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Gravity Probe B Relativity Mission

Analysis of GP-B Telescope Contamination during Component Test Phase

S0578 Rev. –

September 27, 2001
(Report by Lockheed Martin Material & Process Control Laboratories July 01, 1998)

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ITAR Assessment Performed

Summary

Particulate contamination was observed after the flight telescope was tested with Artificial Star #2 in the low temperature test probe #2. In order to find the source of the contamination, various contamination samples were analyzed.

Firstly, the particles collected from the top of the telescope was analyzed by Dale Gill and a report was written in S0328. This provides the information of the contaminant on the telescope.

Secondly, the vacuum can of the test probe along with the vacuum valve for the probe and pumping hose used were rinsed and the particles in the rinsing agent collected from a filter paper. This was to determine if the telescope probe was contaminated like the telescope was.

Thirdly, some samples were collected in the clean room as well as the Artificial Star #2 lab in an effort to match the contaminants found in the vacuum can.

The report of the second and the third analysis are presented as an attachment to this document.

Based on the above analysis, there appears to be little consistency between the contaminants from the telescope and the contaminants from the test probe. This indicates that the test probe is an unlikely source for contamination. The most likely cause was that the telescope was integrated into the test probe in the GP-B class 1000 clean room and was left uncovered for a few days. The static charge on the quartz may have attracted most of the dust particles. The indium particle was most likely due to the change of one of the vacuum feedthroughs while the telescope was in the probe.

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Lab Request/Job: AF1694

MPL File: 519377
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Laboratory Report

Analysis of Particles on Filter Paper from Gravity Probe B Telescope

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Charge No. F1-WM96-0020 TOT N1B0
Information Requested FTIR and EDS to identify particles
Items to Return

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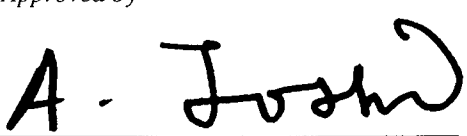

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JOB: AF1694
CN: F1-WM96-0020 TOT N1B0
Requester: Chris Abato, Craig Chivatero
Date Received: 5/5/98 (first filter)
Samples: Unknown particles

1. Particles on filter paper from Gravity Probe B telescope can hose valve.
2. Particles on filter paper -canister flush
3. Particles on filter paper - valve flush
4. Particles on filter paper - hose flush

Candidate Materials

1. String from connectors
2. Clear plastic which was wrapped around connector wires
3. Kapton Tape
4. Black O-ring
5. Wiper #1 (thinner wiper)
6. Wiper #2 (thicker, quilted)
7. Lens Spring
8. Cleanroom garments:
   a. Gloves
   b. Coveralls
   c. Shoe cover
   d. Bouffant
   e. Face mask
9. "Dust" samples from top of dewar (sampled 6/17/98)

Request: Identify particles, compare with candidate materials for possible sources of particles.

Background

Particulate contamination was observed after the Gravity Probe B telescope was vented and opened. Information provided by Suwen Wong indicated that the system had been under vacuum at approximately 10^{-8} torr. It was cycled once down to cold temperature, then warmed to room temperature before venting. The system was opened in a cleanroom to vent. The particles were sampled from the interior of the system by an unknown method. A petri slide that contained a filter paper with a contaminant sample was submitted to the M&P labs by Chris Abato and Craig Chivatero for infrared analysis to identify the particles on the filter paper. The notation on the slide identified the sample as "telescope can hose valve". Three petri slides were submitted later and contained filter papers with particles collected from freon flushes of each of the three components in the system- the canister, the valve and the hose. Analysis was requested to characterize the particles on the original filter, to compare with possible sources, and to compare with the particles from the flushes of the three components in the system.

Examination of Samples

Filter paper from Gravity Probe B "telescope can hose valve"

Examination of the original filter paper indicated that it contained two larger particles which were visible without a microscope and numerous microscopic particles that were observed in two clusters on the filter paper. Some particles were also observed on the inner surface of the cover on the slide. The two macroscopic particles appeared to be a combination of fibers and sticky materials. Microscopic yellow transparent particles were mixed with the fibers of one of the particles. The microscopic particles in the two clusters on the filter paper included numerous dull gray particles, many yellow transparent particles, and some shiny silver and gold colored particles. Several other particles which did not represent the bulk of the material were also observed. These included a red particle, a long yellow fiber, and several opaque white particles. Infrared and elemental analyses were performed to identify the particles.

Three filter papers from separate flushes of the canister, valve and hose
The filter from the flush of the canister visually indicated the most particles of the three filters. The particles included many gray particles and yellow/gold particles. Some shiny silver colored particles were also observed. The filters from the hose flush and the valve flush had significantly less particles than the filter from the flush of the canister. Microscopically, there were numerous particles on both. The hose flush filter appeared to have the fewest particles of the three filters.

Candidate Materials
A sample identified as "string from connectors" was submitted by Chris Abato (Contamination Control O/48-50) as a potential source of the fibers that were observed in the two macroscopic particles on the filter paper. These fibers were analyzed for comparison.

In a visit to the Gravity Probe B site on 5/26/98 by M&P laboratory personnel, samples of materials were collected for comparative analysis. These samples included:

- Clear plastic that was wrapped around connector wires
- Kapton tape
- Black O-ring
- Wiper #1 (thinner - taken from room with GPB)
- Wiper #2 (textured or quilted, thicker-taken from another room)
- Lens spring

Cleanroom garments

- Gloves
- Coveralls
- Shoe cover
- Bouffant
- Face mask

Two samples of "dust" were collected from the top of the dewar by Chris Abato on 6/17/98. The dewar was painted blue. The particles, as noted by Chris, included red chips and dusty clumps, white chalky pieces, black particles, small metallics and fibers. Comparative analysis of these materials to the particles on the filters was requested.

Analysis
Fourier Transform Infrared (FTIR) analysis: The particles and candidate materials were transferred to a 13 mm KBr salt plate with a stainless steel probe and analyzed with a Nicolet Nic-Plan microscope coupled to a Nicolet 730 infrared spectrometer. The data were collected in transmission mode between 4000 and 650 cm^{-1} with 4 cm^{-1} resolution. A small spot size (0.25 mm) mercury-cadmium-telluride (MCT-A) detector was used for signal acquisition. The black O-ring was pyrolyzed and the pyrolyzate was collected on a 25-mm KBr salt plate. The salt plate was tested on the main bench of a Nicolet 730 infrared spectrometer. The main bench was equipped with a TGS detector. The infrared data were collected in transmission mode between 4000 and 650 cm^{-1} with 4 cm^{-1} resolution.

Scanning Electron Microscopy-Energy Dispersive Spectroscopy (SEM-EDS) analysis: SEM was used to focus in on a specific particle. EDS was used to determine the elemental composition of a particle. Samples were analyzed by using a JEOL 840A SEM equipped with a Kevex Model 8000 EDS system. A Leica 360FE field emission SEM equipped with an Oxford Link EDS system was also used for some sample analysis.

Where possible, the same particle was analyzed by both FTIR and EDS analyses.

Results

A summary table of the particles and candidate materials analyzed and the FTIR and EDS results is attached in Table 1.

Original filter paper from Gravity Probe B "telescope can hose valve"

The two macroscopic particles appear to be a combination of a sticky material and fibers. An infrared spectrum of the sticky material (Fig. 1) and corresponding library matches (Figs. 1a-b) suggest that the sticky material is silicone based, such as a silicone adhesive. The fibers appear to be a polypropylene based material, based on the infrared spectrum of the fibers (Fig. 2) and corresponding library matches (Figs. 2a-b).

The dull gray particles visually appear to be a large portion of the microscopic particles in both clusters on the filter paper. The infrared data indicate that the particles are consistent with a polyisoprene, a styrene isoprene copolymer, or a latex rubber. An infrared spectrum of one of the gray particles and corresponding library matches are attached (Figs. 3, 3a-c). Chlorine was the major element detected in all of the gray particles analyzed by EDS. Carbon, sulfur and silicon were also detected. The infrared and EDS results in conjunction suggest that the gray particles are a chlorinated rubber.

The transparent yellow/gold colored particles were observed throughout both clusters and mixed in with the two macroscopic particles. The EDS data indicated aluminum, sulfur, and oxygen as the major elements in these particles. This is consistent with an anodized aluminum. Anodized aluminum would be expected to be gray in color. The yellow, transparent appearance of these particles may be due to a chromate coating. (Chromate coatings may be used to seal anodized aluminum.) Chromium was only detected at trace levels in one of the yellow particles by EDS, but very thin coatings may be missed by the EDS technique. Other analyses may be performed if determination of the source of the yellow color in the anodized aluminum particles would be useful.

Shiny, possibly metallic particles appear to account for only a small portion (less than 10%) of the particles on the filter paper, based on the microscopic observations. Most particles were 11-50 microns in size. Some were 51-250 microns.

The microscopic, shiny, silver colored particles indicated iron and oxygen as the major components in the EDS analysis. The presence of iron, oxygen, chromium, chlorine, nickel and copper suggests that the particles may be a 15-5 stainless steel.

The microscopic, shiny, gold colored particles indicated iron as the major component in the EDS analysis. Detection of iron, chromium and nickel suggest that the particles are most likely a 300 series stainless.

Several miscellaneous particles analyzed (Table #1) reflect a small portion of the contaminants on the filter. Sources of these materials have not been identified at this time. EDS analysis of the long yellow fiber indicates that calcium, lead, carbon, oxygen and possibly sulfur are major components. The infrared spectrum suggests a cellulosic portion mixed with an unknown component. EDS analysis of the red particle indicated tin and oxygen as the major elements, with minor amounts of iron, chlorine and carbon. The infrared spectrum suggests that the particle is inorganic. Several opaque white particles were analyzed and each provided different results. It is likely that there are several different types of opaque white particles present. EDS analysis of one opaque white particle indicated sulfur, oxygen and sodium as major components. Infrared spectra suggested that it was inorganic, but it did provide matches which are consistent with sodium sulfate. An infrared spectrum of a second opaque white particle suggested a cellulosic material. A third white opaque particle provided an infrared spectrum and library matches for an ethylene-vinyl acetate copolymer.

Candidate materials

• "String from connectors"- Fibers from the "string from connectors" sample provide an infrared spectrum which is consistent with a nylon based material. The infrared spectrum (Fig. 4) and corresponding library matches (Figs. 4a-c) are attached. This does not match the fibers observed on the filter paper.

• Clear plastic that was wrapped around connector wires - The material wrapped around the wires of the connector provide an infrared spectrum which is consistent with polyethylene. The infrared spectrum (Fig. 5) and corresponding library matches (Figs. 5a-c) are attached. This does not match the spectra of the particles analyzed from the filter paper.

• Kapton tape - The infrared spectrum of the adhesive from the Kapton tape indicates a silicone based material which is consistent with the sticky material found in the two macroscopic particles on the original filter paper. The infrared spectrum (Fig. 6) is attached. An overlay of the spectrum with the spectrum of the sticky mateial from the filter is attached in Fig. 6a. Note that many other silicones could provide similar spectra. Because the Kapton tape is used extensively within the hardware assembly, this is a likely source, but other sources of silicones such as the Dow Corning High Temperature Grease should not be ruled out.

• Black O-ring - The O-rings used in the Gravity Probe B assembly are reportedly Viton, a fluoropolymer. The black O-ring which was provided for analysis produced an infrared spectrum (when pyrolyzed) which is consistent with an acrylonitrile or an acrylonitrile-butadiene copolymer, which are common rubbers. The infrared spectrum (Fig. 7) and corresponding library matches (Figs. 7a-c) are attached. The infrared spectrum is markedly different from the spectrum from Viton (Fig. 7d), indicating that the O-ring is not Viton. The infrared spectra of the gray particles from the original filter and the pyrolyzed O-ring do not appear to be a good match and no chlorine was detected in the EDS analysis of the O-ring. This suggests that this O-ring is not the source of the gray particles on the filter which seem to be a chlorinated rubber material.

• Wiper #1 (thinner - taken from room with GPB) - The infrared spectrum of fibers from this wiper suggests a cellulosic material. The infrared spectrum (Fig. 8) and corresponding library matches (Figs. 8a-c) are attached. This does not match the materials analyzed on the original filter paper.

• Wiper #2 (textured or quilted, thicker-taken from another room) - The fibers from this wiper provide an infrared spectrum which is consistent with polypropylene. The infrared spectrum (Fig. 9) and corresponding library matches (Figs. 9a-c) are attached. These are the same type of fibers that were observed in the macroscopic particles on the original filter paper. The infrared spectra of the fibers from the filter and the wiper are overlaid in Fig. 9d. Note that other types of polypropylene materials (i.e., the face mask) would provide similar matches. Wipers were reportedly used to wipe out the canister, which is anodized aluminum. The presence of transparent gold-colored particles (aluminum, oxygen and sulfur - anodized aluminum) in the fibers supports the argument that the wiper fibers are a likely source of the contaminant fibers.

• Lens spring - EDS analysis of the lens spring indicates that nickel, chromium and carbon are the major elements. Iron, titanium, aluminum and silicon were also present. The EDS spectrum is attached (Fig. 10). This suggests that the lens spring is not a likely source of the metallic particles on the filter paper.

Cleanroom garments

• Gloves - The labeling on the package of the gloves indicates that they are composed of three polymers. The infrared spectrum of the glove material (Fig. 11) provides matches for latex rubbers (Figs. 11a-c). Spectra of a gray particle from the filter paper and the latex glove reference are overlaid in Fig. 11d. (Note that there are some differences in the spectra which may suggest a different lot or brand of gloves or some other similar source.) EDS analysis of the gloves indicated chlorine as a major component (Fig. 11e). The infrared and EDS data suggest that the gloves may be a source of the chlorinated rubber material observed on the original filter paper.

• Coveralls - Infrared analysis of the coveralls indicates an infrared spectrum which is consistent with polyethylene. The infrared spectrum (Fig. 12) is attached. This is not a match for the fibers on the original filter paper sample.

• Shoe cover - The upper portion of the shoe cover and the sole of the shoe cover consist of different materials. The upper portion provides an infrared spectrum which is consistent with polyethylene. The infrared spectrum (Fig. 13) is attached. The sole provides an infrared spectrum (Fig. 14) which is consistent with polyvinyl chloride (PVC) and plasticizers. Corresponding library matches (Figs. 14a-c) are attached. Neither of these materials provide a good match for the fibers from the macroscopic particles which were analyzed from the contaminants on the original filter paper.

• Bouffant - The bouffant provides an infrared spectrum which is consistent with a polyethylene based material. Signals in the infrared spectrum suggest it is not a pure polyethylene material. The infrared spectrum (Fig. 15) and corresponding library matches (Figs. 15a-c) are attached. The bouffant is not a likely source of the fibers on the filter.

• Face mask - Fibers from the face mask provide an infrared spectrum which is consistent with polypropylene. The infrared spectrum (Fig. 16) and corresponding library matches (Figs. 16a-c) are attached. This is a possible source of the polypropylene fibers observed on the original filter paper in the two macroscopic particles. (The wiper may be a more likely source - see Wiper #2). Infrared spectra for fibers from the face mask and a fiber from the filter paper are overlaid in Fig. 16d. The infrared spectrum for the elastic bands on the face mask (Fig. 17) suggests that they are a polyethylene terephthalate (PET) based material. Corresponding library matches (Figs. 17a-c) are attached. This material does not match the particles analyzed from the filter paper.

• "Dust" from top of dewar - EDS analysis was performed on several of the particles from the "dust" sample to determine if it may be a source of the gray chlorinated rubber particles . The black particles were elastomeric. EDS analysis of two of the black particles indicated carbon, oxygen and silicon as major elements, suggesting a possible silicone rubber. Although chlorine was detected, it was not a major component and was not detected throughout the particle. Particles embedded on the surface of the black particle may be contributing to these results. These black particles do not appear to be related to the gray particles on the original filter sample. Other particles from the dust which were analyzed included the orange/red particles (major iron and oxygen, indicating rust), the white chalky pieces (major zinc and oxygen, possibly zinc oxide), and a shiny metallic particle (major aluminum, possibly aluminum foil). None of the particles analyzed indicated the elements detected in the chlorinated rubber particles on the original filter.

Filter papers from flushes of canister, hose, and valve

The filter paper from the freon flush of the canister indicated high levels of particles. The filter paper was inverted onto a silver filter paper and flushed with freon to attempt to transfer the particles to the silver filter paper. The filter paper was then flushed at an angle onto a second silver filter paper to attempt to remove more of the particles. Several particles were marked for analysis and analyzed by EDS. Many particles still remained on the first filter paper. Most of the particles on the second silver filter paper appear to be an agglomeration of particles. Particles that contain major components of aluminum, sulfur and oxygen appear to be predominant in the particles analyzed. These would be consistent with the probable anodized aluminum particles observed previously on the original filter paper sample.

Visually, there was much less material on the hose flush filter sample than on the canister flush filter. The filter was rinsed with freon onto a silver filter paper to attempt to transfer the particles. More particles remained on the initial filter paper than transferred to the silver filter paper. The initial filter paper was cut in half, carbon coated and analyzed by EDS. At least 1/3 of the particles analyzed indicated aluminum, sulfur, and oxygen (anodized aluminum). EDS analysis of 30 of the particles on the silver filter suggest that the particles analyzed were primarily anodized aluminum (aluminum, sulfur and oxygen), chlorinated rubber (major chlorine and carbon, silicon and sulfur), silicates and teflon.

More particles were observed on the valve flush filter sample, as compared with the hose flush filter sample. This filter was also flushed with freon onto a silver filter paper in an attempt to transfer the particles. Again, few of the particles transferred to the silver filter paper. The initial filter paper was cut in half, carbon coated and analyzed by EDS. Most of the particles that were analyzed were consistent with brass (copper and zinc). Stainless steel and teflon particles were also indicated. Some aluminum and some silicon-containing particles were also detected. None of the particles analyzed indicated anodized aluminum or chlorinated rubber. Analysis of 30 particles on the silver filter paper suggested the presence of stainless steel particles, silicone particles, copper oxide particles and silicates. None of the particles tested indicated anodized aluminum or chlorinated rubber.

Summary

The two macroscopic particles on the original filter paper appear to be a combination of polypropylene fibers and silicone. Particles embedded in the fibers appear to be anodized aluminum. The thicker, quilted wipers which were analyzed for comparison appear to be a likely source of the fibers. This is consistent with information provided which indicated wipers were used to wipe out the anodized aluminum canister. The face masks and other polypropylene materials, however, cannot be ruled out as sources of the fibers. The silicone adhesive of the Kapton tape is a likely source of the silicone portions of the two macroscopic particles. The Kapton tape is reportedly used extensively inside the assembly. Again, other sources of similar silicones (possibly the Dow Corning High Temperature Grease) cannot be ruled out.

The majority of the microscopic particles appear to be opaque gray and gold transparent particles. The gray particles are most likely a chlorinated rubber. Of the candidate materials tested, the latex gloves are the most likely source. (Differences between the particles and the glove spectra may be due to different lots of gloves or changes in the glove material upon exposure to high vacuum.) The gold transparent particles indicate anodized aluminum (aluminum, sulfur and oxygen). The anodized aluminum canister is a likely source. (The surface may also have been chromate sealed which may account for the yellow/gold color). A small percentage of the particles appear to be related to stainless steels, possibly 15-5 and 300 series. The valve may be one source of these particles. The lens spring does not appear to be a source of the metal particles. Analysis of other possible metals in the hardware assembly may be useful in identifying other sources of the metal particles observed. Sources of other miscellaneous particles (Table #1) have not been determined.

The data from the filters from the flushes of the canister, hose and valve components individually suggest that the anodized aluminum particles are the predominant particles in the canister with some also in the hose. The chlorinated rubber particles are most evident in the hose. The particles tested from the valve do not appear to indicate the anodized aluminum or the chlorinated rubber in the valve. Pumpdown and venting of the system may have caused movement of the particles to different components. The current locations of particles may not reflect the original source of the particles.

The types of particles detected and the information about the system setup and operation suggests that much of the particulate contamination observed on the filter is related to cleaning of the canister prior to use. An alternative cleaning method or alternative cleaning materials (wipers, gloves) and restricted use of Kapton tape may be necessary to reduce the contamination observed.

Attachments

Table 1.	Summary table of particles analyzed, candidate materials and FTIR and EDS results.
Fig. 1.	Infrared spectrum of sticky material from original filter paper.
Figs. 1a-c.	Corresponding library matches.
Fig. 2.	Infrared spectrum of fibers from original filter paper.
Figs. 2a-b.	Corresponding library matches.
Fig. 3.	Infrared spectrum of dull, gray particles from original filter paper.
Figs. 3a-e.	Corresponding library matches.
Fig. 4.	Infrared spectrum of fibers from the "string from connectors".
Figs. 4a-c.	Corresponding library matches.
Fig. 5.	Infrared spectrum of clear plastic wrapped around connector wires.
Fig. 5a.	Corresponding library match.
Fig. 6.	Infrared spectrum of adhesive from Kapton tape.
Fig. 6a.	Overlay of spectra for Kapton adhesive and sticky material from original filter.
Fig. 7.	Infrared spectrum of black O-ring (pyrolyzed).
Figs. 7a-c.	Corresponding library matches.
Fig. 7d.	Infrared library spectrum of Viton A.
Fig. 8.	Infrared spectrum of Wiper #1 (thinner).
Figs. 8a-b.	Corresponding library matches.
Fig. 9.	Infrared spectrum of Wiper #2 (thicker, quilted).
Figs. 9a-b.	Corresponding library matches.
Fig. 9c.	Overlay of fibers from Wiper #2 and fibers from original filter paper.
Fig. 10.	EDS spectrum of lens spring.
Fig. 11.	Infrared spectrum of glove.
Figs. 11a-c.	Corresponding library matches.
Fig. 11d.	Overlay of sample from glove and gray particle from original filter paper.
Fig. 11e.	EDS spectrum of glove.
Fig. 12.	Infrared spectrum of coveralls.
Fig. 13.	Infrared spectrum of shoe cover, upper.
Fig. 14.	Infrared spectrum of shoe cover, sole.
Figs. 14a-b.	Corresponding library matches.
Fig. 15.	Infrared spectrum of bouffant.
Figs. 15a-d.	Corresponding library matches.
Fig. 16.	Infrared spectrum of face mask.
Figs. 16a-c.	Corresponding library matches.
Fig. 17.	Infrared spectrum of elastic bands from face mask.
Figs. 17a-c.	Corresponding library matches.

K. Gibb
3915-7
6/30/98

Table 1: AF1694 GPB Particles Summary

IR File	Particle Description	IR	EDS	Possible ID	Possible Sources
	Macroscopic #1				
A	Sticky material	Silicone		Silicone adhesive	Kapton tape
B	White fibers	Polypropylene or ethylene propylene copolymer			• Wiper, thicker quilted, • Face mask
	Macroscopic #2				
E	White fibers	Polypropylene or ethylene propylene copolymer			• Wiper, thicker quilted, • Face mask
C, D	Sticky material	Silicone		Silicone adhesive	
X,W, S, T, U	**Microscopic gray (bulk of particles)**	Polyisoprene, isoprene styrene copolymer, latex rubber OR chloro flame retardant OR polypropylene	Cl - major, Si, S major/minor, (Al, C)	Chlorinated rubber	Cleanroom gloves
Y, K, V, F, G, H, I	**Microscopic yellow/gold transparent particles**	Inorganic?	Al- major, S, O, (Fe, Ni)	aluminum sulfate	anodized aluminum
N, P	**Microscopic shiny silver particles**	Inorganic?	Fe, O - major Cr, Cl, Al, Si, Ni Minor (Cu, C, Ti?, (S/Mo?))	15-5 stainless (with corrosion products?)	
M	**Microscopic shiny gold particles**	Inorganic?	Fe - major, Cr, Ni- minor, (Si, P, Ca, O, S)	300 series stainless	
	Miscellaneous particles				
R	**Long Yellow fiber**	Cellulosic + Unknown	Ca, Pb, C, O, (S?) - Major Fe, Cu - minor		
L	**Red particle**	Inorganic?	Sn, O - major Fe, Cl, C- minor (Al, Si, Cl)		
Z, O	**Opaque white particle**	Inorganic? (Sodium sulfate?)	S, O, Na - major K, Ca - minor (Ti, Fe, Br)	Sodium sulfate	
O	**Opaque white particle**	Cellulosic		Cellulosic	
Q	**Opaque white particle**	Ethylene-Vinyl acetate		Ethylene-Vinyl acetate	
	CANDIDATE MATERIALS				
ZZ	String from Connectors	Nylon		Nylon	
	Lens spring		Ni, Cr, C - major Fe, Ti, - minor Al, Si - Trace		Not a likely source of the metal particles on filter
R4	Clear Plastic wrapped around connector wires	Polyethylene		Polyethylene	
R8	Kapton Tape	Silicone		Silicone	Possible source of silicone on filter
R1	Black o-ring	Acrylonitrile or acrylonitrile-butadiene, NOT Viton	No chlorine detected Carbon - major S, O, Zn, Al - minor	Acrylonitrile or acrylonitrile-butadiene rubber	Not a likely source of chlorinated rubber particles on filter
R5	Wiper #1 (Thinner wiper)	Cellulosic		Cellulosic	
R6	Wiper #2 (Thicker, quilted)	Polypropylene		Polypropylene	Possible source of fibers on filter
	Cleanroom Garments				
R3, R9	Gloves	Latex	Cl, C -major O, S, Zn - minor	Chlorinated rubber	Possible source of chlorinated rubber particles on filter
R7	Coveralls	Polyethylene		Polyethylene	
S1	Shoe Cover: Upper	Polyethylene		Polyethylene	
S3	Shoe Cover: Sole	Polyvinyl chloride (PVC) + plasticizer		PVC + plasticizer	
S4	Bouffant	Polyethylene based material		Polyethylene based material	
S5, S6, T2, T4	Bouffant thread	Polyethylene terephthalate (PET) based		Polyethylene terephthalate (PET) based	
S7	Face Mask	Polypropylene		Polypropylene	Possible source of fibers on filter
S8	Elastic band of Face Mask	Polyethylene terephthalate (PET), based		Polyethylene terephthalate (PET), based	

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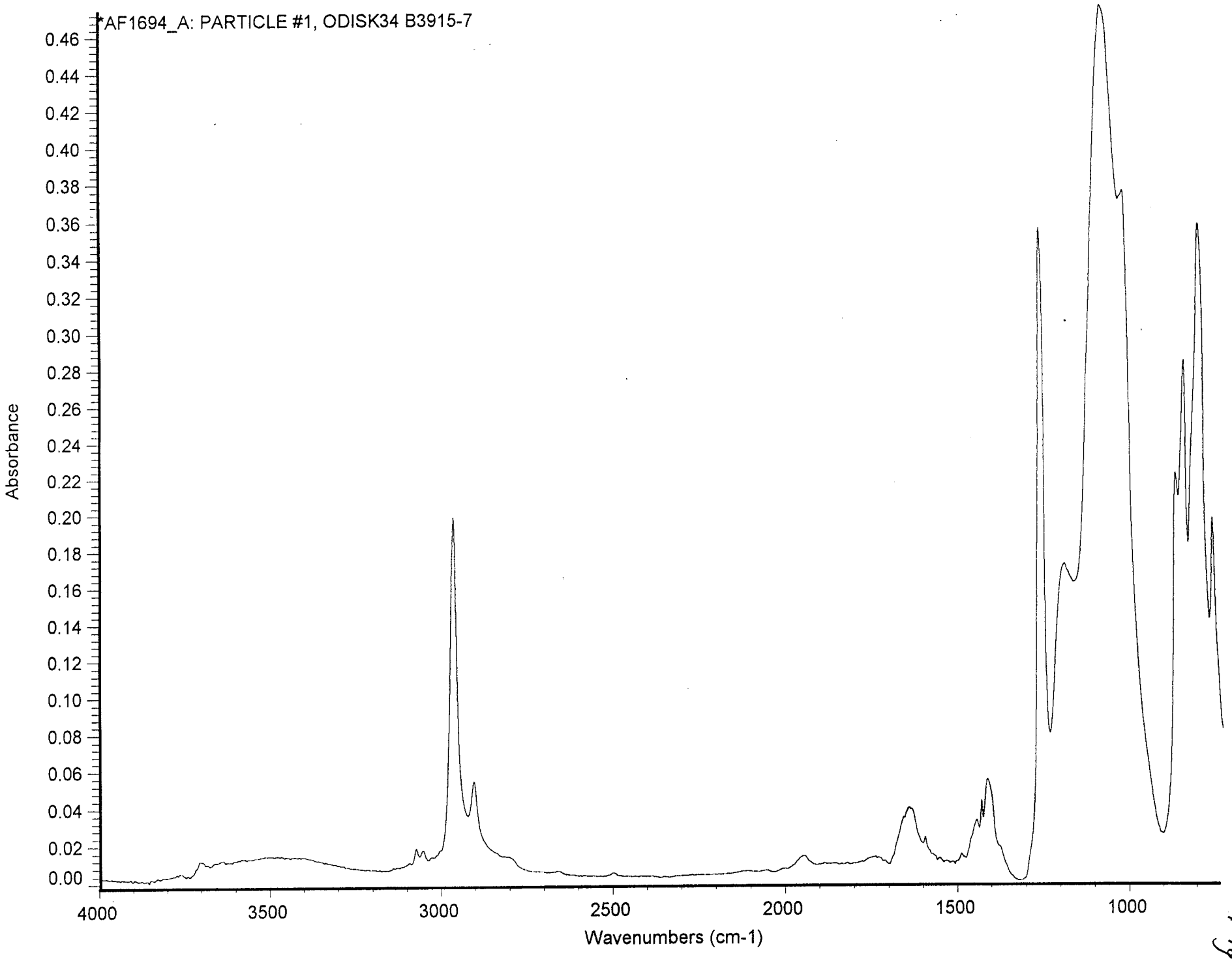
*AF1694_A: PARTICLE #1, ODISK34 B3915-7
Absorbance
0.46
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0.34
0.32
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
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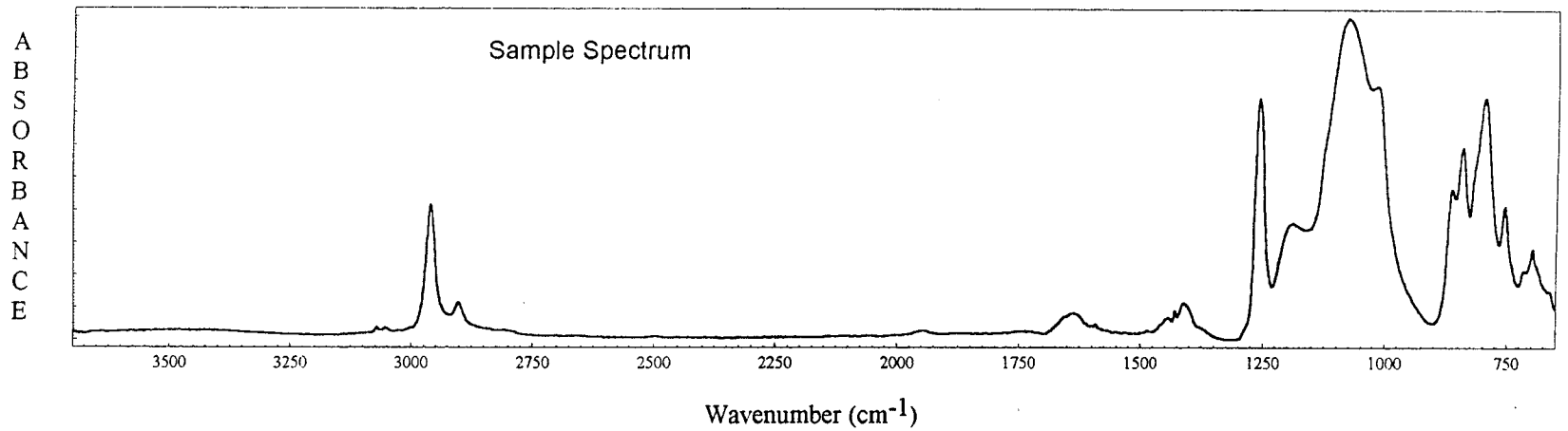
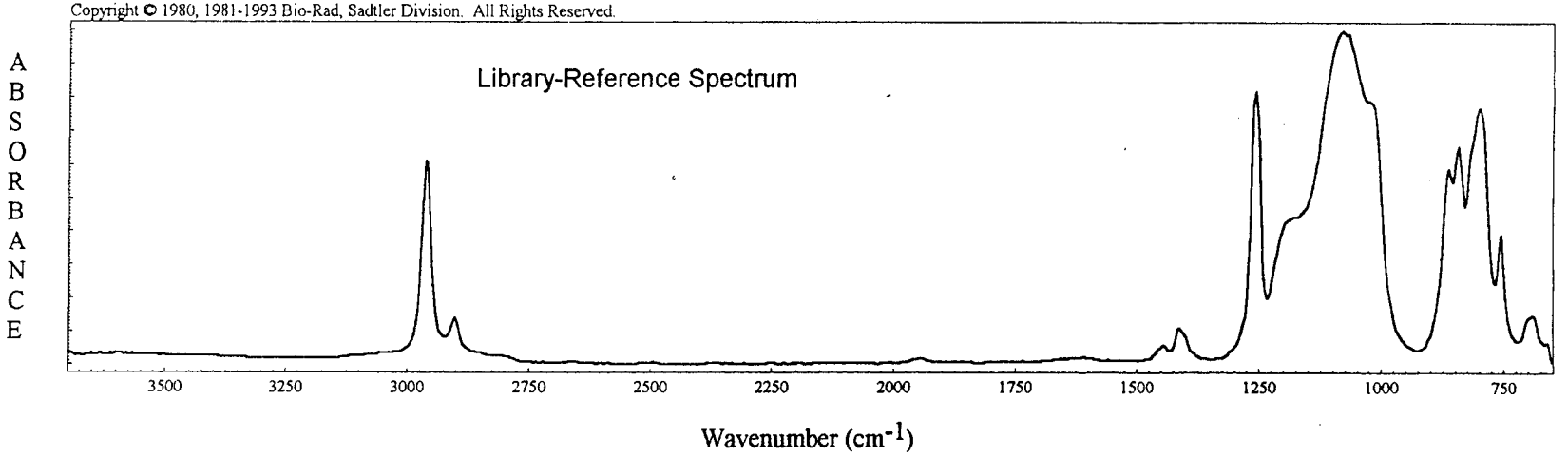
Wavenumbers (cm-1)

Fig. 1

AF1694_A.SPA





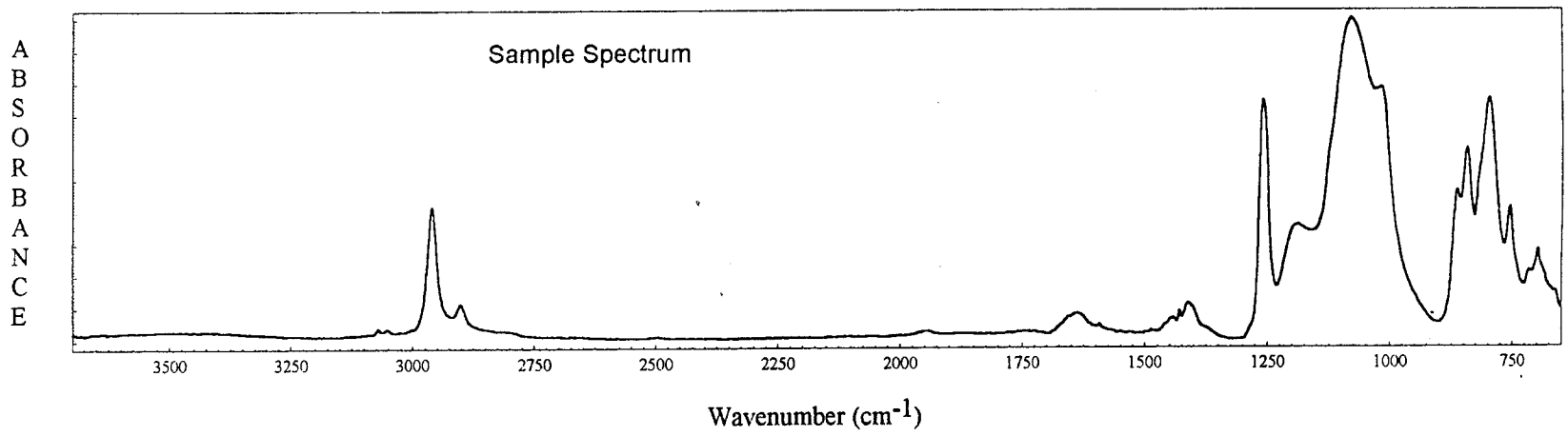
D11472 DOW CORNING Q2-7406 POLYDI- METHYL SILOXANE GUM AND RESIN DISPERSION

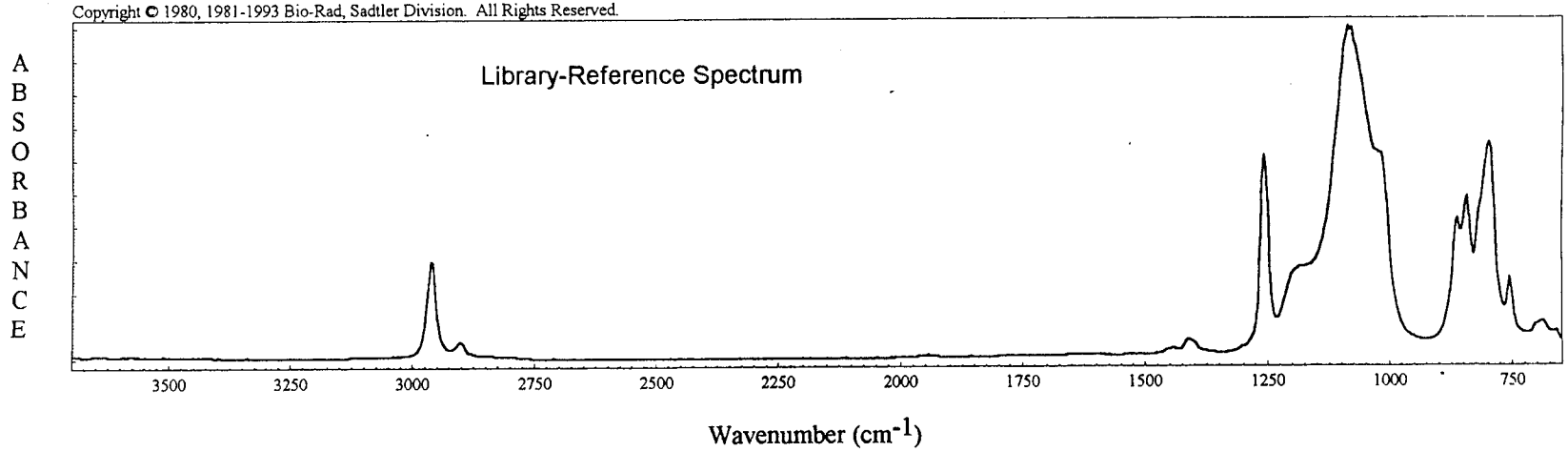
Technique: NEAT
Source of Sample: DOW CORNING CORPORATION
Boiling Point: 143C
Density: (25C) 0.98
Flash Point: (TCC) 27C
Viscosity Data: Viscosity: (25C) 30000-80000 CPS
Comments: Chemical Description: POLYDIMETHYL SILOXANE GUM AND RESIN DISPERSION
Active Ingredients: Active Ingredient: 55-57%

13

Fig. 1a.

AF1694_A.SPA





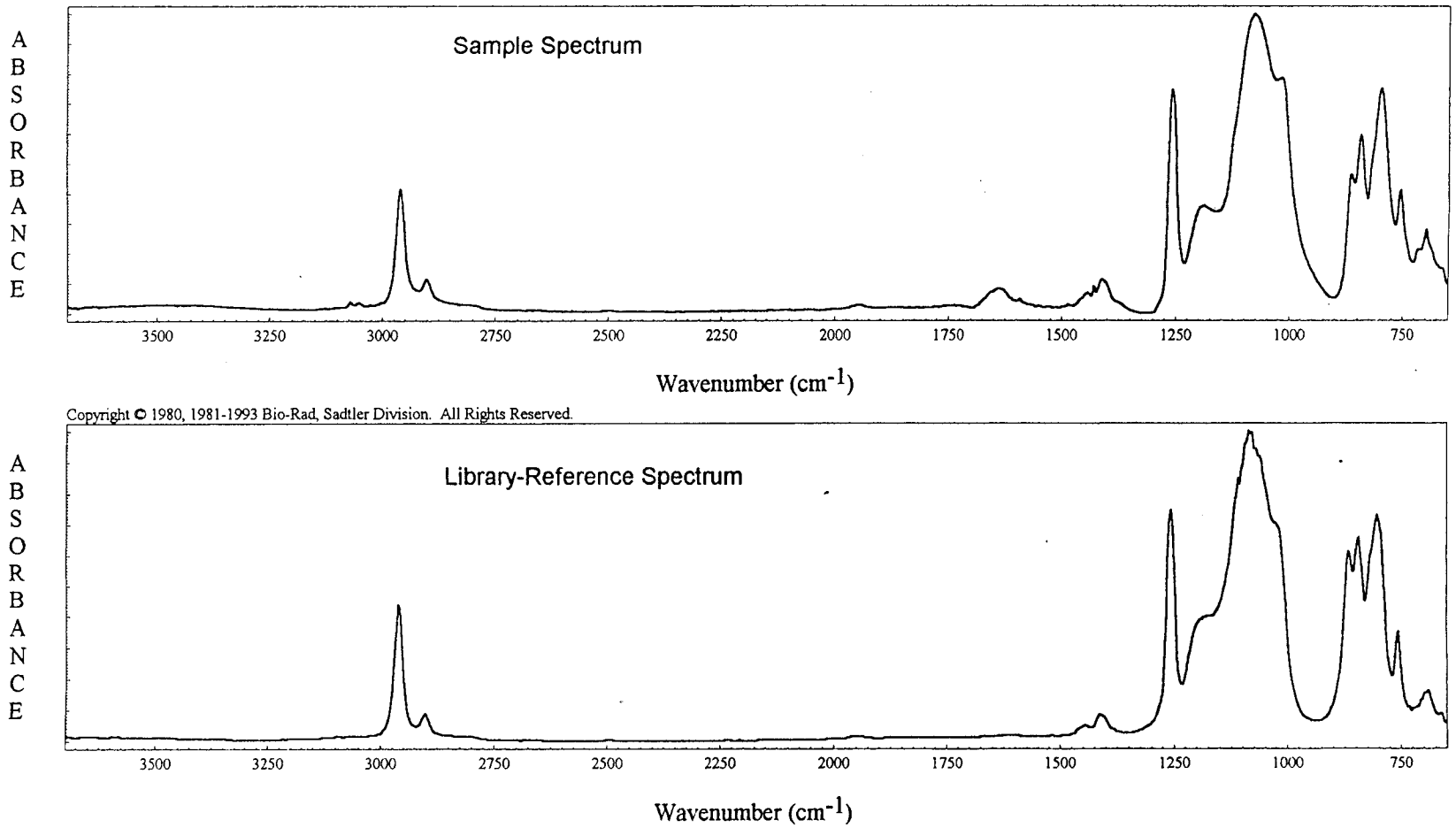
AS1368 SILGRIP SR-585

Technique: FILM (CAST FROM CHLOROFORM)
Source of Sample: GENERAL ELECTRIC COMPANY
Comments: Chemical Description: SILICONE ADHESIVE

14

Fig. 1b

AF1694_A.SPA



AS1874 DOW CORNING 282 PRESSURE SENSITIVE SILICONE ADHESIVE

Technique: NEAT
Source of Sample: DOW CORNING CORPORATION
Density: (25C) 0.98
Flash Point: 45F
Comments: Chemical Description: PRESSURE-SENSITIVE SILICONE ADHESIVE
Classification: Adhesives and Sealants: PRESSURE SENSITIVE

15

Fig. 1c

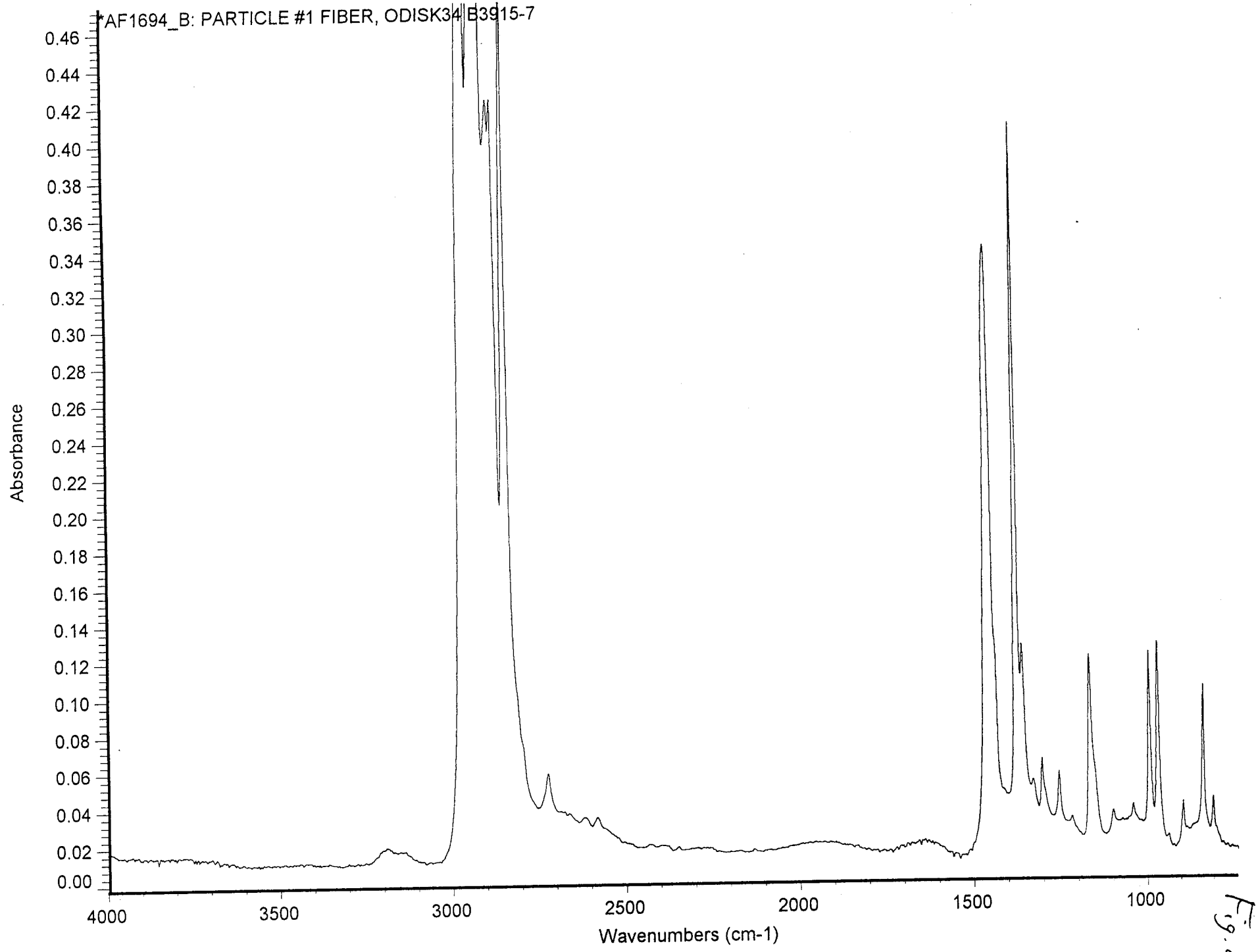
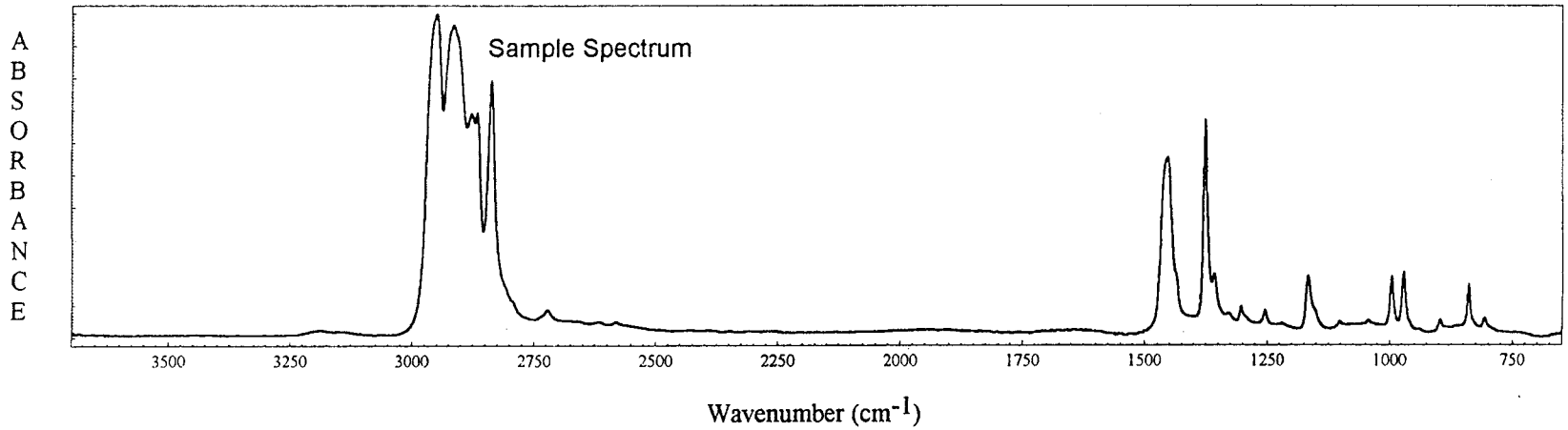
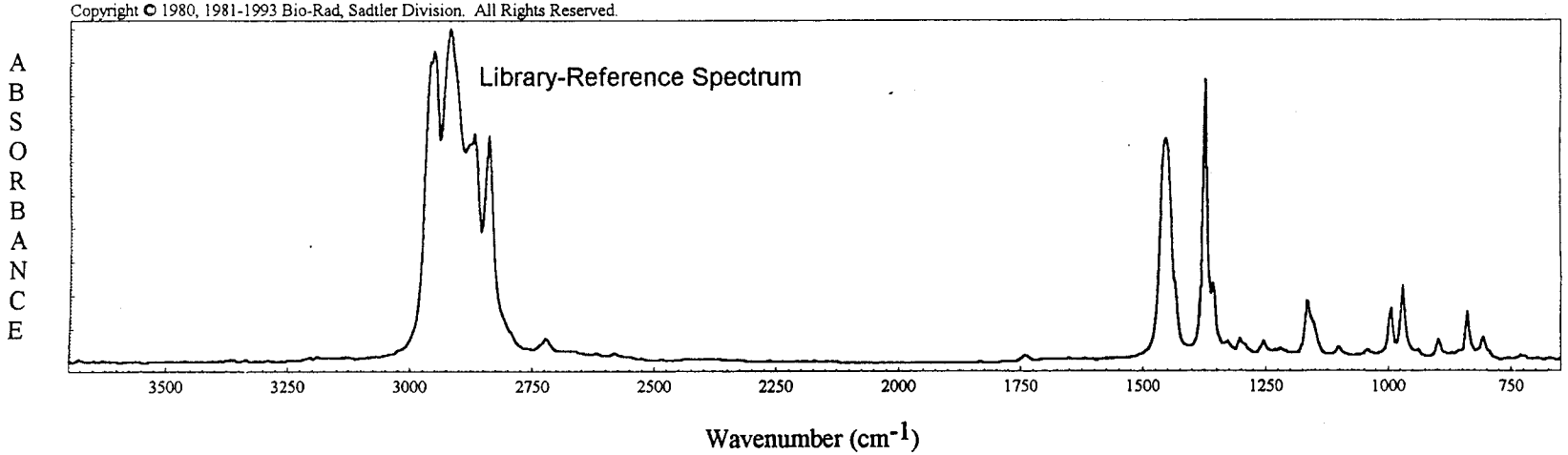

*AF1694_B: PARTICLE #1 FIBER, ODISK34 B3915-7
Absorbance
0.46
0.44
0.42
0.40
0.38
0.36
0.34
0.32
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
4000
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

Fig. 2

AF1694_B.SPA



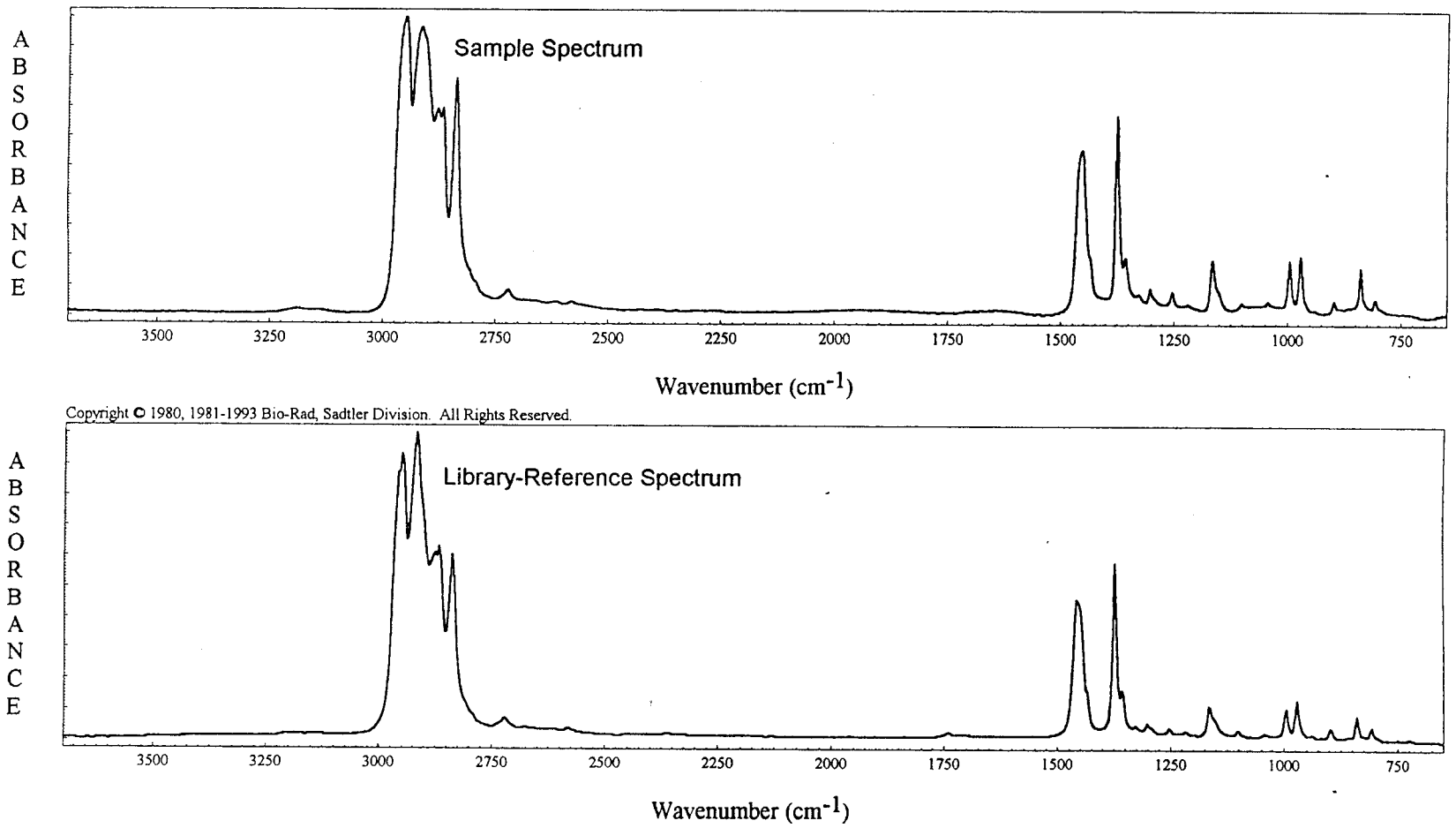


W1650 POLYPROPYLENE M7853-363A

Technique: FILM (CAST FROM o-DICHLOROBENZENE)
Source of Sample: EASTMAN CHEMICAL PRODUCTS, INC.
Comments: Chemical Description: POLYPROPYLENE

Fig. 2a

AF1694_B.SPA

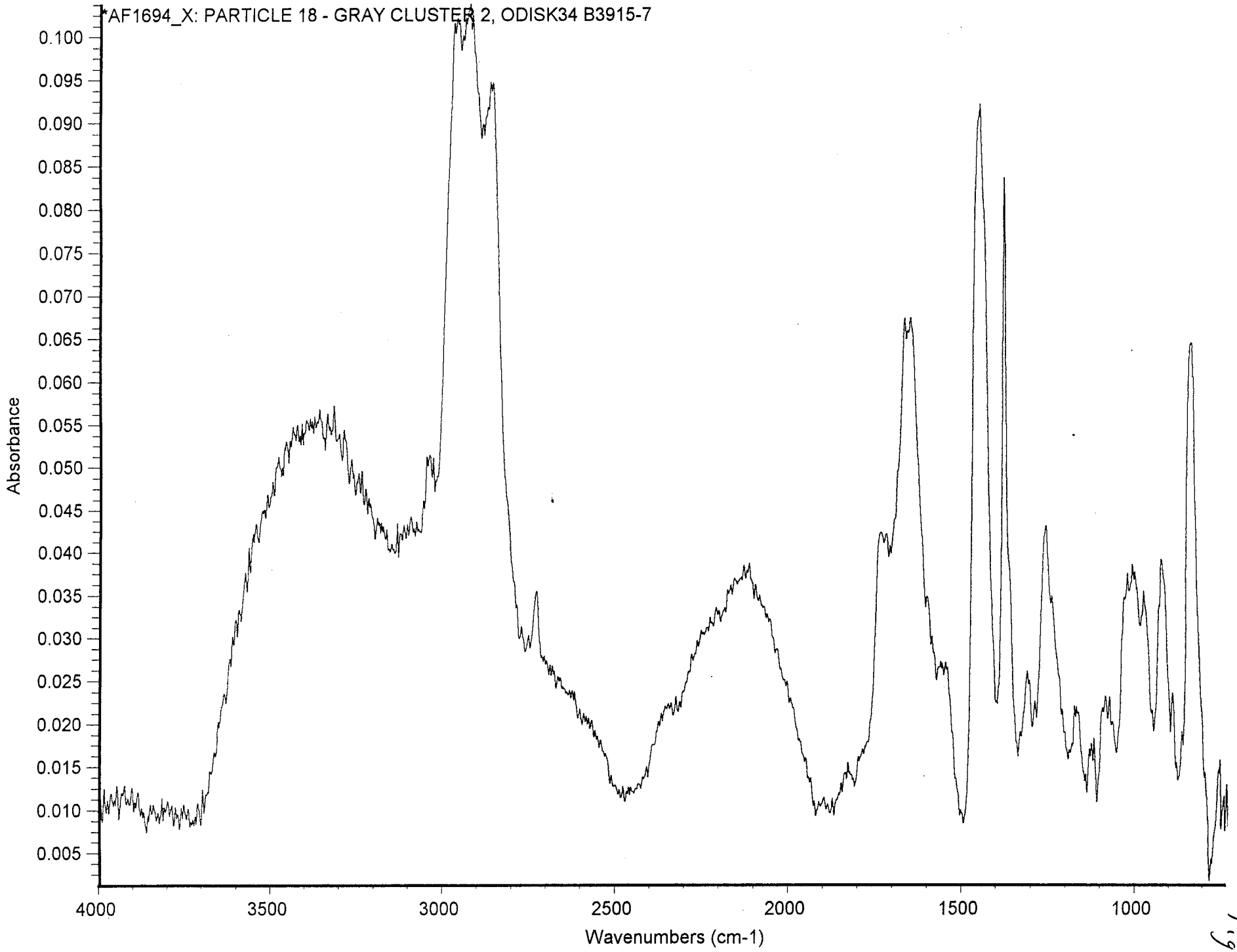


HU5057 PROPYLENE-ETHYLENE COPOLYMER

Technique: FILM (CAST FROM o-DICHLOROBENZENE)
Spectrometer Recording Technique: DIGILAB FTS 15C
Source of Sample: SCHOLVEN-CHEMIE AG, GELSENKIRCHEN-BUER, GERMANY
Comments: HUMMEL/SCHOLL "INFRARED ANALYSIS OF POLYMERS, RESINS AND ADDITIVES, AN ATLAS" VOLUME 1 (1969); SPECTRU
Composition: PROPYLENE-ETHYLENE COPOLYMER (1% ETHYLENE)
Description: SATURATED LINEAR POLYHYDROCARBON
Classification: Hummel: POLYHYDROCARBON
Source of Spectrum: SRL
Use: THERMOPLASTIC MATERIAL

81

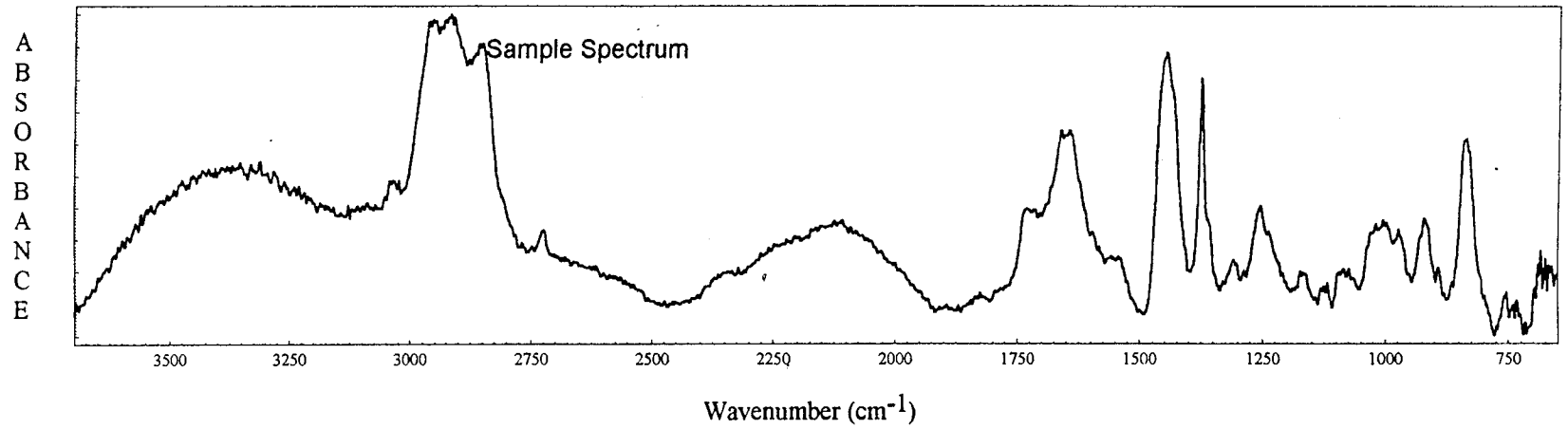
Fig. 2b

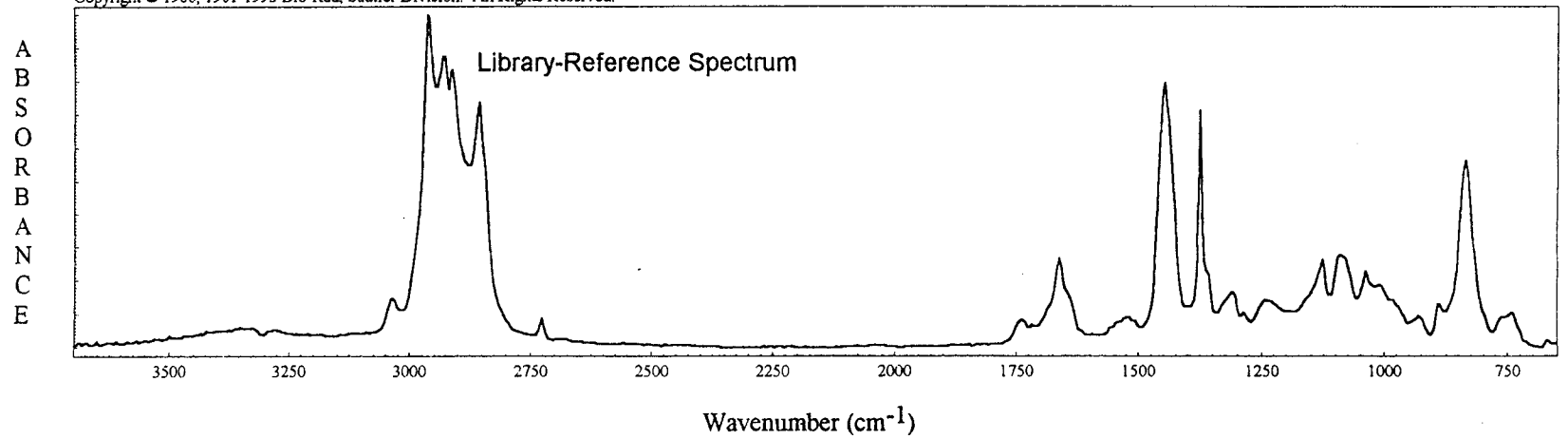

*AF1694_X: PARTICLE 18 - GRAY CLUSTER 2, ODISK34 B3915-7
Absorbance
0.100
0.095
0.090
0.085
0.080
0.075
0.070
0.065
0.060
0.055
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
4000
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

19

Fig. 3

AF1694_X.SPA





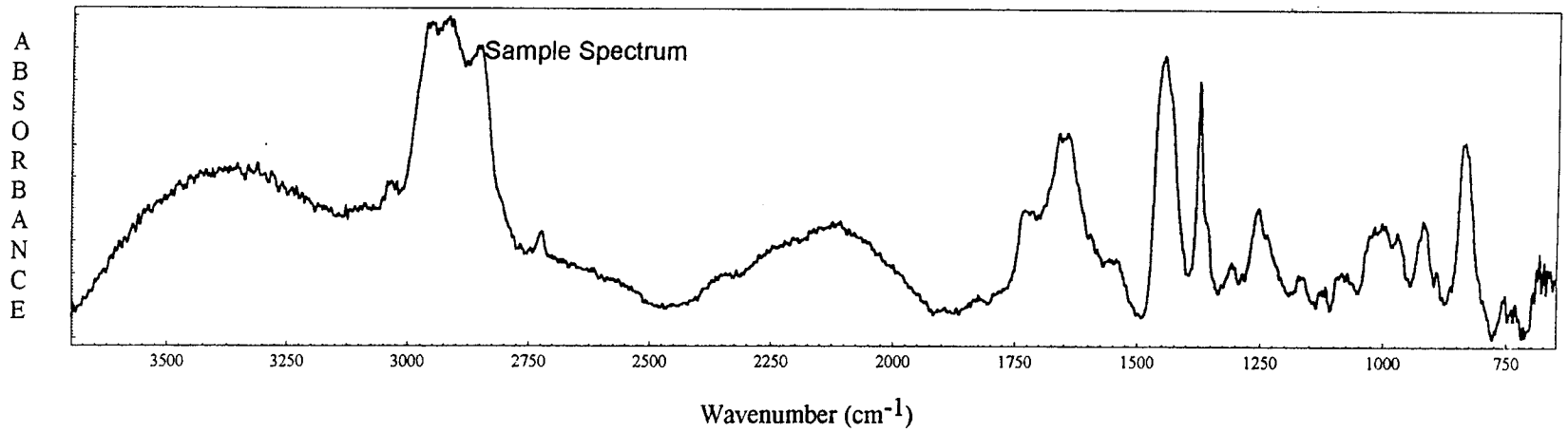
W2151 NATURAL RUBBER

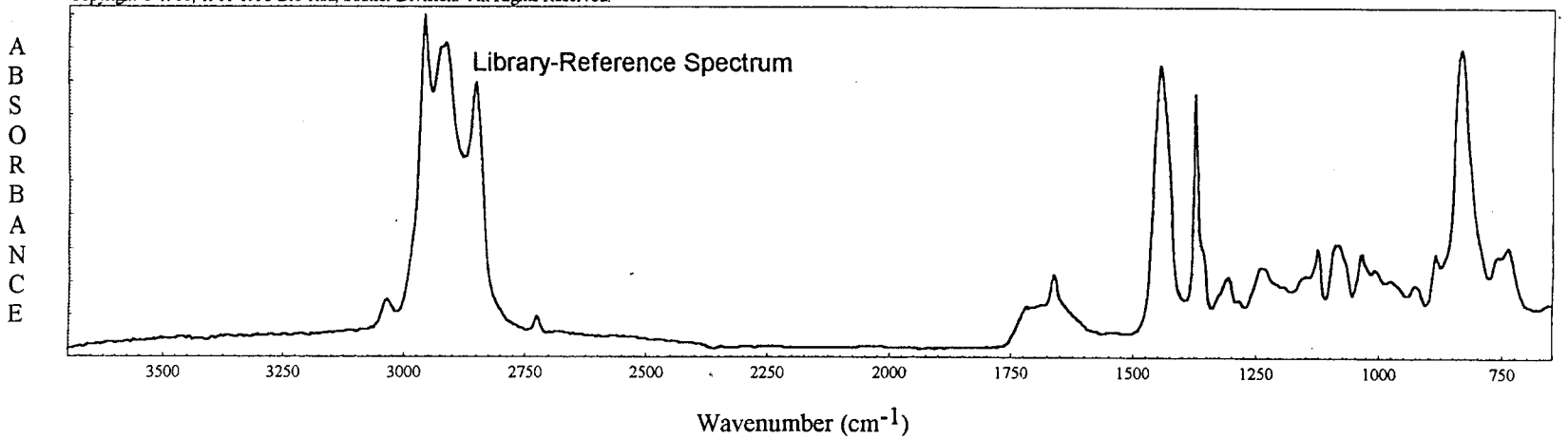
Technique: FILM (CAST FROM TRICHLOROETHANOL)
Source of Sample: POLYSCIENCES, INC.
Comments: Chemical Description: NATURAL RUBBER

Fig. 3a

2d

AF1694_X.SPA





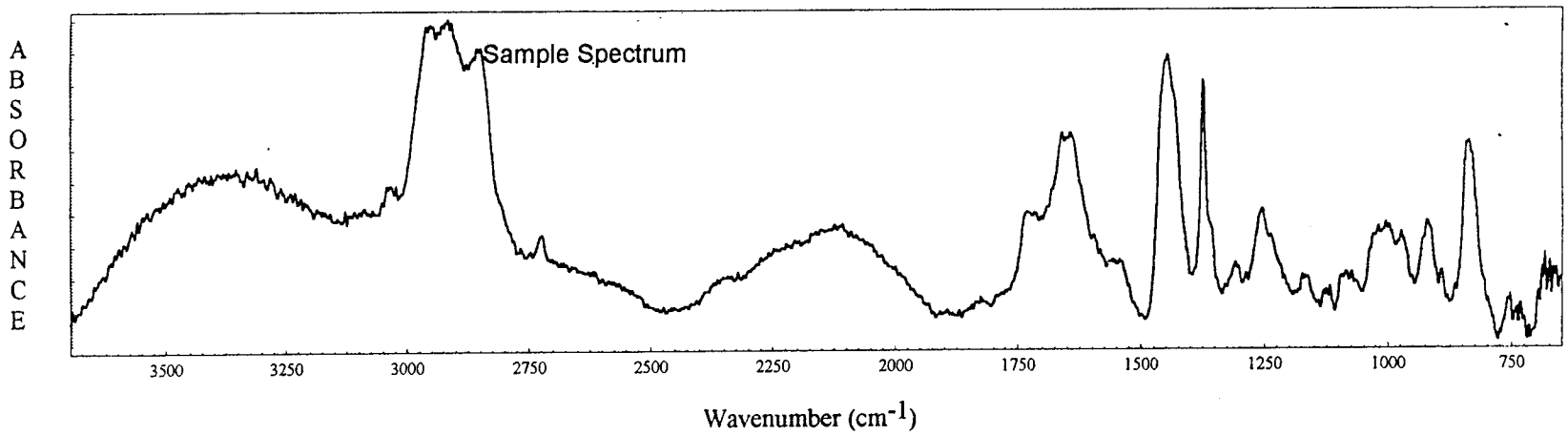
W697 POLY(ISOPRENE), CIS

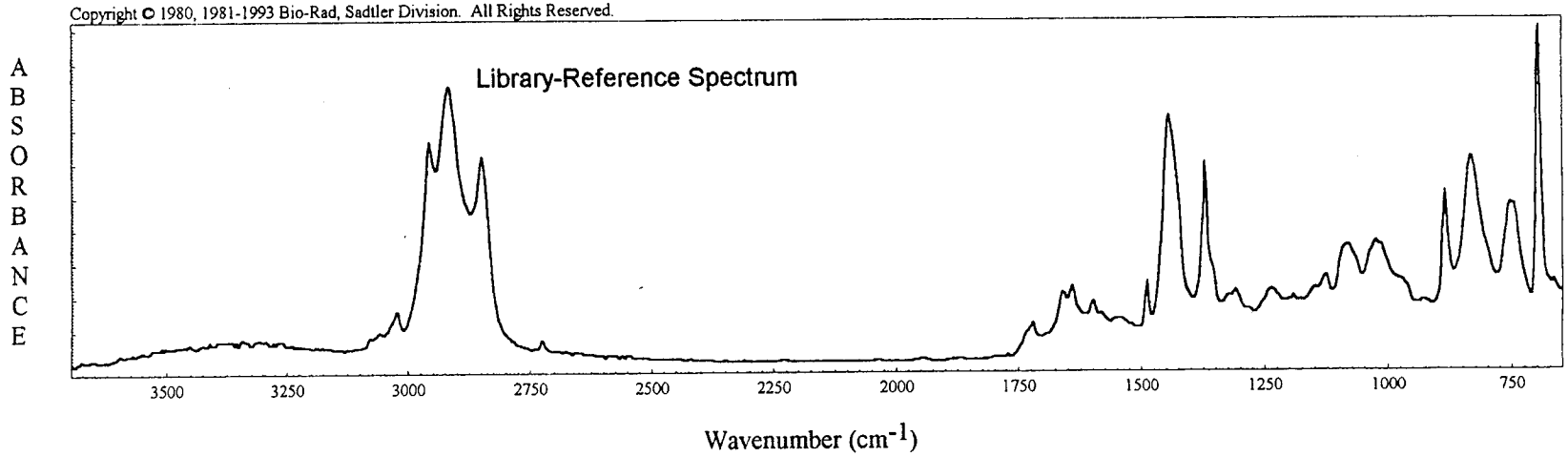
Technique: NEAT
Source of Sample: ALDRICH CHEMICAL COMPANY, INC.
Density: 0.910
Melting Point: 36C
Optical Properties: Index of Refraction: (20C) 1.5191
Solubility: Solubility Parameter: 7.9
Comments: Chemical Description: POLY(ISOPRENE), cis
Glass Properties: Glass Transition Temperature: -67C

17

Fig. 36

AF1694_X.SPA



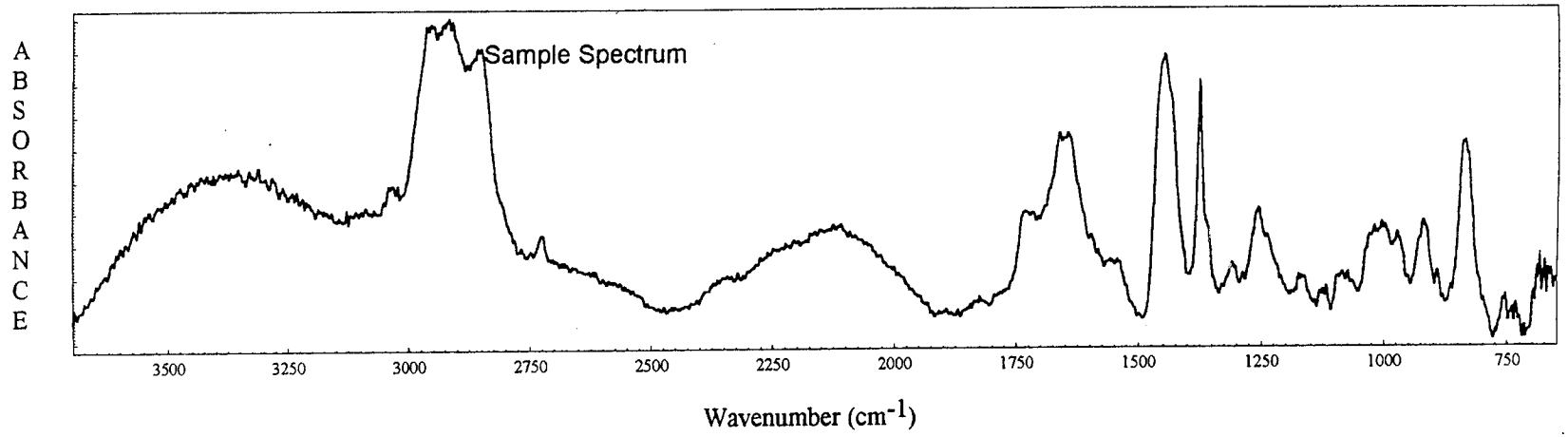


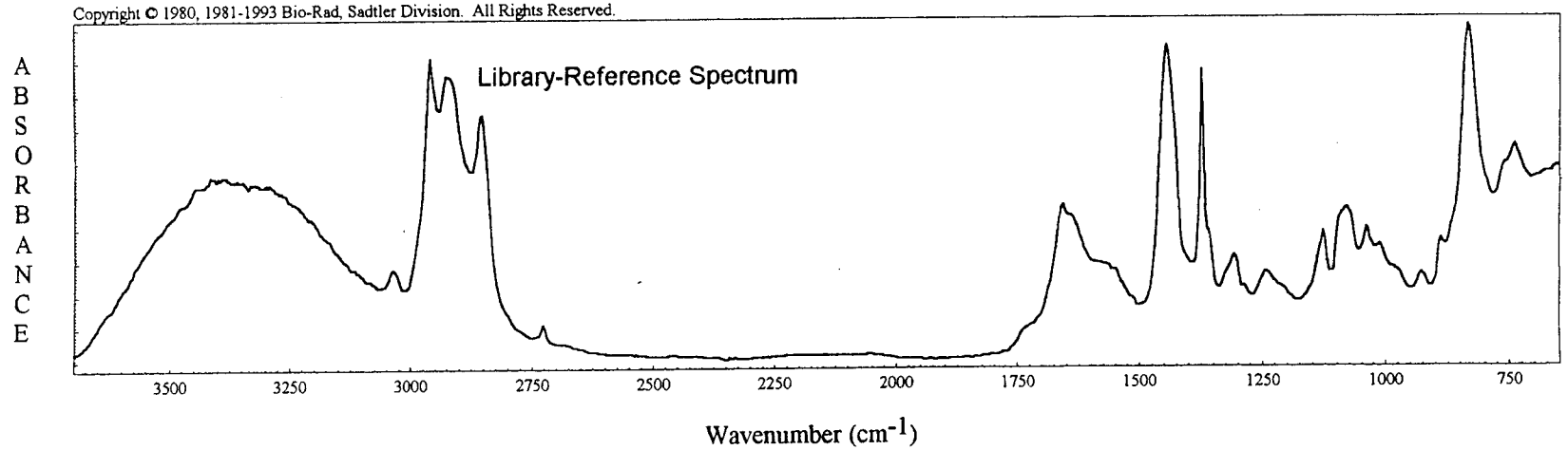
W737 STYRENE/ISOPRENE COPOLYMER

Technique: NEAT
Source of Sample: ALDRICH CHEMICAL COMPANY, INC.
Density: 0.92
Viscosity Data: Intrinsic Viscosity: 1.13
Content: Styrene Content: 14%
Comments: Chemical Description: STYRENE/ISOPRENE COPOLYMER; STYRENE 14%

Fig. 3c

AF1694_X.SPA





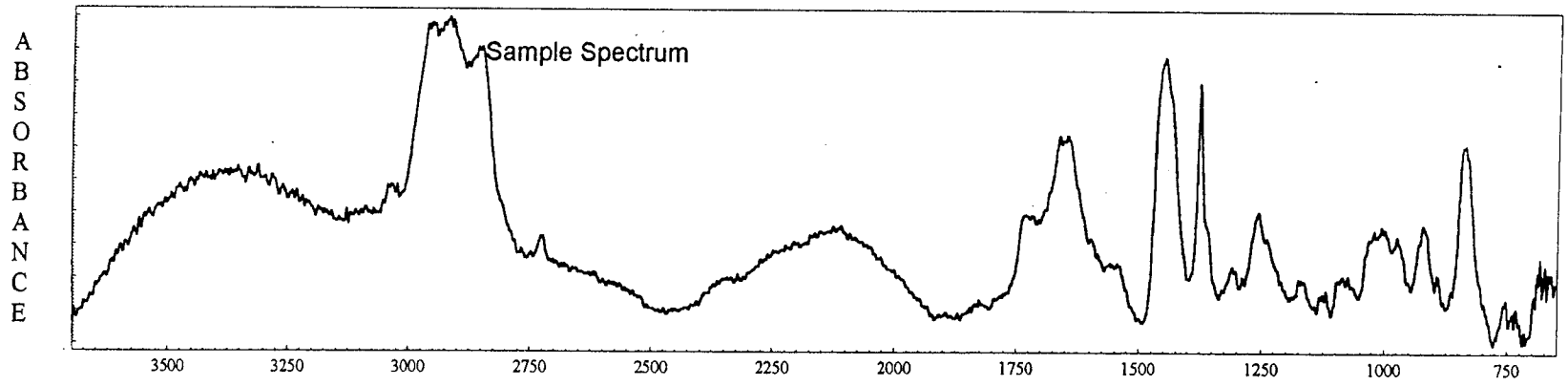
W1027 HARTEX 103

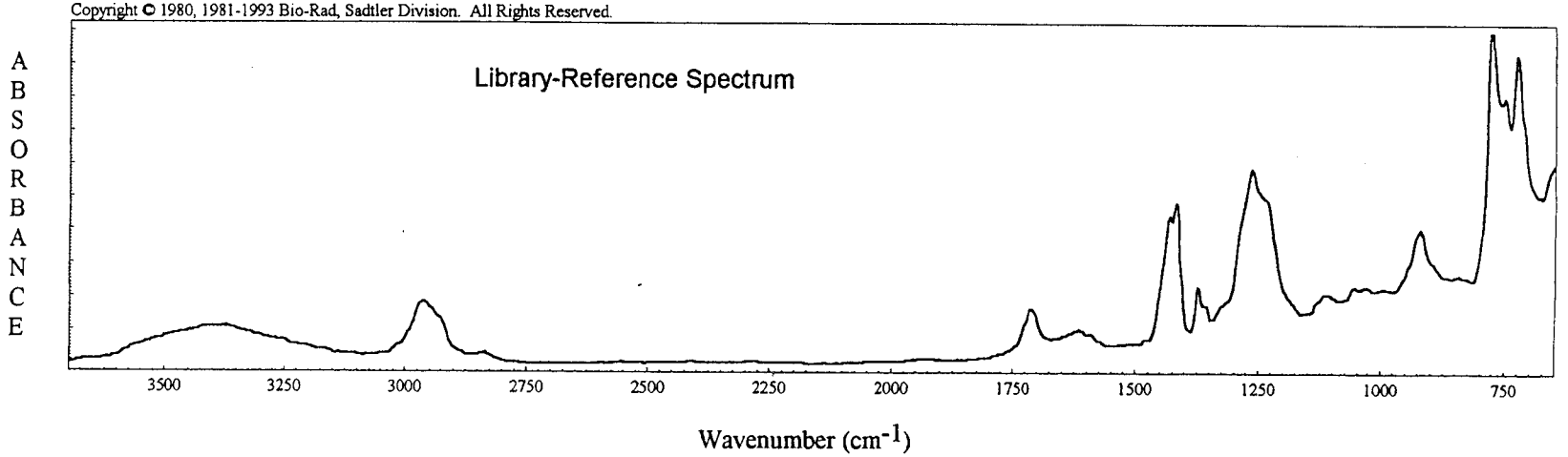
Technique: NEAT
Source of Sample: FIRESTONE NATURAL RUBBER AND LATEX COMPANY
Solution Data: pH: 9.5
Comments: Chemical Description: LOW-AMMONIA NATURAL LATEX

23

Fig. 3d

AF1694_X.SPA





BP347 POLY(ISOPRENE), CHLORINATED

Technique: KBr WAFER
Source of Sample: NAFTONE, INC.
Classification: Polymers: CHLORINATED HYDROCARBON RESINS
Viscosity Data: Viscosity: 35-55 cps
Molecular Weight: 165000

24

Fig. 3e

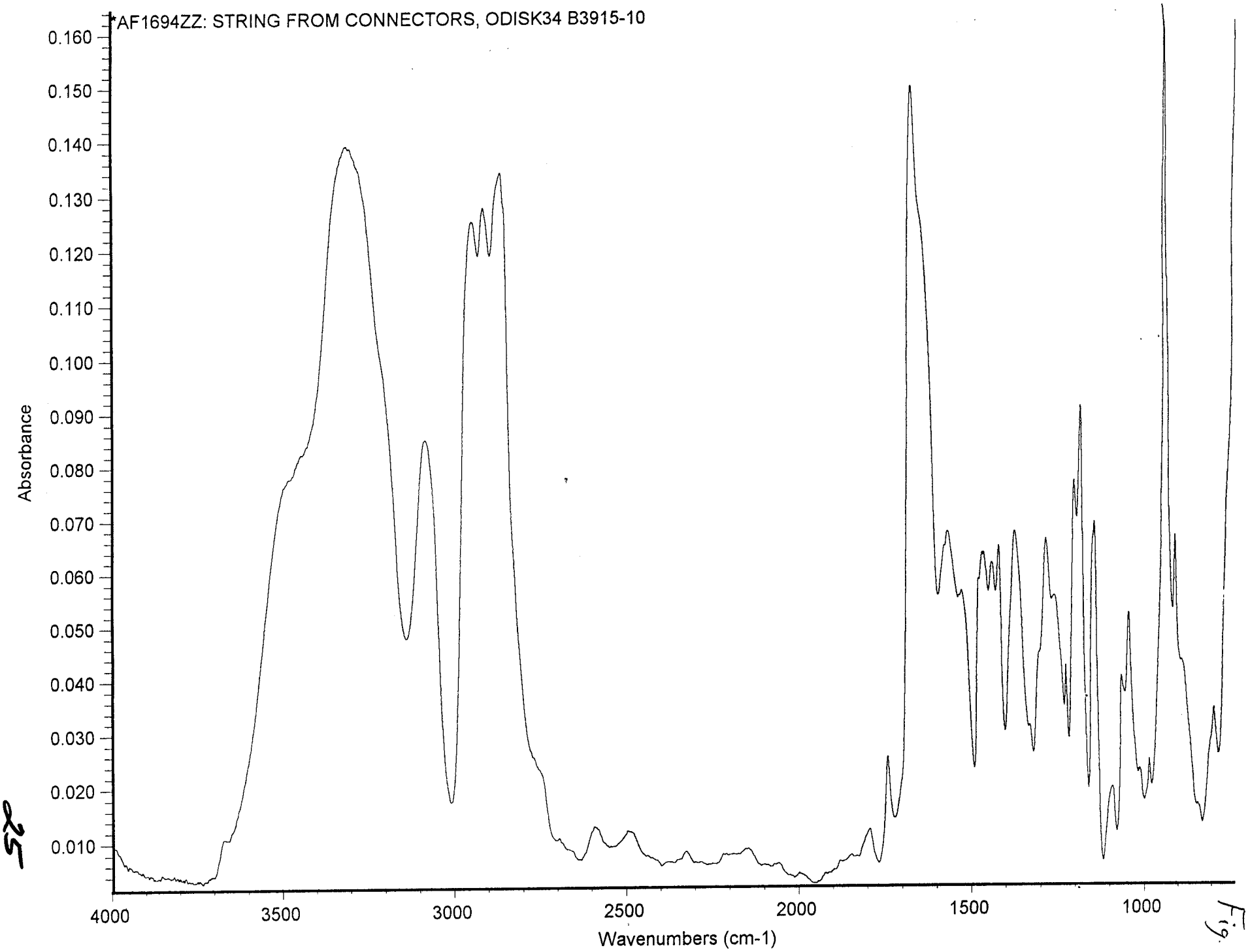
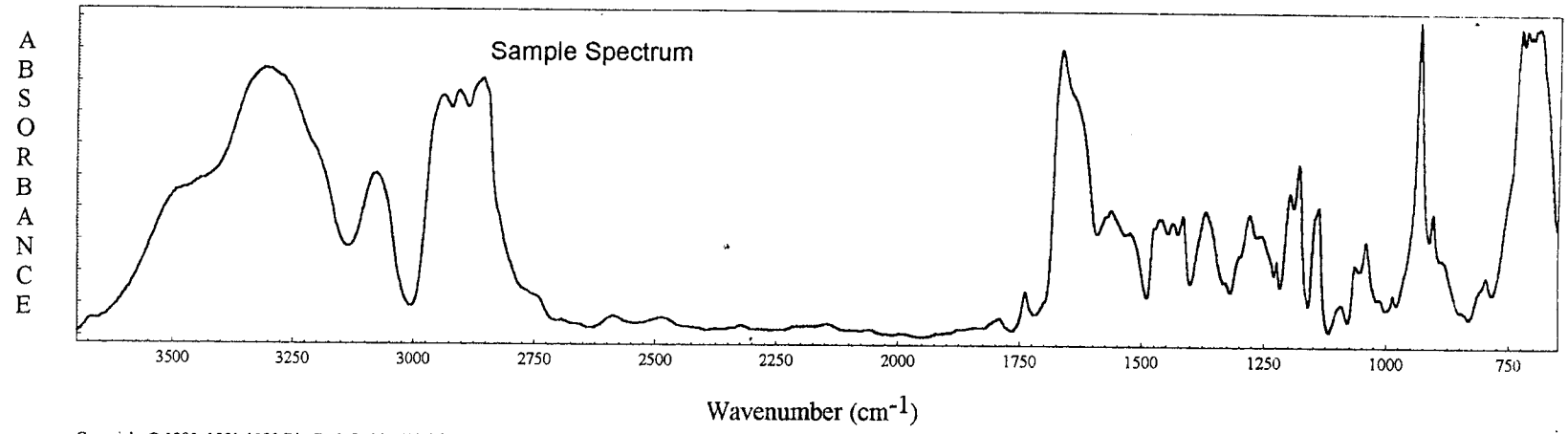
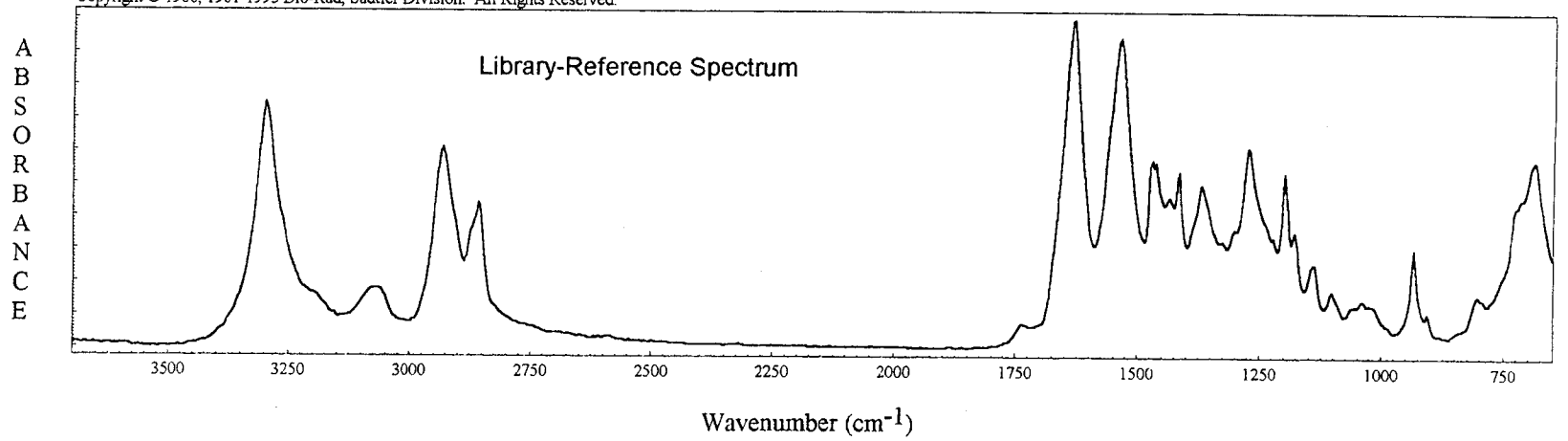

*AF1694ZZ: STRING FROM CONNECTORS, ODISK34 B3915-10
Absorbance
0.160
0.150
0.140
0.130
0.120
0.110
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
4000
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

Fig. 4

AF1694ZZ.SPA



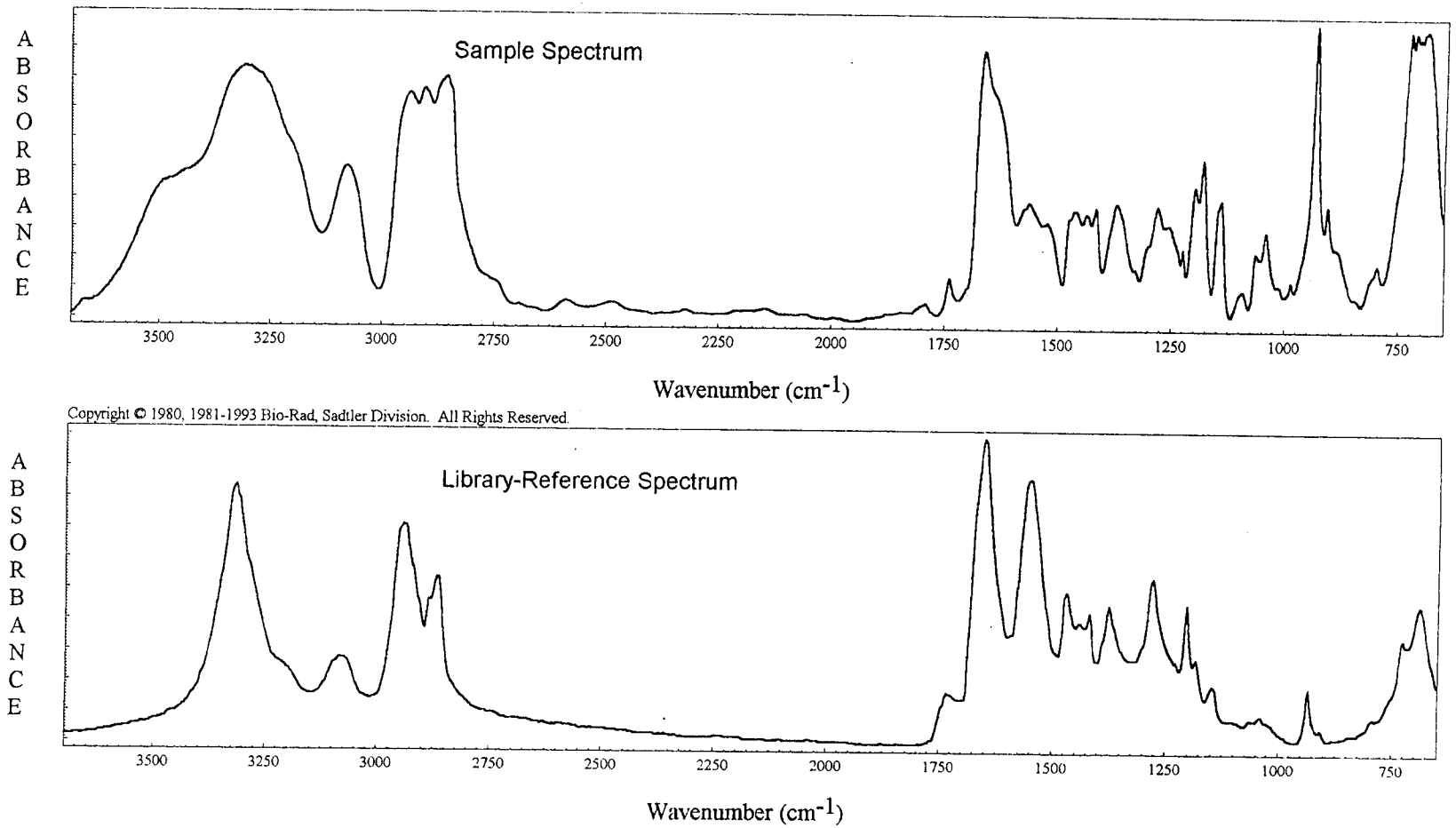


W1949 VYDYNE 22H HEAT STABLE NYLON 66

Technique: FILM (CAST FROM TRICHLOROETHANOL)
Source of Sample: MONSANTO POLYMER PRODUCTS COMPANY
Density: 1.14
Tensile Strength: 12.4
Elongation: 70%
Deflection Temperature: (66 PSI) 232C; (264 PSI) 88C
Comments: Chemical Description: HEAT STABLE NYLON 66

Fig. 4e

AF1694ZZ.SPA



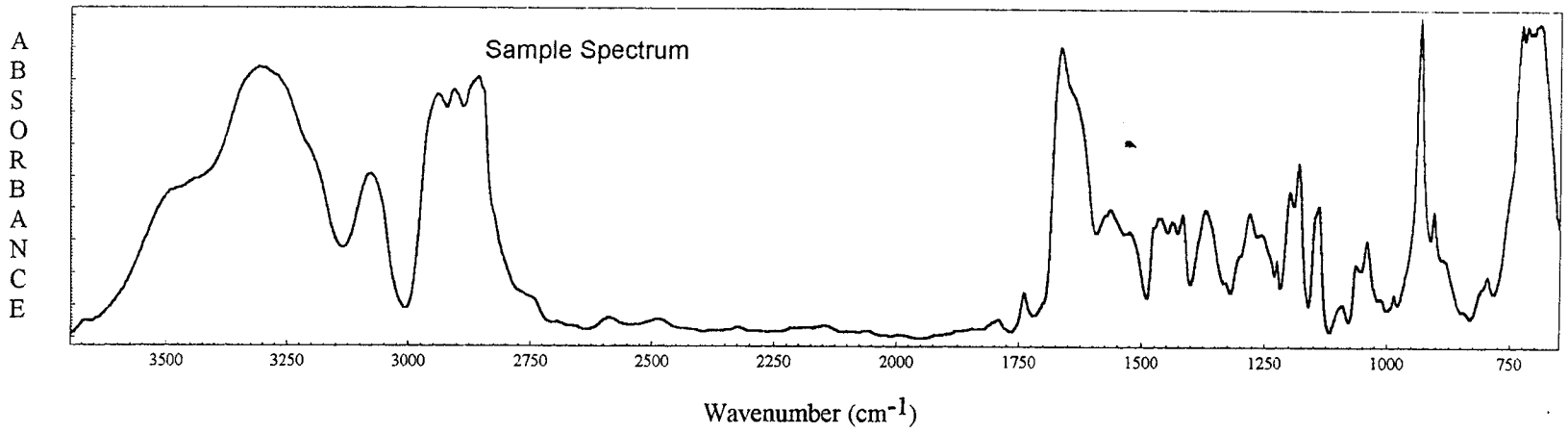
D687 BCI NYLON M 66-01 POLY/HEXA- METHYLENE ADIPAMIDE/

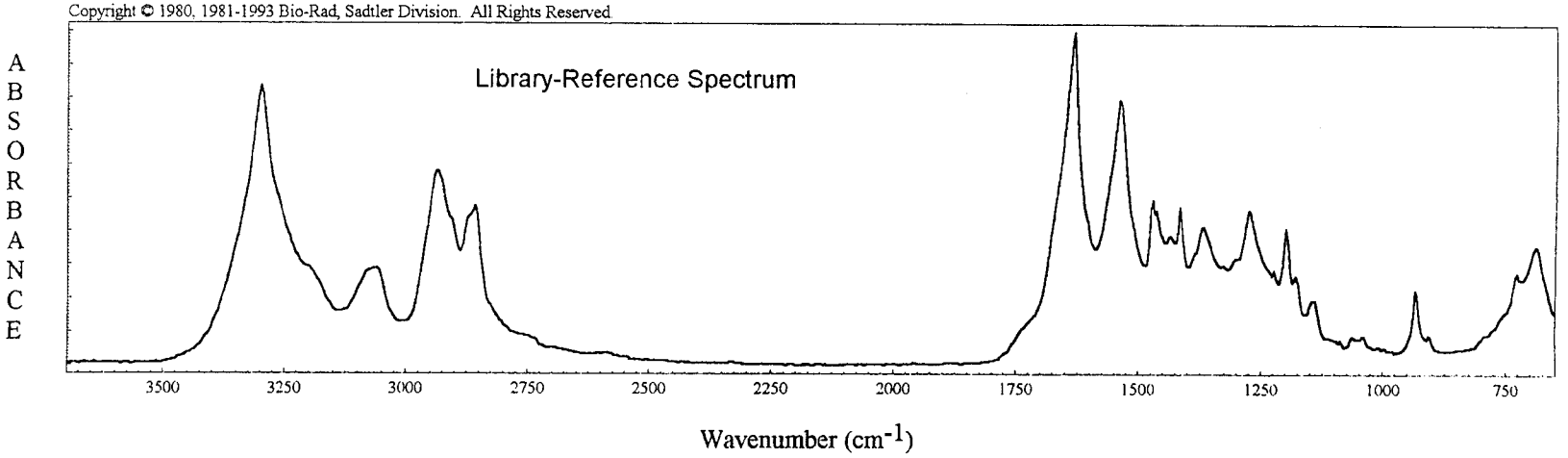
Technique: FILM
Source of Sample: BELDING CHEMICAL INDUSTRIES
Melting Point: 253-256C
Density: 1.14
Comments: Chemical Description: POLY(HEXAMETHYLENE ADIPAMIDE) [NYLON 66]

47

Fig. 4b

AF1694ZZ.SPA





HU2185 ULTRAMID A3

Technique: FILM RECRYSTALLIZED FROM THE MELT BETWEEN KBr
Spectrometer Recording Technique: PE 580 B, FLAT, SMOOTH 3, ABEX 2.3
Source of Sample: BASF AG, LUDWIGSHAFEN
Classification: Hummel: 11421.212111
Comments: Physical Description: COLORLESS, CLOUDY GRANULES
Chemical Description: POLYAMIDE-6,6
Source of Spectrum: HUMMEL
Use: THERMOPLASTIC RESIN
Molecular Formula: C.12.H.22.N.2.O.2.

28

Fig. 4c

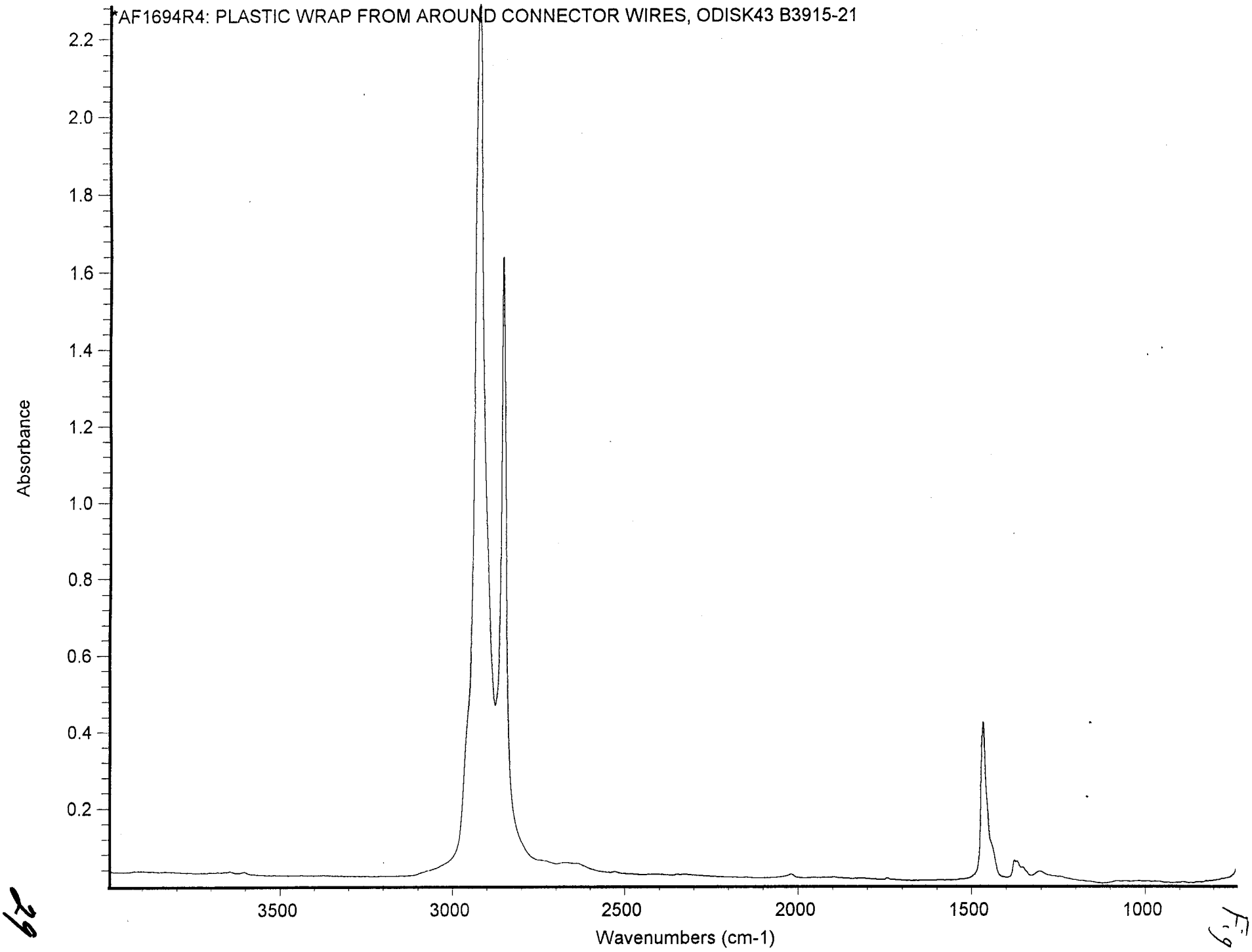
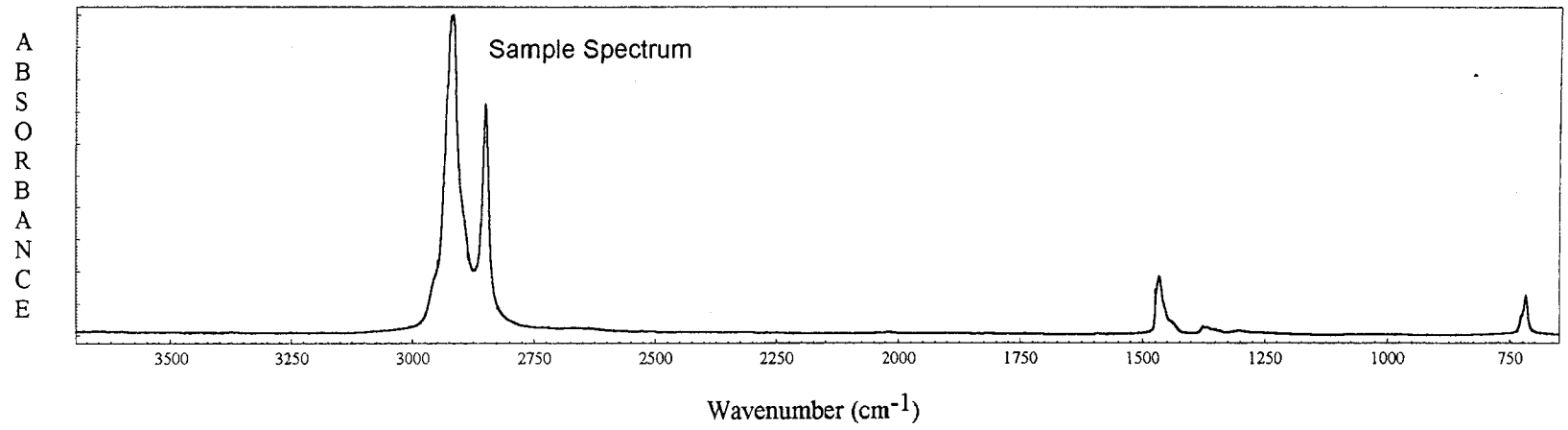
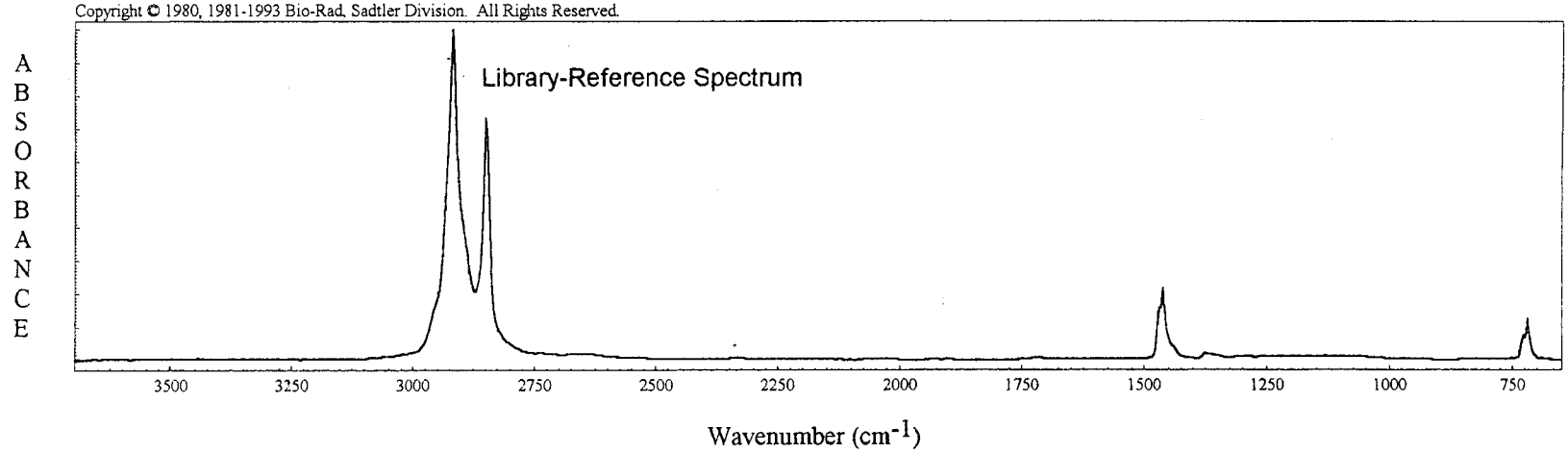

*AF1694R4: PLASTIC WRAP FROM AROUND CONNECTOR WIRES, ODISK43 B3915-21
Absorbance
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

Fig. 5

AF1694R4.SPA





D7944 CX 1016

Technique: FILM (CAST FROM o-DICHLOROBENZENE)
Source of Sample: CHEMPLEX COMPANY
Comments: Chemical Description: POLYETHYLENE

Fig. 5a

30

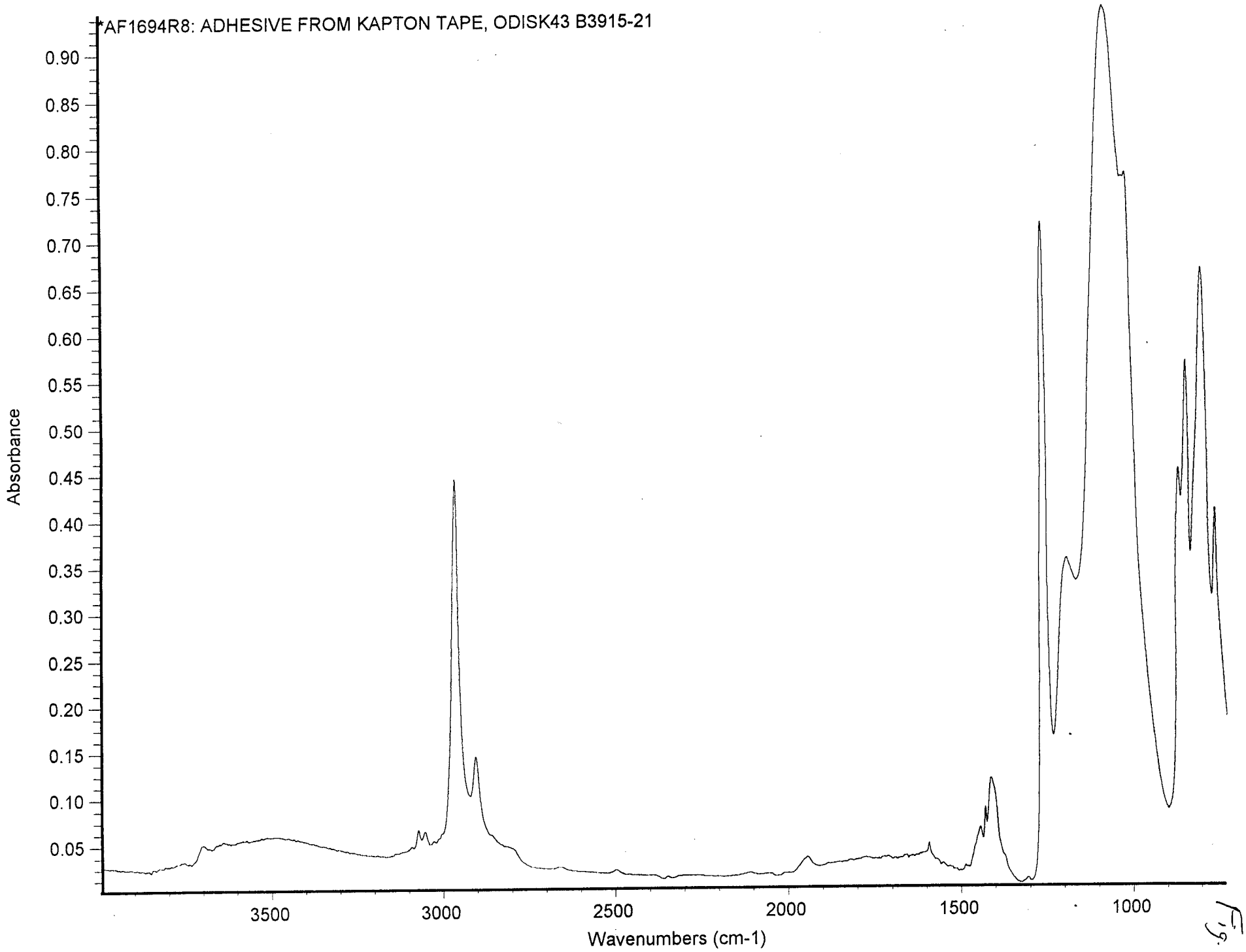
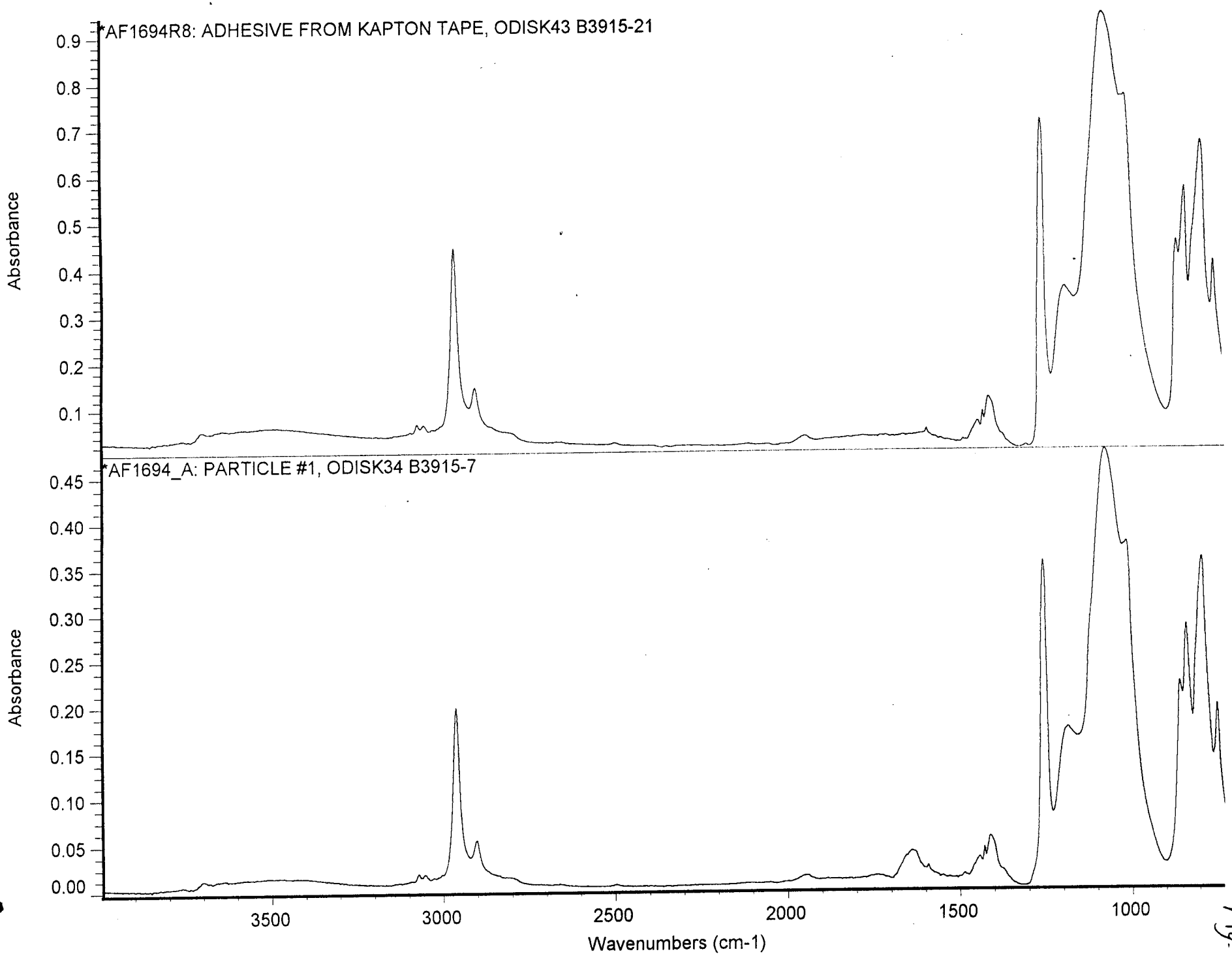
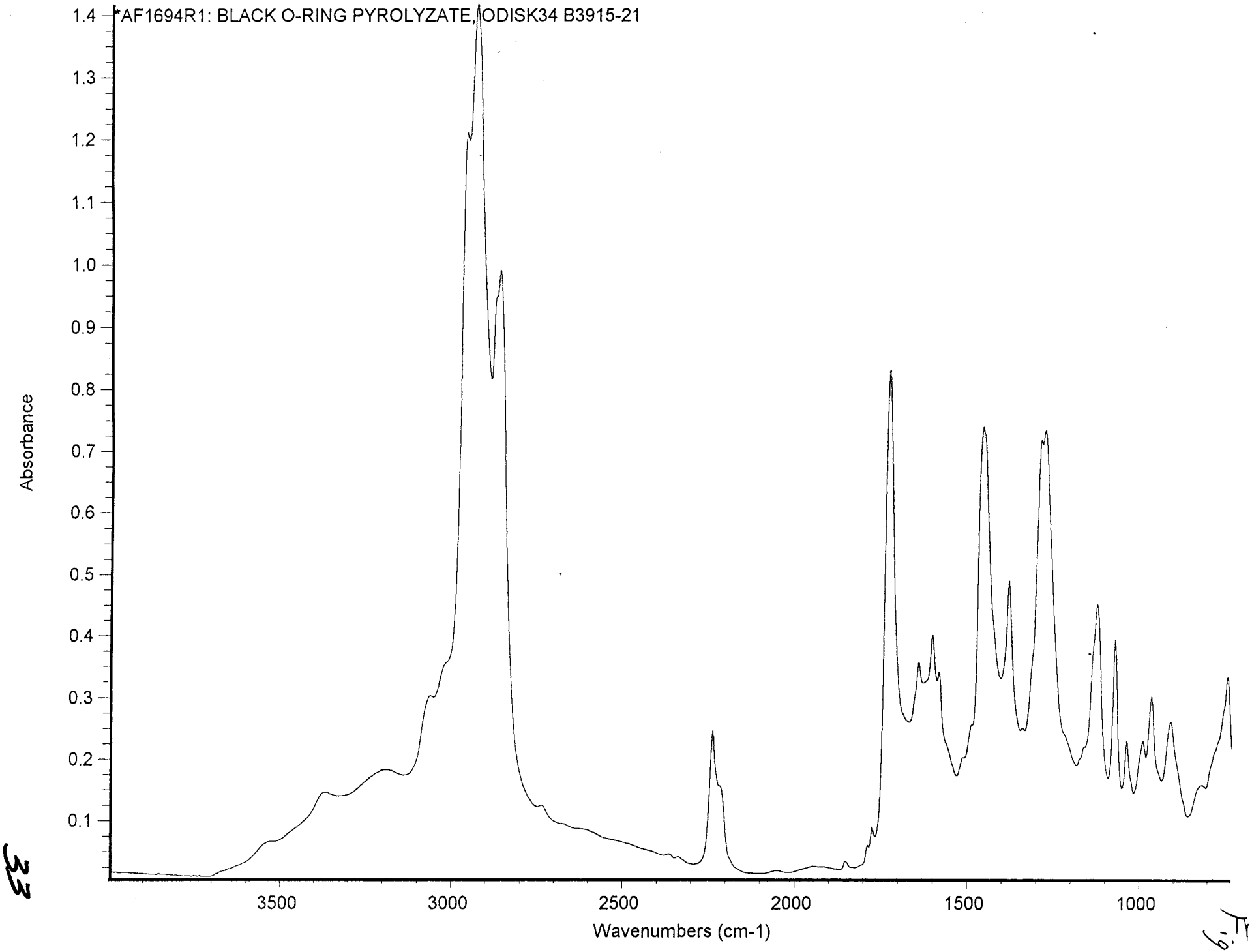

*AF1694R8: ADHESIVE FROM KAPTON TAPE, ODISK43 B3915-21
Absorbance
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

Fig. 8


*AF1694R8: ADHESIVE FROM KAPTON TAPE, ODISK43 B3915-21
Absorbance
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
*AF1694_A: PARTICLE #1, ODISK34 B3915-7
Absorbance
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

32

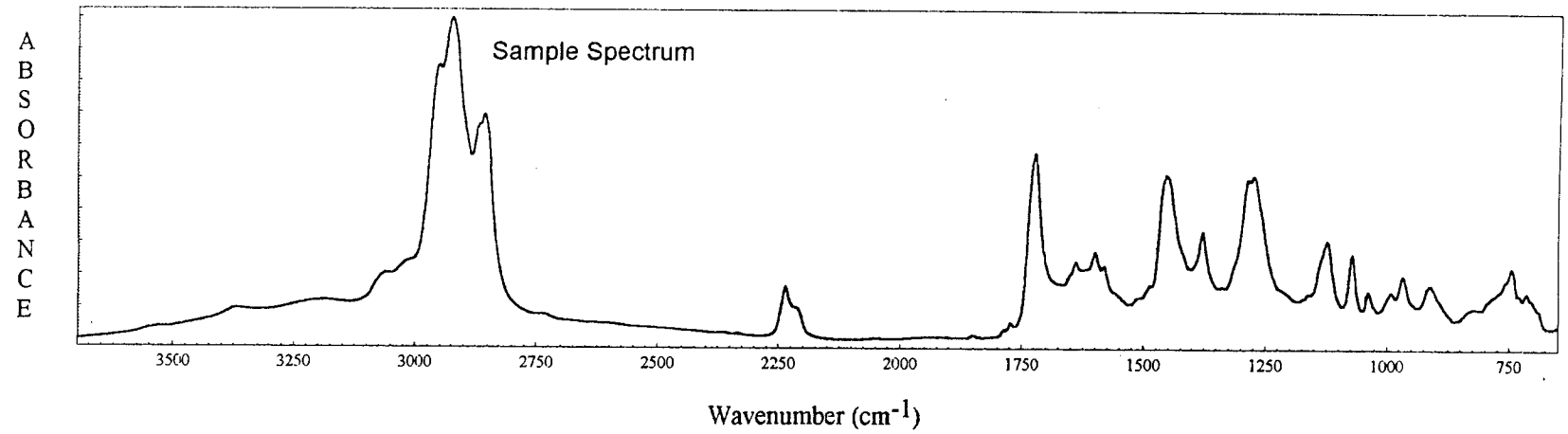
Fig. 6a

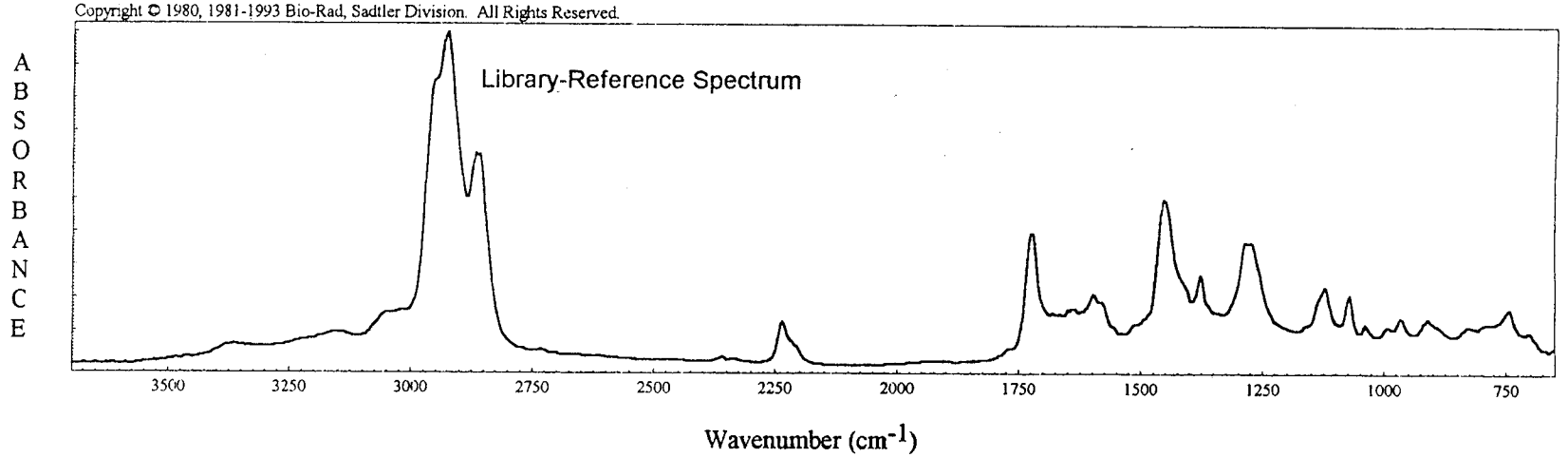

*AF1694R1: BLACK O-RING PYROLYZATE, ODISK34 B3915-21
Absorbance
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

33

Fig 7

AF1694R1.SPA





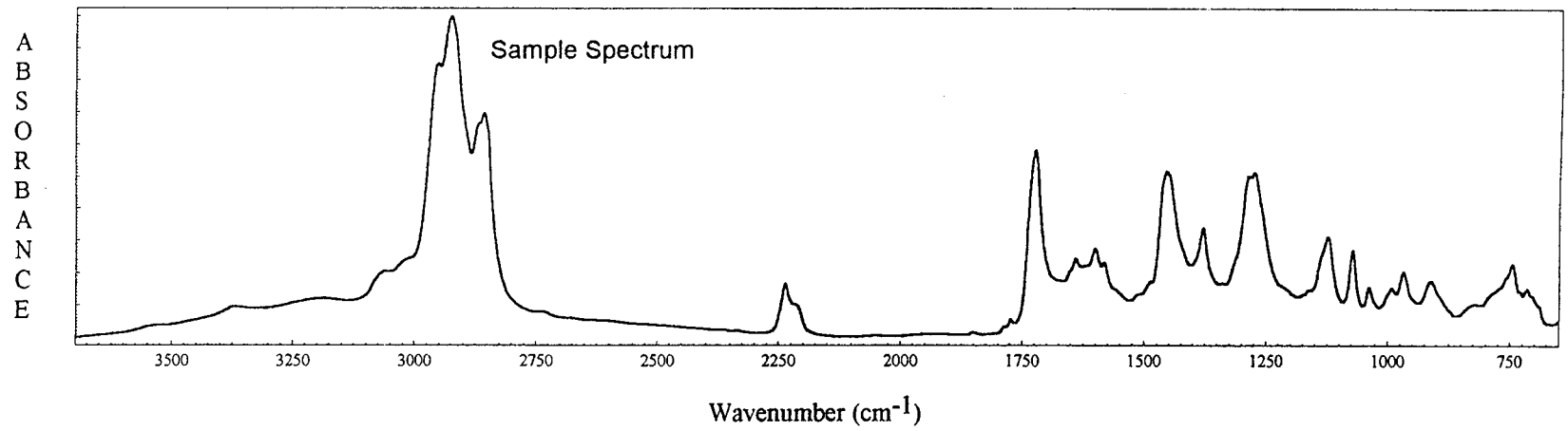
DD2244 HYCAR 1082 CONDENSED PHASE

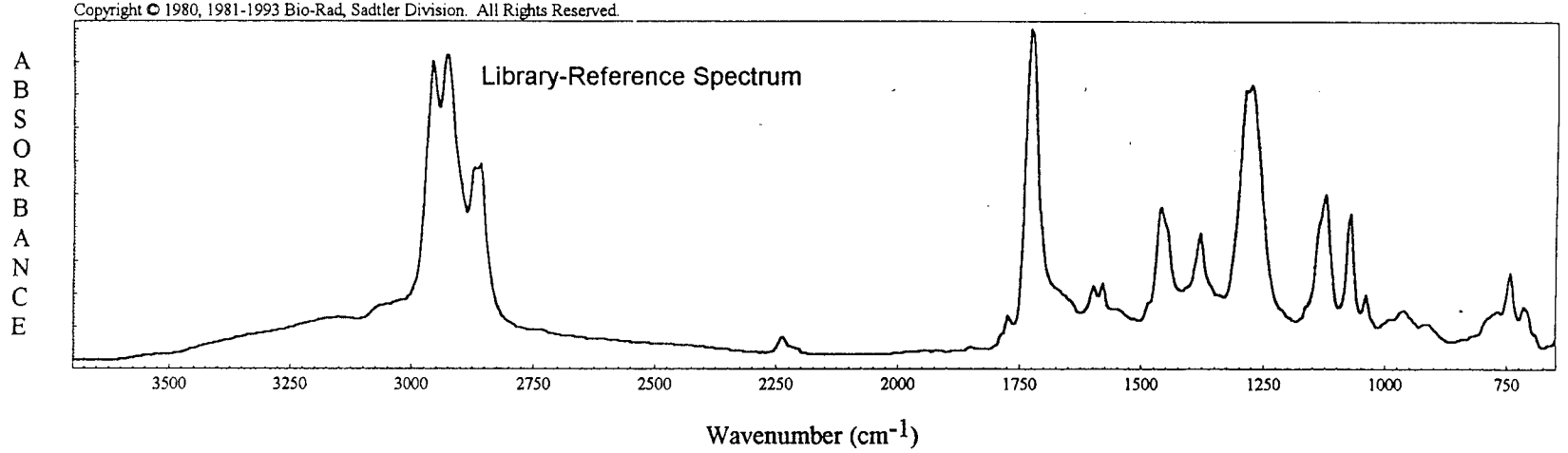
Technique: CONDENSED PHASE
Source of Sample: B. F. GOODRICH CHEMICAL COMPANY
Comments: Chemical Description: ACRYLONITRILE RUBBER

34

Fig. 7a

AF1694R1.SPA





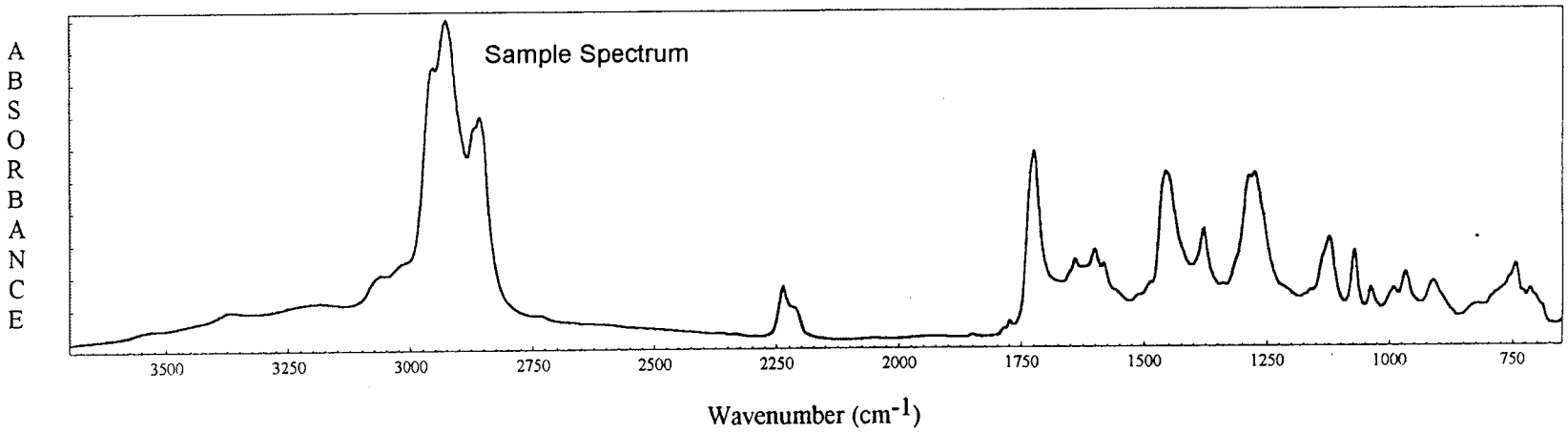
DD3756 KRYNAC 801 CONDENSED PHASE

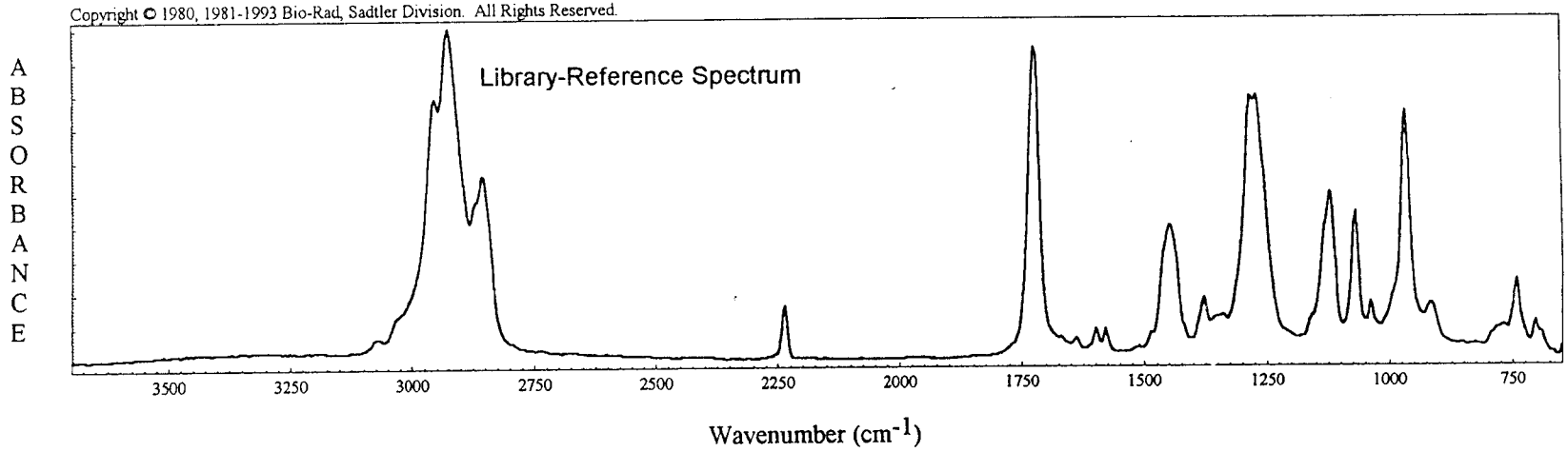
Technique: CONDENSED PHASE
Source of Sample: POLYSAR INC.
Density: 0.99
Comments: Chemical Description: ACRYLONITRILE-BUTADIENE COPOLYMER

39

Fig. 7b.

AF1694R1.SPA





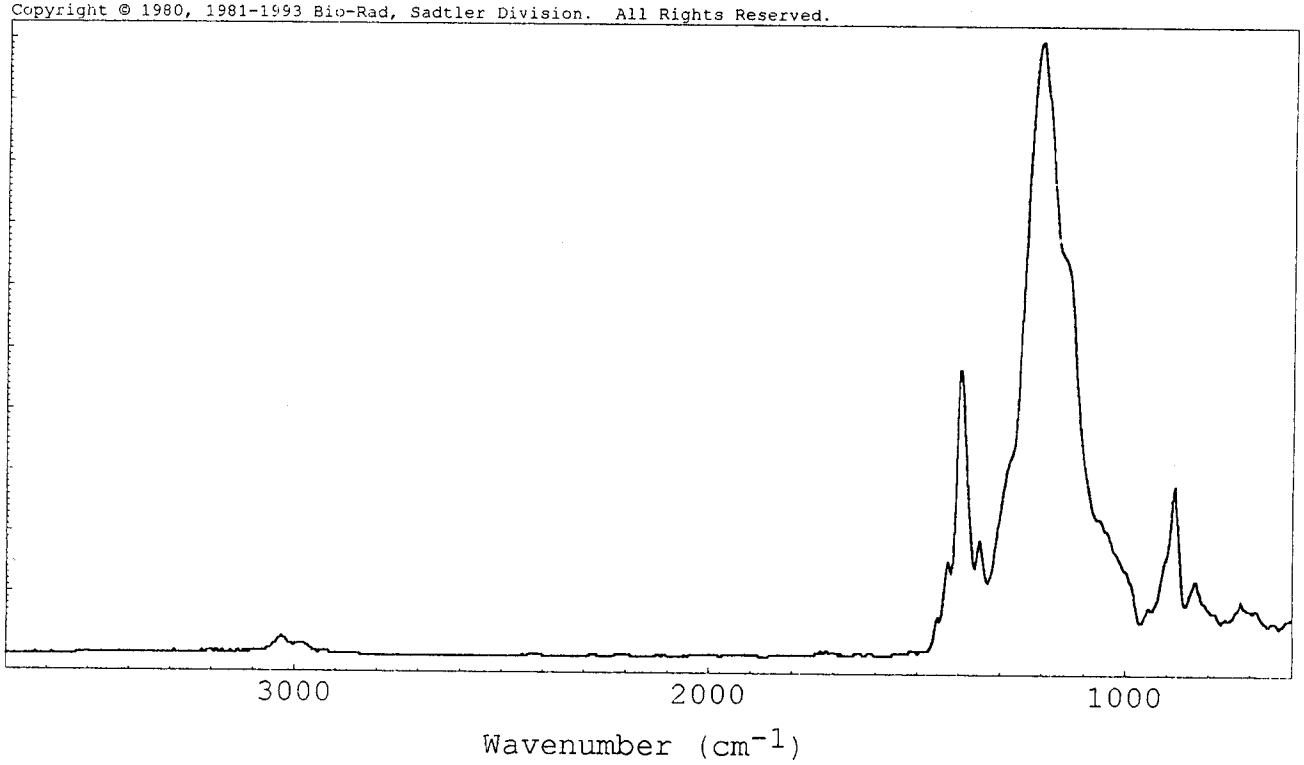
D10921 CHEMIGUM N634 COLD ACRYLO- NITRILE POLYMER CONTAINING 50 PARTS OF DIOCTYL PHTHALATE/100 PARTS OF RUBBER HYDROCARBON

Technique: FILM (CAST FROM o-DICHLOROBENZENE)
Source of Sample: GOODYEAR TIRE AND RUBBER COMPANY
Density: 0.99
Comments: Chemical Description: COLD ACRYLONITRILE POLYMER CONTAINING 50 PARTS OF DIOCTYL PHTHALATE/100 PARTS OF RI

Fig. 7c

VITON A

Library-Reference Spectrum



HU5112; VITON A

Technique: FILM (CAST FROM ETHYL ACETATE)
Spectrometer Recording Technique: DIGILAB FTS 15C
Source of Sample: E. I. DU PONT de NEMOURS & COMPANY, INC., WILMINGTON,
Comments: HUMMEL/SCHOLL "INFRARED ANALYSIS OF POLYMERS, RESINS AND ADDI'
Composition: VINYLIDENE FLUORIDE-HEXAFLUOROPROPYLENE COPOLYMER (65% F)

Fig. 7d

37

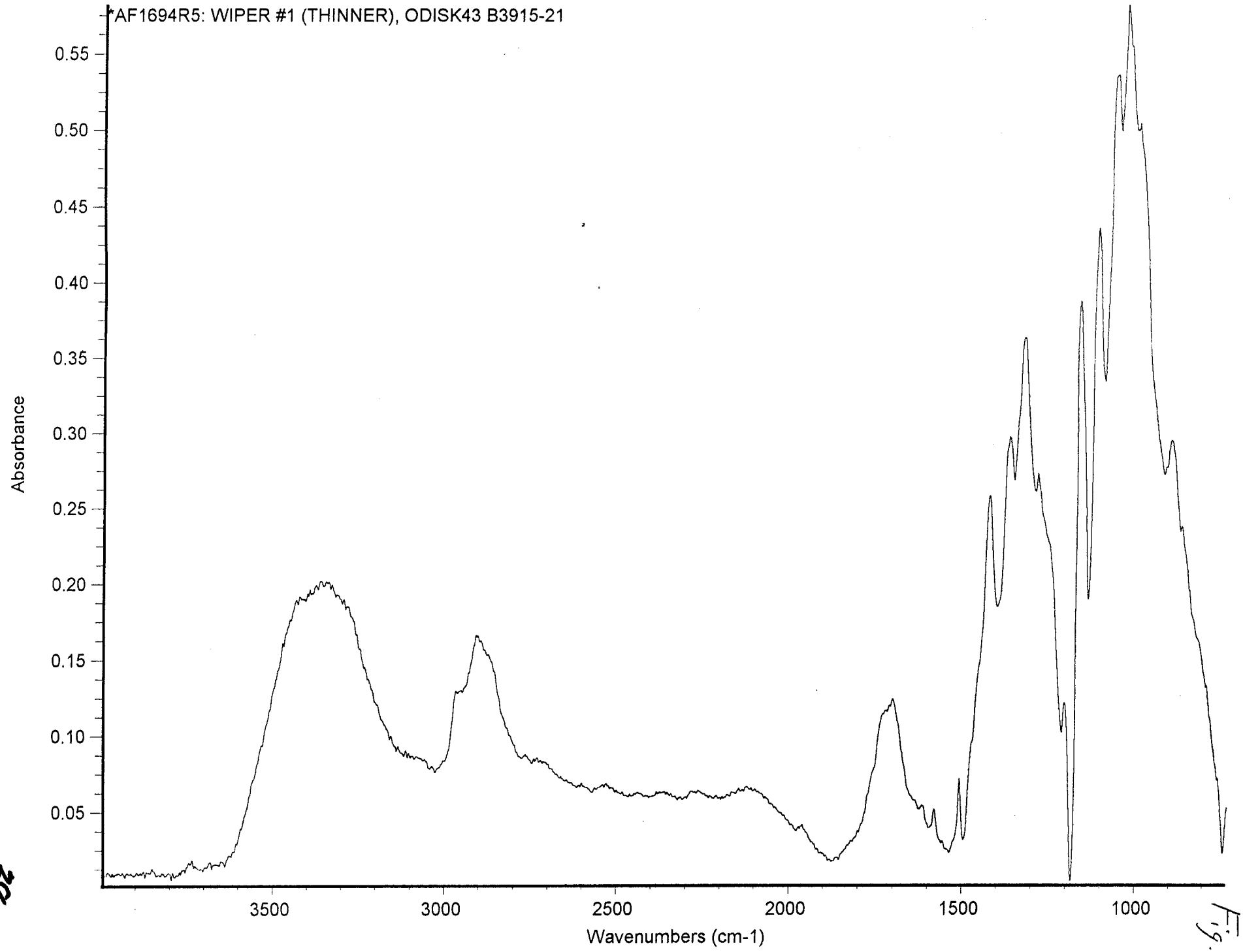
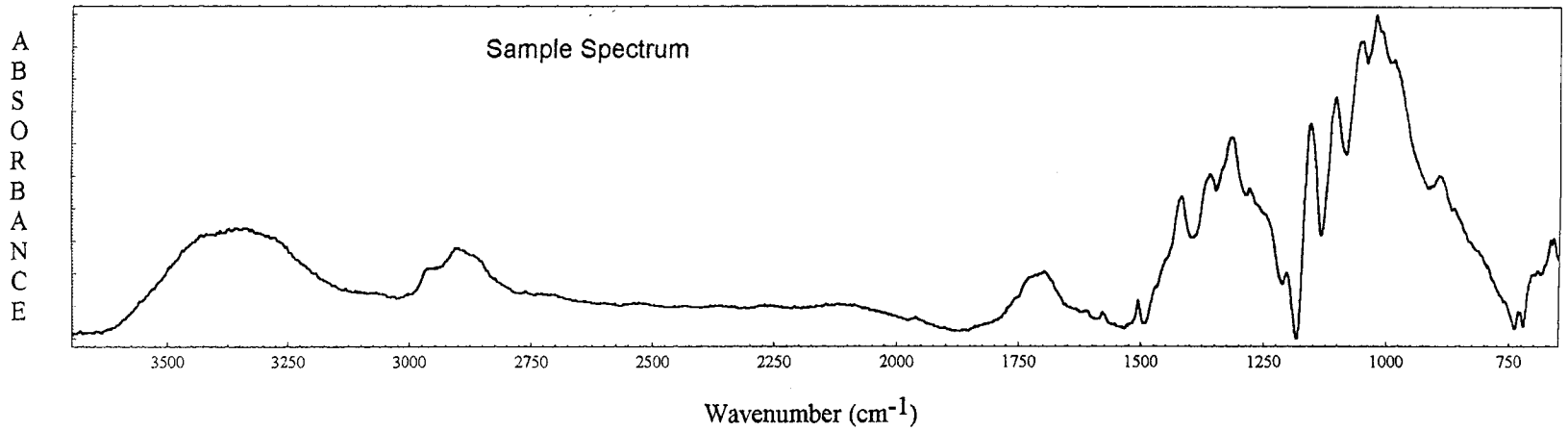
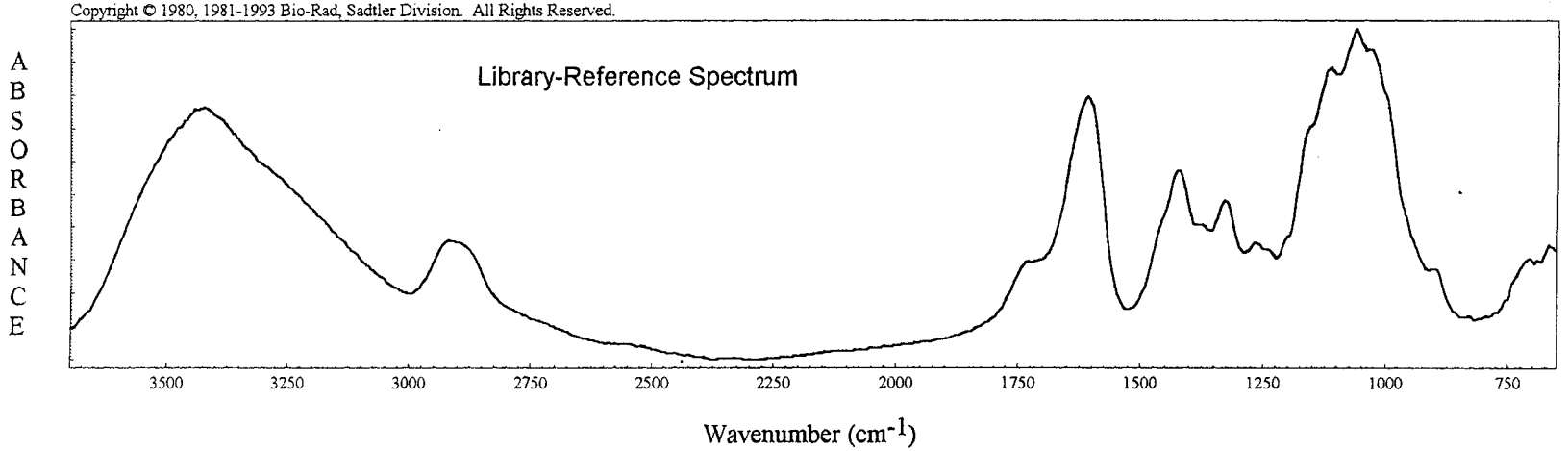

*AF1694R5: WIPER #1 (THINNER), ODISK43 B3915-21
Absorbance
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

Fig. 8

AF1694R5.SPA



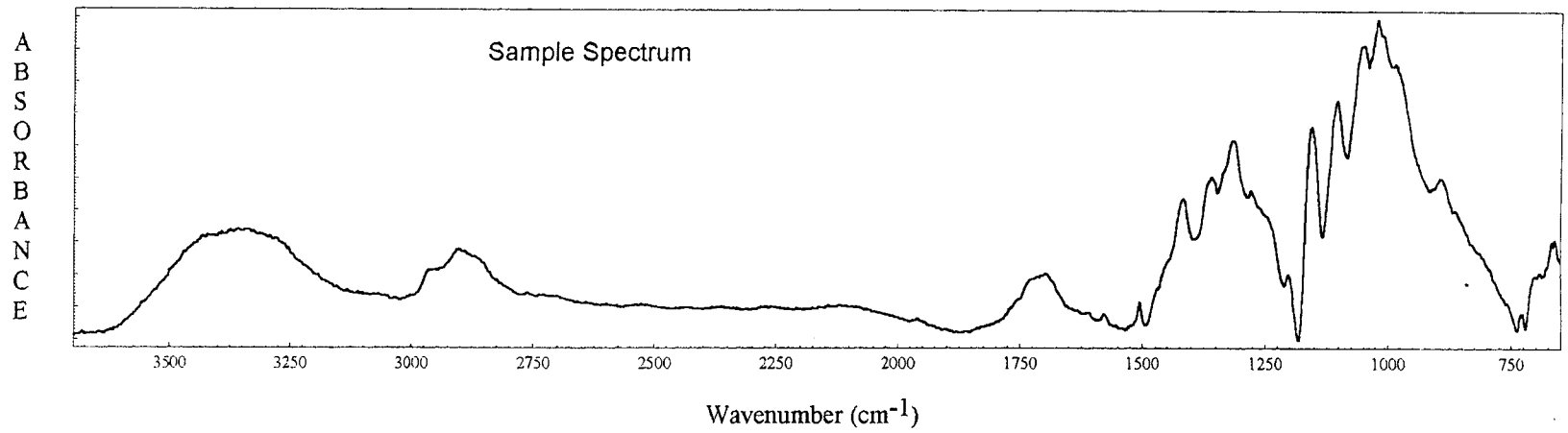


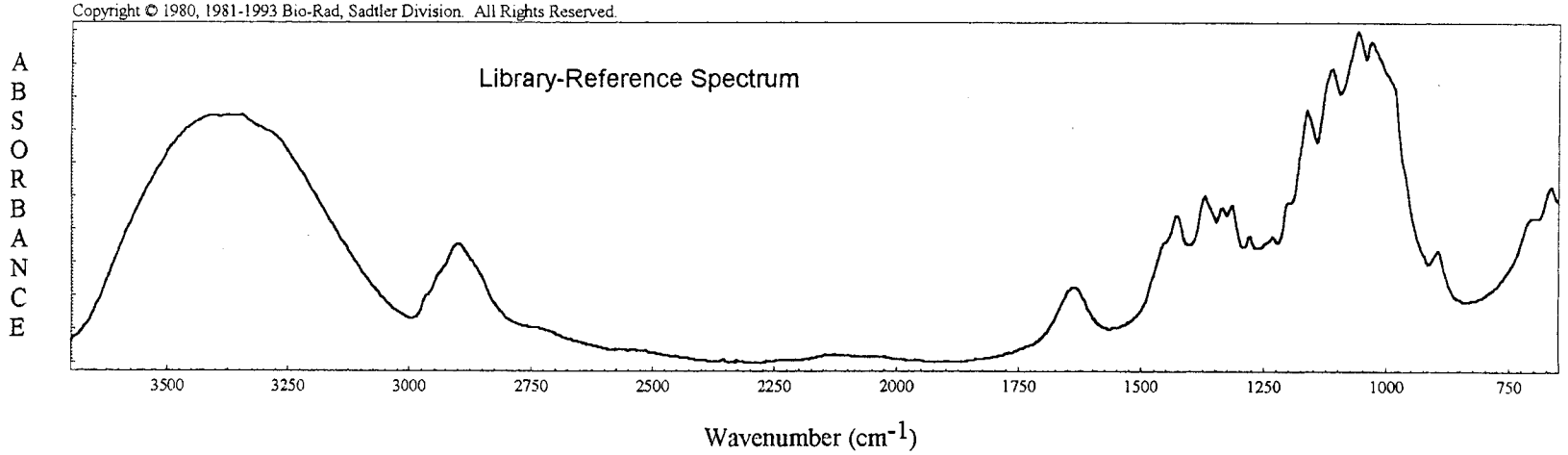
D9278 AC-DI-SOL MODIFIED CELLULOSE GUM, INTERNALLY CROSS-LINKED FORM OF SODIUM CARBOXYMETHYLCELLULOSE /NACMC/

Technique: KBr WAFER
Source of Sample: FMC CORPORATION
Comments: Chemical Description: MODIFIED CELLULOSE GUM; INTERNALLY CROSS-LINKED FORM OF SODIUM CARBOXYMETHYL CEL

Fig. 8a

AF1694R5.SPA





HU2637 alpha-CELLULOSE (COTTON WOOL)

Technique: FINELY CHOPPED KBr (2.5/355)
Spectrometer Recording Technique: PE 580 B, ABEX
Source of Sample: COMMERCIAL PRODUCT
Classification: Hummel: 14.31/1233.4
Comments: Physical Description: WHITE FIBERS
Chemical Description: POLYSACCHARIDE FROM CELLOBIOSE UNITS
Source of Spectrum: HUMMEL
Molecular Formula: C.12.H.20.O.10.

Fig. 8b

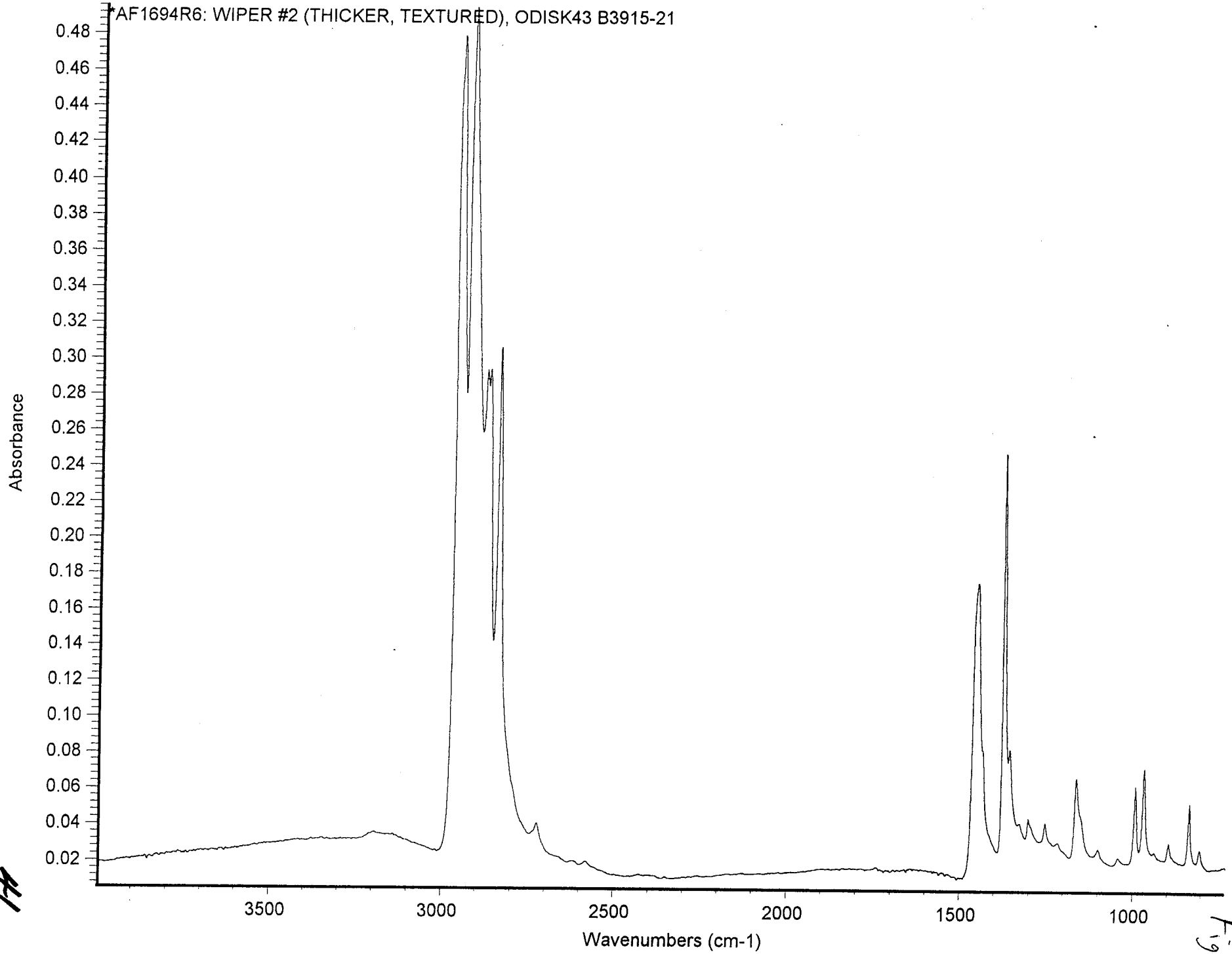
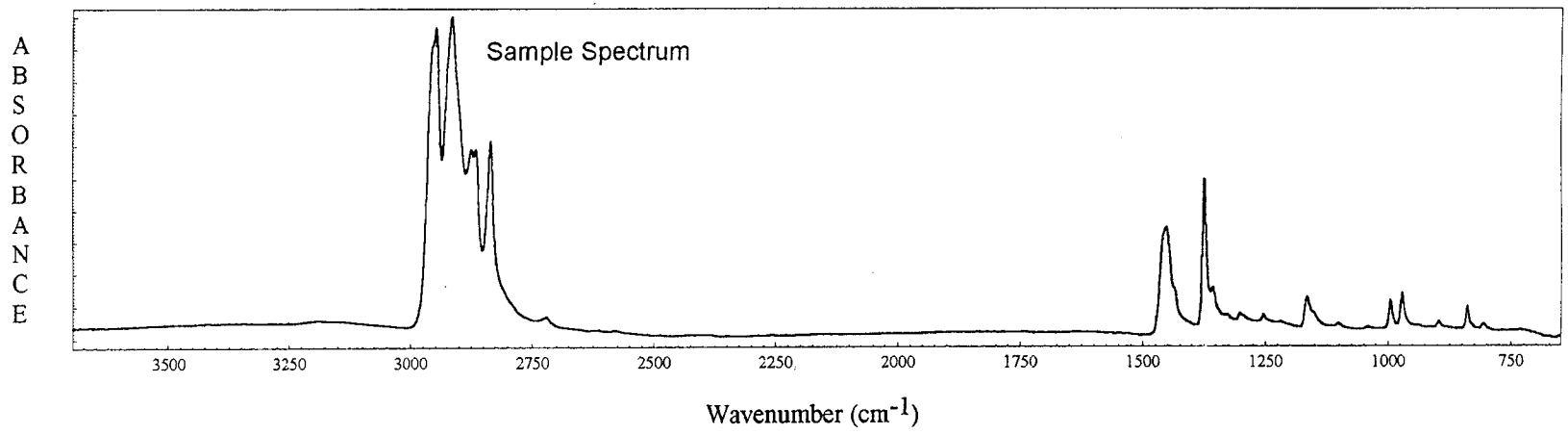
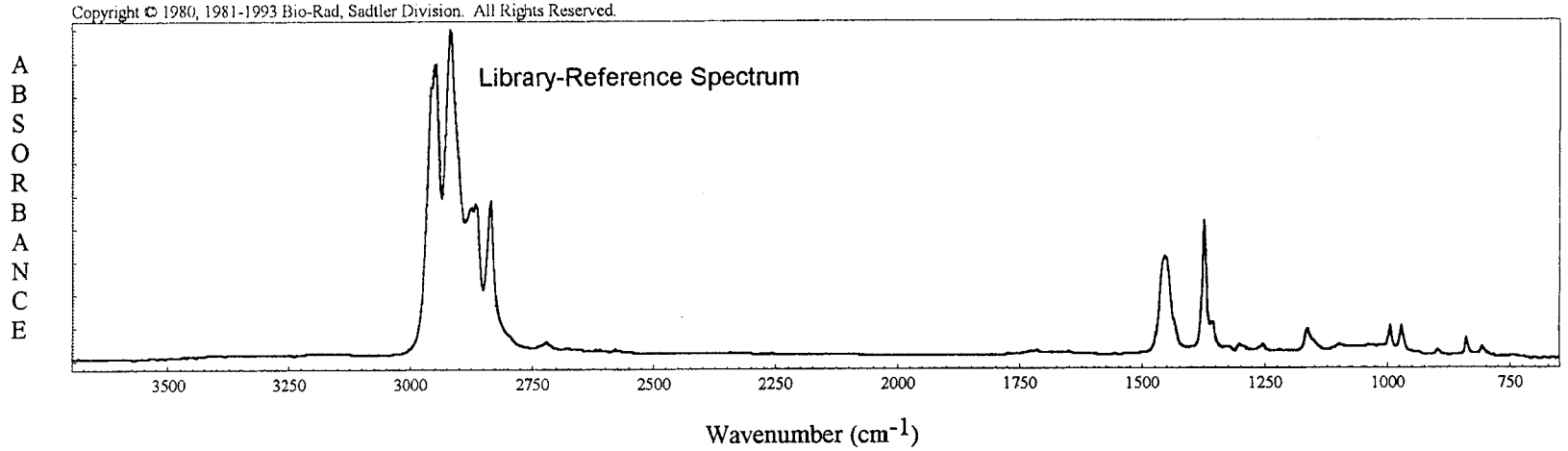

AF1694R6: WIPER #2 (THICKER, TEXTURED), ODISK43 B3915-21
Absorbance
0.48
0.46
0.44
0.42
0.40
0.38
0.36
0.34
0.32
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

Fig. 9

AF1694R6.SPA





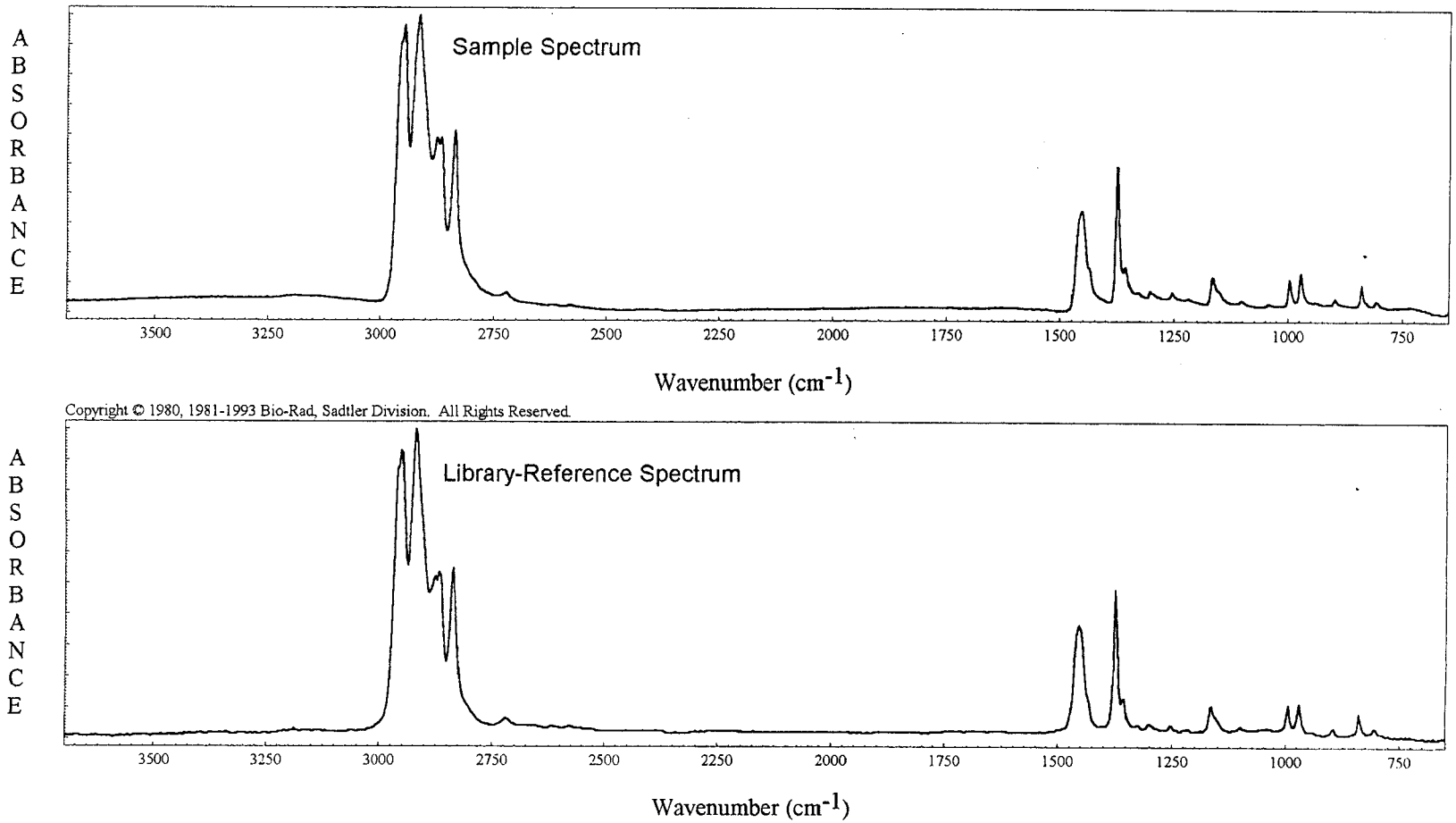
D6824 MOPLEN C-040-Y POLYPROPYLENE

Technique: FILM (CAST FROM o-XYLENE)
Source of Sample: NOVAMONT CORPORATION
Melting Point: 168C
Density: (23C) 0.905 G/CC
Softening Point: 152C
Safety Data: Flammability: 1 IN/MIN
Viscosity Data: Flow Rate: 4.0 G/10 MIN.
Comments: Chemical Description: POLYPROPYLENE
Description: DRY AND WET-HEAT GRADE

42

Fig. 9a.

AF1694R6.SPA



D6853 ELTEX P HL-200

Technique: FILM (CAST FROM o-DICHLOROBENZENE)
Source of Sample: SOLTEX POLYMER CORPORATION
Comments: Chemical Description: POLYPROPYLENE

Fig. 9b

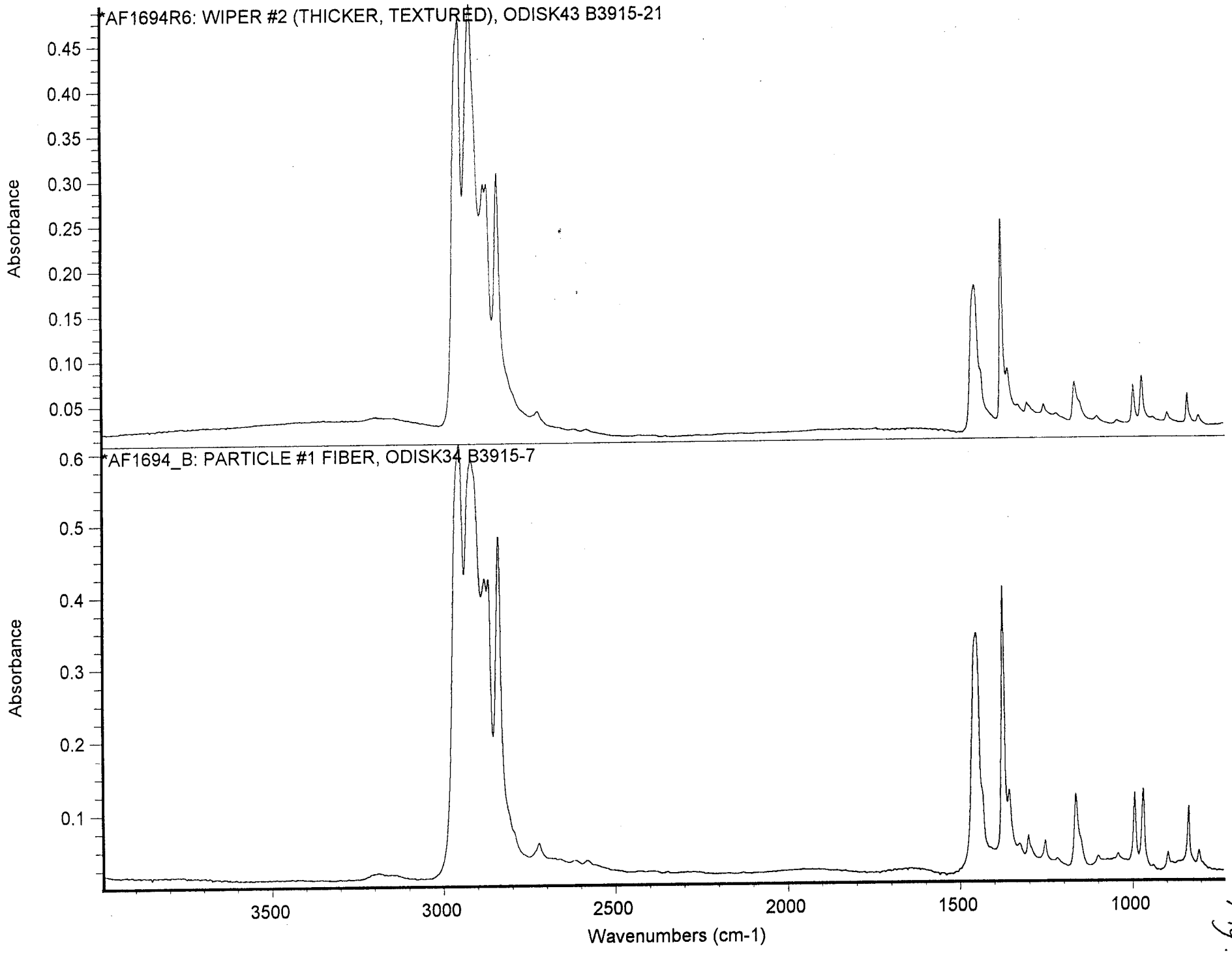
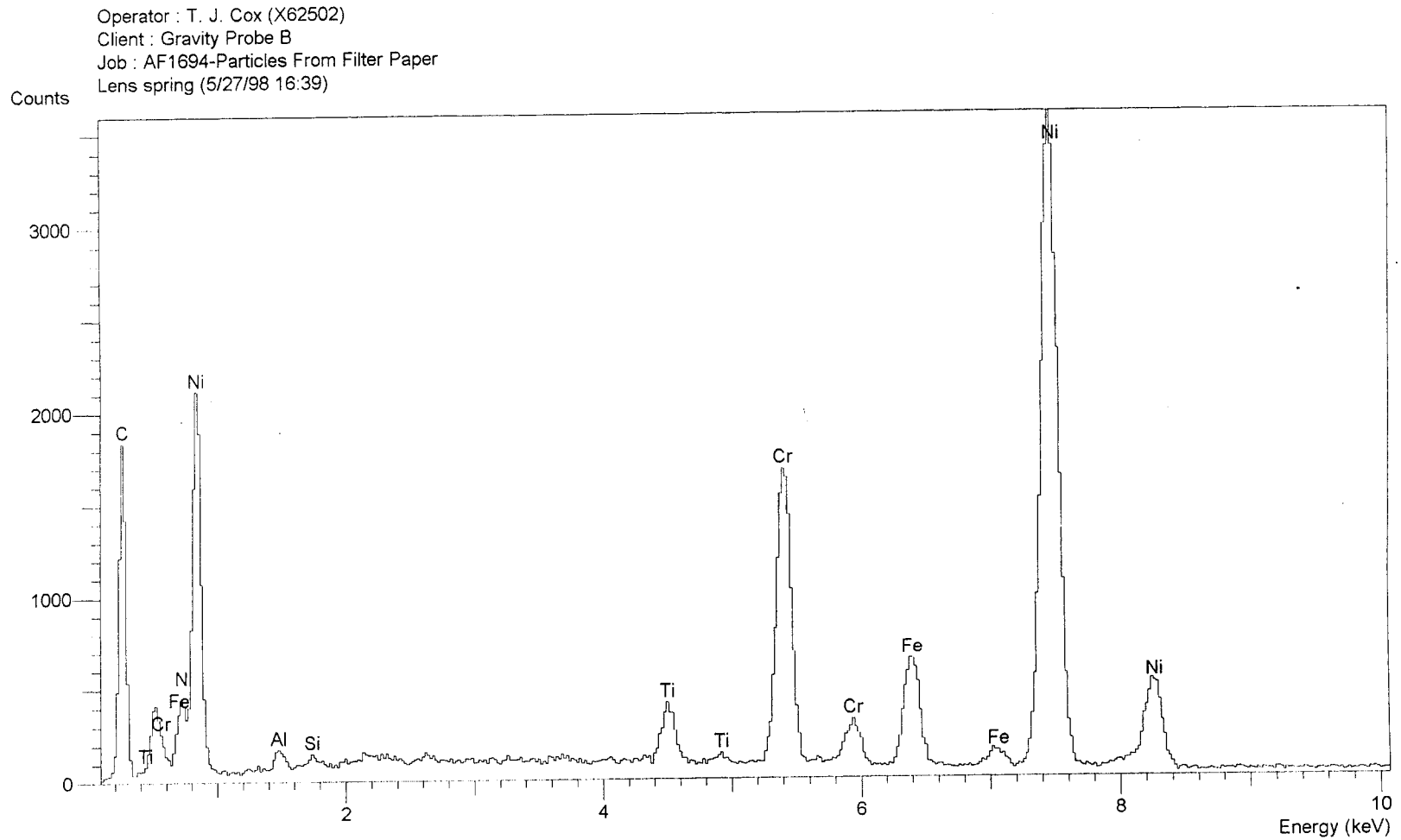

*AF1694R6: WIPER #2 (THICKER, TEXTURED), ODISK43 B3915-21
Absorbance
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
*AF1694_B: PARTICLE #1 FIBER, ODISK34 B3915-7
Absorbance
0.6
0.5
0.4
0.3
0.2
0.1
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

Fig. 9A



AF1694
Fig. 10

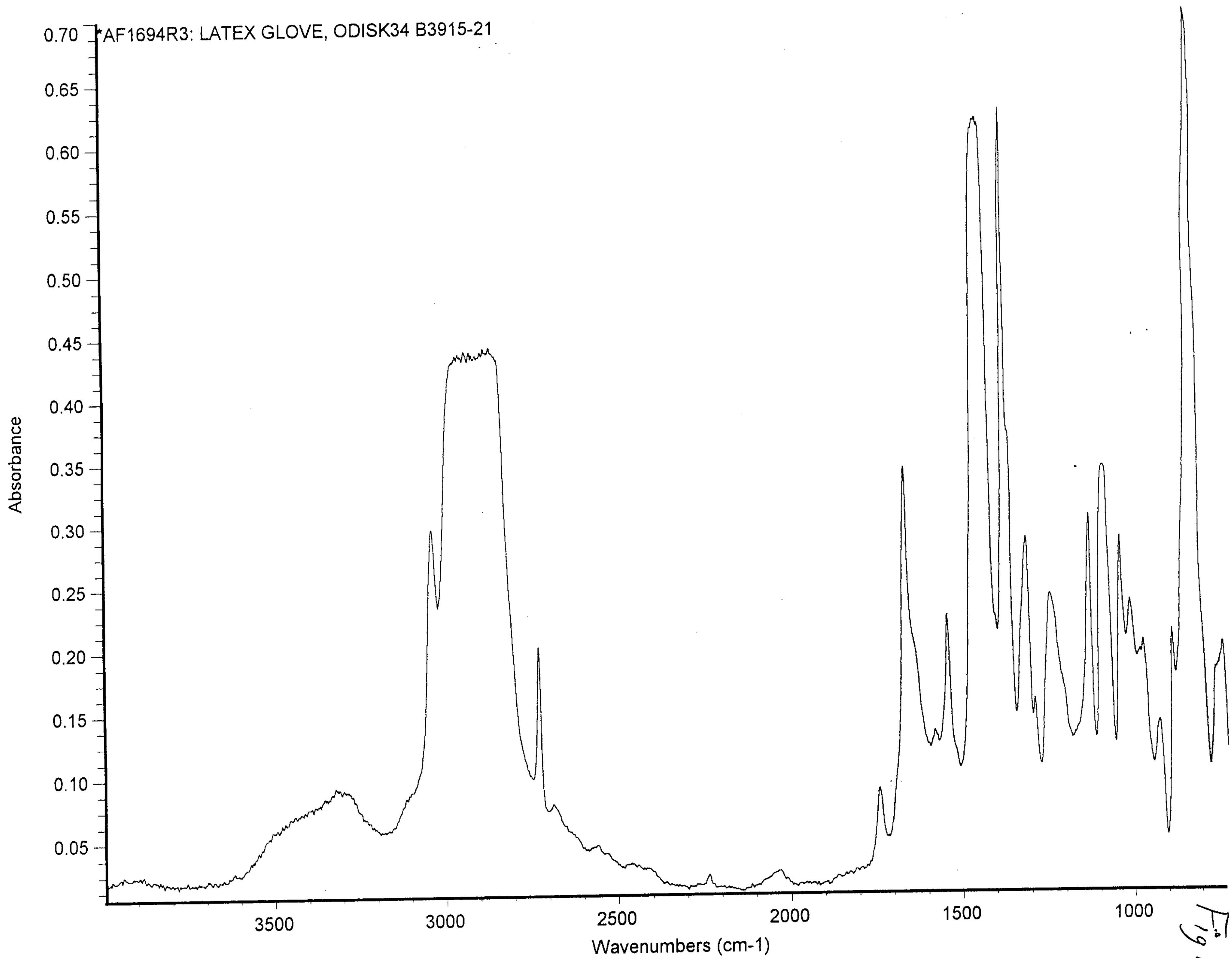
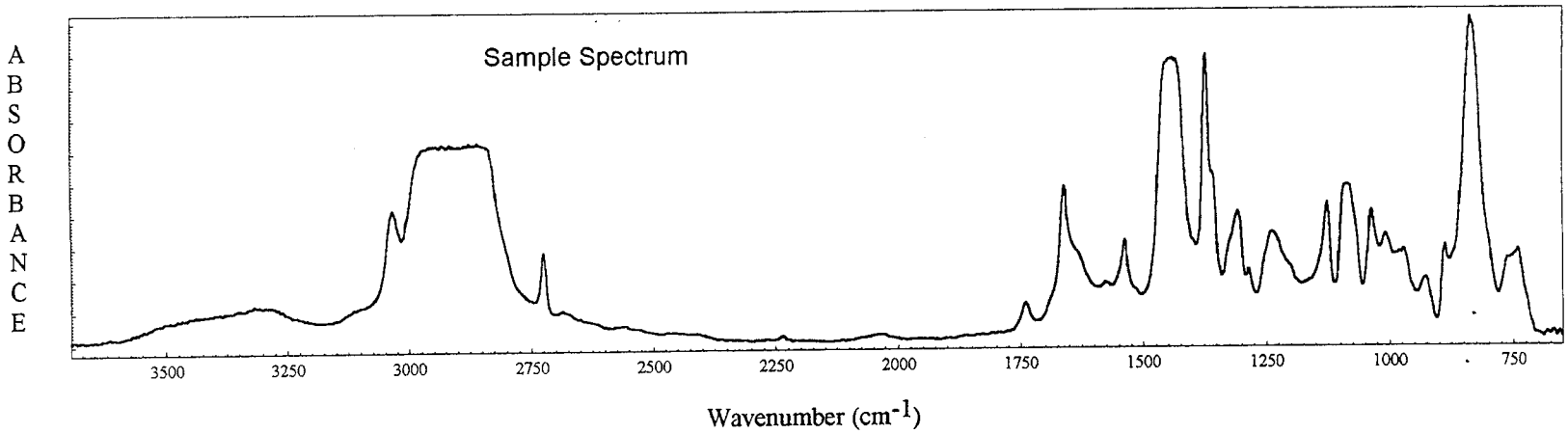
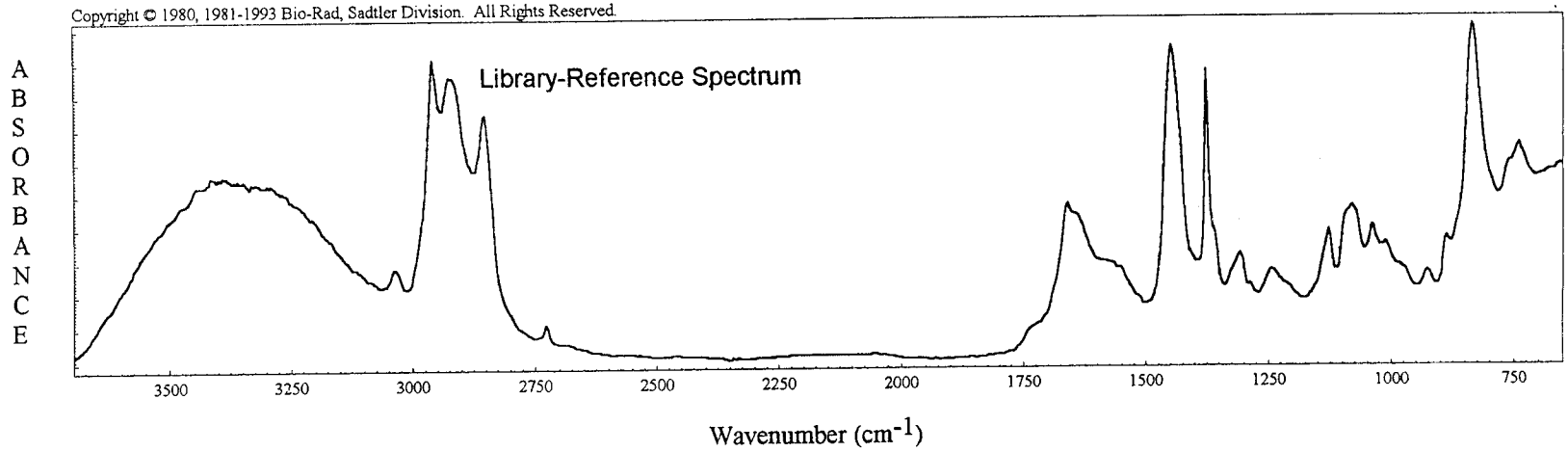

*AF1694R3: LATEX GLOVE, ODISK34 B3915-21
Absorbance
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

Fig 11

AF1694R3.SPA



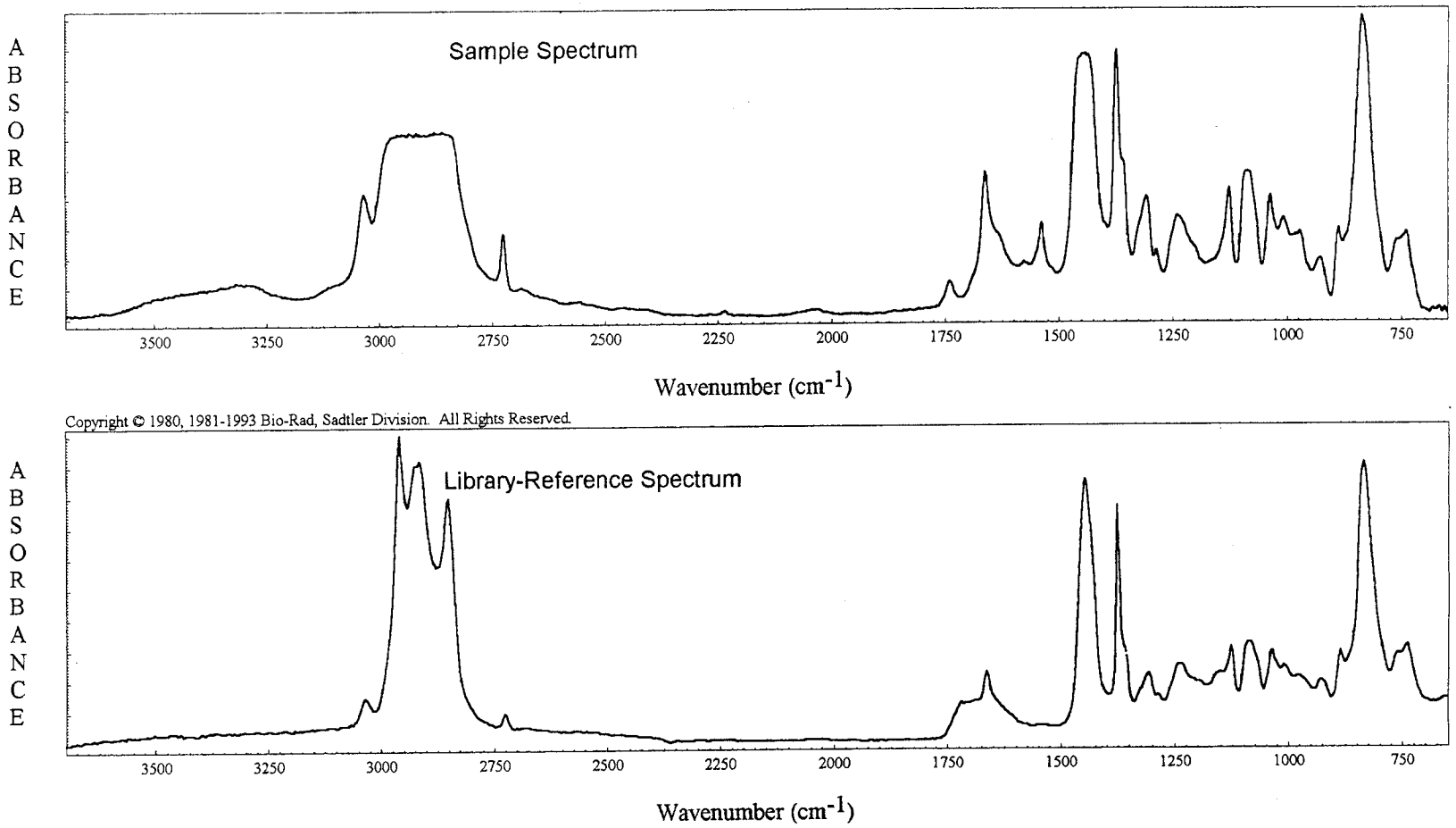


W1027 HARTEX 103

Technique: NEAT
Source of Sample: FIRESTONE NATURAL RUBBER AND LATEX COMPANY
Solution Data: pH: 9.5
Comments: Chemical Description: LOW-AMMONIA NATURAL LATEX

Fig. 11a.

AF1694R3.SPA



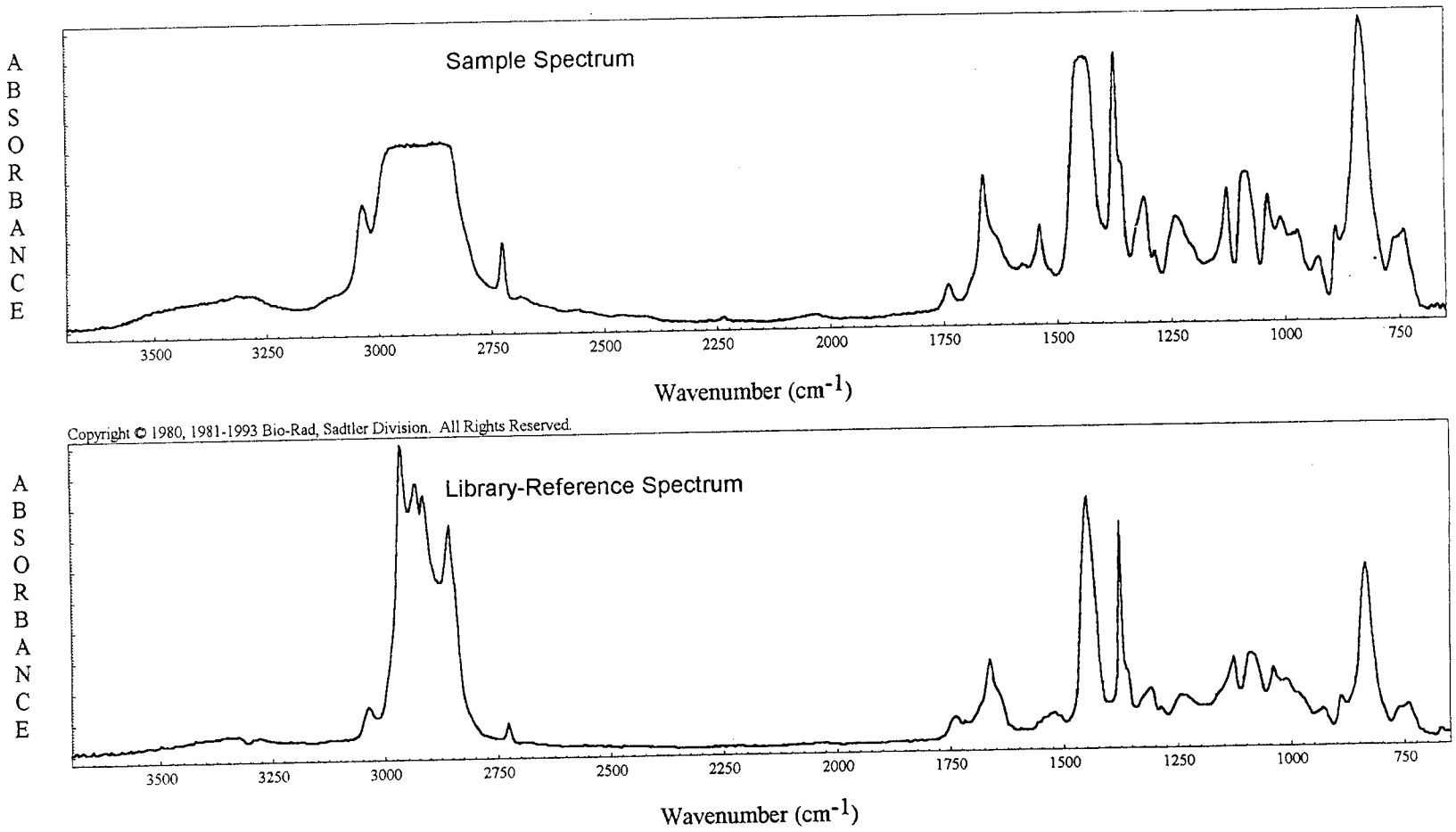
W697 POLY(ISOPRENE), CIS

Technique: NEAT
Source of Sample: ALDRICH CHEMICAL COMPANY, INC.
Density: 0.910
Melting Point: 36C
Optical Properties: Index of Refraction: (20C) 1.5191
Solubility: Solubility Parameter: 7.9
Comments: Chemical Description: POLY(ISOPRENE), cis
Glass Properties: Glass Transition Temperature: -67C

48

Fig. 11b.

AF1694R3.SPA



W2151 NATURAL RUBBER

Technique: FILM (CAST FROM TRICHLOROETHANOL)
Source of Sample: POLYSCIENCES, INC.
Comments: Chemical Description: NATURAL RUBBER

46

Fig. 11c

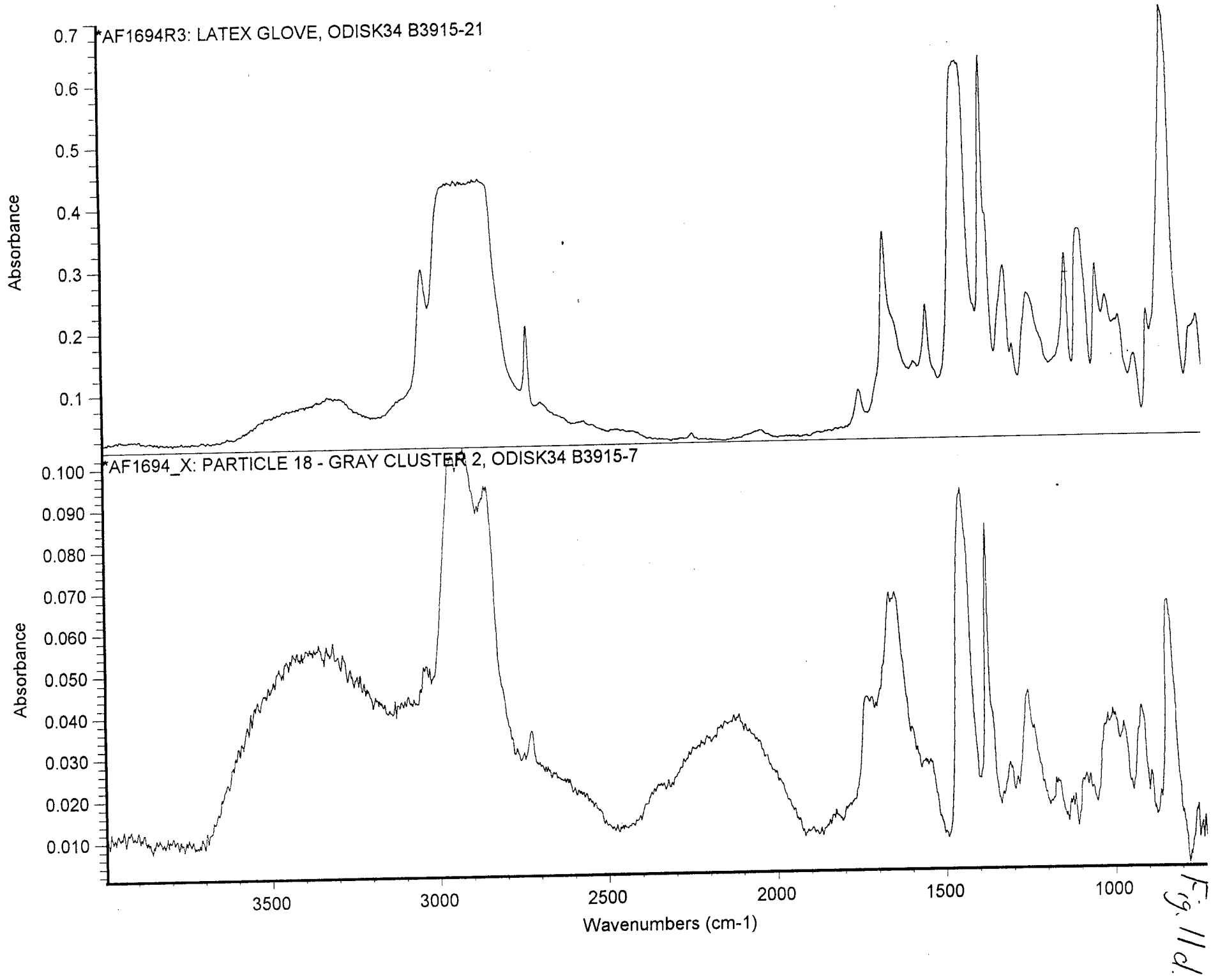

*AF1694R3: LATEX GLOVE, ODISK34 B3915-21
Absorbance
0.7
0.6
0.5
0.4
0.3
0.2
0.1
*AF1694_X: PARTICLE 18 - GRAY CLUSTER 2, ODISK34 B3915-7
Absorbance
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

Fig. 11d.

50

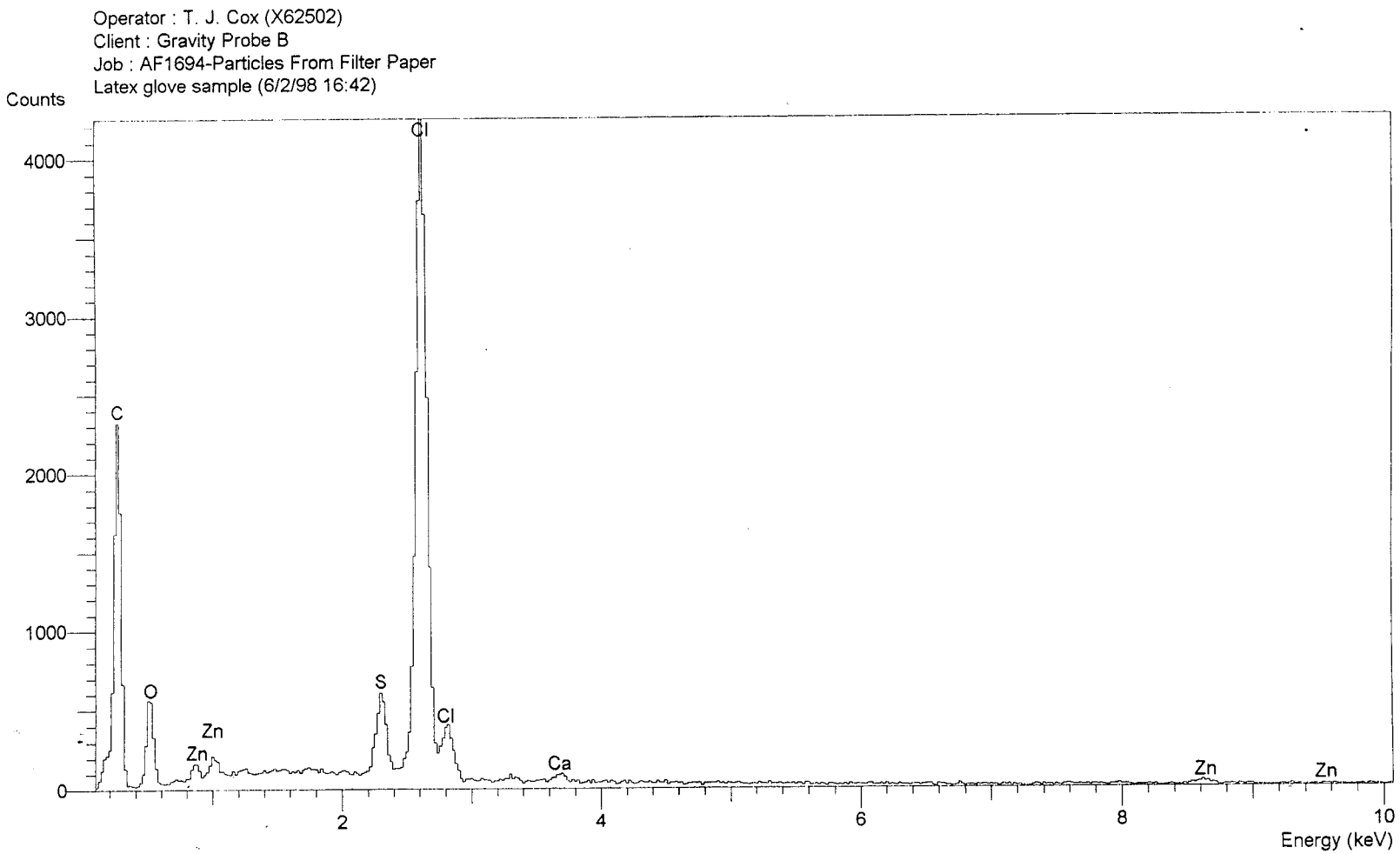
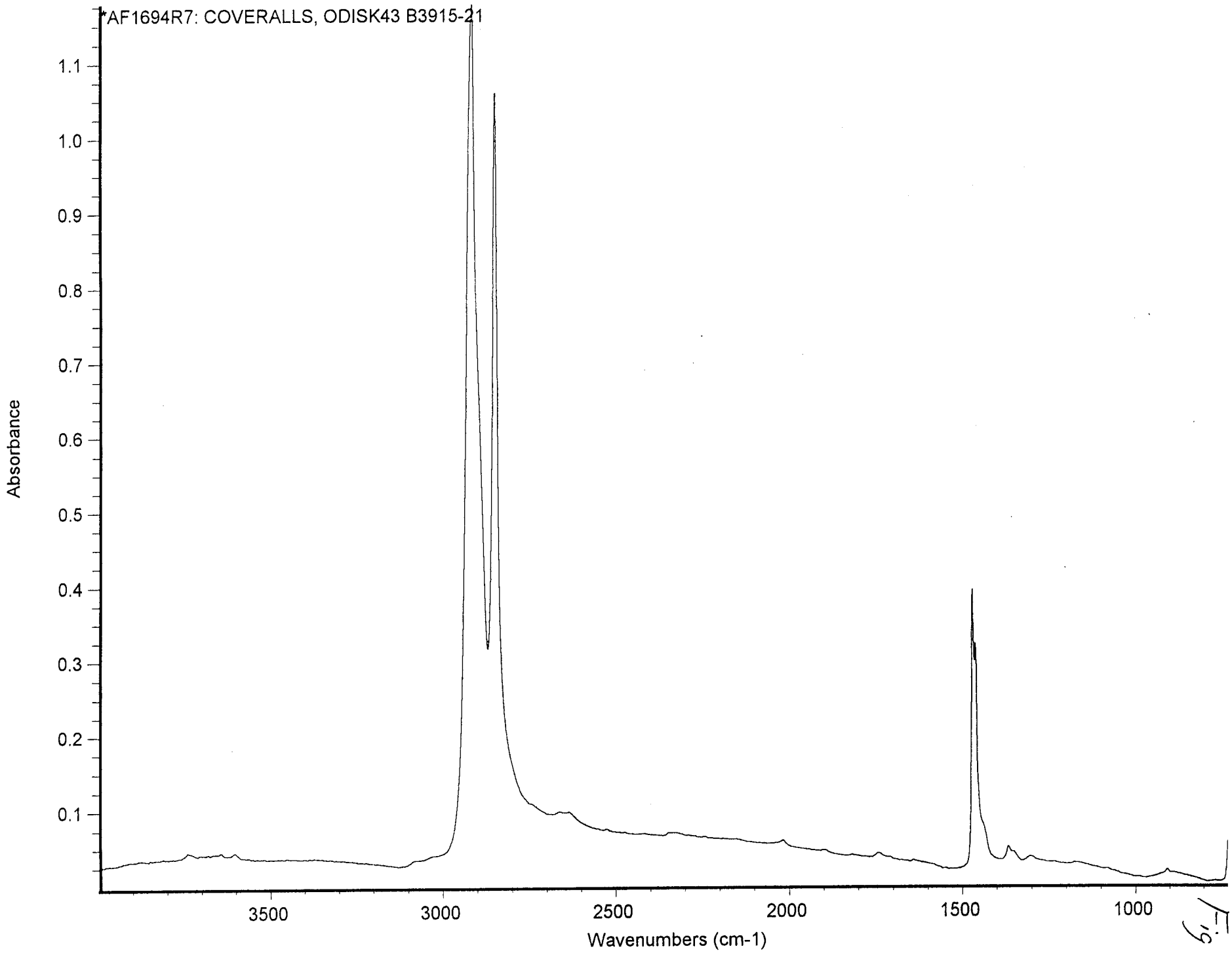


Fig 11e
AF1694


*AF1694R7: COVERALLS, ODISK43 B3915-21
Absorbance
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

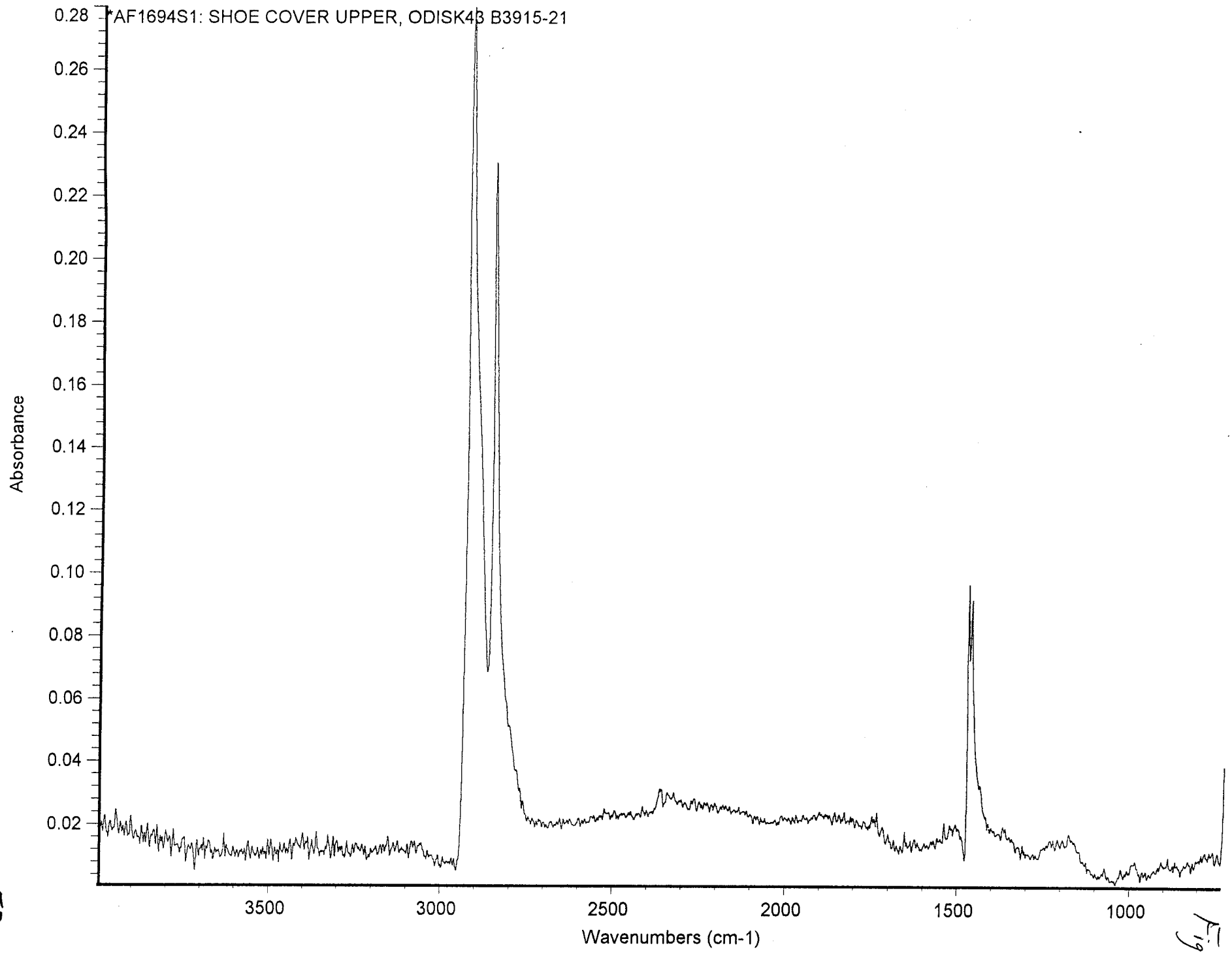

AF1694S1: SHOE COVER UPPER, ODISK43 B3915-21
Absorbance
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

Fig. 13

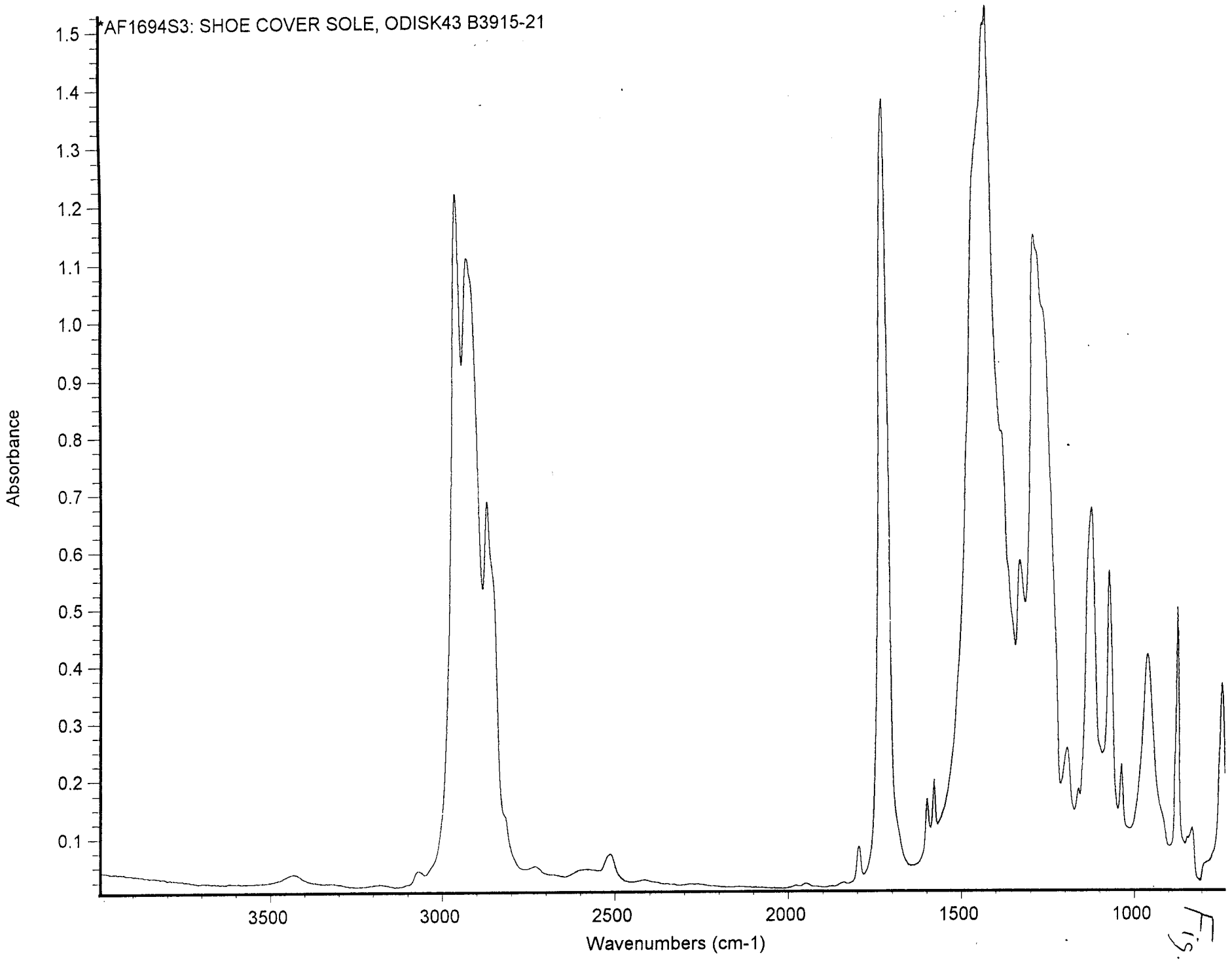
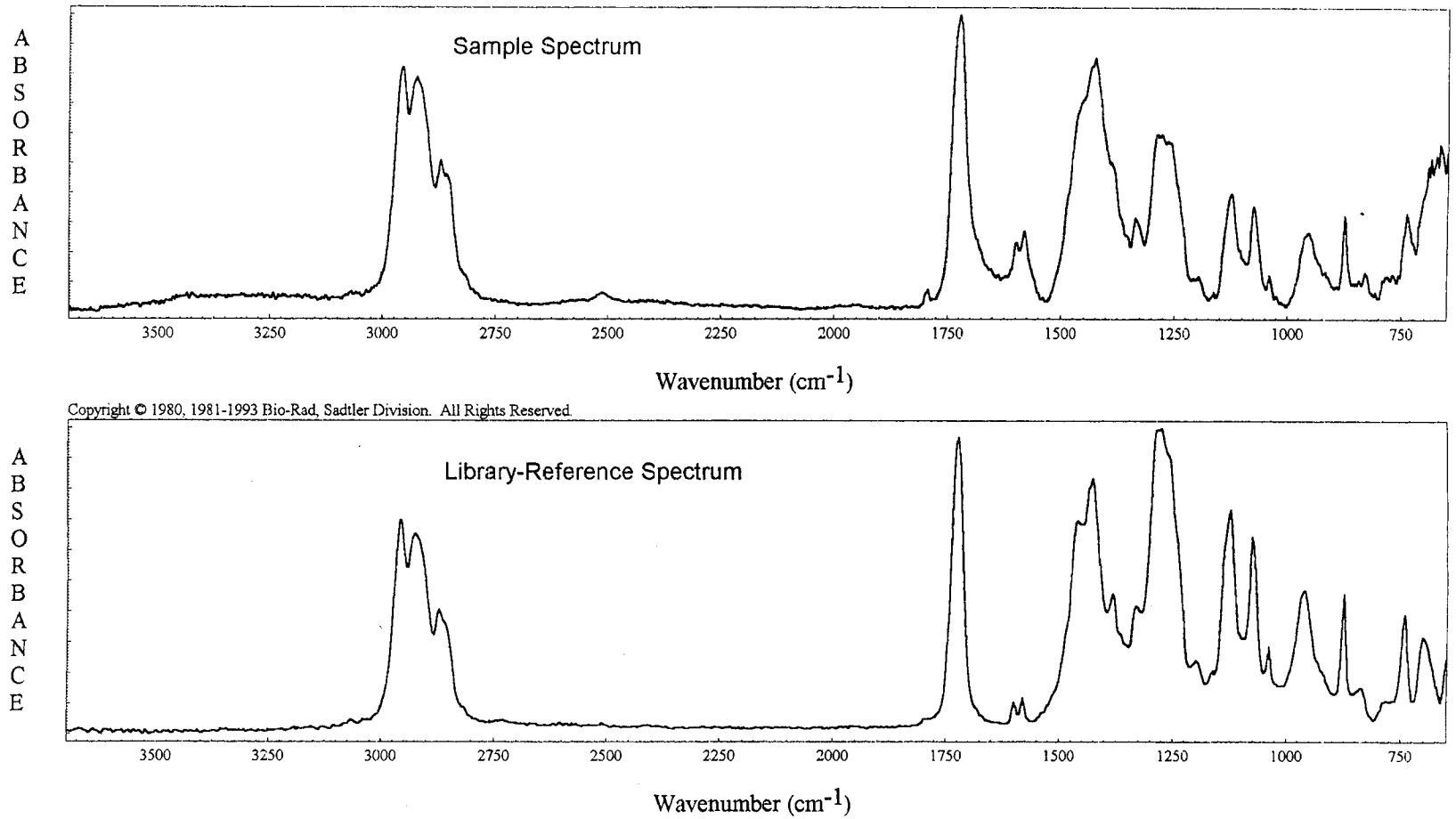

AF1694S3: SHOE COVER SOLE, ODISK43 B3915-21
Absorbance
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

Fig. 14

AF1694S2.SPA



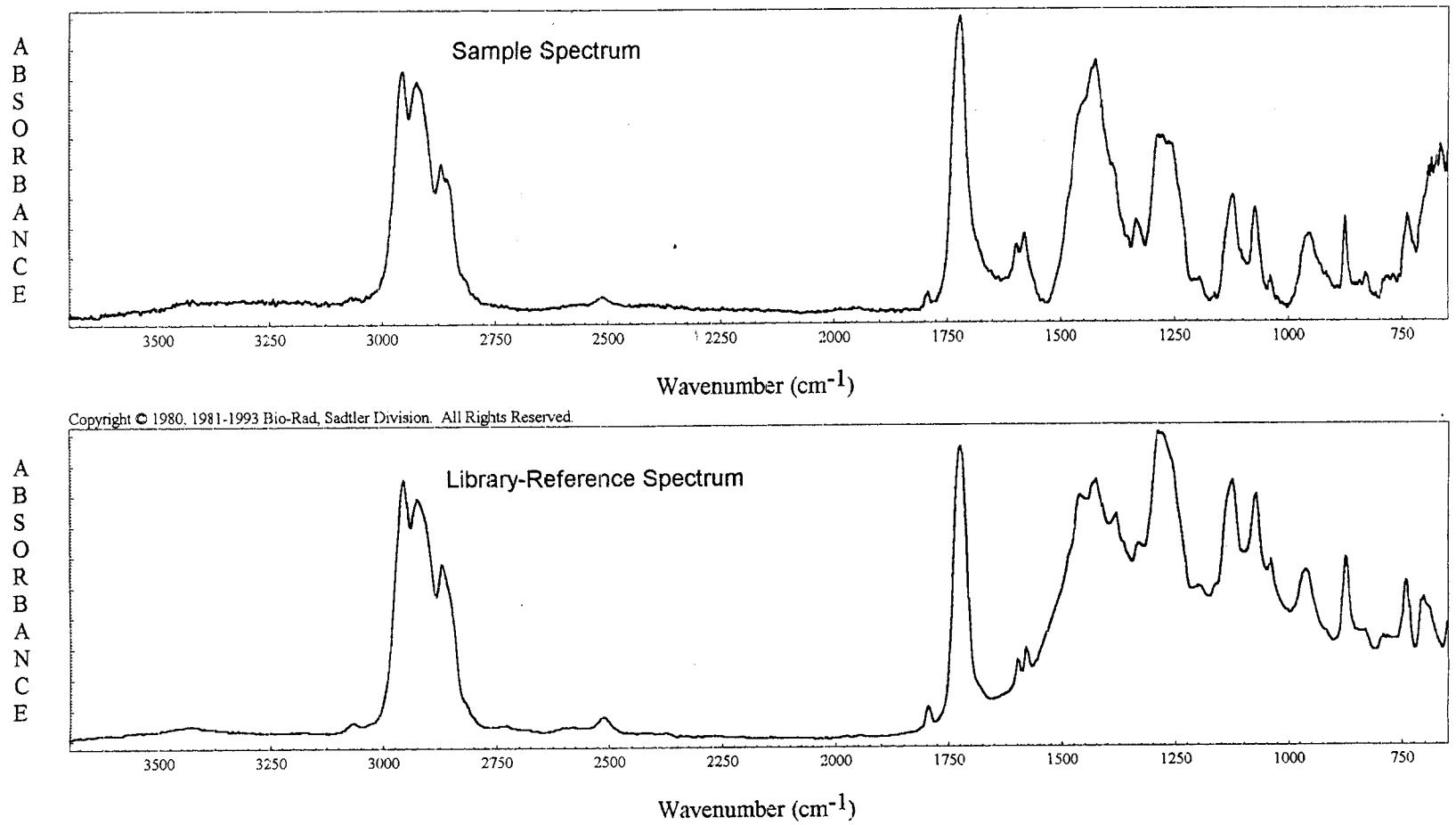
W1274 CONOCO 48562 BLK PVC INJECTION MOLDING COMPOUND

Technique: FILM (CAST FROM o-DICHLOROBENZENE)
Source of Sample: CONOCO CHEMICALS COMPANY, A DIVISION OF CONOCO INC.
Density: 1.36
Comments: Chemical Description: PVC INJECTION MOLDING COMPOUND

55

Fig. 14a

AF1694S2.SPA



D6833 BLANE 312 NATURAL

Technique: FILM (CAST FROM o-DICHLOROBENZENE)
Source of Sample: REICHHOLD CHEMICALS INC.
Comments: Chemical Description: POLYVINYL CHLORIDE

Fig. 14b.

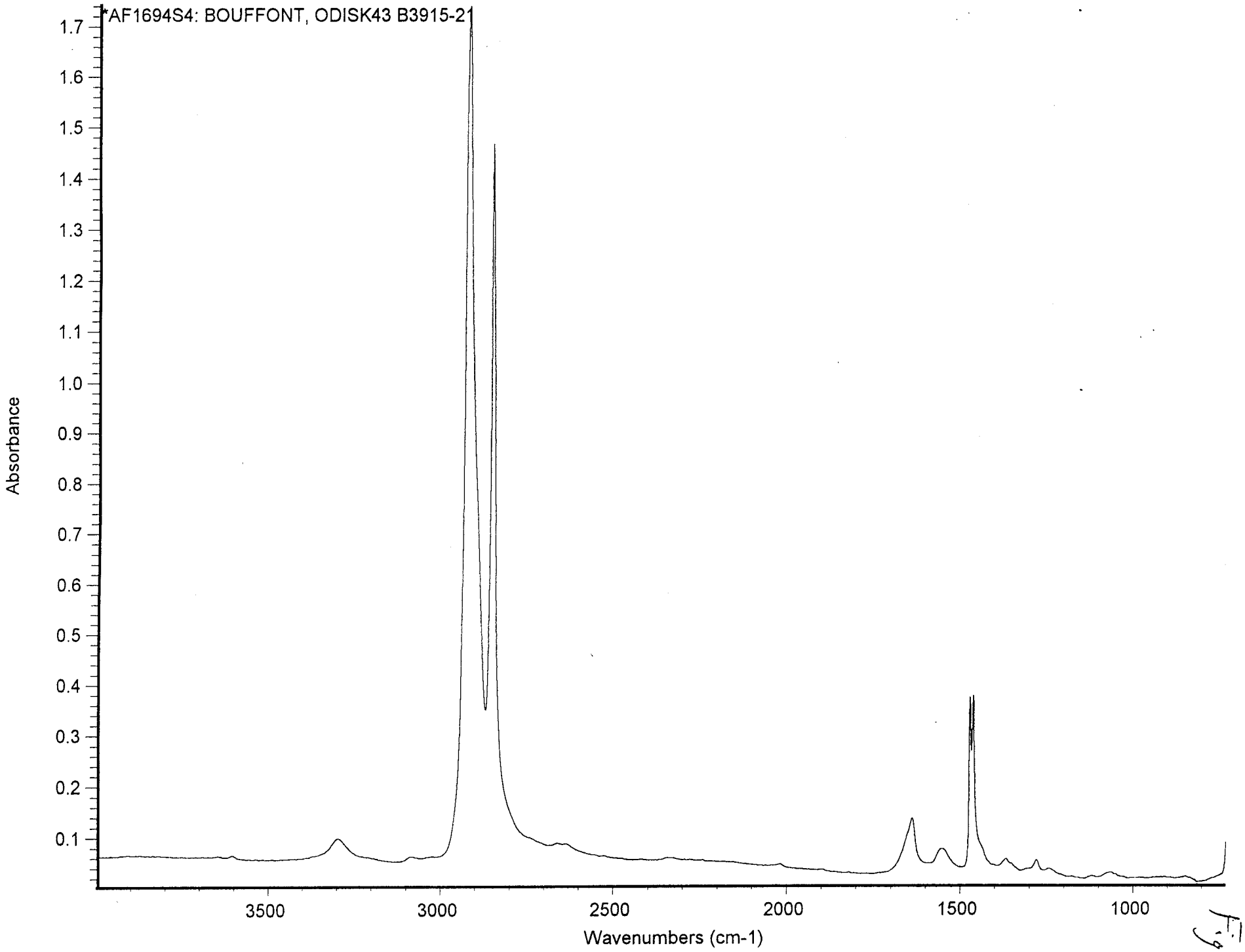
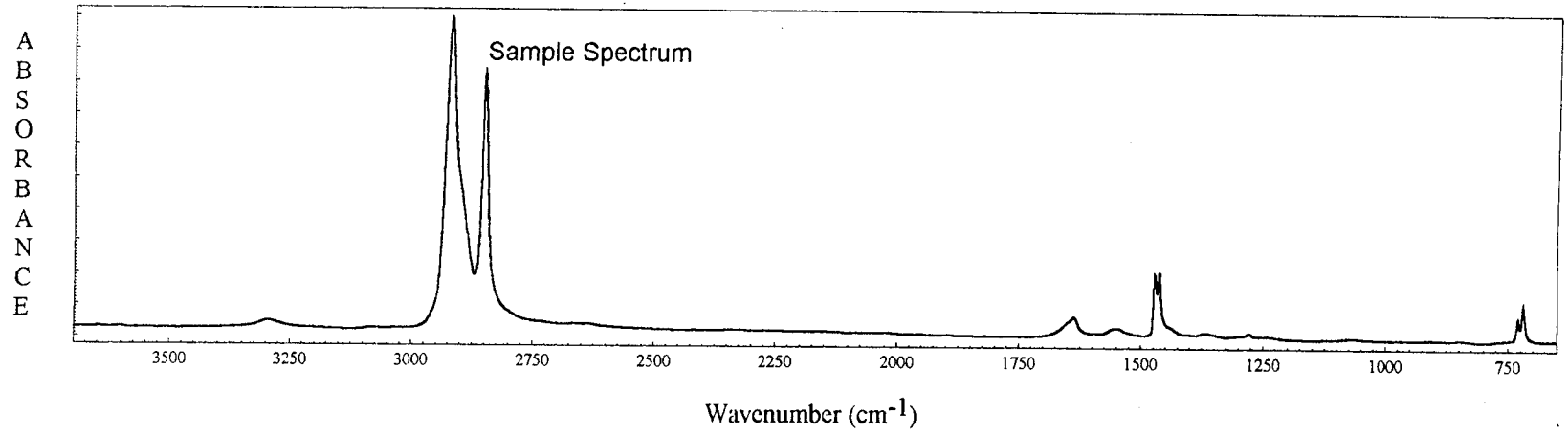
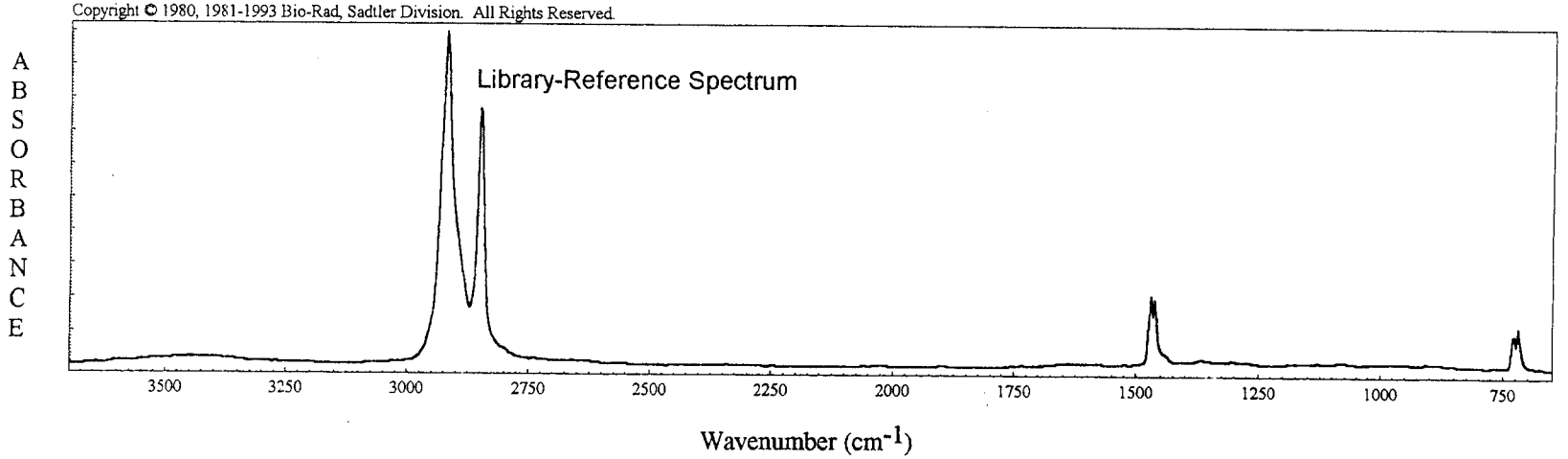

*AF1694S4: BOUFFONT, ODISK43 B3915-21
Absorbance
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

Fig. 15

AF1694S4.SPA





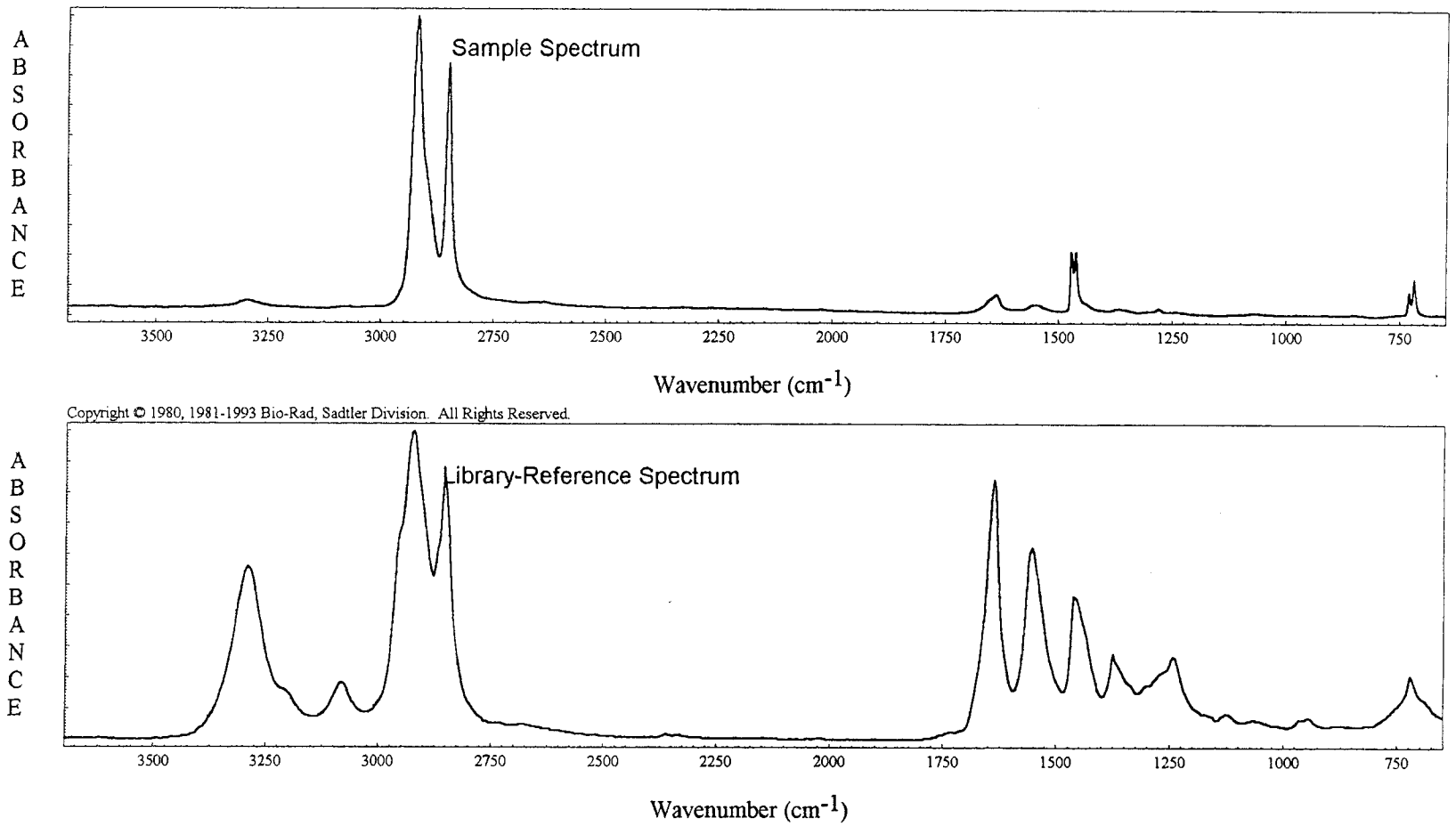
D8245 MARLEX HHM TR-480

Technique: FILM (CAST FROM o-XYLENE)
Source of Sample: PHILLIPS CHEMICAL COMPANY
Density: 0.955
Comments: Chemical Description: POLYETHYLENE COPOLYMER

58

Fig. 15a.

AF1694S4.SPA



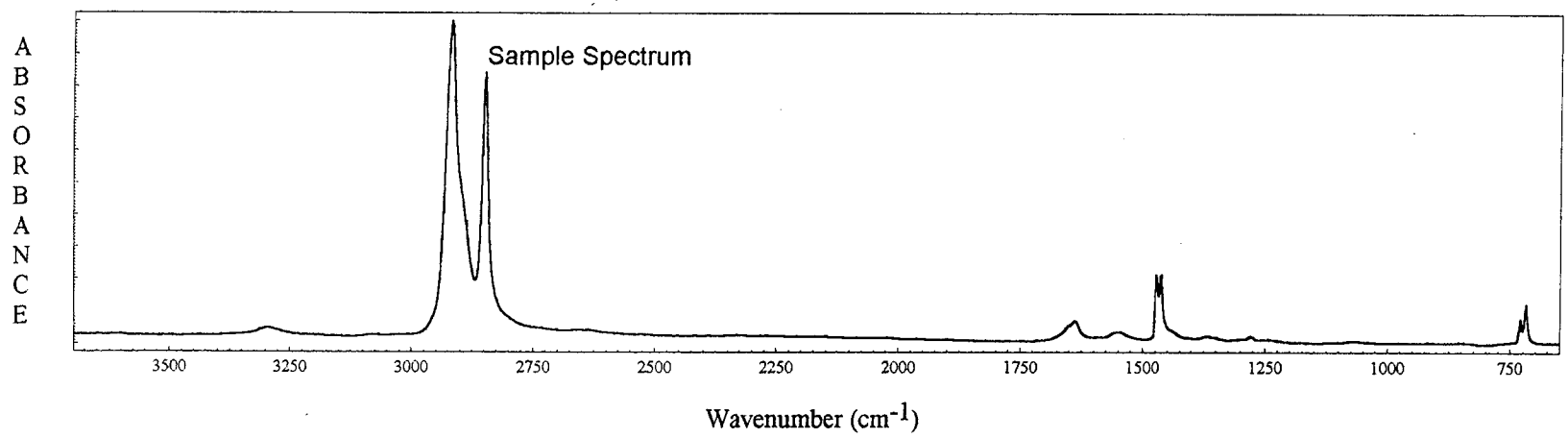
D7846 POLYAMIDE RESIN

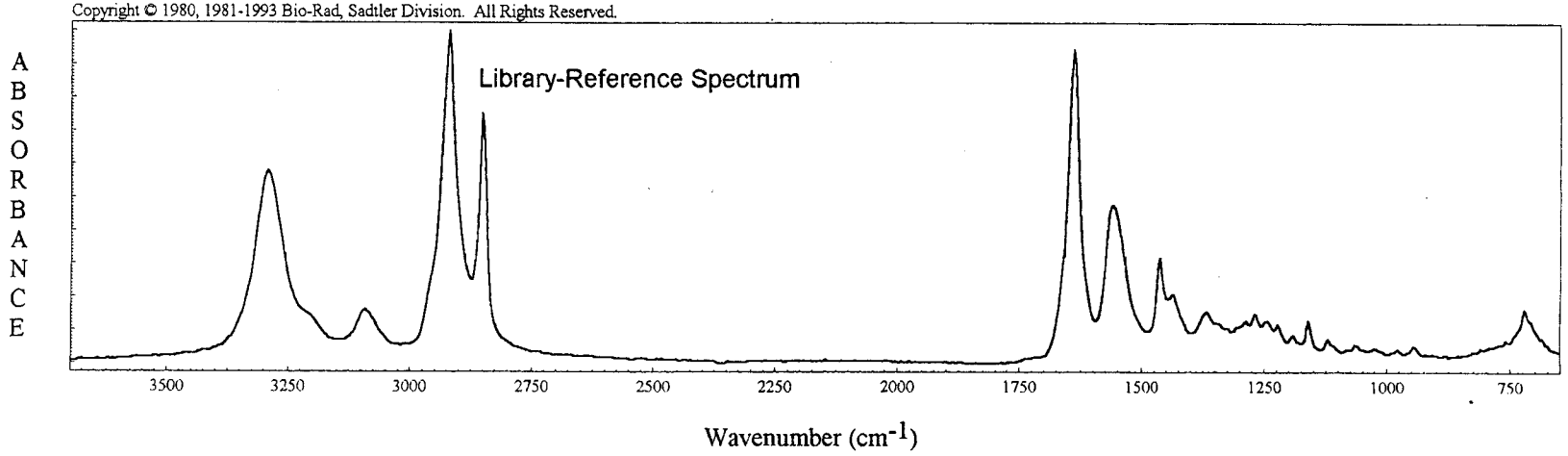
Technique: FILM (CAST FROM CHLOROFORM)
Source of Sample: SCIENTIFIC POLYMER PRODUCTS, INC.
Density: 0.97
Comments: Chemical Description: POLYAMIDE RESIN

59

Fig. 15b.

AF1694S4.SPA





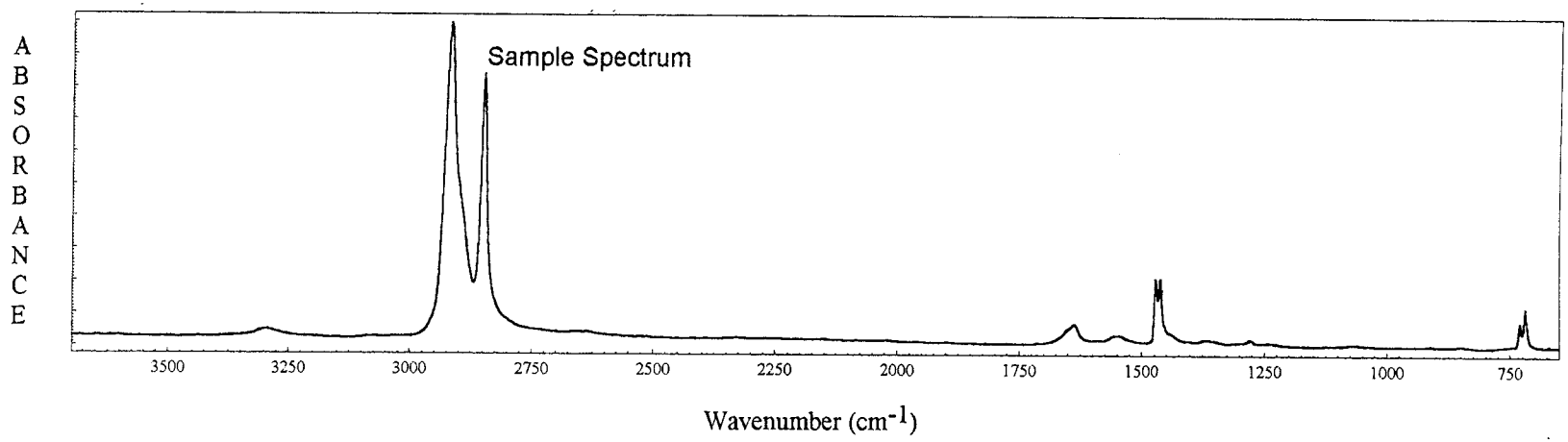
D8056 NYLON 12-L2101F

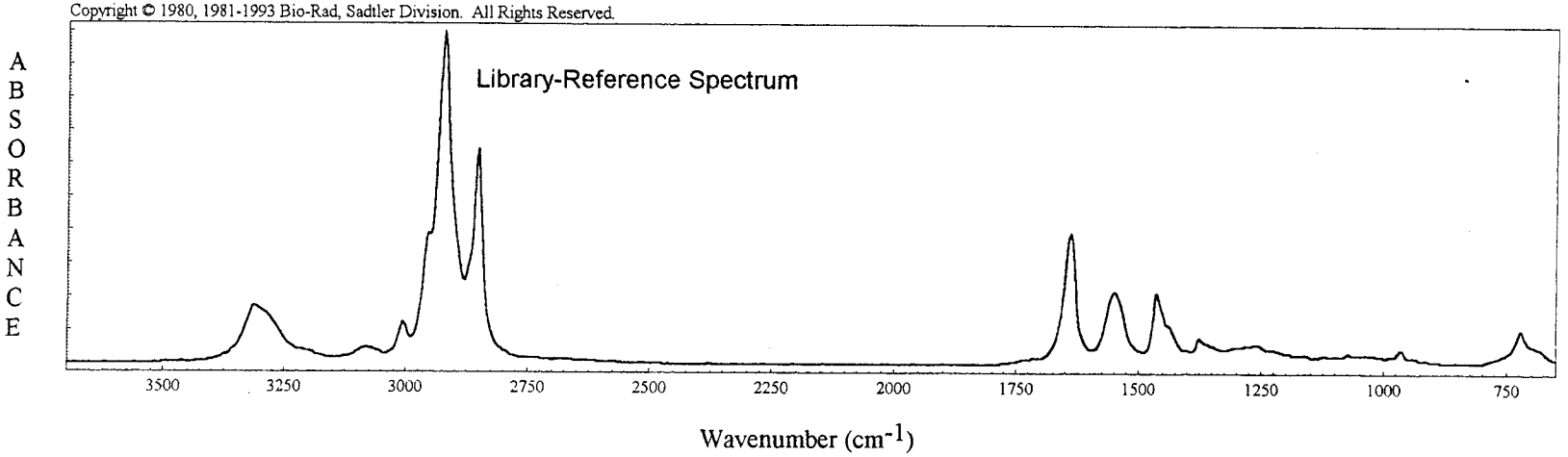
Technique: FILM (CAST FROM TRICHLOROETHANOL)
Source of Sample: HUELS CORPORATION
Comments: Chemical Description: NYLON

60

Fig. 15c

AF1694S4.SPA

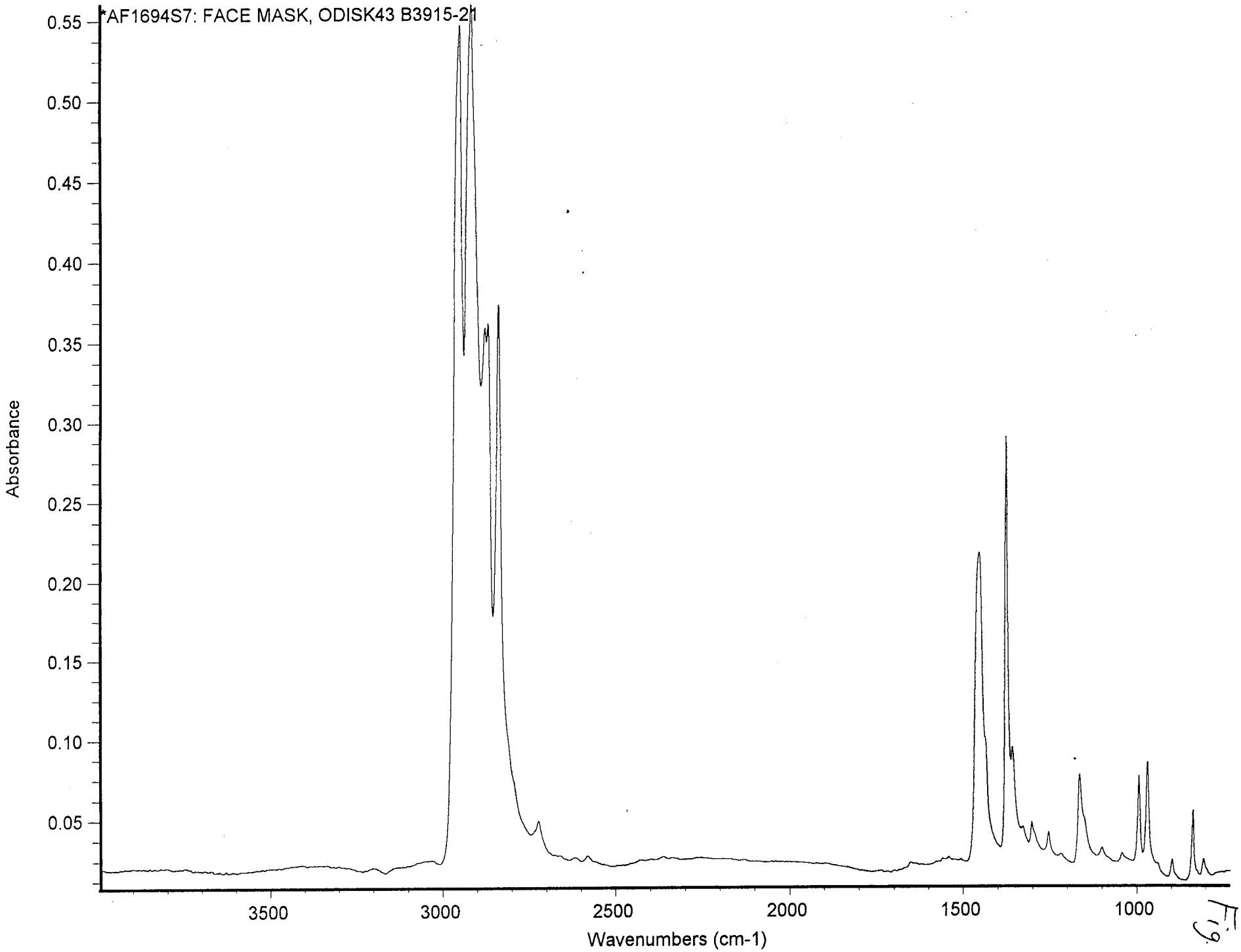




G2092 KEMAMIDE U-181 OLEYL OLEAMIDE

Technique: MELT (CRYSTALLINE PHASE)
Source of Sample: WITCO CORPORATION, HUMKO CHEMICAL DIVISION
Melting Point: 42-44C
Flash Point: (CC) 260C MAX
Solution Data: Acid Number: 10 MAX
Values: Iodine Value: 84
Comments: Chemical Description: OLEYL OLEAMIDE

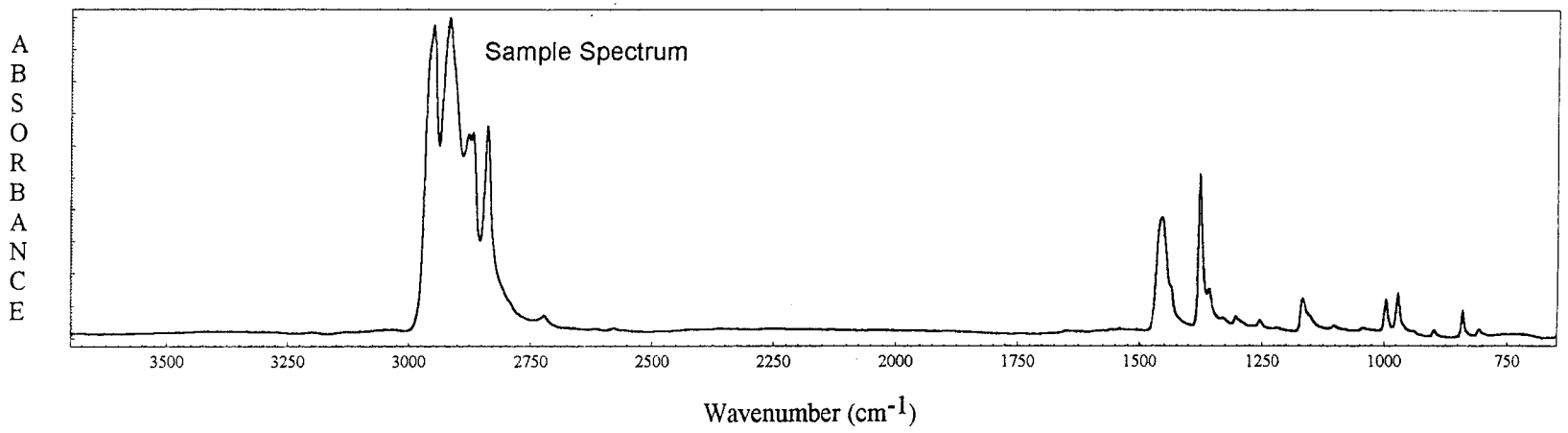
Fig. 15d.

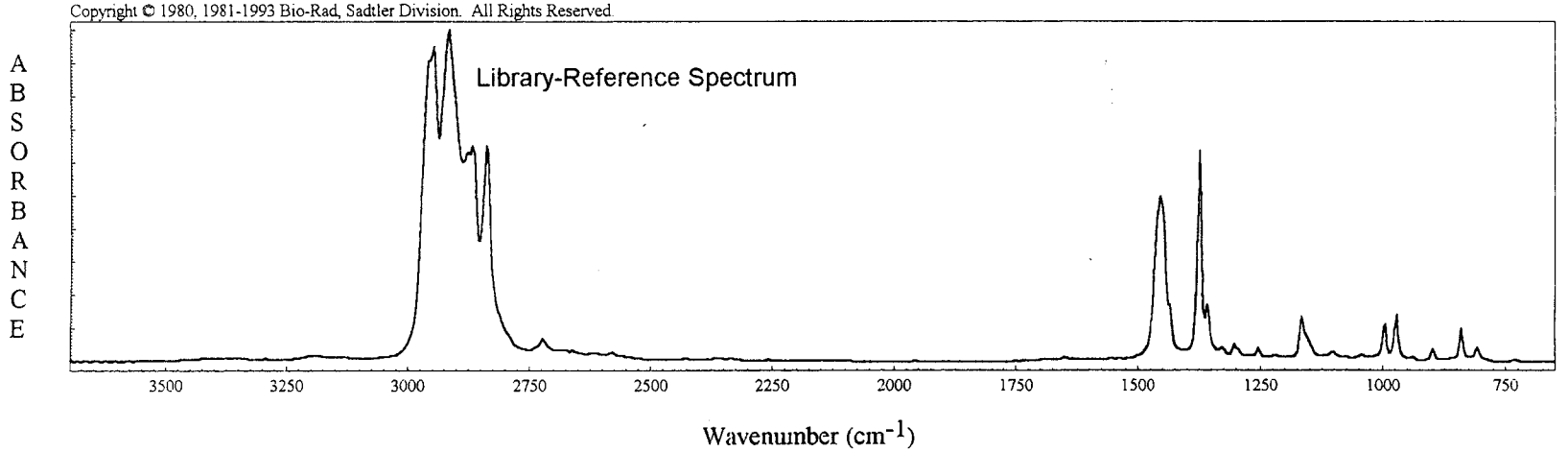

*AF1694S7: FACE MASK, ODISK43 B3915-21
Absorbance
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

62

Fig. 16

AF1694S7.SPA



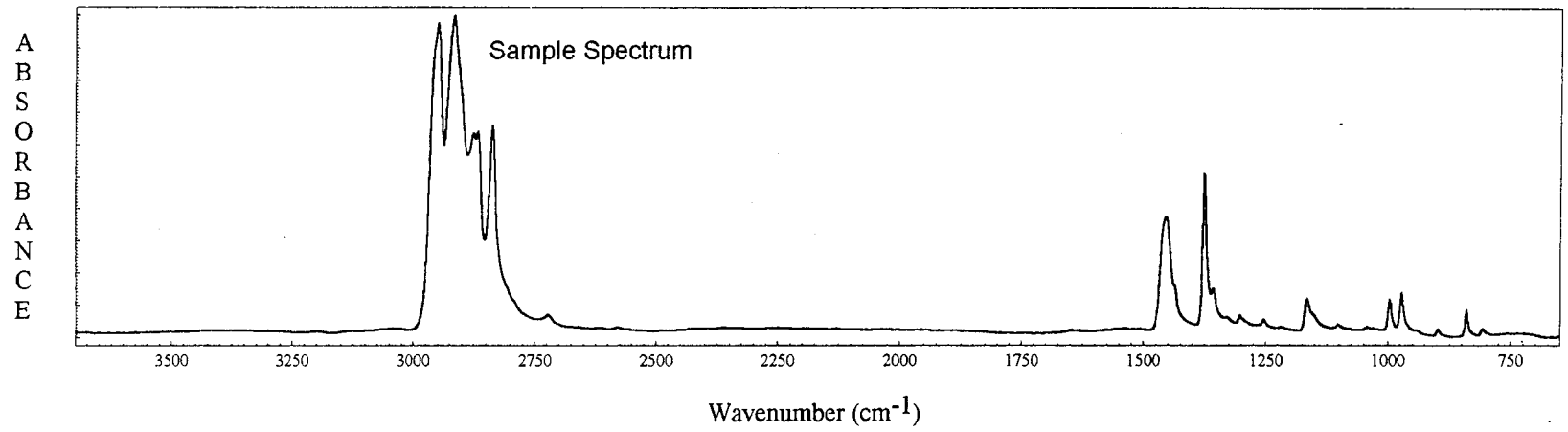


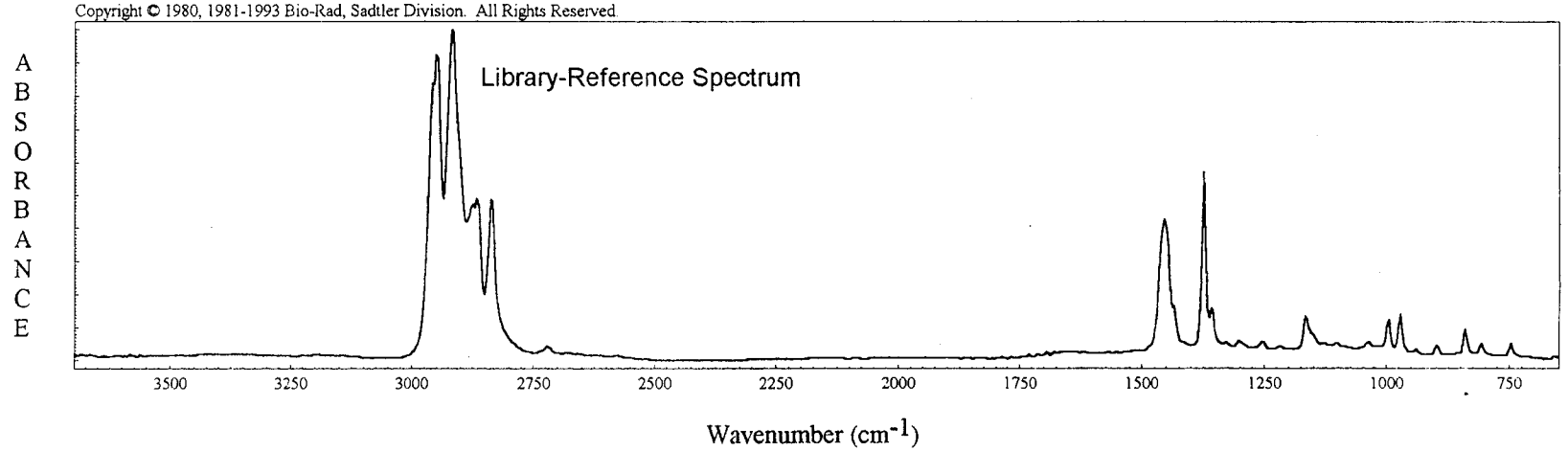
D11661 UNIPOL PP 6C20 POLYPROPYLENE RANDOM COPOLYMER

Technique: FILM (CAST FROM o-DICHLOROBENZENE)
Source of Sample: SHELL CHEMICAL COMPANY
Melting Point: 149C
Density: (23C) 895 KG/M^3
Tensile Strength: (YIELD) 26 MPA
Elongation: (YIELD) 11%
Hardness: (ROCKWELL) R80
Comments: Chemical Description: POLYPROPYLENE RANDOM COPOLYMER
Viscosity Data: Melt Flow Rate: 2.0 G/10 MIN

Fig. 16a

AF1694S7.SPA





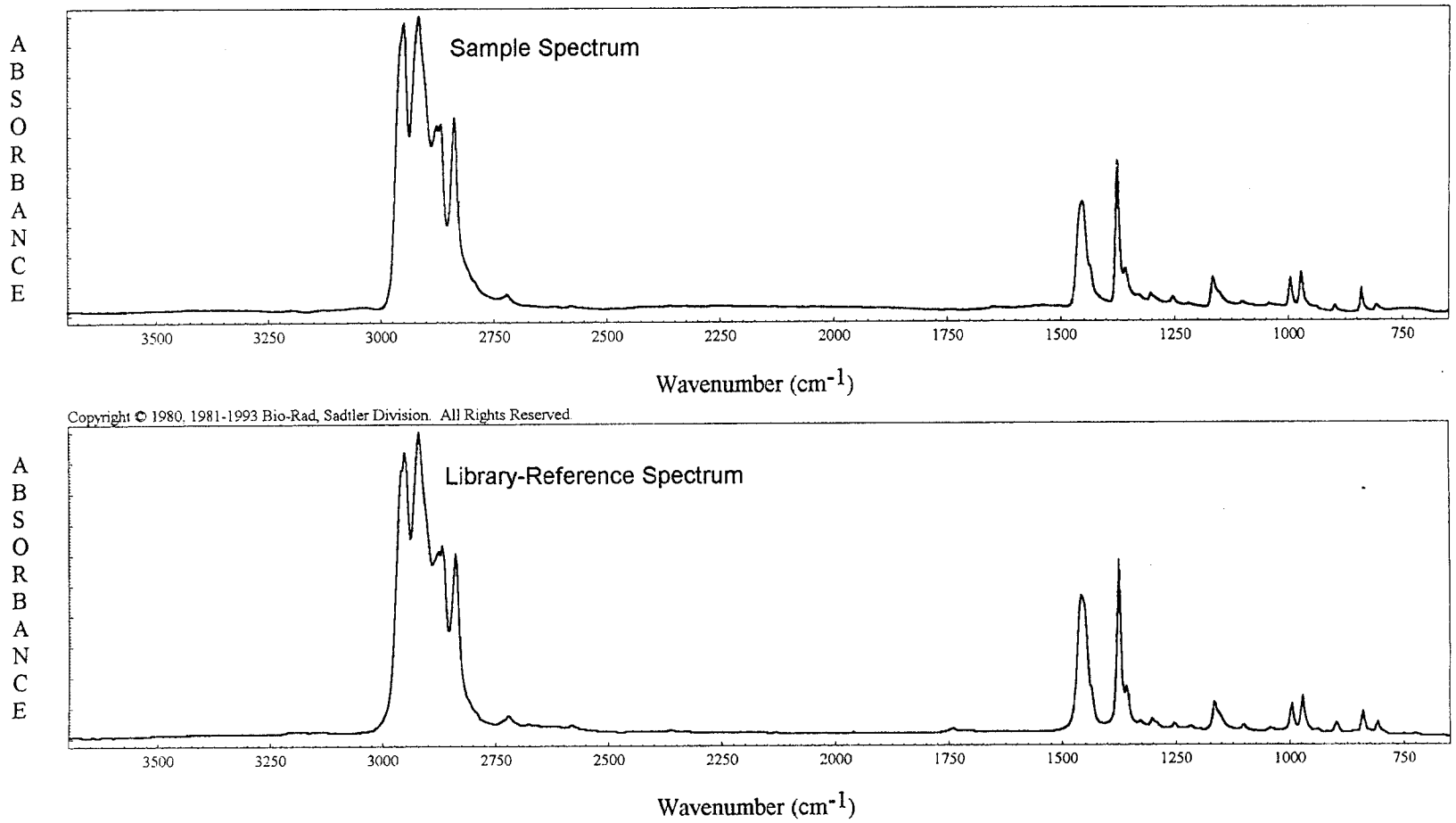
D11659 UNIPOL PP 5C08 POLYPROPYLENE HOMOPOLYMER

Technique: FILM (CAST FROM o-DICHLOROBENZENE)
Source of Sample: SHELL CHEMICAL COMPANY
Melting Point: 163-168C
Density: (23C) 903 KG/M^3
Tensile Strength: (YIELD) 34.5 MPA
Elongation: (YIELD) 10%
Hardness: (ROCKWELL) R97
Comments: Chemical Description: POLYPROPYLENE HOMOPOLYMER
Viscosity Data: Melt Flow Rate: 2.9 G/10 MIN

64

Fig. 16.

AF1694S7.SPA



HU5057 PROPYLENE-ETHYLENE COPOLYMER

Technique: FILM (CAST FROM o-DICHLOROBENZENE)
Spectrometer Recording Technique: DIGILAB FTS 15C
Source of Sample: SCHOLVEN-CHEMIE AG, GELSENKIRCHEN-BUER, GERMANY
Comments: HUMMEL/SCHOLL "INFRARED ANALYSIS OF POLYMERS, RESINS AND ADDITIVES, AN ATLAS" VOLUME 1 (1969); SPECTRL
Composition: PROPYLENE-ETHYLENE COPOLYMER (1% ETHYLENE)
Description: SATURATED LINEAR POLYHYDROCARBON
Classification: Hummel: POLYHYDROCARBON
Source of Spectrum: SRL
Use: THERMOPLASTIC MATERIAL

65

Fig. 16c

99

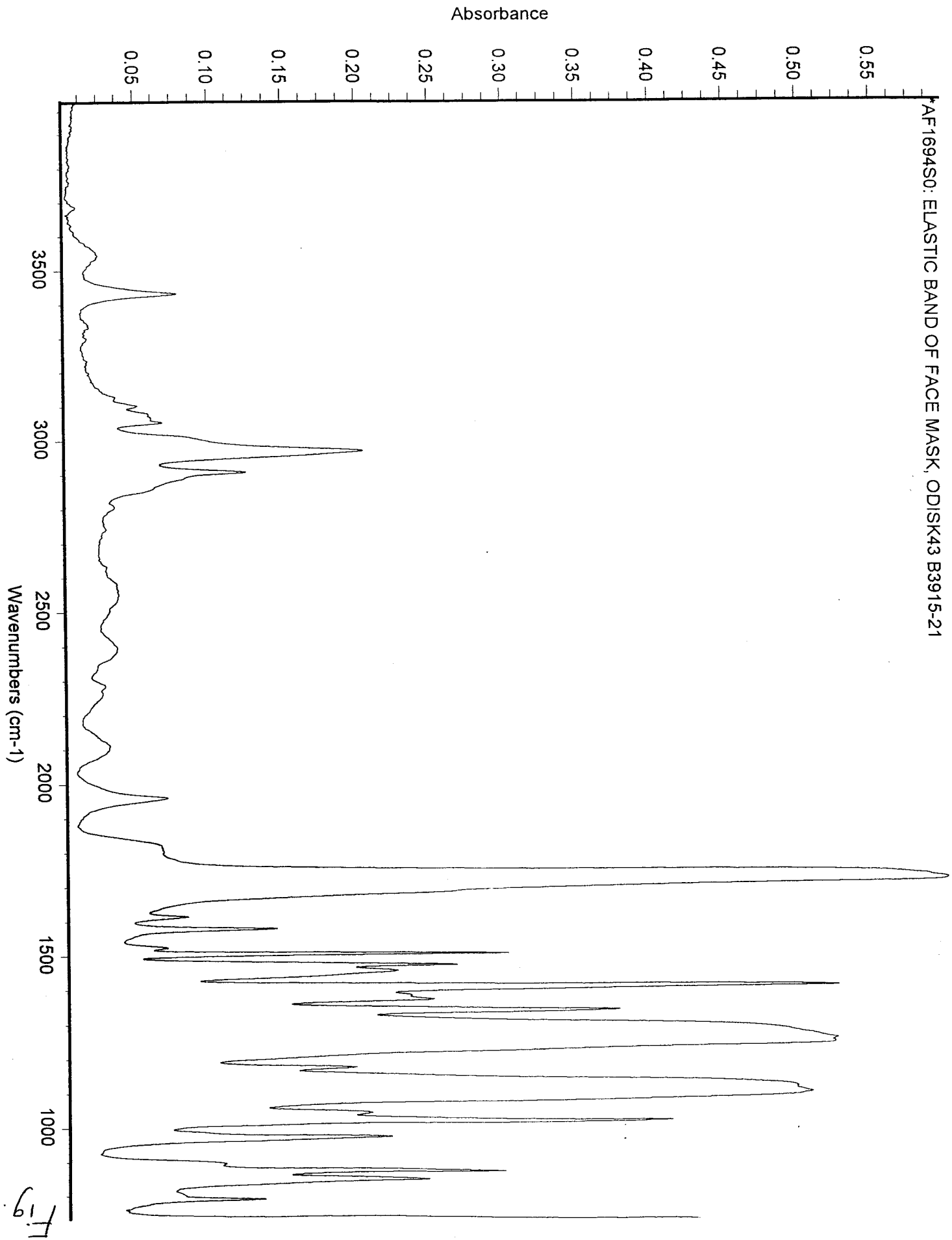
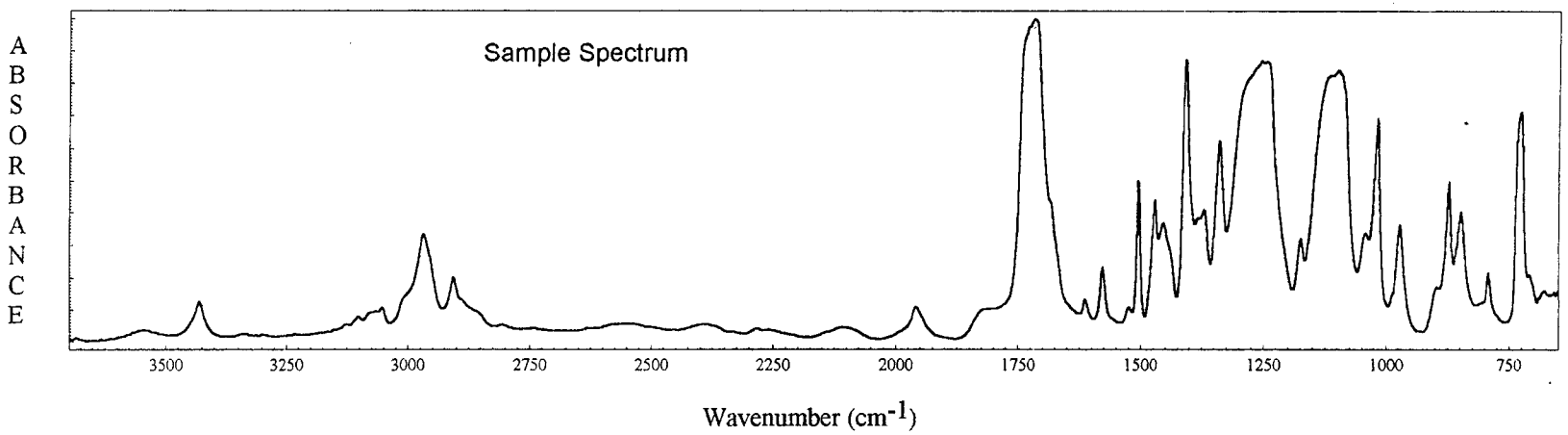
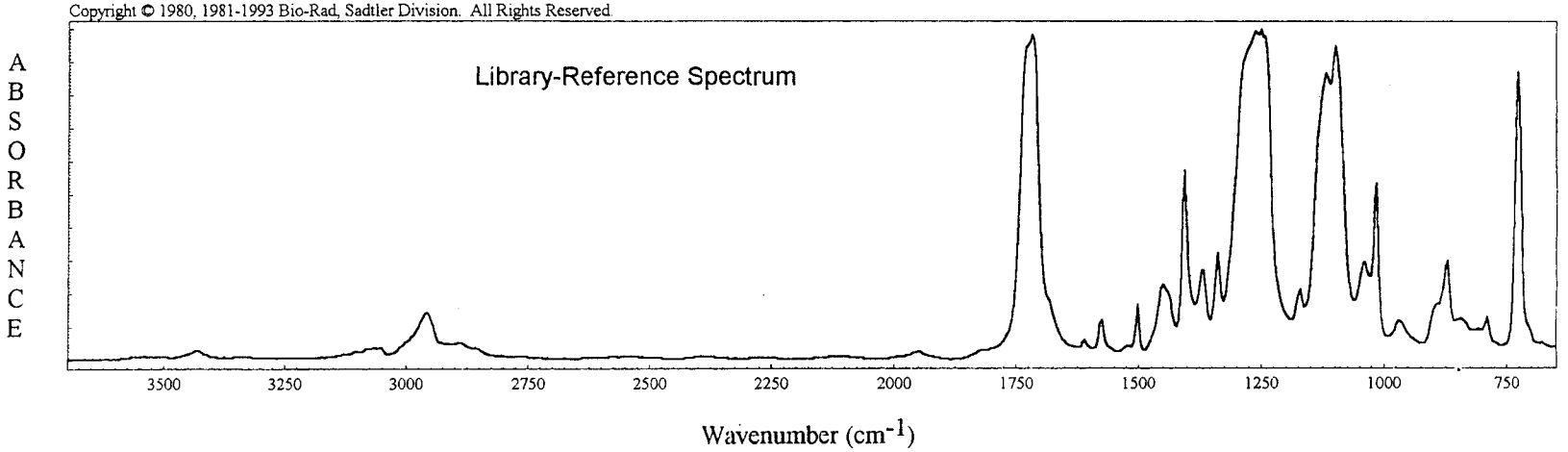

AF1694S0: ELASTIC BAND OF FACE MASK, ODISK43 B3915-21
Absorbance
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.55
3500
3000
2500
2000
1500
1000
Wavenumbers (cm-1)

Fig. 17

AF1694S0.SPA



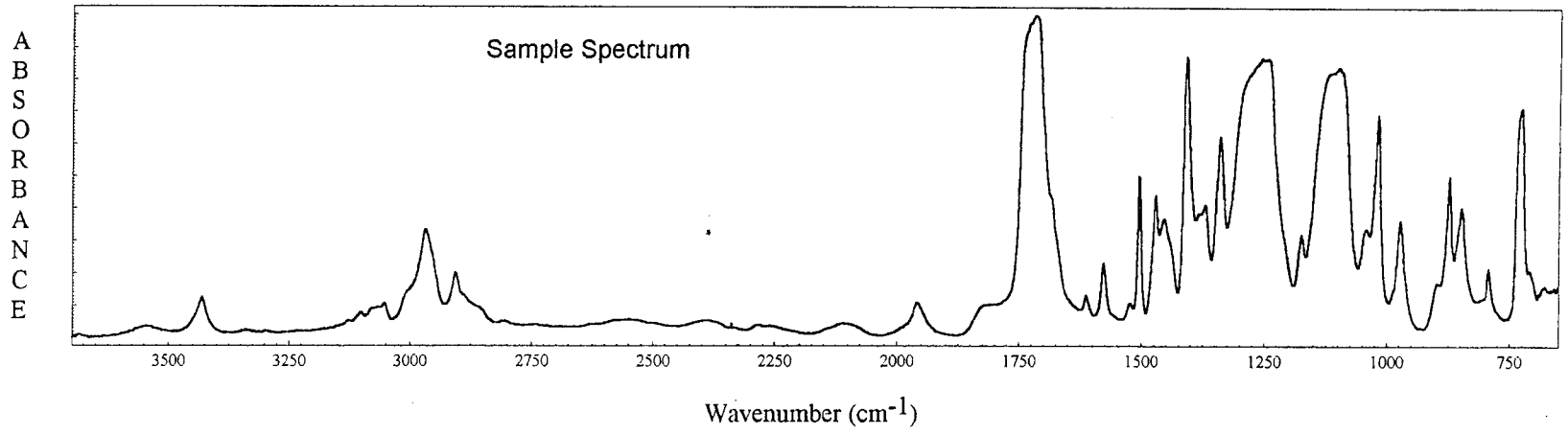


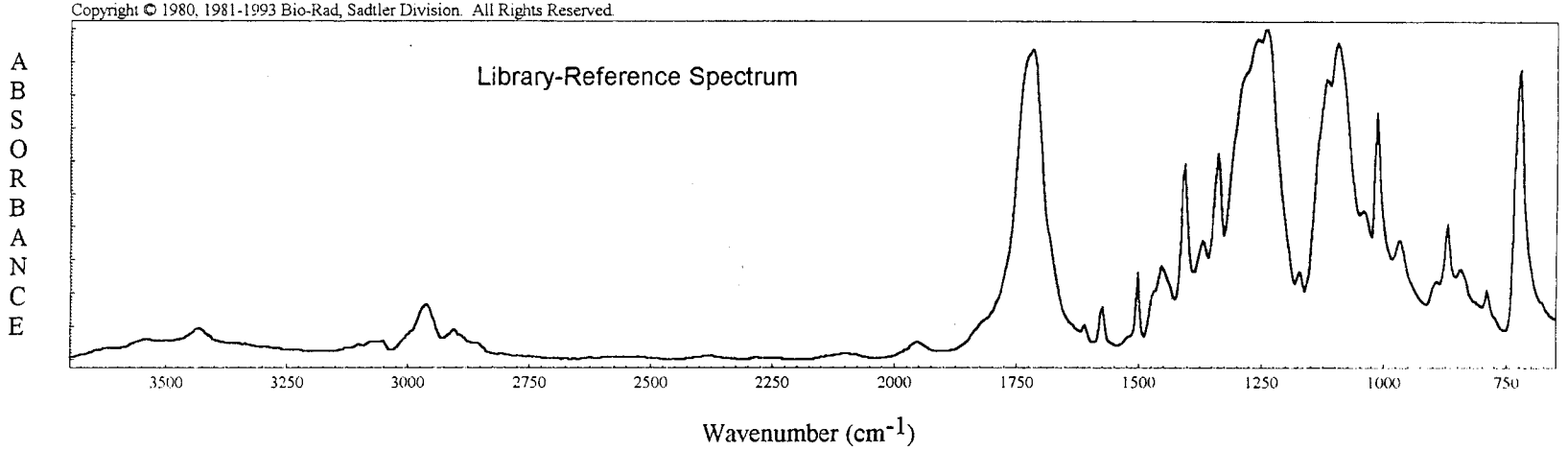
HU2091 TREVIRA CS, POLYMERIC RAW MATERIAL

Technique: FILM FROM THE MELT (20 MICROMETERS)
Spectrometer Recording Technique: PE 580 B, SMOOTH 2
Source of Sample: HOECHST AG, FRANKFURT/MAIN-HOECHST
Comments: V. FREUDENBERGER, F.JAKOB, ANGEW. MAKROMOL. CHEM. 105 (1982) 203...15
Physical Description: PALE GREY GRANULES
Chemical Description: POLY(ETHYLENE TEREPHTHALATE) MODIFIED WITH 2-METHYL-2,5-DIOXO-1,2-OXAPHOSPHOLANE
Classification: Hummel: 11(33.71221-842.)
Source of Spectrum: HUMMEL
Use: RAW MATERIAL FOR THE MANUFACTURE OF FLAME-RETARDING, POLYESTER FIBERS

Fig. 17a

AF1694S0.SPA





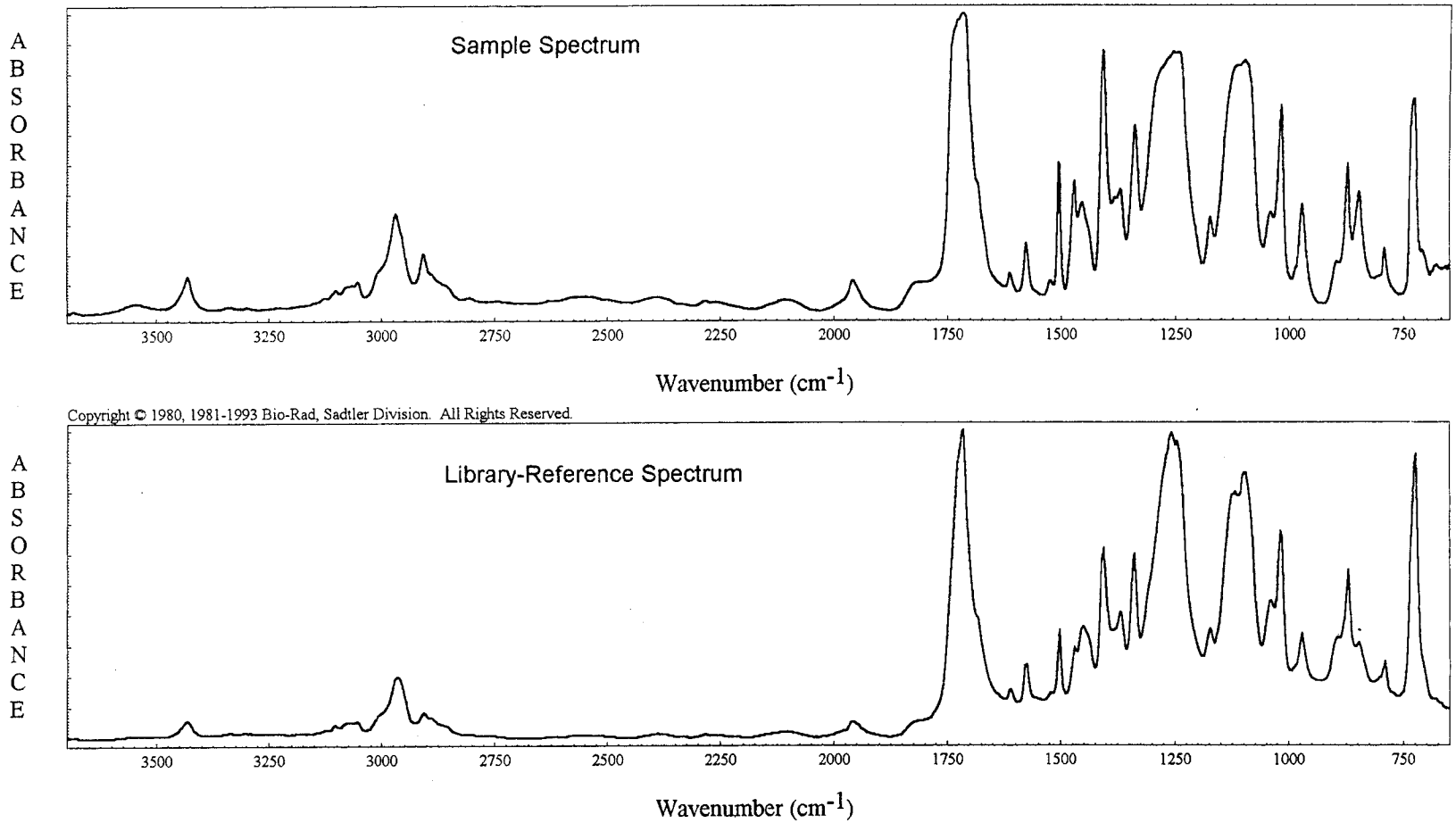
HU2261 DACRON

Technique: KBr (2.28/300)
Spectrometer Recording Technique: PE 580 B, FLAT, ABEX 1.59: WATER SUBTRACTED
Source of Sample: DU PONT, WILMINGTON, DELAWARE
Classification: Hummel: 1233.71221
Comments: Physical Description: WHITE, SILKY FABRIC
Chemical Description: POLY(ETHYLENE TEREPHTHALATE), POLY(OXYETHYLENEOXYTEREPHTHALOYL)
Source of Spectrum: HUMMEL
Molecular Formula: C.10.H.8.O.4.

68

Fig. 176

AF1694S0.SPA



HU2088 ARNITE AV 4-340 NATURAL

Technique: FILM FROM THE MELT (38 MICROMETERS)
Spectrometer Recording Technique: PE 580 B, FLAT, SMOOTH 2
Source of Sample: AKZO PLASTICS, ARNHEM
Classification: Hummel: 1133.71221+19.172
Comments: Physical Description: BEIGE-COLORED GRANULES
Chemical Description: THERMOPLASTIC POLYESTER BASED ON POLY(ETHYLENE TEREPHTHALATE) WITH 20% GLASS FIBER
Source of Spectrum: HUMMEL
Use: FOR DIMENSIONALLY STABLE, INJECTION-MOLDED, TECHNICAL ARTICLES

Fig 1.