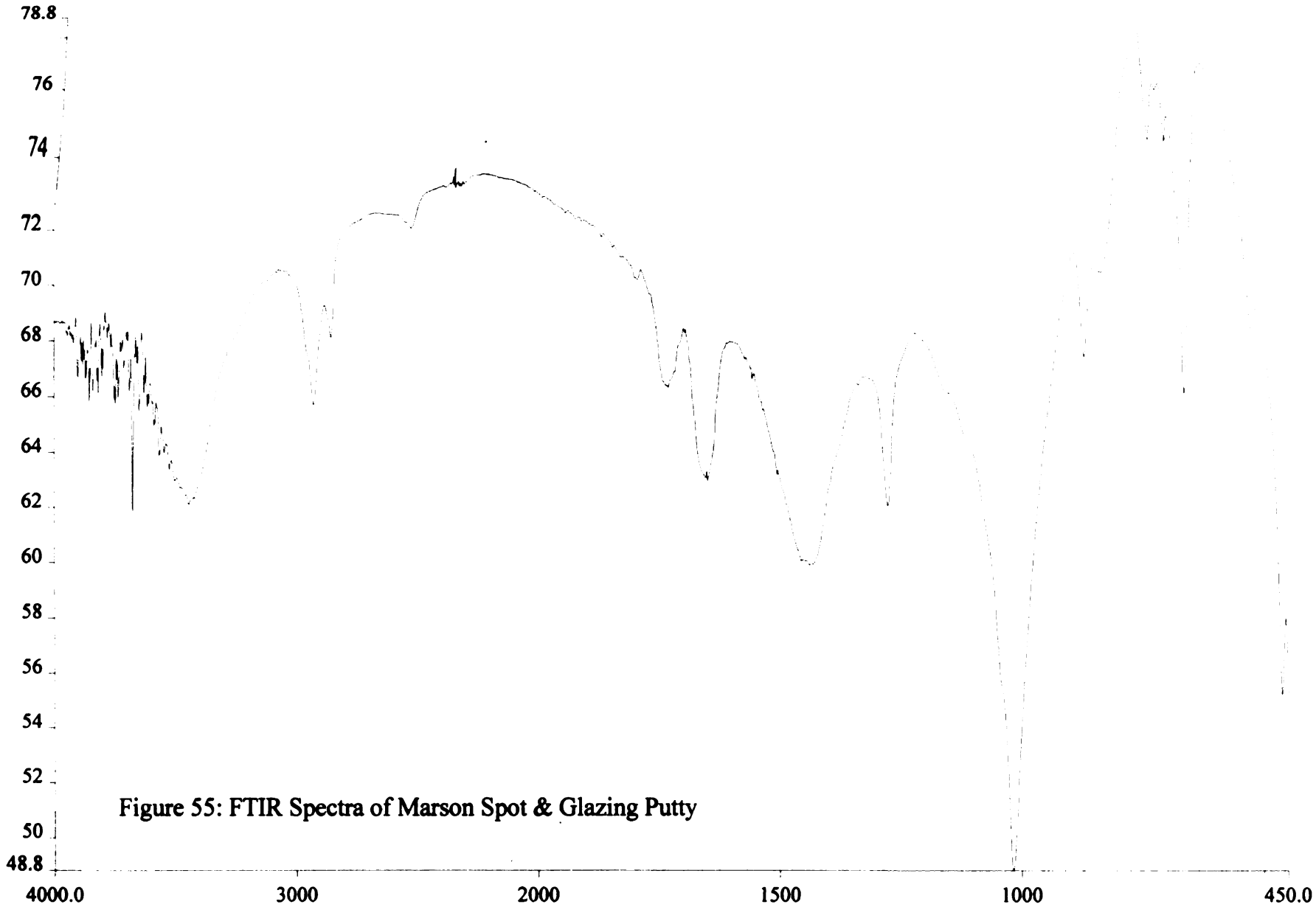

Figure 55: FTIR Spectra of Marson Spot & Glazing Putty

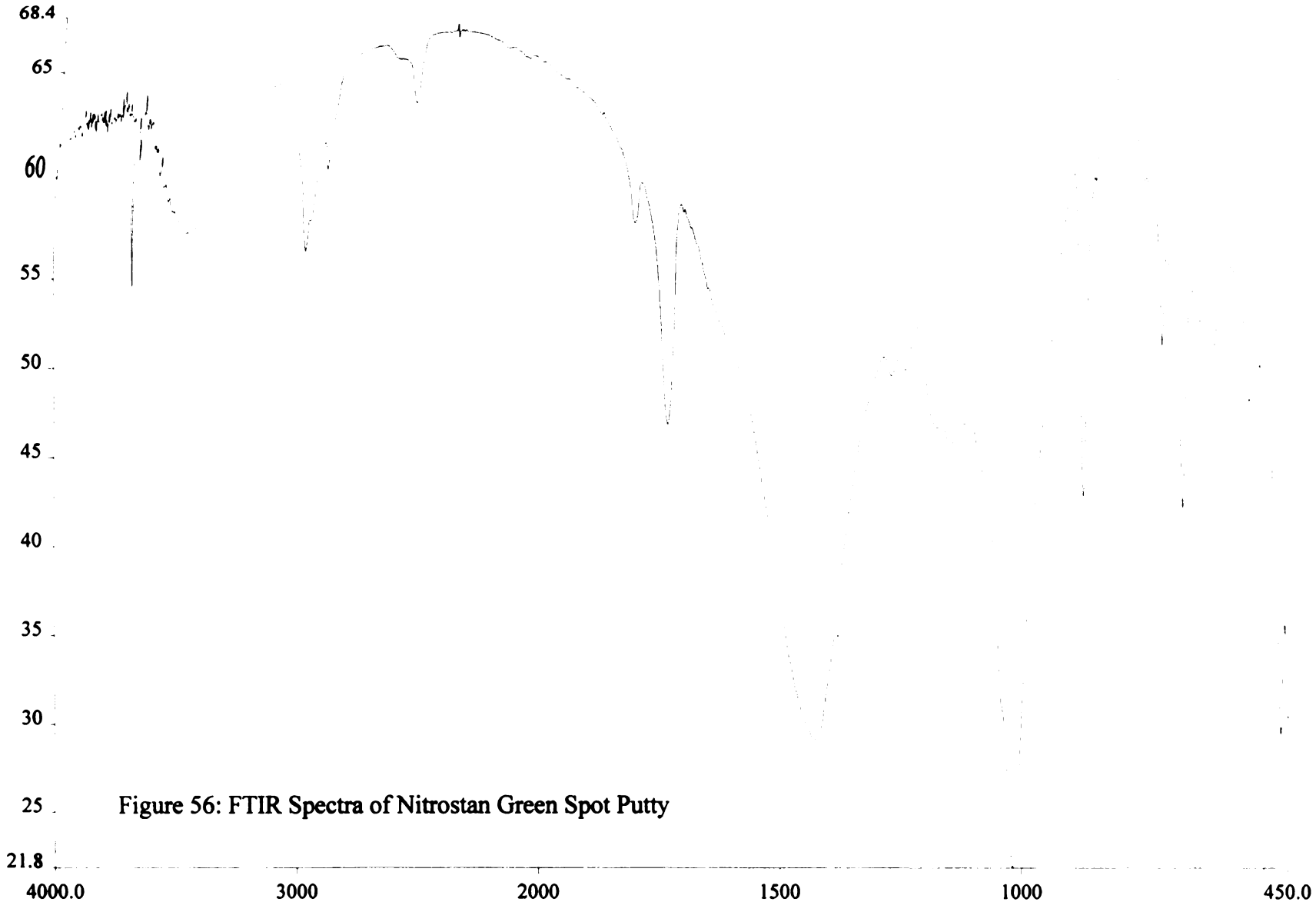

Figure 56: FTIR Spectra of Nitrostan Green Spot Putty

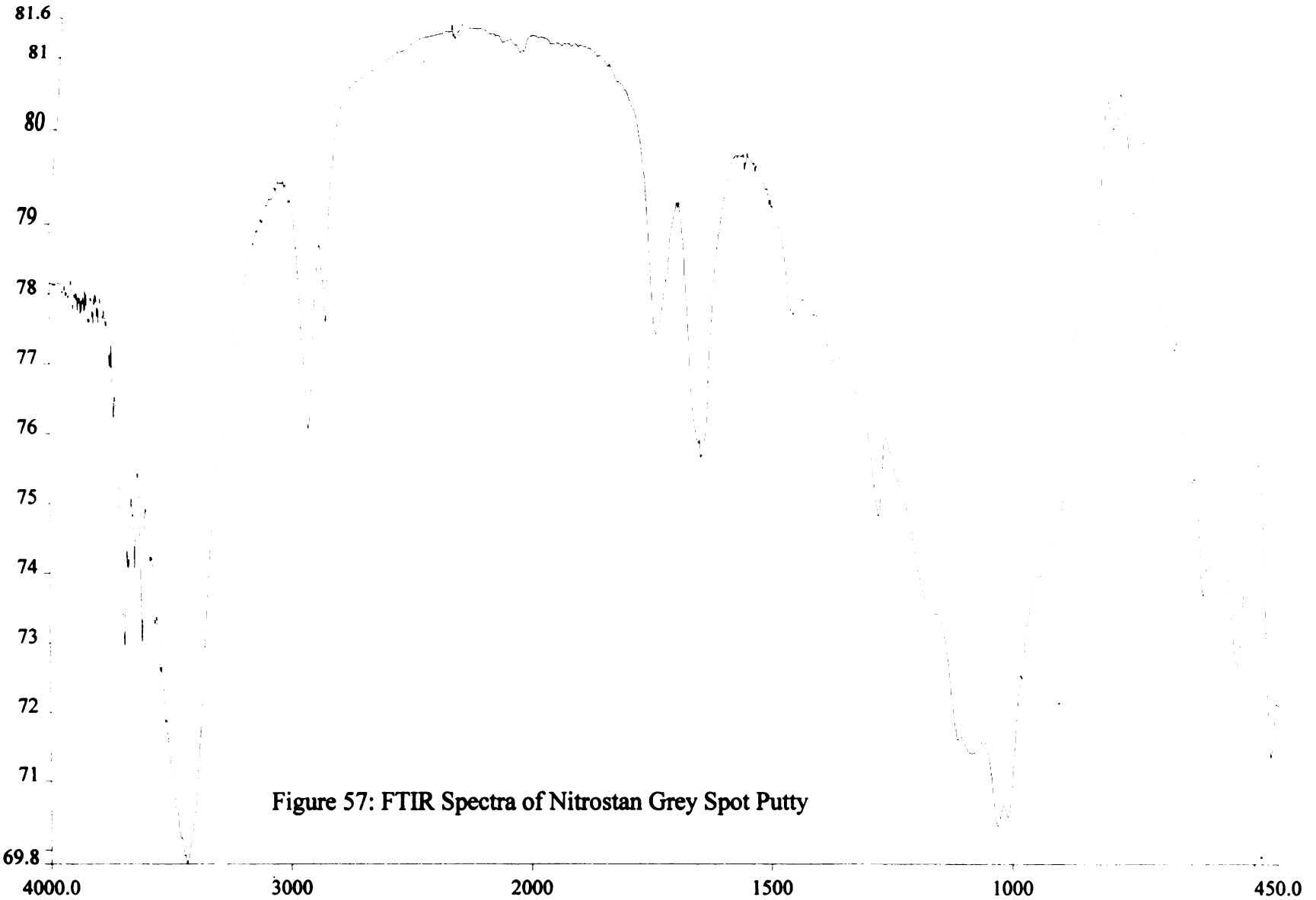

Figure 57: FTIR Spectra of Nitrostan Grey Spot Putty

APPENDIX B

Pyrolysis Gas Chromatograms from Sample Analysis

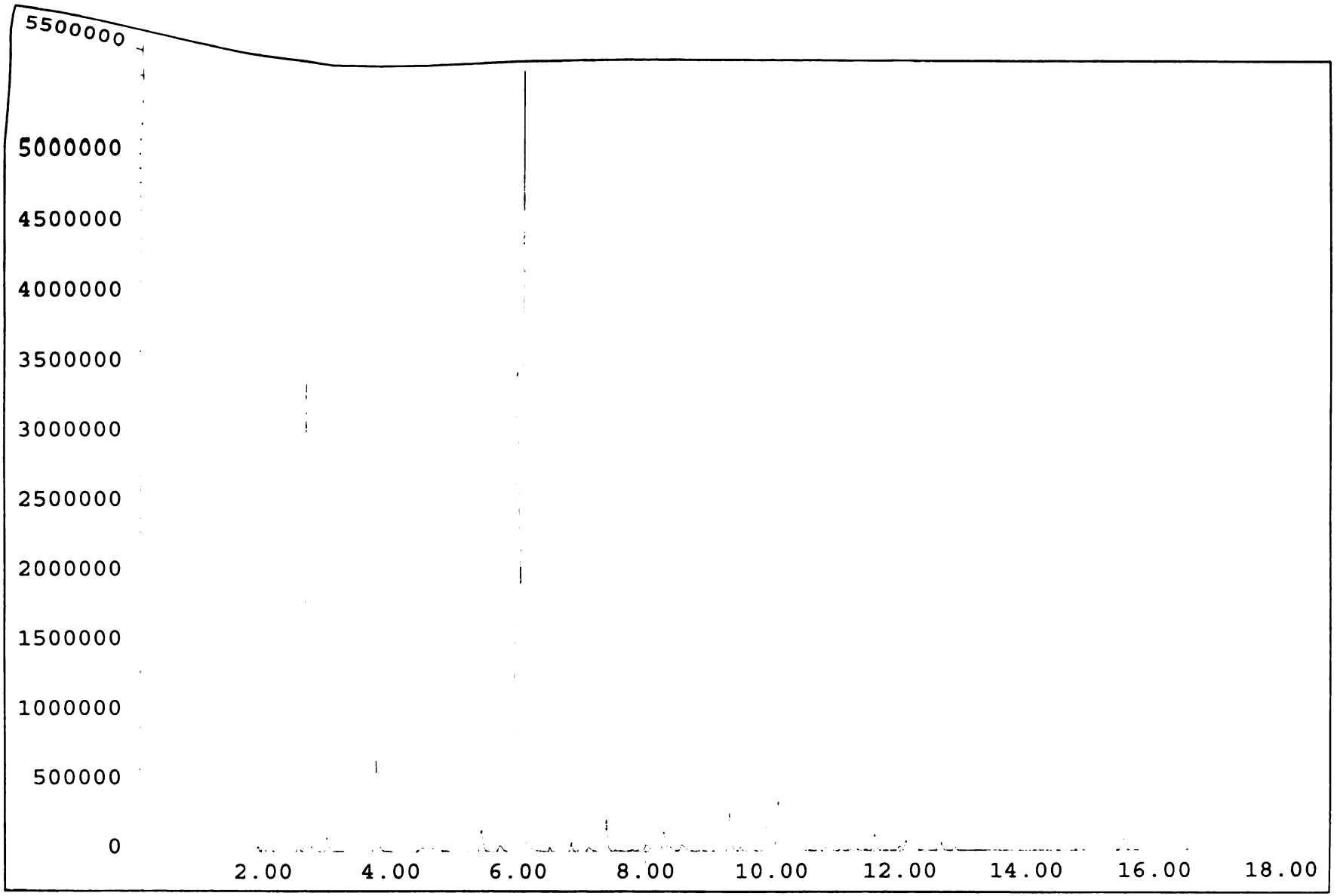

Figure 58: pyGC Chromatograph of U.S.C. Quality Light-weight Feather-rite

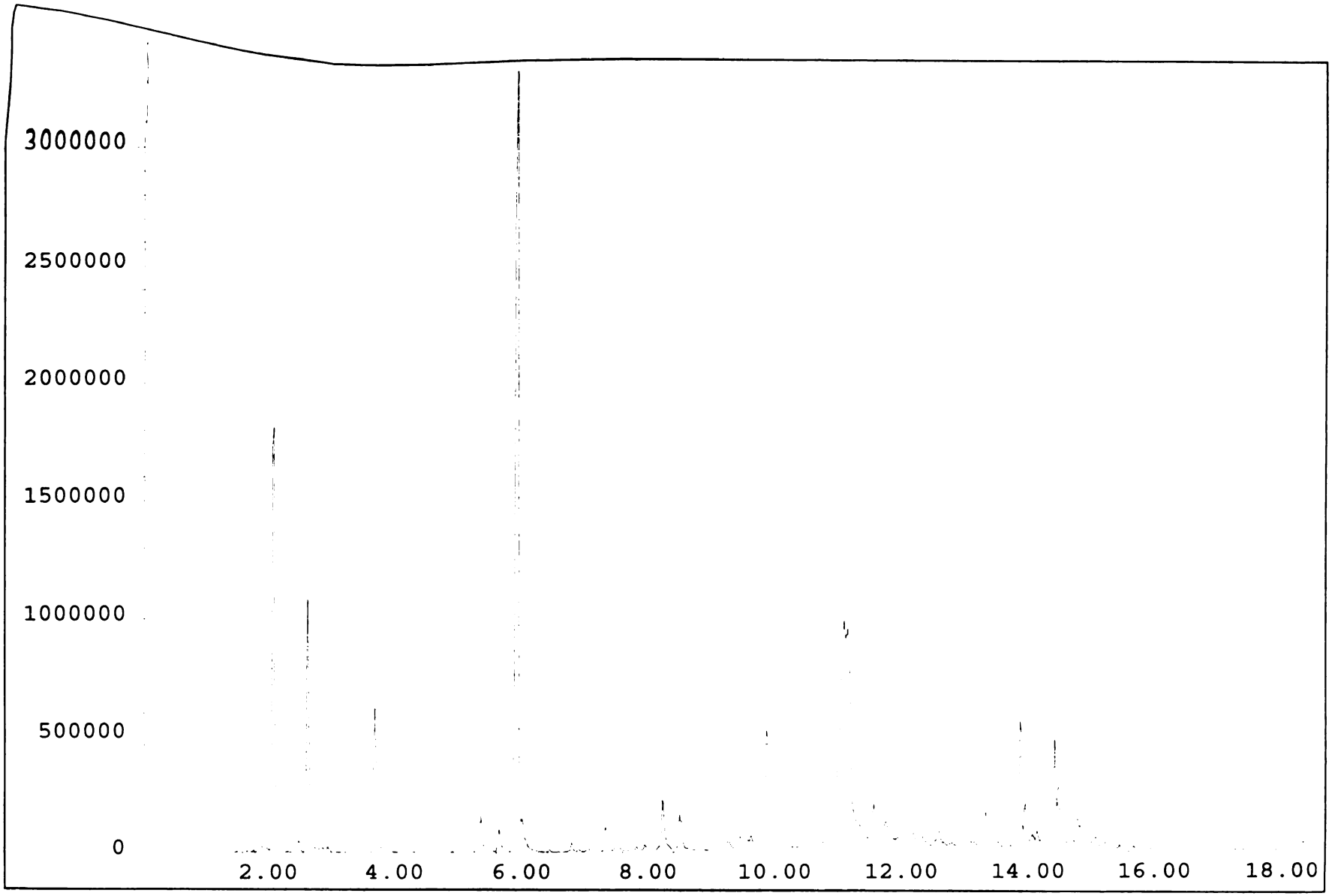

Figure 59: pyGC Chromatograph of U.S.C. Premiere Light-weight

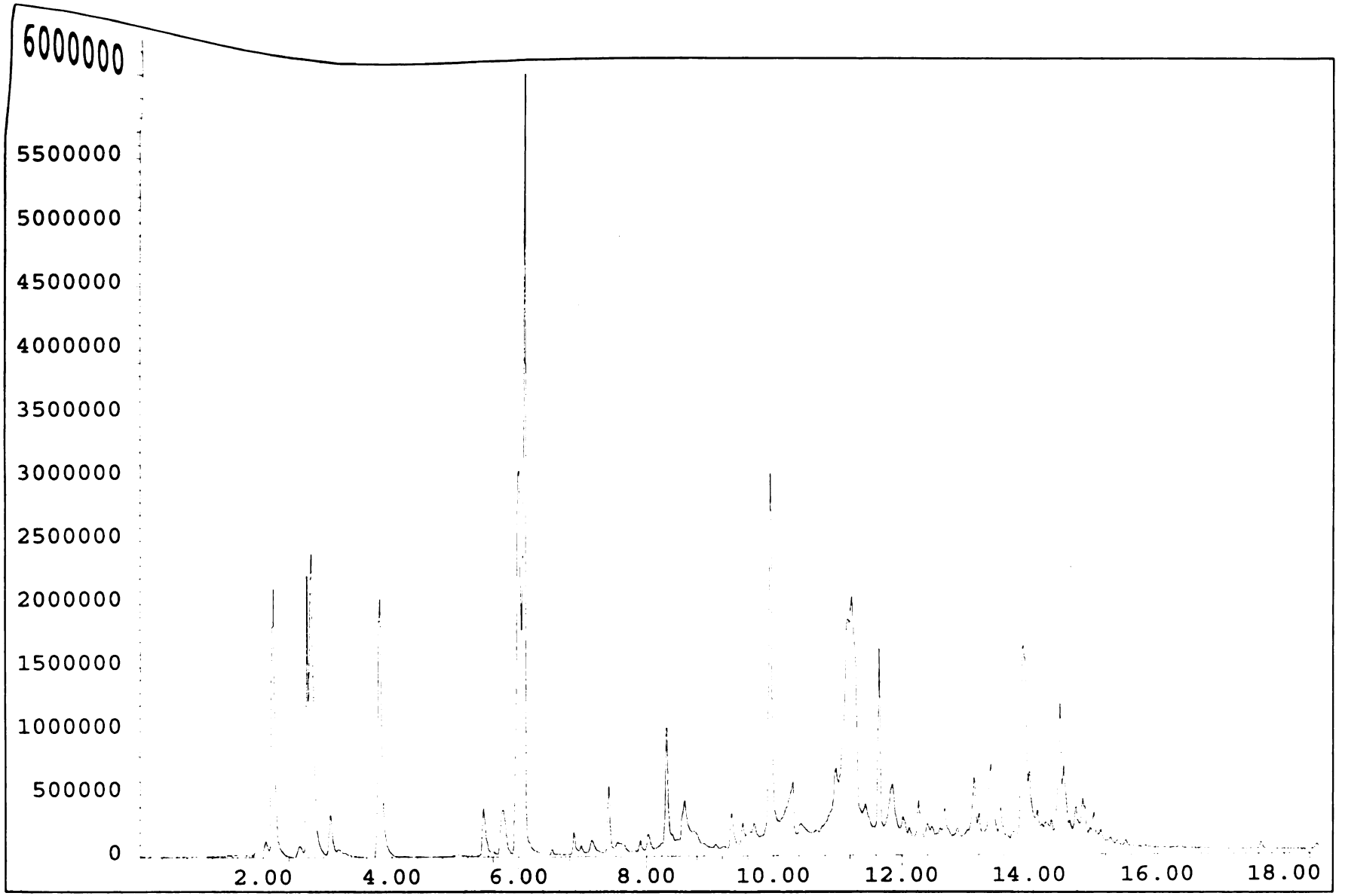

Figure 60: pyGC Chromatograph of U.S.C. Basecoat/Clearcoat Extra

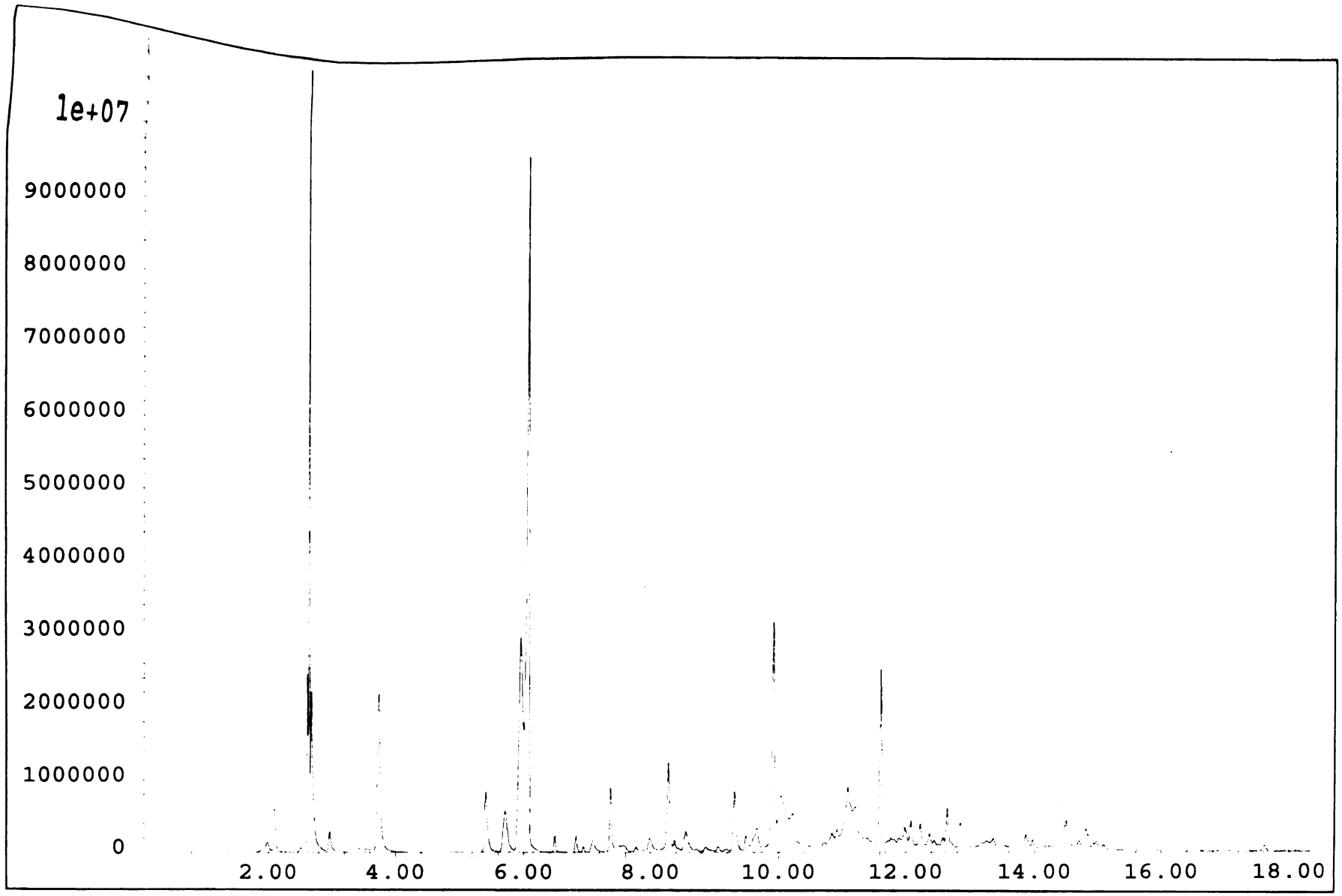

Figure 61: pyGC Chromatograph of U.S.C. Light-weight Kromate Light

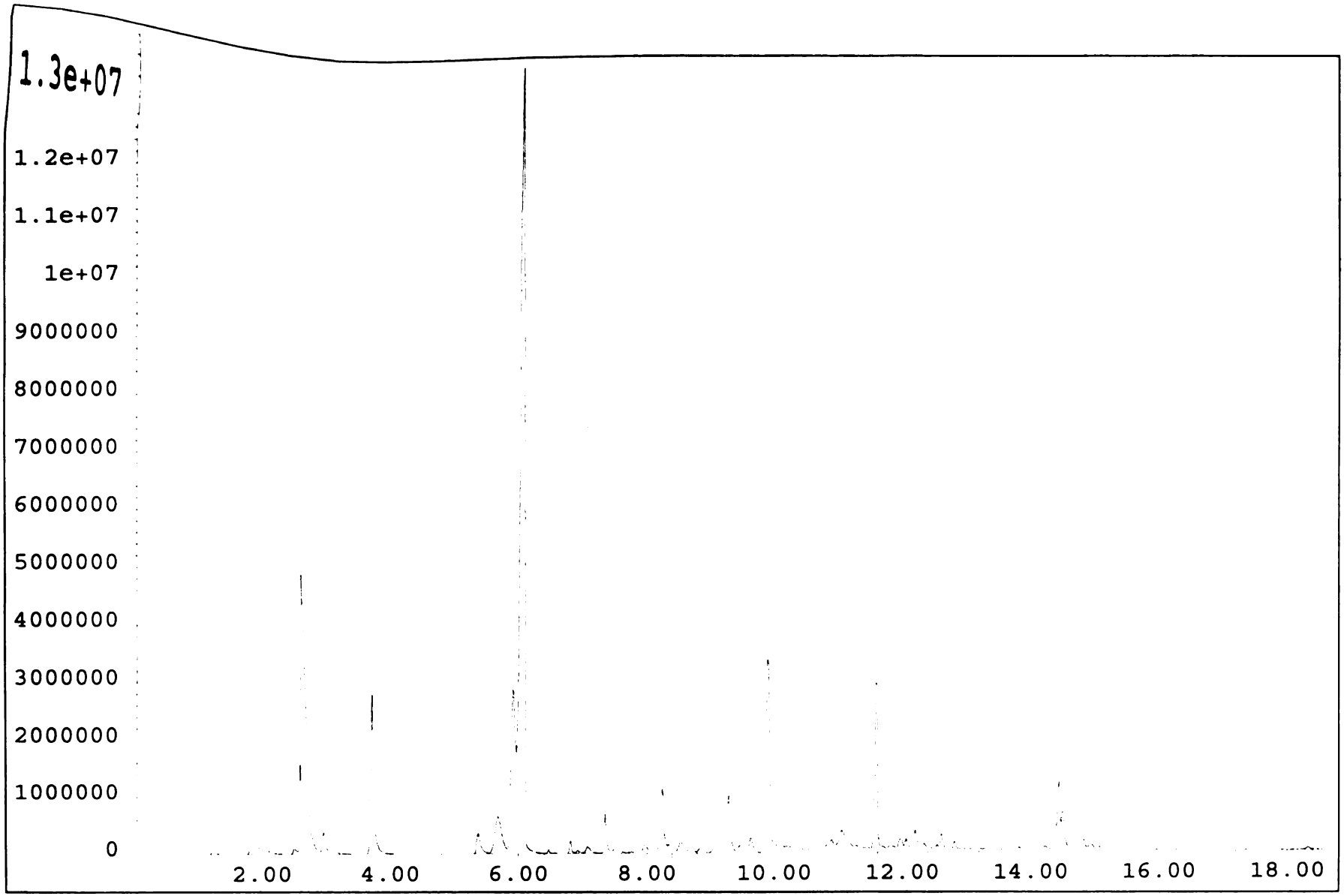

Figure 62: pyGC Chromatograph of 3M Light-weight

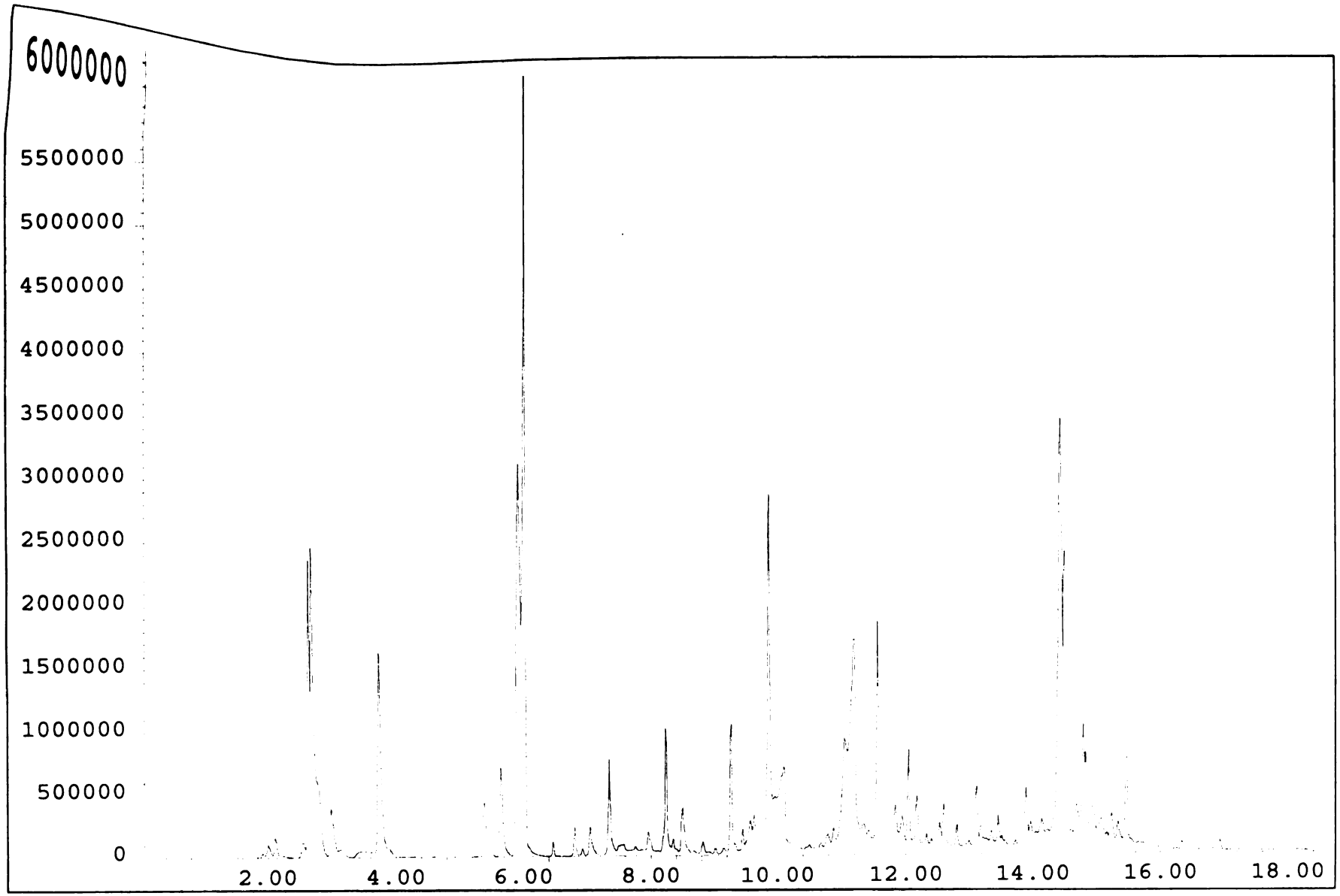

Figure 63: pyGC Chromatograph of Marson Body Light

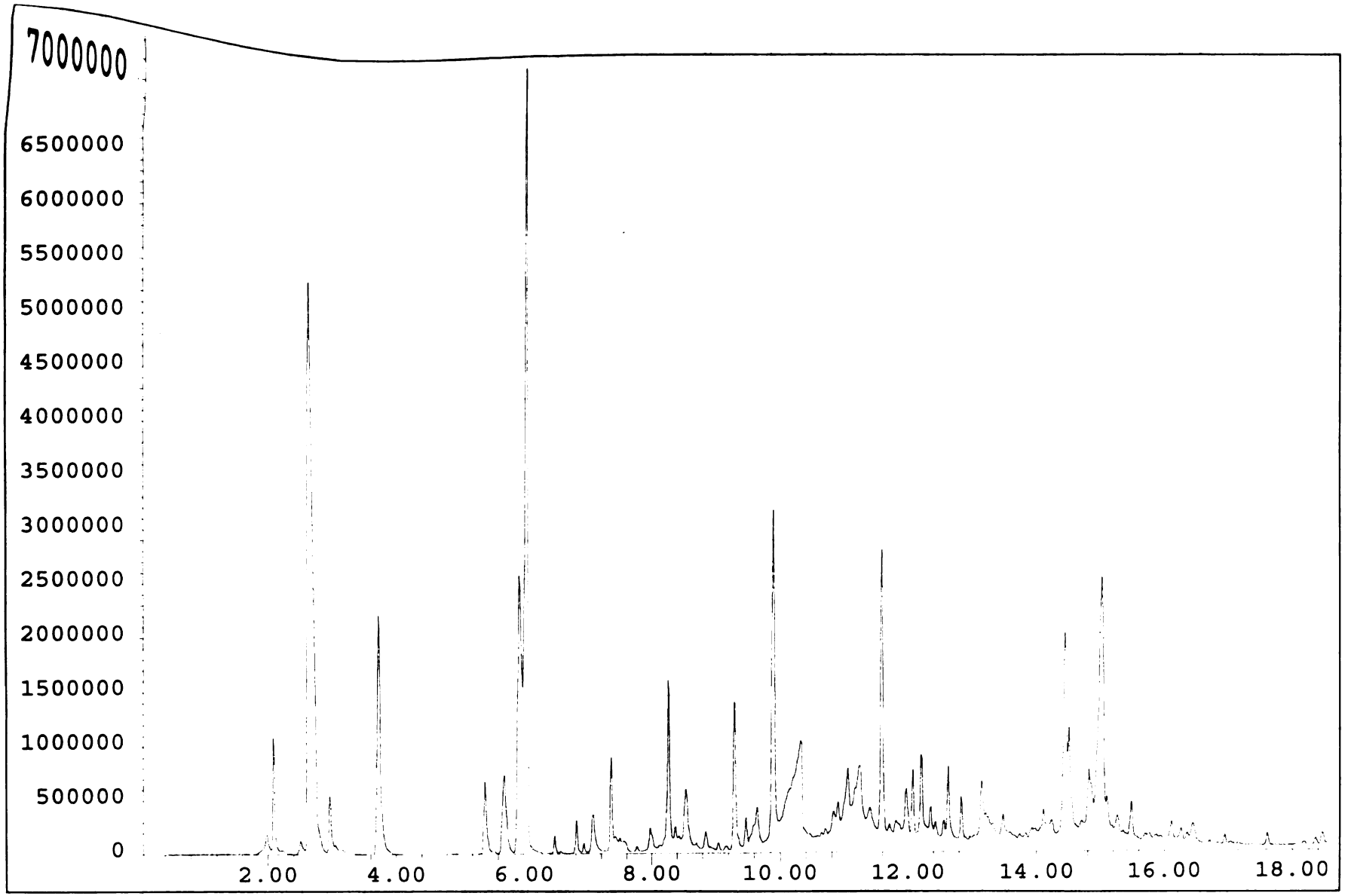

Figure 64: pyGC Chromatograph of Bondo

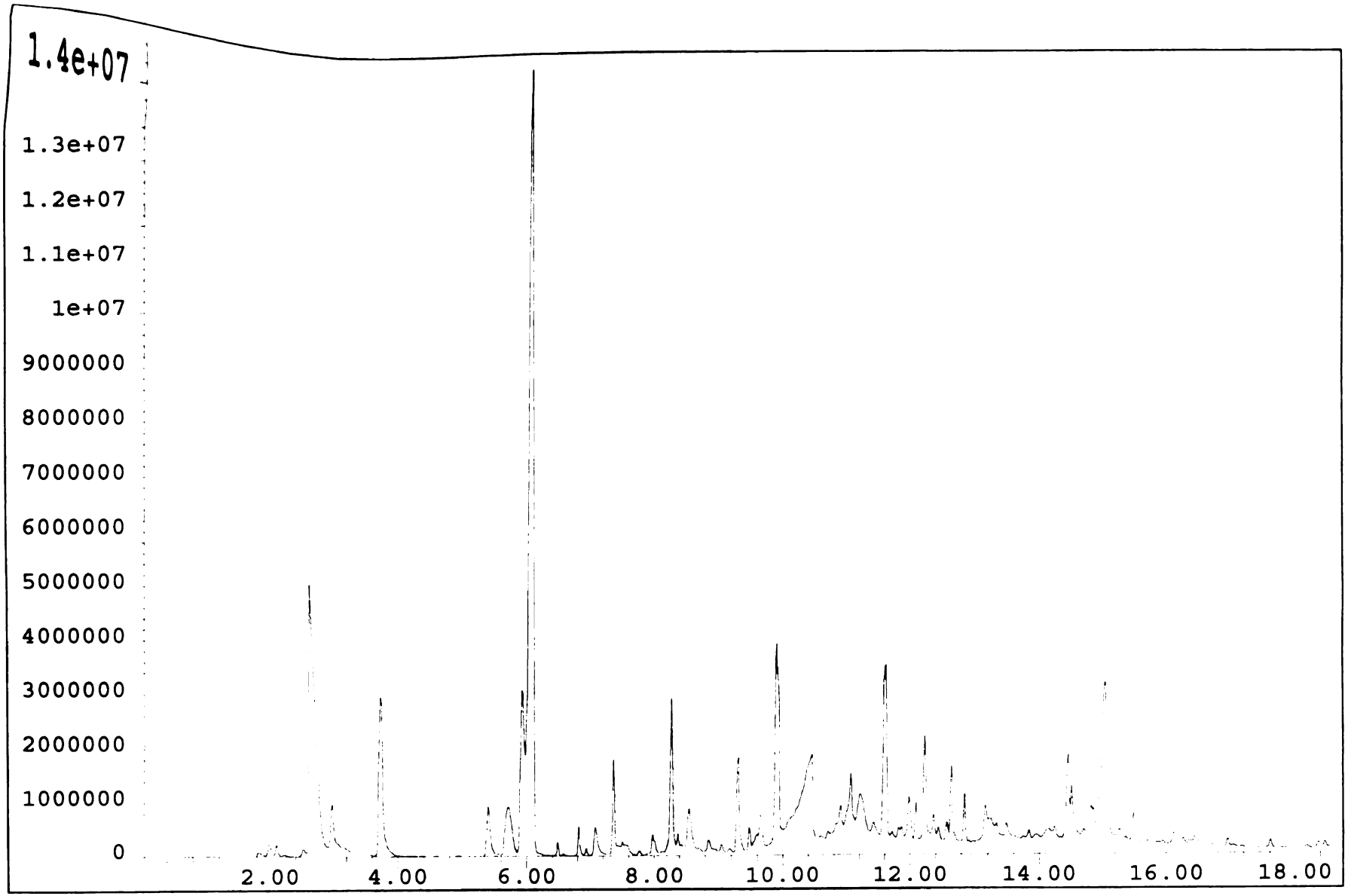

Figure 65: pyGC Chromatograph of Marson White Fill

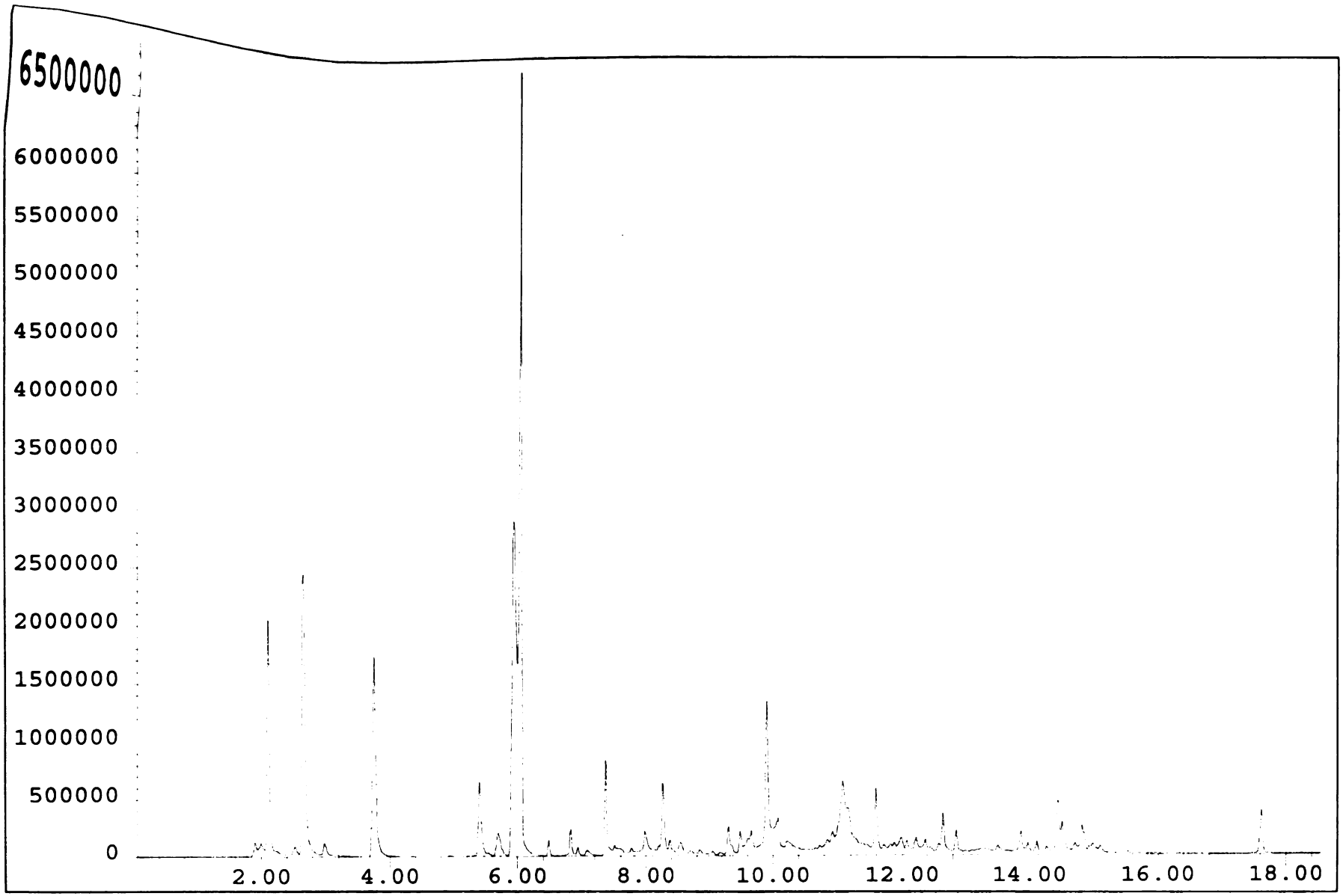

Figure 66: pyGC Chromatograph of Marson Platinum Premium Light-weight

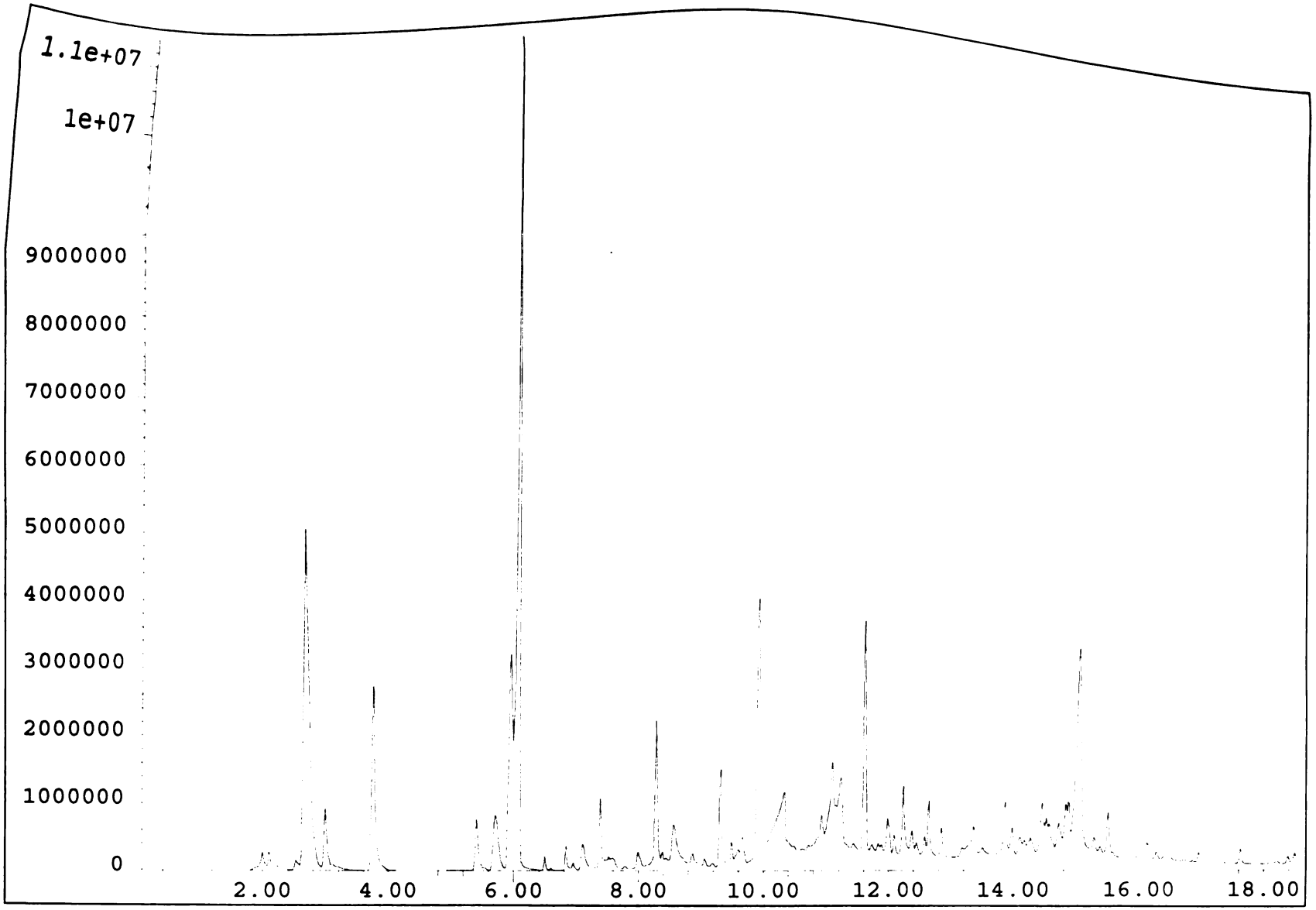

Figure 67: pyGC Chromatograph of Marson Golden Extra

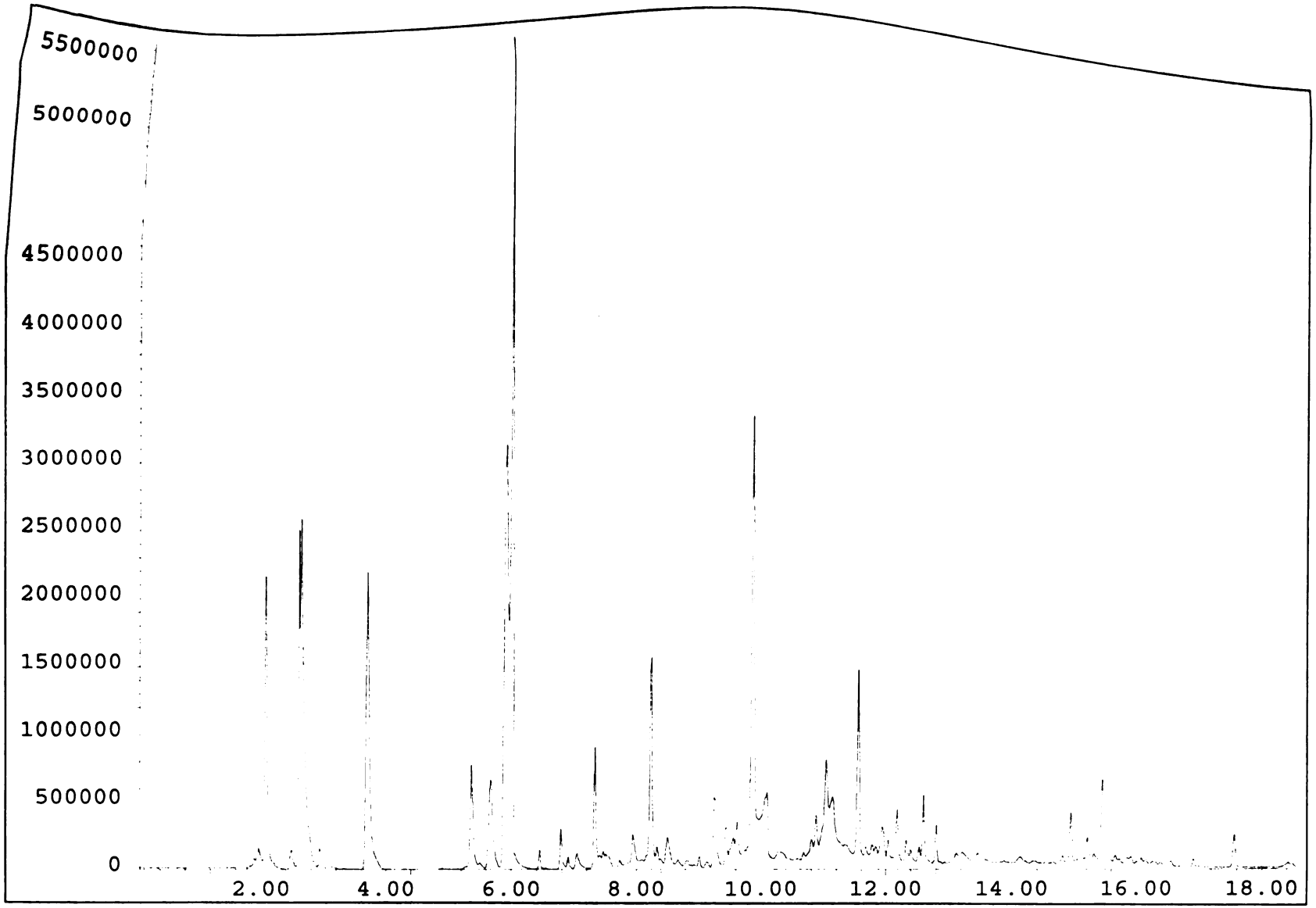

Figure 68: pyGC Chromatograph of Evercoat Rage Gold

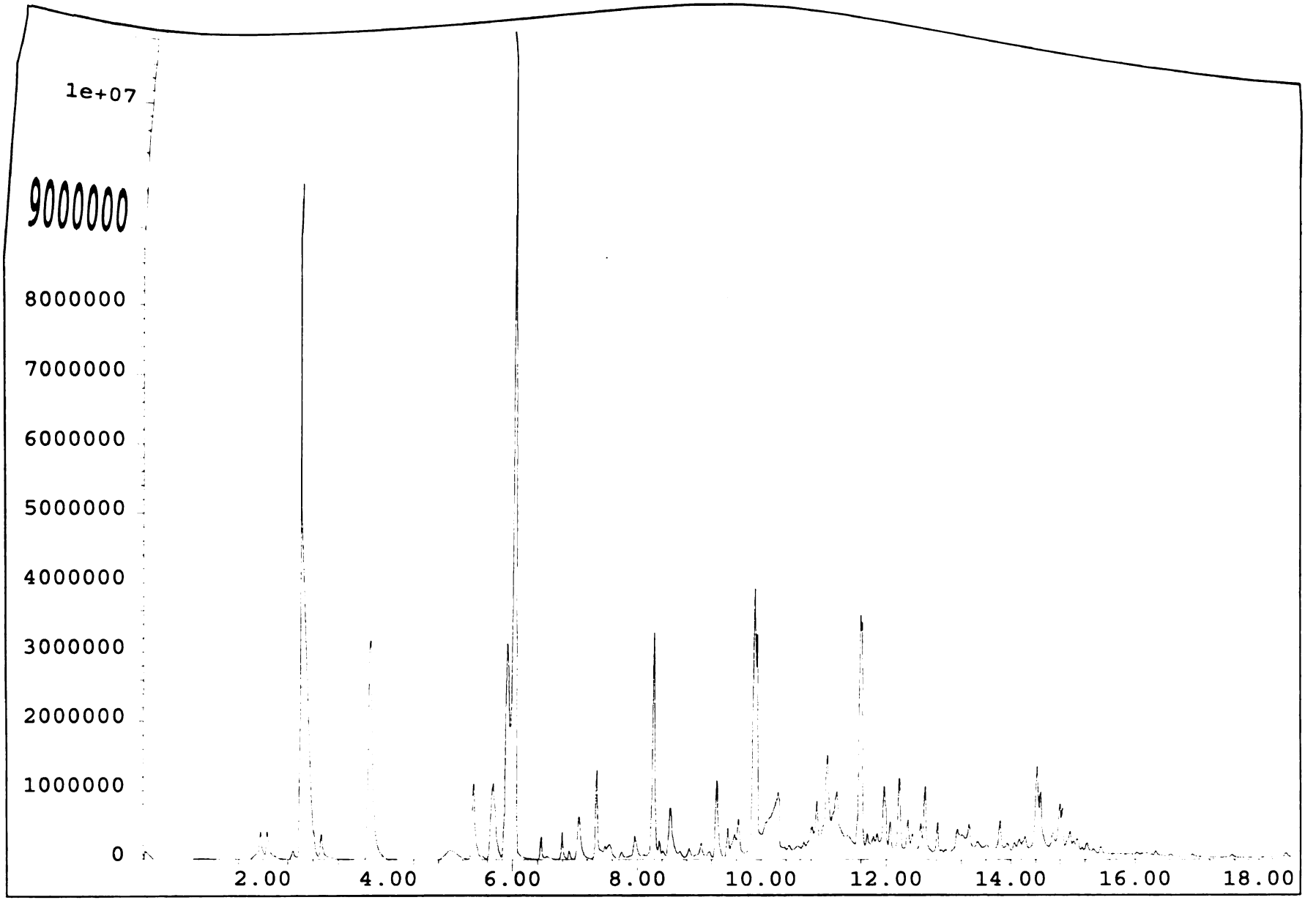

Figure 69: pyGC Chromatograph of Evercoat Light-weight

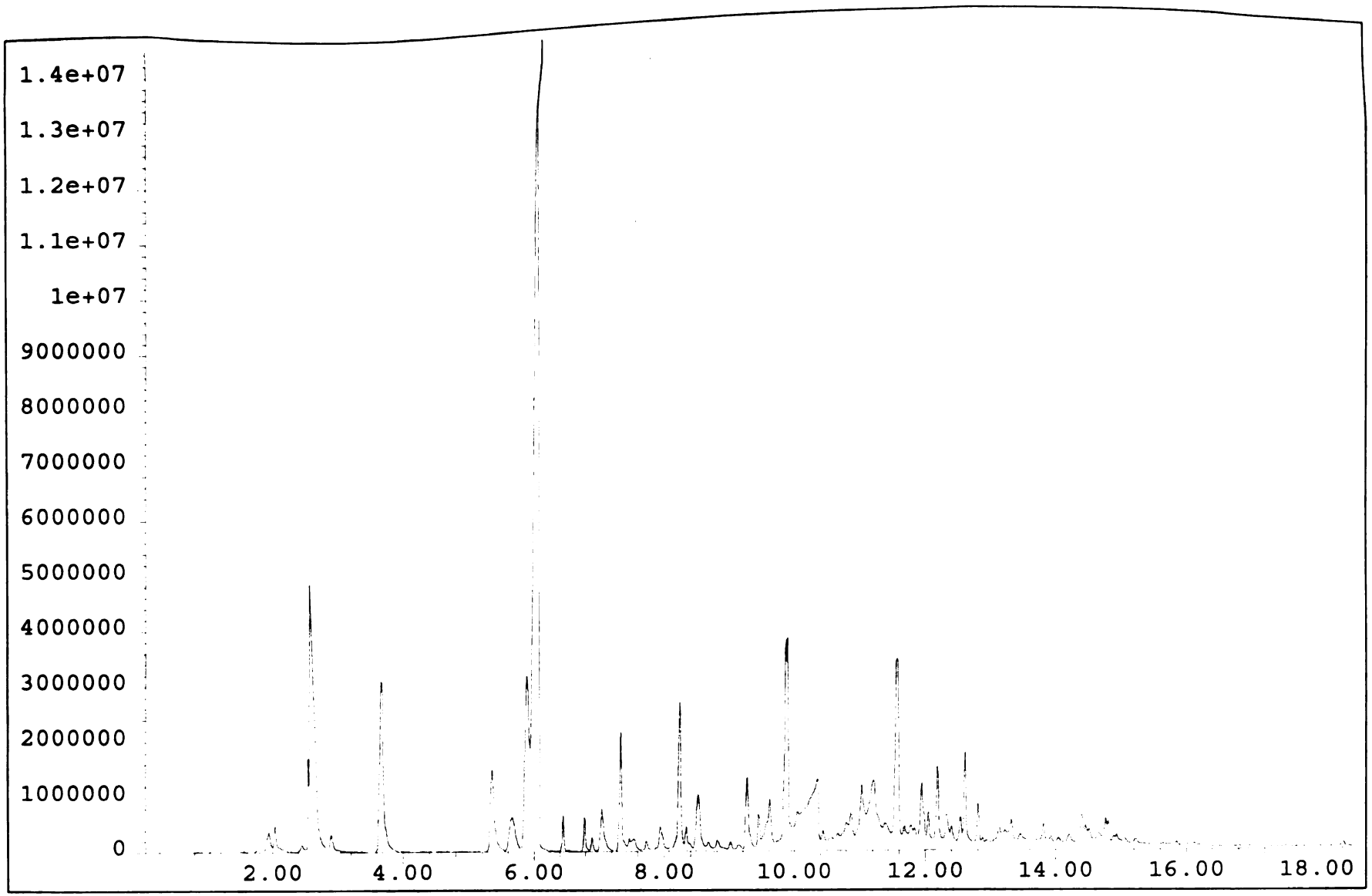

Figure 70: pyGC Chromatograph of Evercoat Chrome-a-Lite

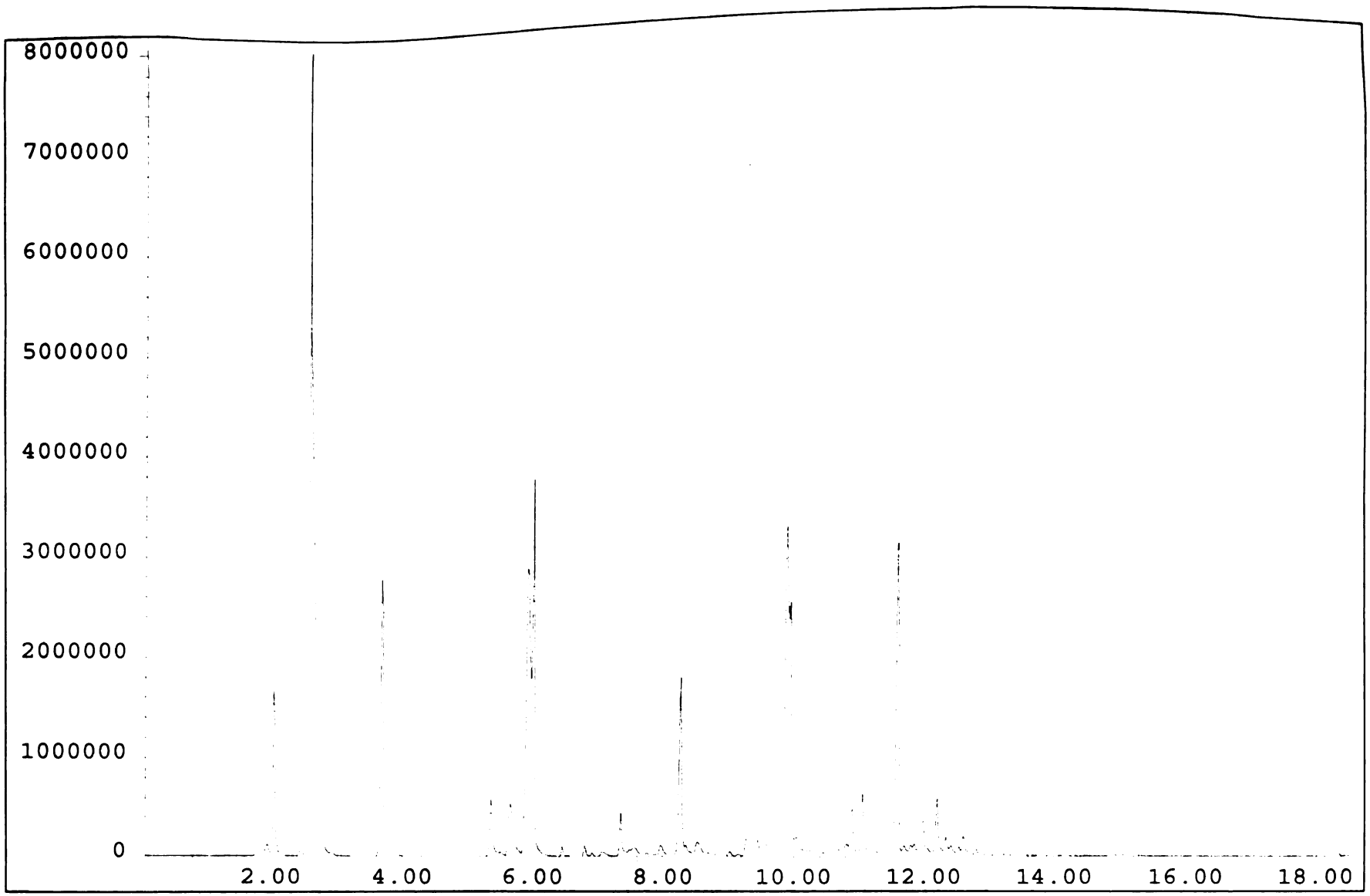

Figure 71: pyGC Chromatograph of Evercoat Rage

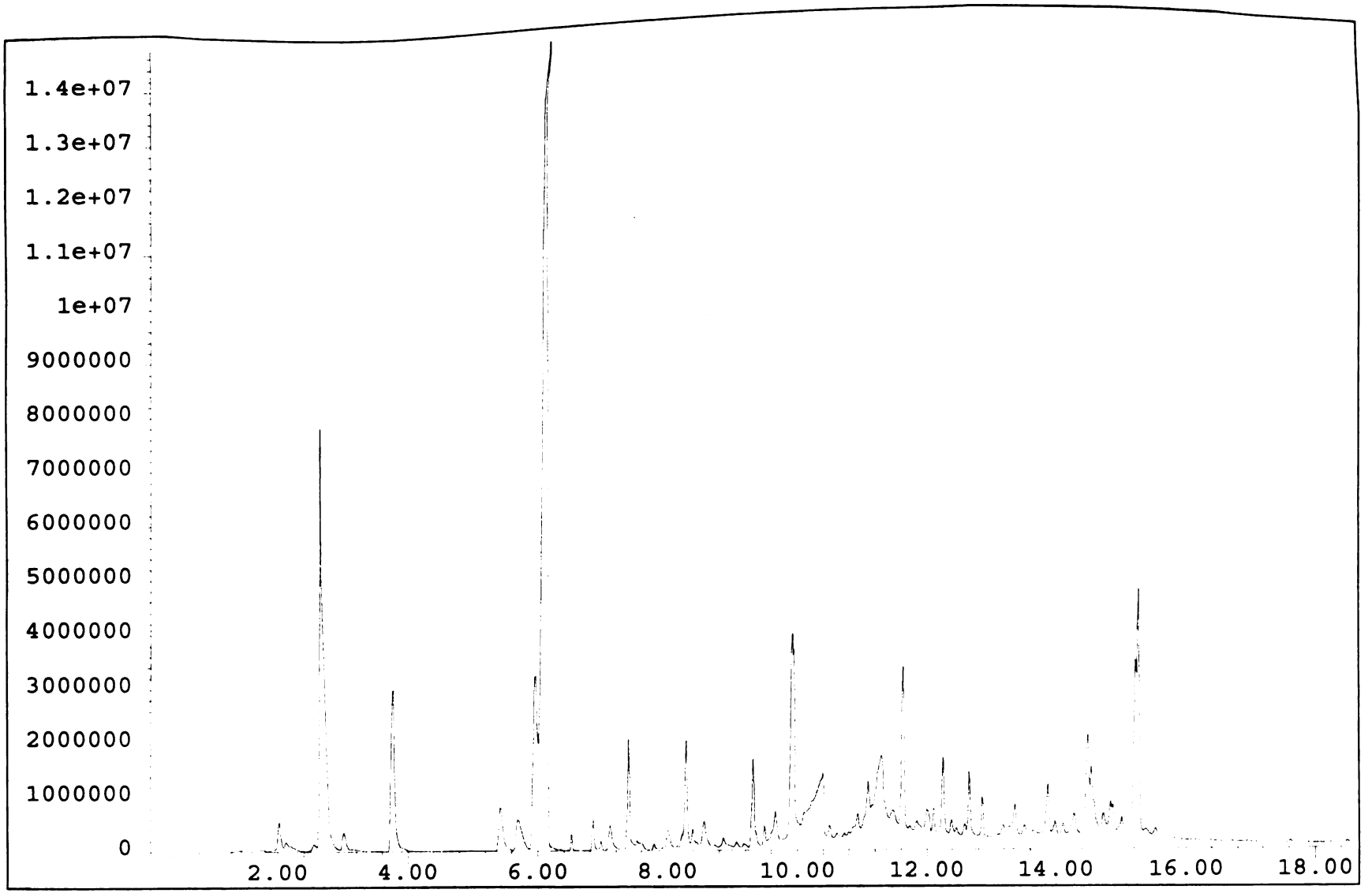

Figure 72: pyGC Chromatograph of Evercoat Z-Grip

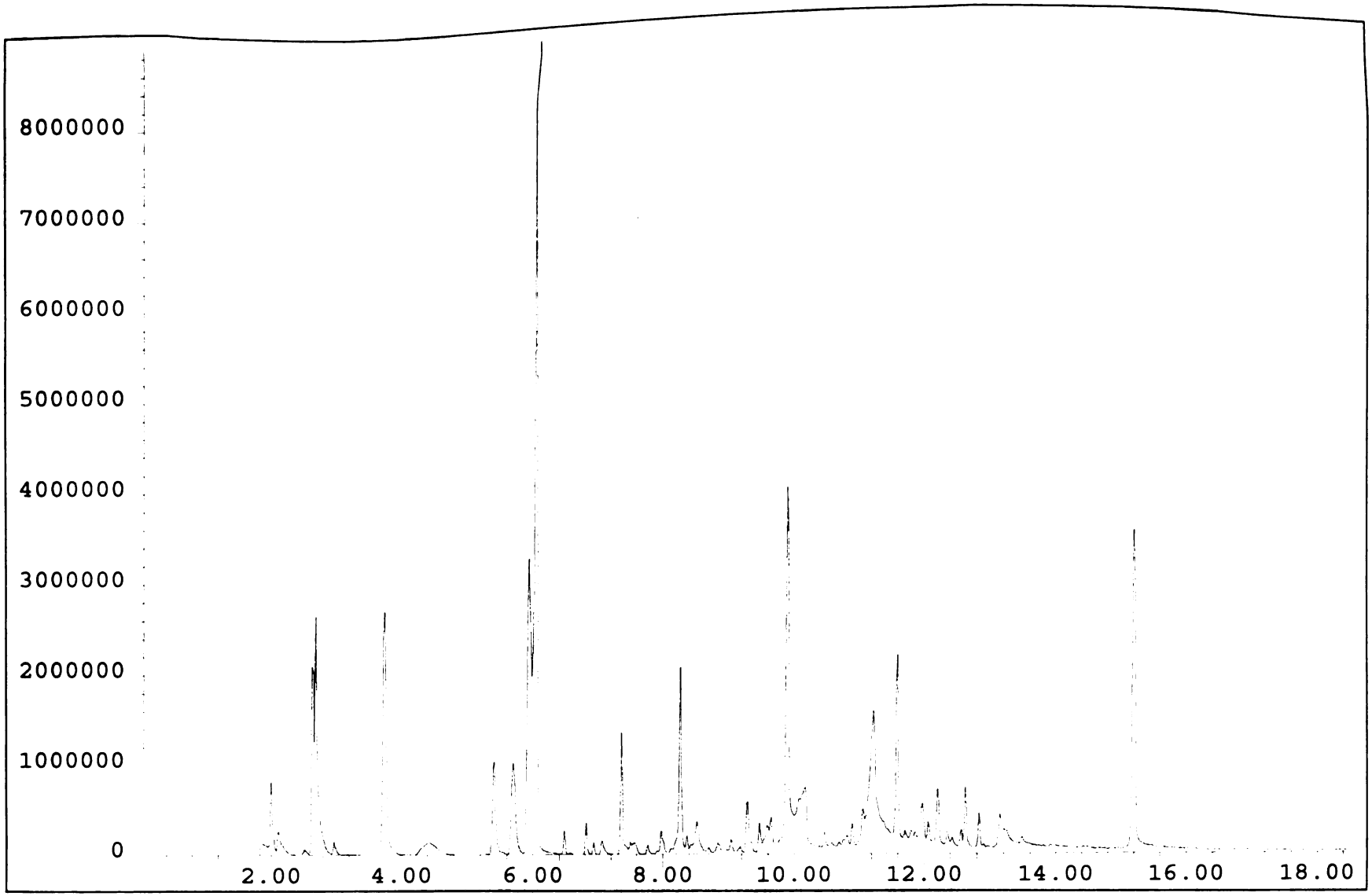

Figure 73: pyGC Chromatograph of Evercoat Tack Free

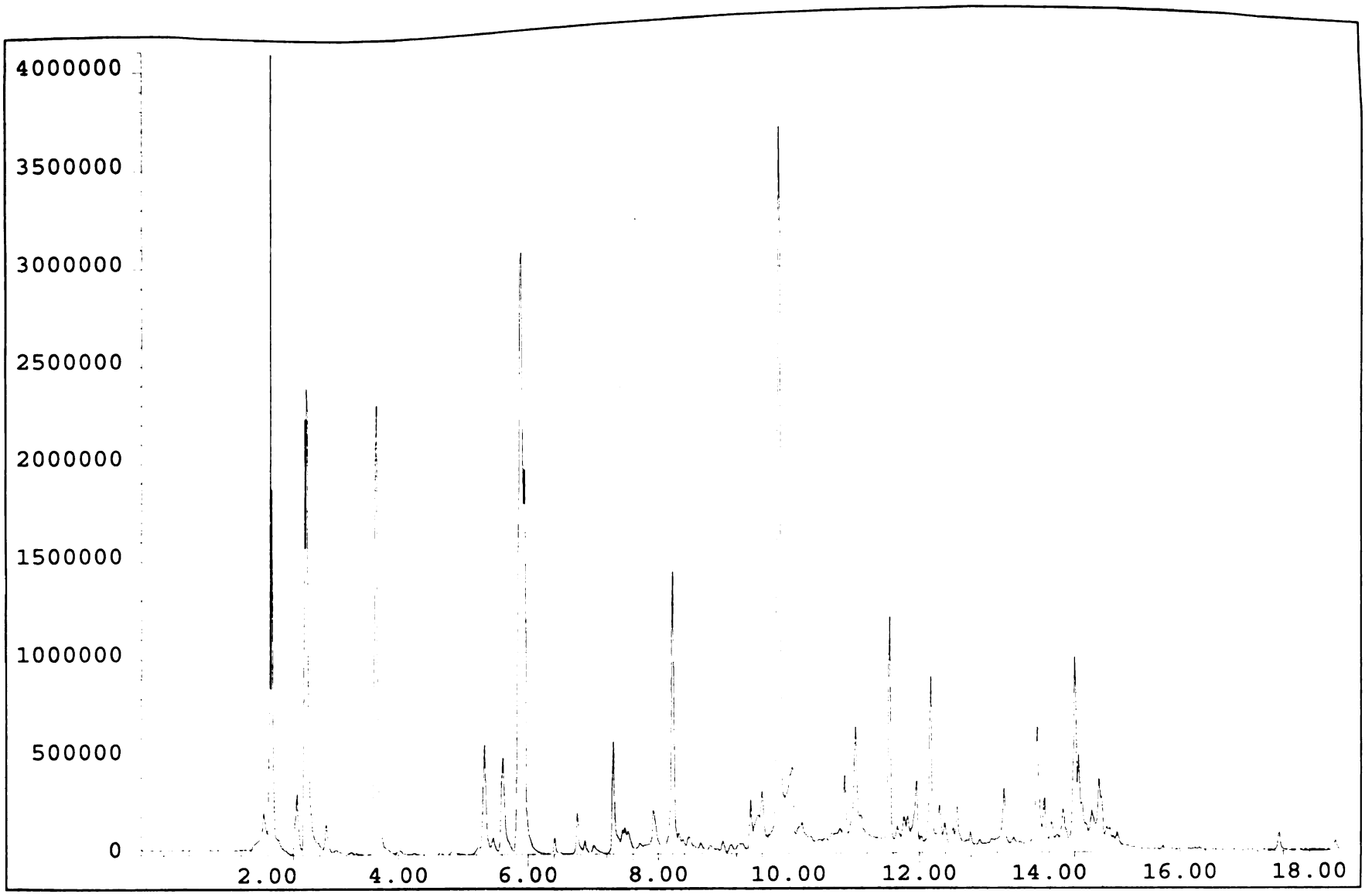

Figure 74: pyGC Chromatograph of DuPont Final Fil

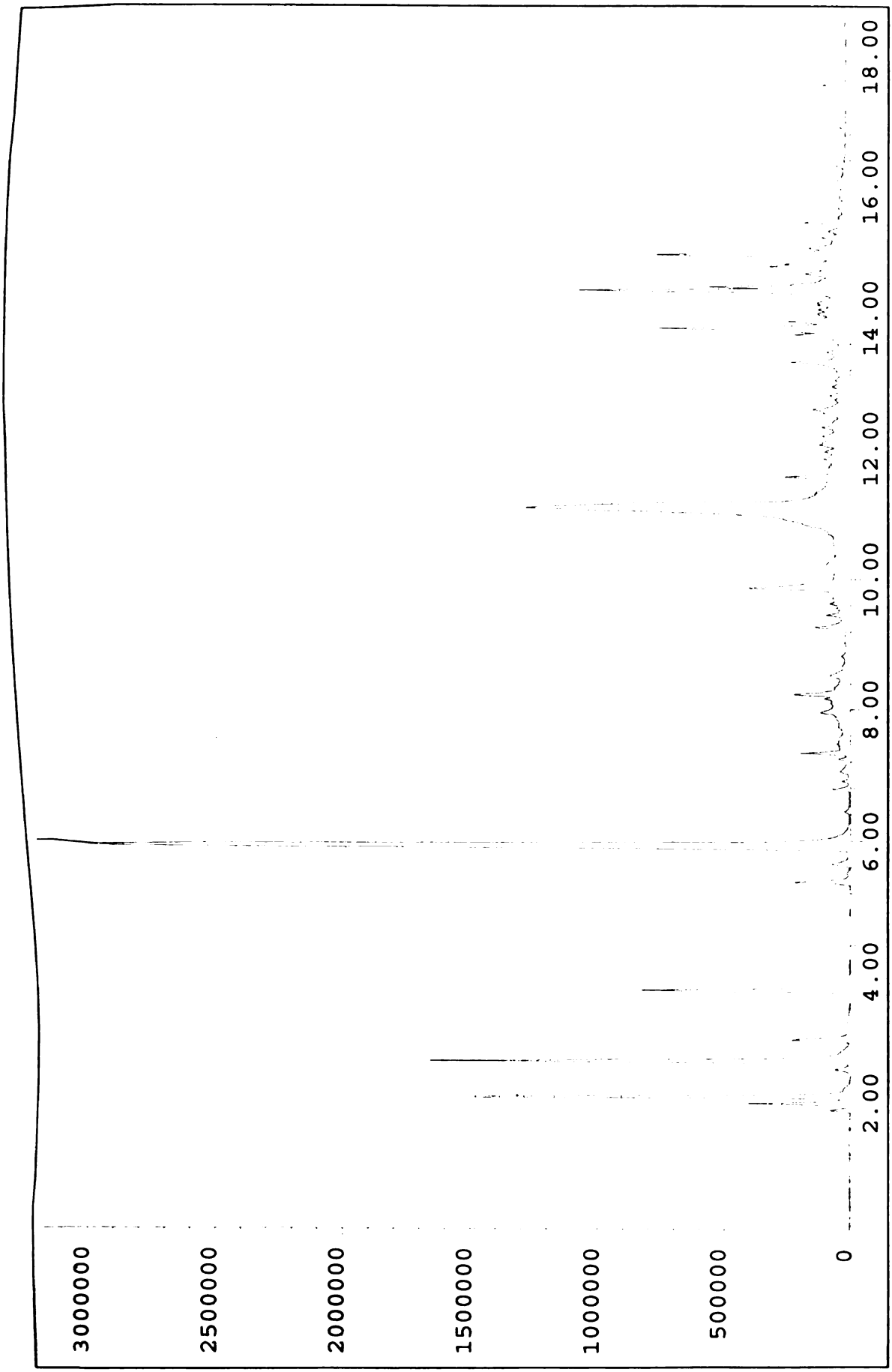

Figure 75: pyGC Chromatograph of Dynatron Ultimate Premium Light-weight

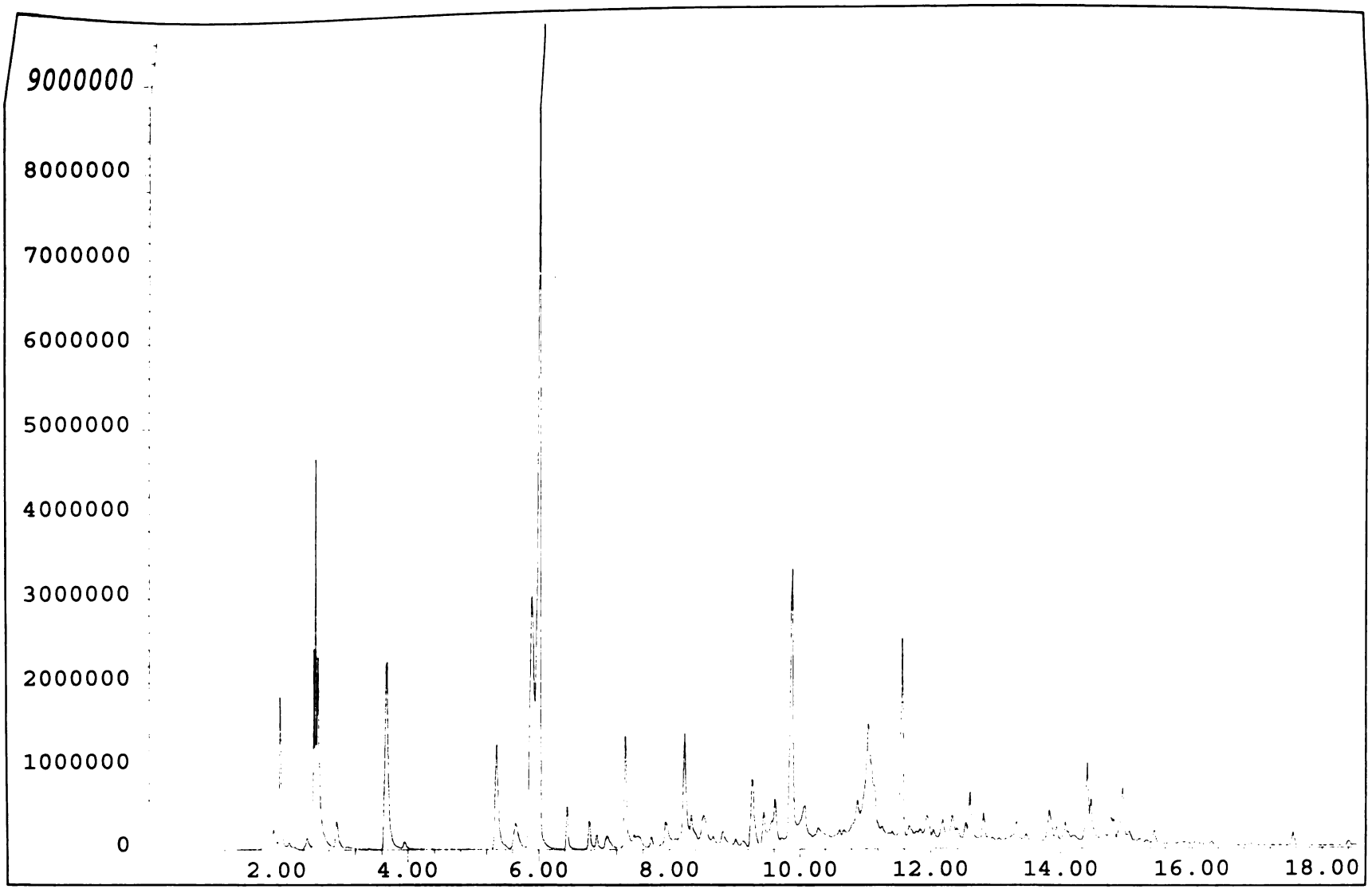

Figure 76: pyGC Chromatograph of Dynatron Ultragrip

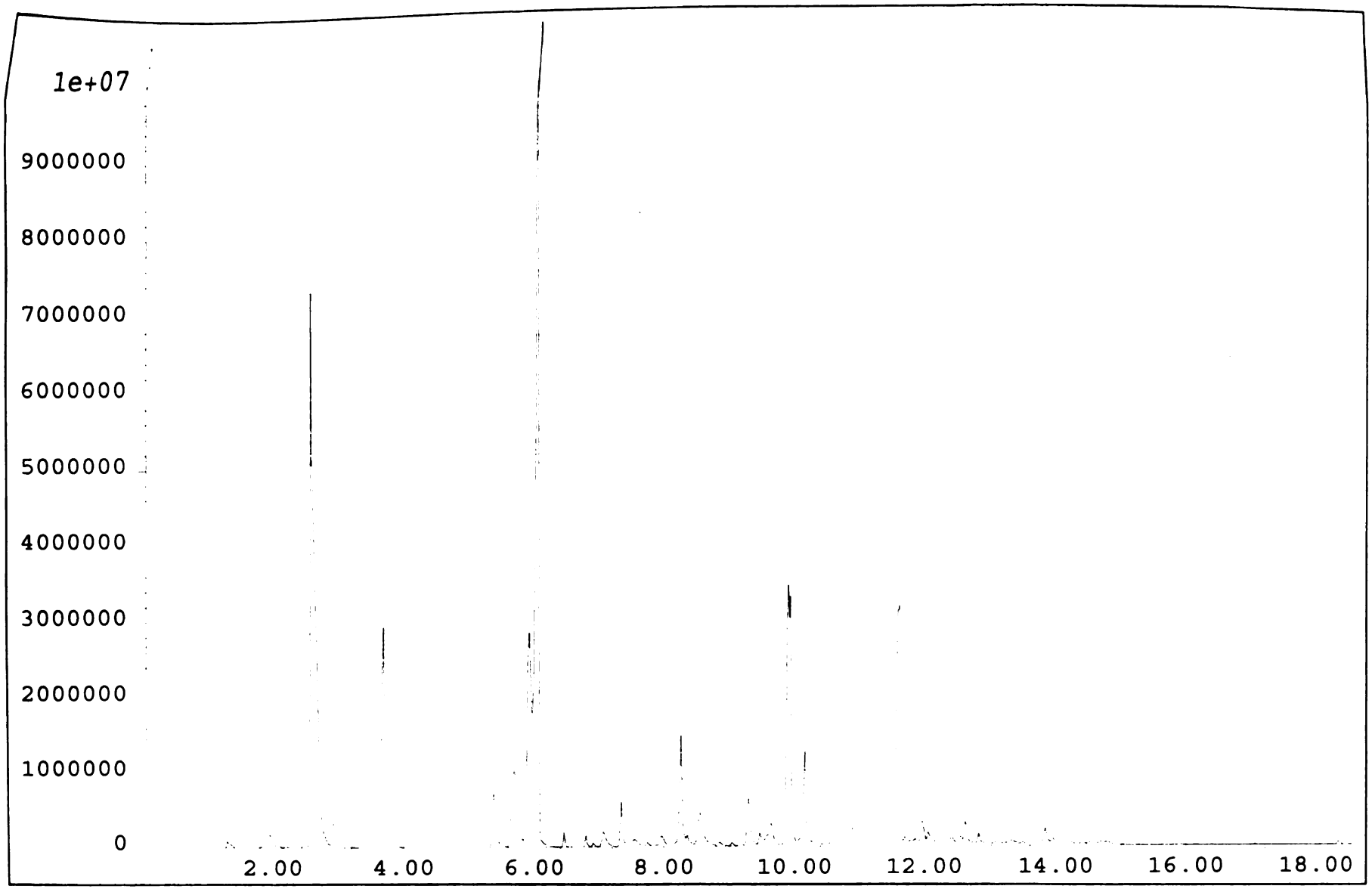

Figure 77: pyGC Chromatograph of U.S.C. Easywhite Lite

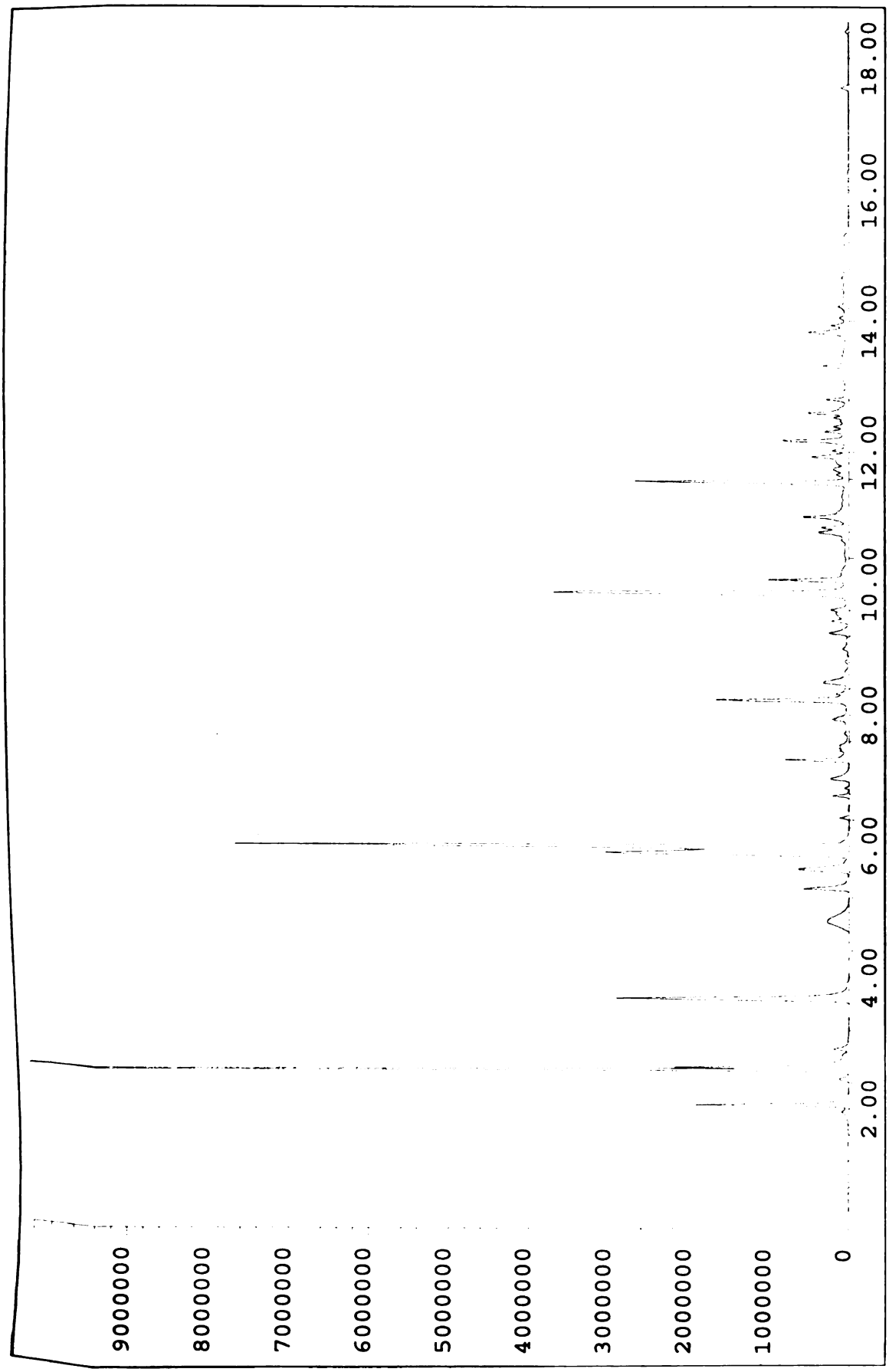

Figure 78: pyGC Chromatograph of U.S.C. Blue Ice

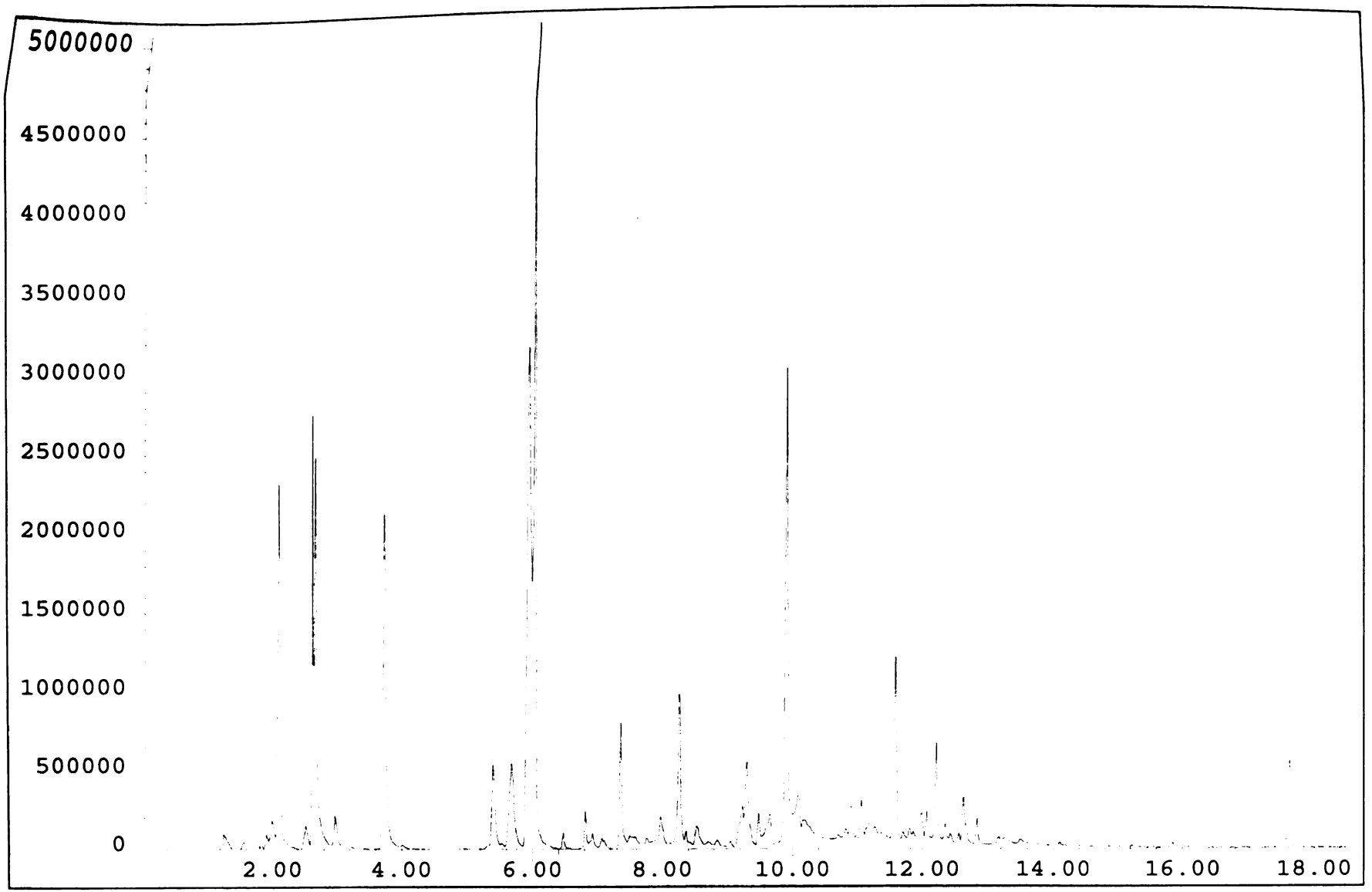

Figure 79: pyGC Chromatograph of 3M Body Filler Gold QBA

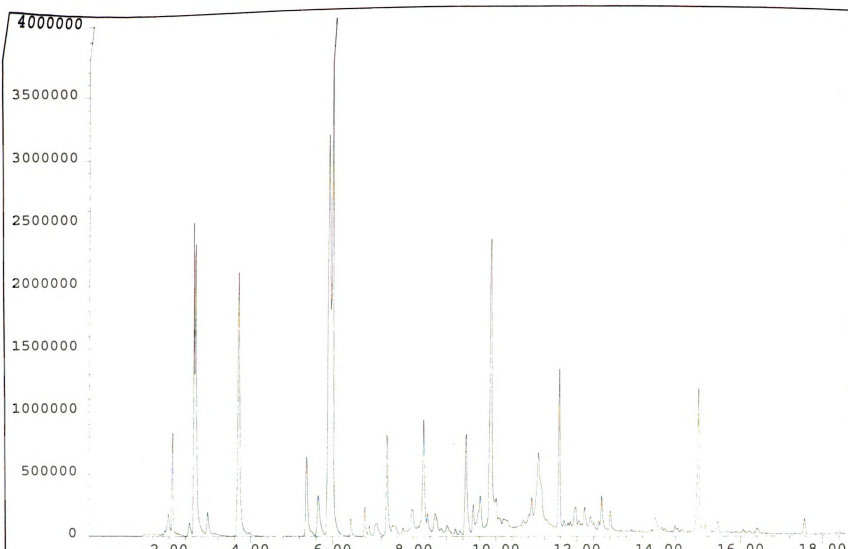

Figure 80: pyGC Chromatograph of 3M Zebra Tack Free Light-weight

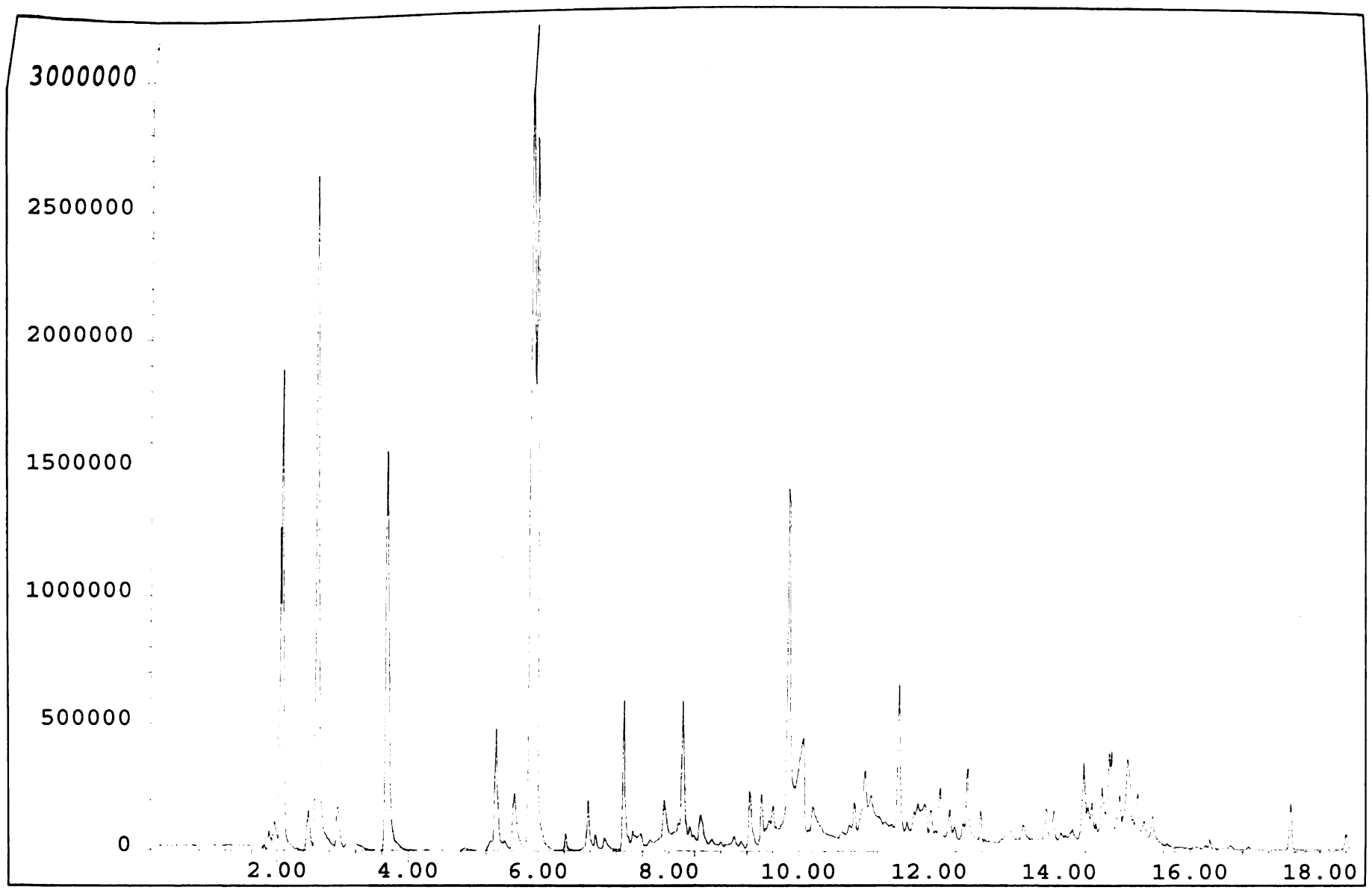

Figure 81: pyGC Chromatograph of 3M Premium Light-weight

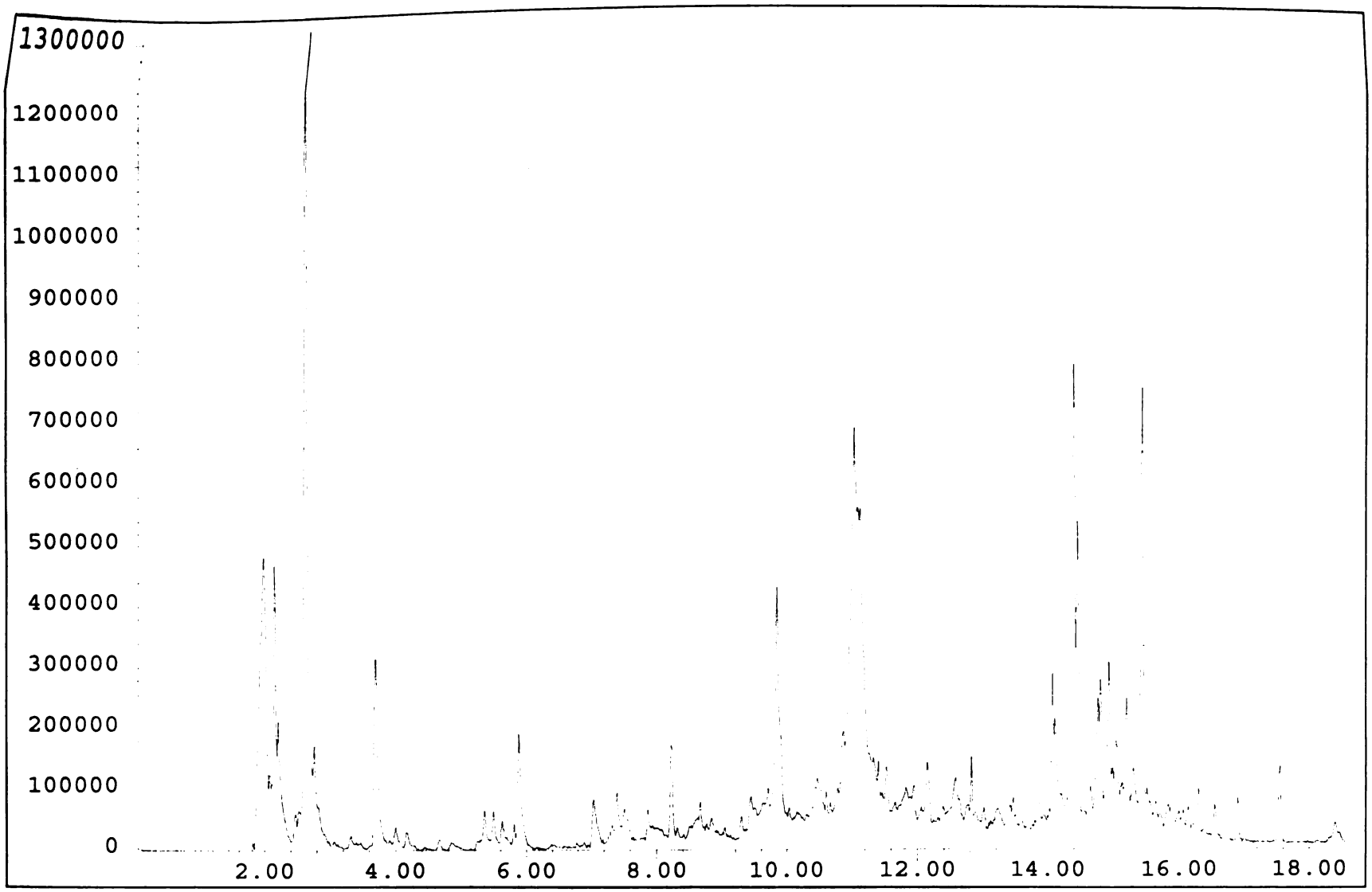

Figure 82: pyGC Chromatograph of PPG Red Oxide

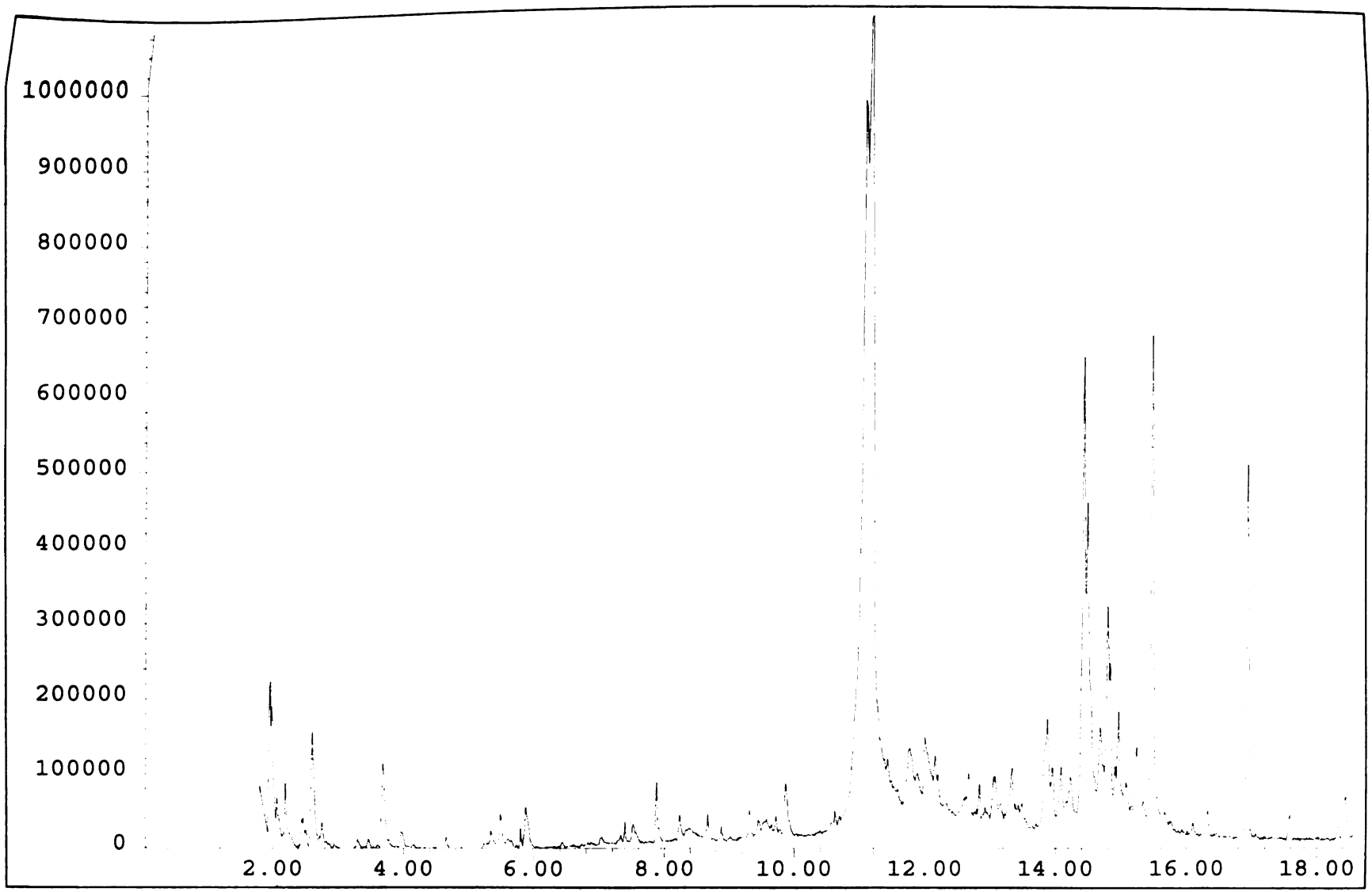

Figure 83: pyGC Chromatograph of Evercoat Ever-Glaze and Spot Putty

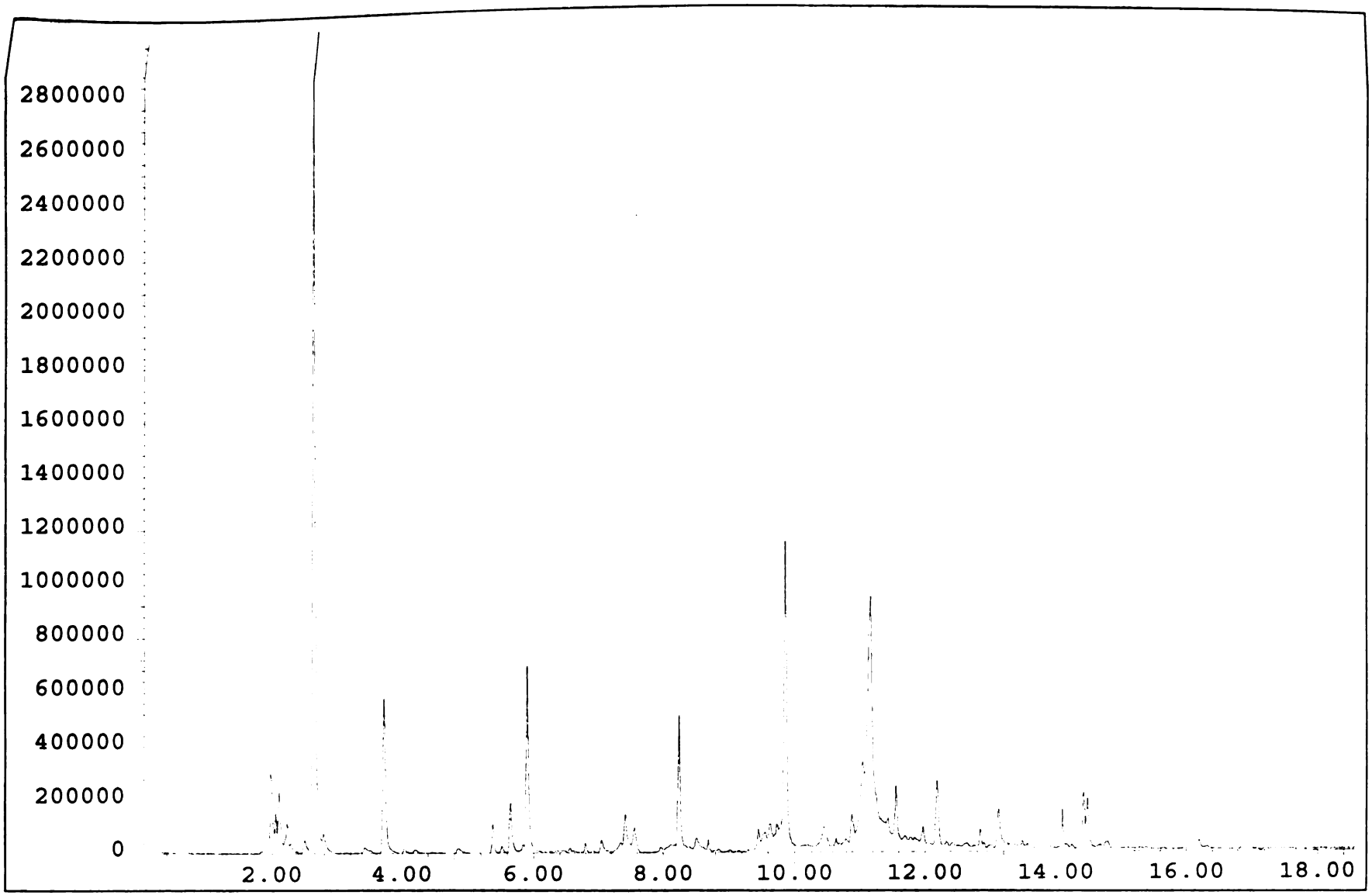

Figure 84: pyGC Chromatograph of Bondo Glazing & Spot Putty

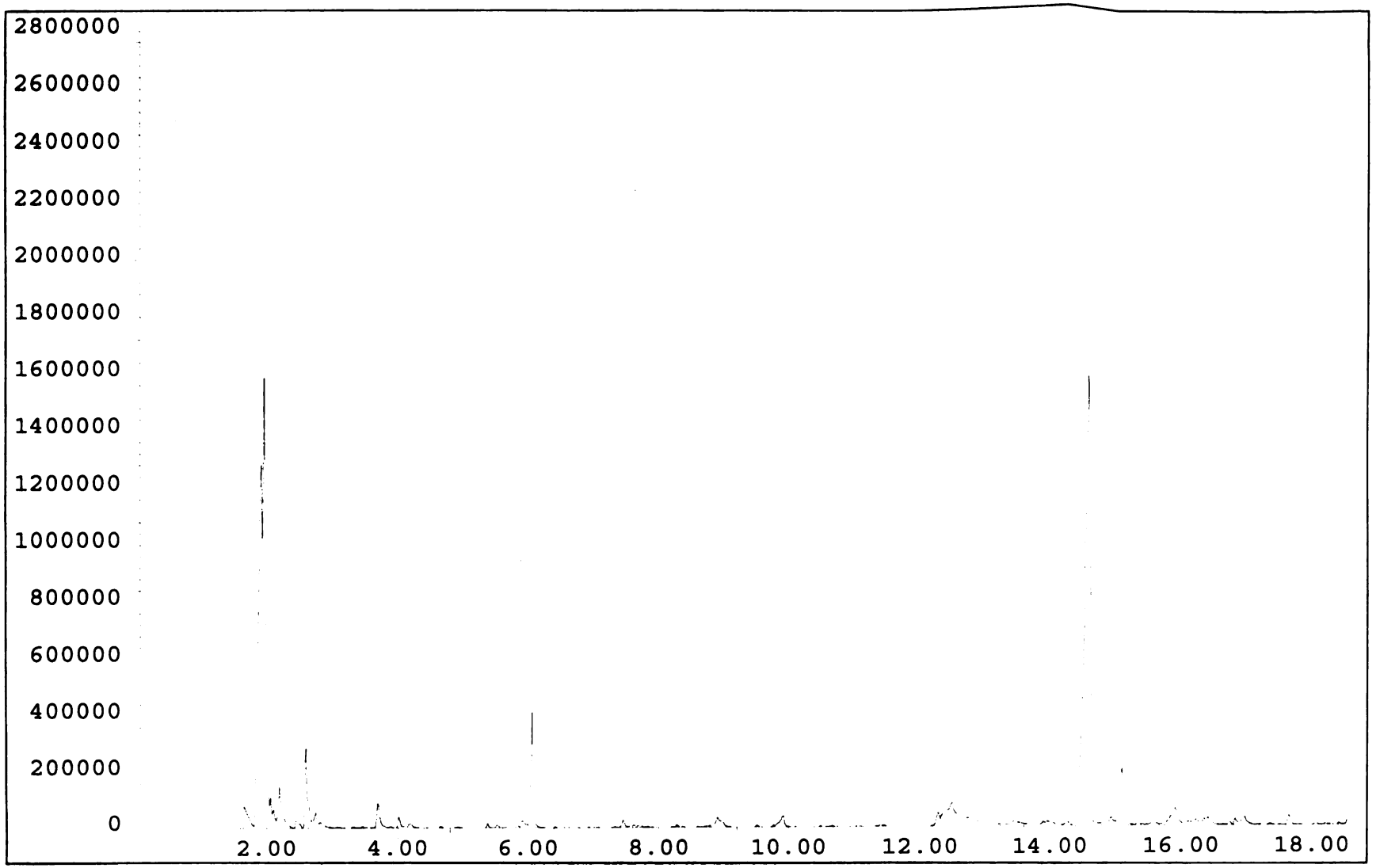

Figure 85: pyGC Chromatograph of Nitrostan Red Spot & Glayze Putty

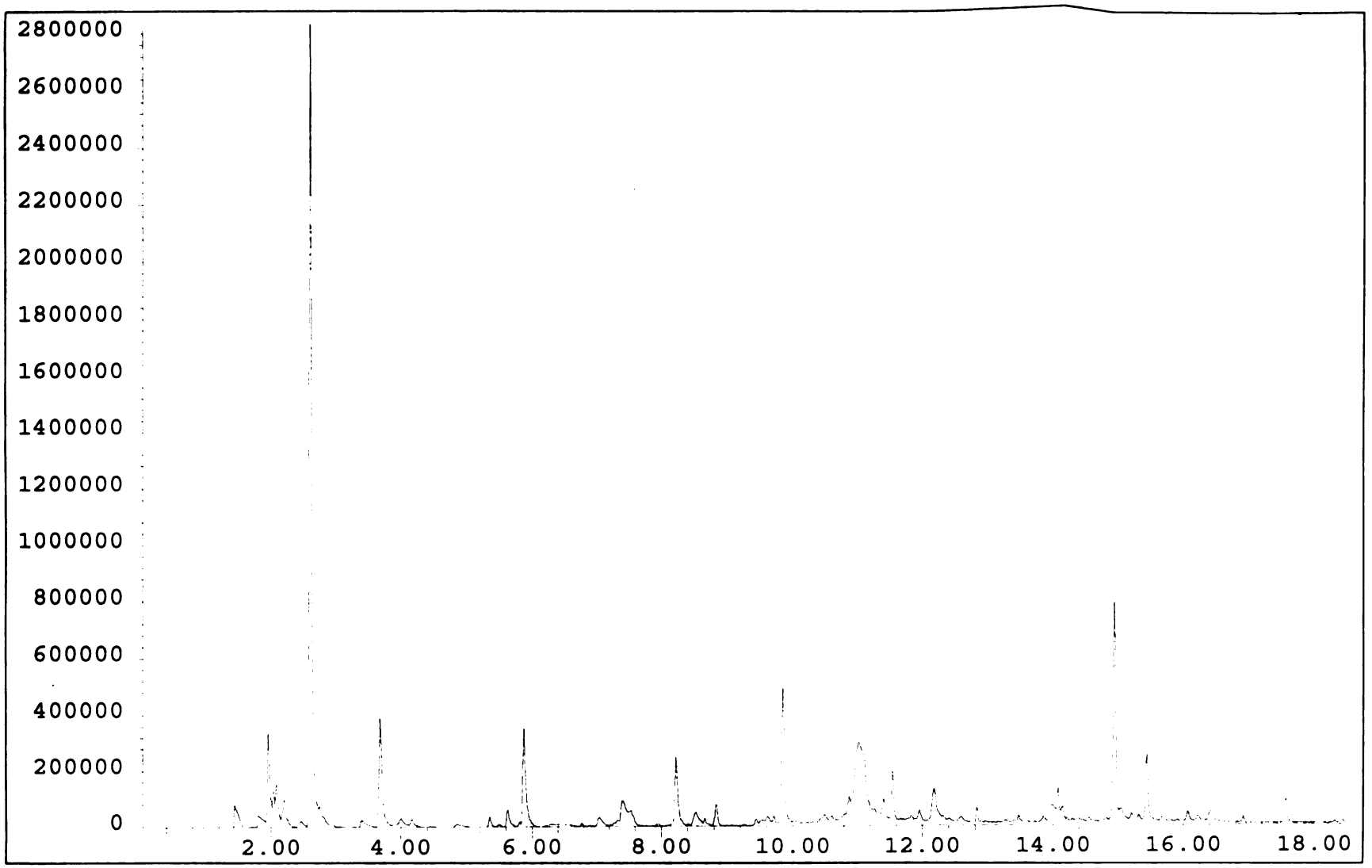

Figure 86: pyGC Chromatograph of Dynatron Glazing & Spot Putty

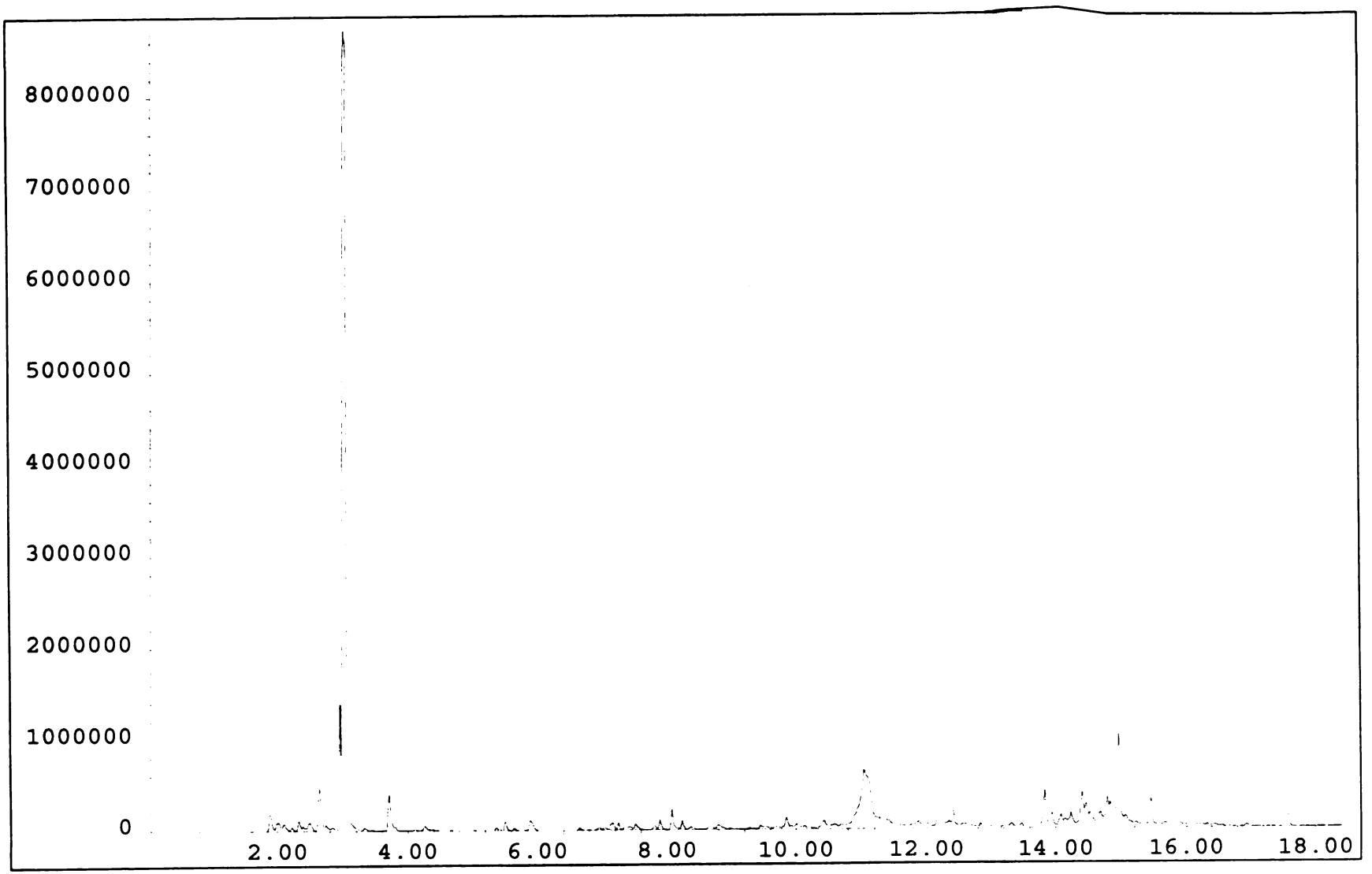

Figure 87: pyGC Chromatograph of 3M Acryl Green Spot Putty

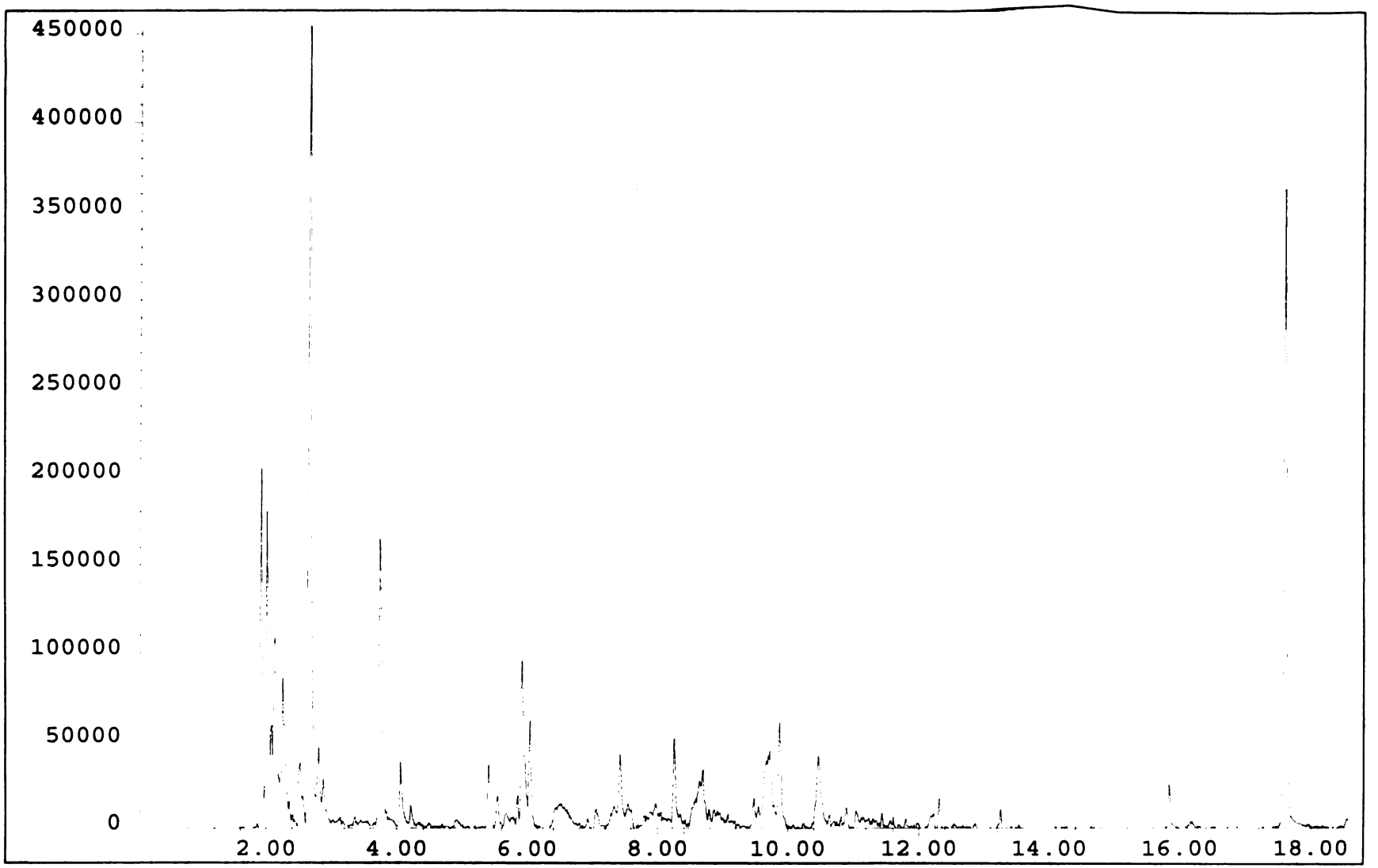

Figure 88: pyGC Chromatograph of Marson Spot & Glazing Putty

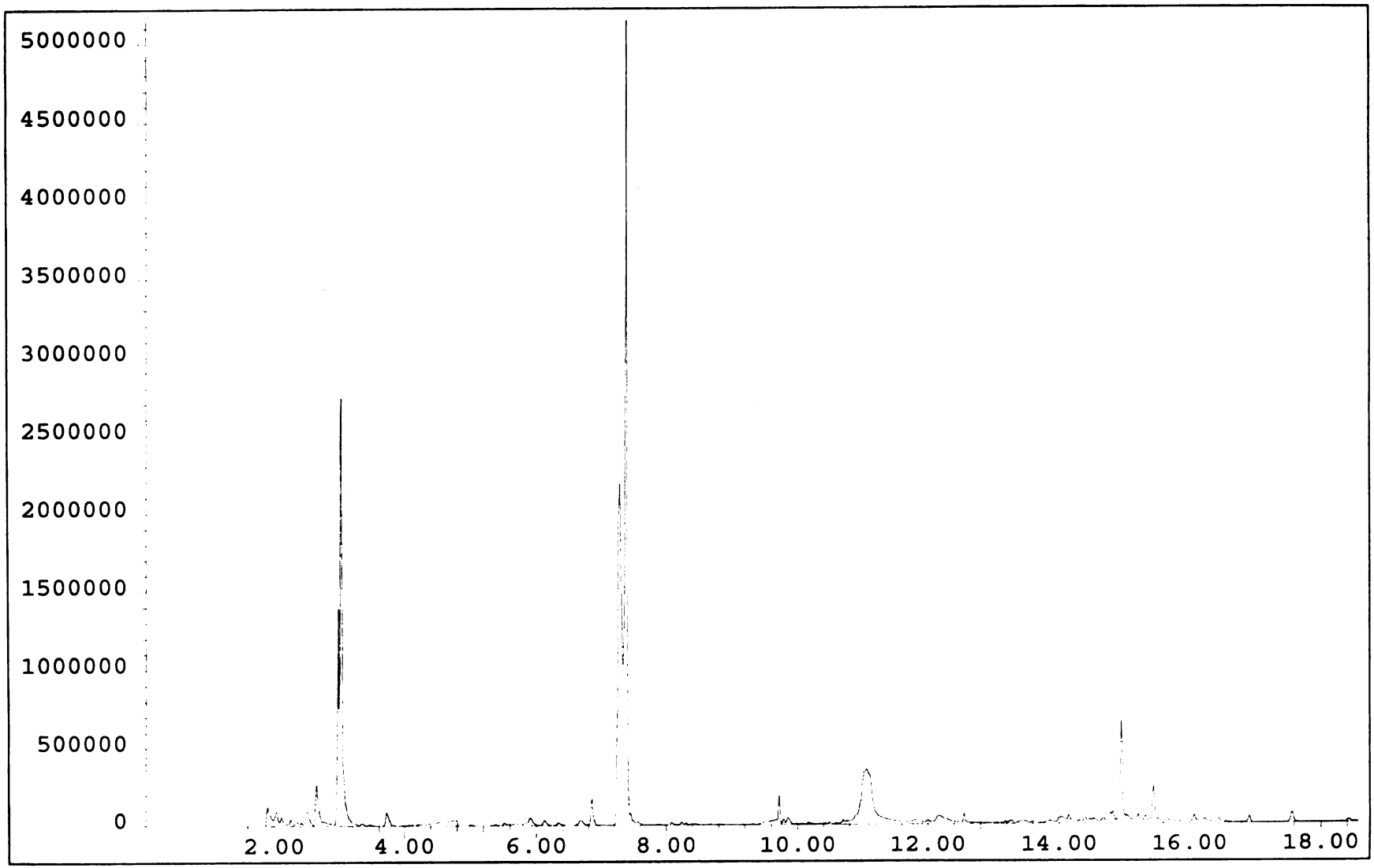

Figure 89: pyGC Chromatograph of Nitrostan Green Spot Putty

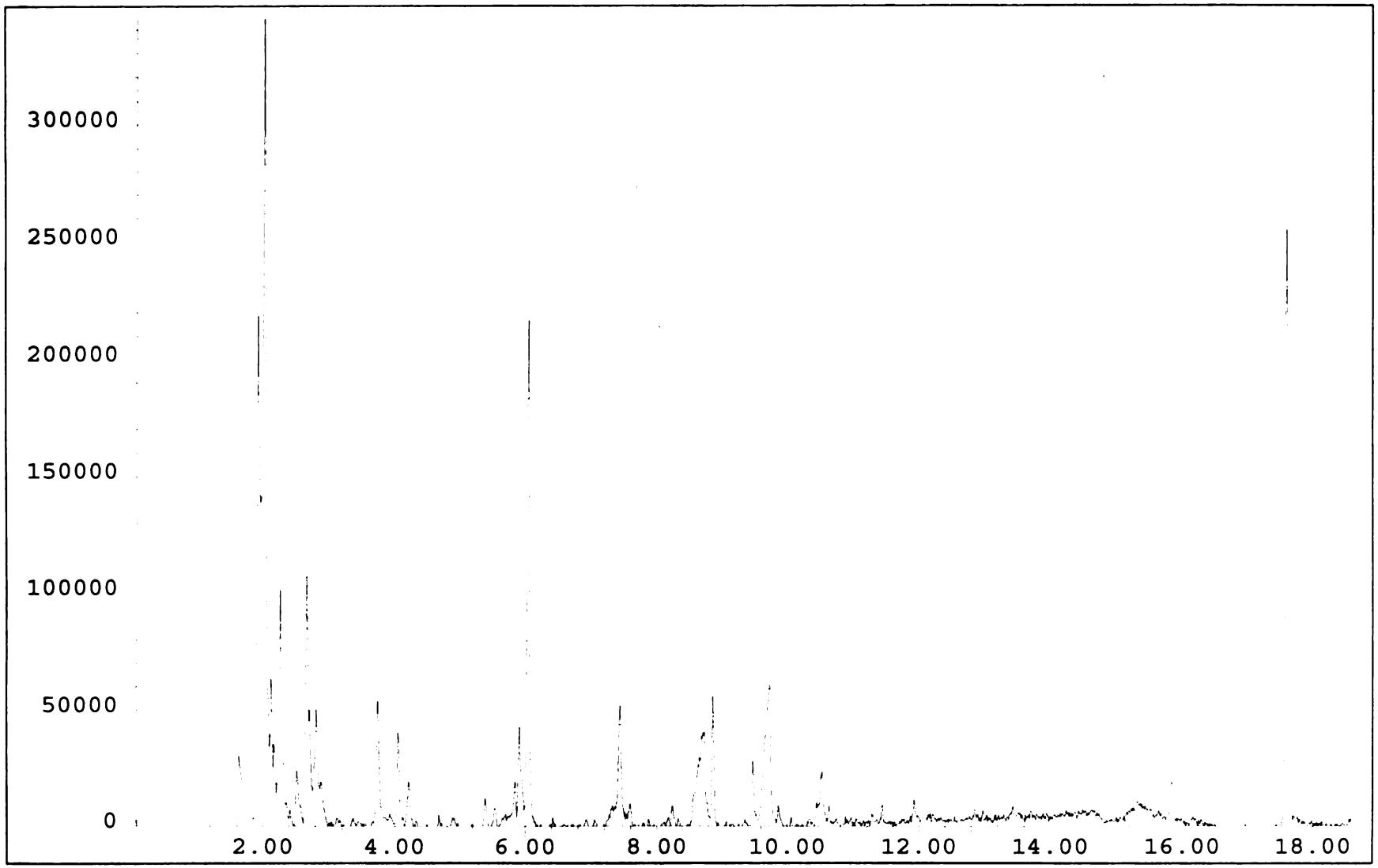

Figure 90: pyGC Chromatograph of Nitrostan Grey Spot Putty

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