This is to certify that the

thesis entitled

DEVELOPMENT OF A COMPREHENSIVE ADHESIVE SPECTRAL

LIBRARY - CYANOACRYLATE GLUES

presented by

Stephen G. Borowski

has been accepted towards fulfillment
of the requirements for

Master of Science degree in Criminal Justice with Specialization in Forensic Science

Jay Siegel
Major professor

Date 4/20/00

DEVELOPMENT OF A COMPREHENSIVE ADHESIVE SPECTRAL LIBRARY - CYANOACRYLATE GLUES

By

Stephen G. Borowski

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

School of Criminal Justice

2000

ABSTRACT

DEVELOPMENT OF A COMPREHENSIVE ADHESIVE SPECTRAL LIBRARY - CYANOACRYLATE GLUES

By

Stephen G. Borowski

Adhesive-type evidence can appear in a variety of forensic science cases ranging from postal fraud, product tampering, and to certain cases involving homicide. In such cases, a comprehensive library composed of adhesive spectra collected by Fourier transform infrared (FTIR) spectrophotometry would aid the forensic scientist analyzing such evidence. The purpose of this research was to focus on the individual adhesive class of cyanoacrylate glues, or "super glues." Fifty cyanoacrylate glue spectra were collected and entered into a spectral library. A test of the library was then performed to demonstrate the practicality of such a database. The test showed that, despite the similarities between cyanoacrylate glue spectra, individual samples could be identified.

I would like to dedicate this to my Parents, my wife Susan, and to Amy. Their support and encouragement over the years have helped me during my time at MSU more than they will ever know.

ACKNOWLEDGMENTS

I would like to thank Dr. Jay Siegel, my professor and advisor at Michigan State University for his assistance and guidance through the Forensic Science Master's program. I would also like to thank Mindy Ferguson for her invaluable assistance and hard work on this project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AES - Auger Electron Spectroscopy

ATR - Attenuated Total Reflection

FTIR - Fourier Transform Infrared

FTMS - Fourier Transform Mass Spectroscopy

IR - Infrared

KBr - potassium bromide

PGC - Pyrolysis-Gas chromatography

XPS - Photo-electron Spectroscopy

INTRODUCTION

Spectral libraries serve as an important part in forensic science today. There are numerous libraries in existence, but none have exclusively dealt with adhesive compounds. In order to accomplish this, fifty cyanoacrylate FTIR spectra were collected and put into a spectral library. These spectra would act as a starting point for the addition of other adhesive types in the hopes that a comprehensive, searchable adhesive database might be created to better aid the forensic community.

Forensic science laboratories handle a myriad of cases everyday, ranging from product tampering to complex homicide cases. In each instance, the evidence submitted for analysis is often as unique as the case itself, and each piece of evidence must be looked at individually in order to try to create a "whole picture" of what might have transpired. In order to do this, today's forensic scientist must call upon a wide array of resources and techniques to provide as much information as possible.

Forensic scientists often rely on instrumental analysis to provide a better understanding of the evidence in question. One of the most powerful instruments used in the analysis of chemical compounds is a Fourier transform infrared spectrophotometer. This instrument makes use of an analytical technique know as Fourier transform infrared (FTIR) spectrophotometry. The FTIR spectrophotometer works in conjunction with a computer and specially designed software. An infrared source in the instrument is used to give off an infrared beam of light, which passes through a given sample. The sample will absorb certain portions of the light depending on its chemical nature. The light transmitted by the sample is then detected by the instrument. This is repeated over a set number of scans, and the information is fed into the attached computer. The software then displays the spectrum of the sample being analyzed.

The spectrum serves a very useful function in the analysis of chemical compounds. Depending on the chemical composition of the evidence in question, the FTIR spectrum can give a chemical profile of the substance based on its spectral peaks. With this in mind, a forensic scientist can use the information generated in a sample's profile to determine the nature, and quite often, the identity of the evidence in question. One of the most powerful ways to do this is through the creation and use of a spectral library.

A spectral library is a collection of spectra obtained under controlled conditions. These spectra are usually in database form and can be easily searched using FTIR software. Spectral databases are widely used in the analysis of drug, accelerant, and fiber evidence. Many of these databases can be commercially purchased for use in forensic science laboratories. The spectrum of the evidence in question can be run against a spectral library, and the computer will attempt to find the entries that appear the most similar, usually giving a "match percentage." While a search against a spectral library may not give one hundred percent accuracy, it can be a powerful tool in helping to identify or exclude evidence being analyzed.

In 1997, Jeffrey Kindig published a thesis based on his research in creating a spectral library of adhesives (1). Kindig used FTIR spectrophotometry to evaluate a variety of commercially available adhesive types. The term adhesive was used very broadly and defined as "any material used to fasten one thing to another." In his work, Kindig produced spectra of various adhesive classes including cyanoacrylate glues ("super glues"), hide glues, glue sticks, cements, and silicone-type adhesives. Kindig's paper served as the basis for the research presented in this thesis.

In light of results produced by Jeffrey Kindig, Michigan State University's School of Criminal Justice decided to create a comprehensive database of adhesive spectra. To facilitate this, MSU entered into a contract with Nicolet Instrument Corporation - "Nicolet." In the agreement, Michigan State would produce digital spectra of various classes of adhesives using FTIR spectrophotometry. Nicolet, in turn, would receive these spectra and incorporate them into a complete, searchable spectral library available to forensic and industrial laboratories. Once complete, this would be the first comprehensive database of commercial and industrial adhesives available.

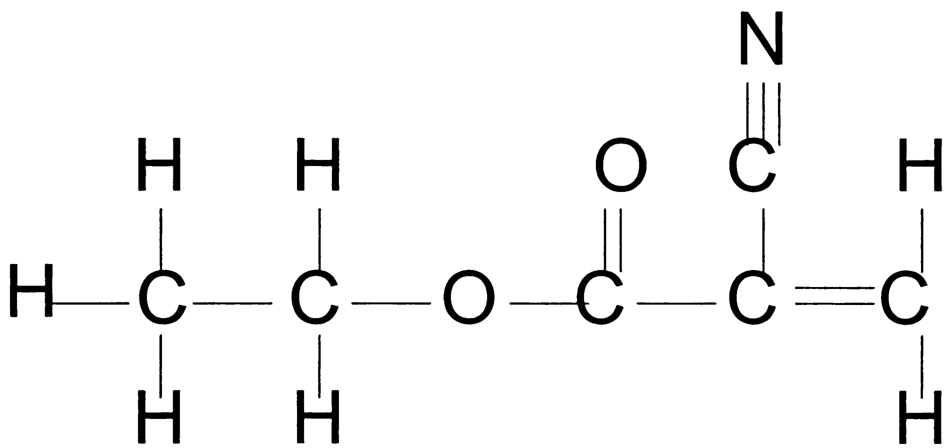
The availability of a searchable adhesive library has numerous applications in the area of forensic science. Evidence involving adhesives can come into question in a wide variety of cases. Evidence involving glues can be submitted in cases of postal fraud, product tampering, and product counterfeiting. Cases involving industrial-type tape adhesives can range from drug packaging evidence to duct-tapes possibly used in abduction or homicide cases. Adhesives are so prevalent in our everyday life, that evidence involving adhesive tapes or "post-it note™" adhesives may be vital in cases of questioned document analysis.

For this research, the area of cyanoacrylate glue analysis was chosen. Cyanoacrylate glue adhesives all have ethyl-2-cyanoacrylate, or some derivative of it as their active ingredient. When exposed to hydroxyl ions found in atmospheric moisture, the double bond between the carbon atoms in the Ethyl-2-cyanoacrylate polymerizes. Because of this, the double bonds become single bonds which act to link long chains together, forming a hard, acrylic plastic (2). The chemical reactions are shown in Figures A and B. Because cyanoacrylate glues are such popular and effective adhesives, they provide a logical starting point in the creation of the adhesives database.

Cyanoacrylate glues may turn up as evidence in any number of crimes. In cases of postal fraud or product tampering, these glues would seem the logical choice due to ease of drying and clear color. Because of the wide array of surfaces to which cyanoacrylate glue easily binds, the opportunities for its use in any number of crimes are limited only by the imagination. Also, cyanoacrylate is used in the application of artificial finger nails, and cyanoacrylate glue samples may come into play in crimes where fingernail evidence may be left behind, such as in certain cases of assault or homicide.

The easy availability and accessibility of cyanoacrylate glues in virtually any retail store also made commercially purchased cyanoacrylate glues a good choice for analysis. Because most crimes involving adhesive-type evidence would be perpetrated by individuals without access to industrial adhesives, most

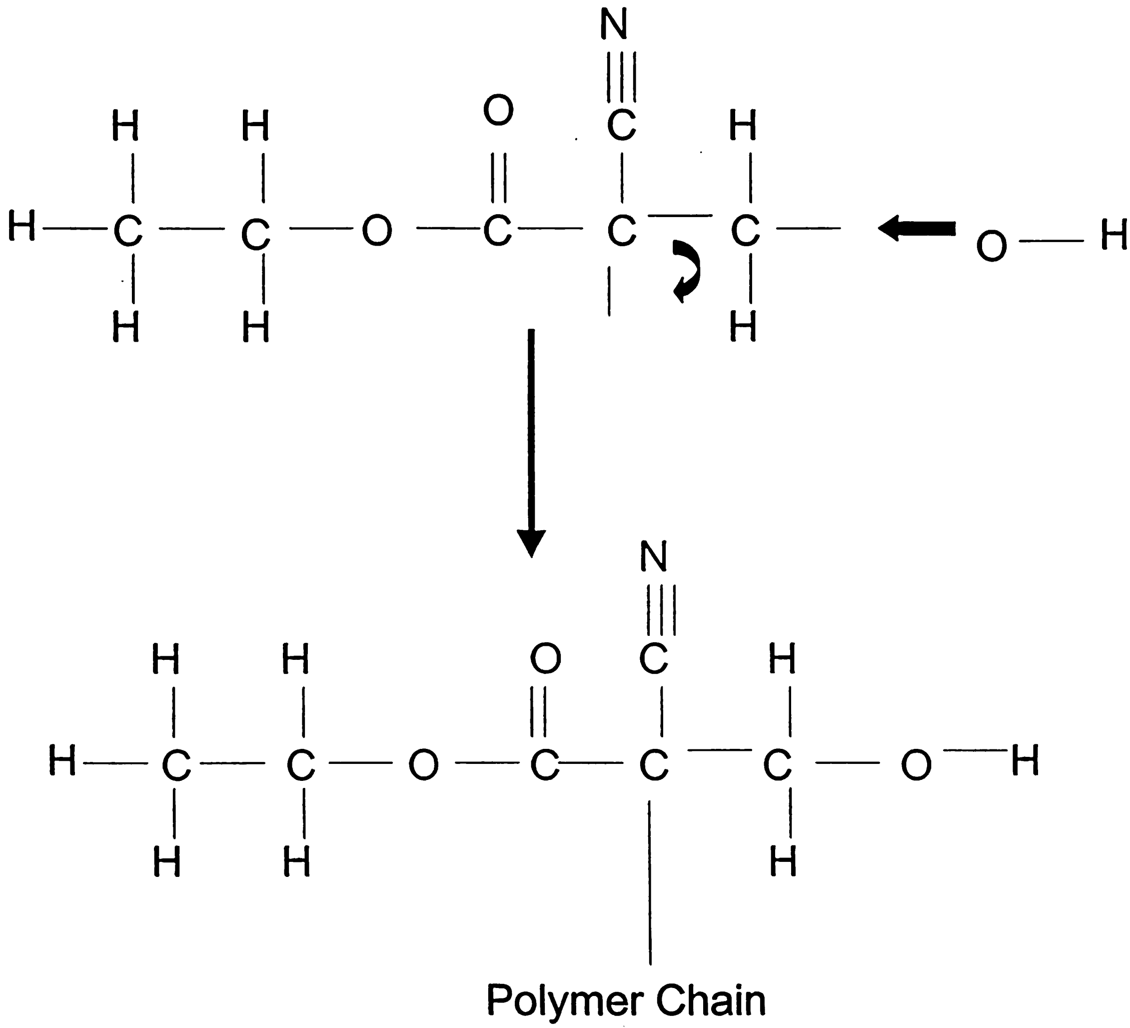
FIGURE A



Ethyl-2-Cyanoacrylate

Hydroxyl Ion

FIGURE B



of the samples analyzed in this research were purchased from various stores in the local area. Several different types of cyanoacrylate glues were examined, including cyanoacrylate glue liquids, cyanoacrylate "gels," finger nail glues, and specialized cyanoacrylate glues for wood. A complete listing of the glues analyzed in this thesis is seen in Table 1.

Table 1

Sample	Slide	Common Name	Collected	Dried
1	A	Instant Krazy Glue - Skin Guard Formula	10/19/99	9/15/99
2	B	Future Glue Instant Thick Gel	10/29/99	10/23/99
3	C	Quick Tite Super Glue	10/23/99	9/15/99
4	D	Quick Tite Super Glue Gel	11/8/99	10/23/99
5	E	Pacer Tech. "High Performance" Future Glue	11/4/99	10/23/99
6	F	Duro Quick Gel	10/20/99	8/16/99
7	G	Permatex Super Glue	10/20/99	8/16/99
8	H	Loctite Plastix - Bonding Agent	10/23/99	8/16/99
9	I	Loctite Brush-on Instant Wood Glue	10/23/99	8/16/99
10	J	Instant Krazy Glue - All Purpose	11/3/99	10/23/99
11	K	Duro Super Glue	11/4/99	10/23/99
12	L	Super Glue for Leather and Wood	10/29/99	10/23/99
13	M	Ross Super Glue	11/5/99	10/23/99
14	N	Power Poxy Super Glue	11/12/99	10/23/99
15	O	Meijer Super Glue (Kwik-Fix)	12/3/99	10/23/99
16	P	Meijer Super Glue Gel	11/3/99	10/23/99
17	Q	Duro Super Glue 5	10/29/99	8/24/99
18	R	Bondini-2	10/15/99	8/24/99
19	S	Power Poxy Nail Art Brush-on Super Glue	10/27/99	8/24/99
20	T	Super Glue	10/23/99	8/27/99
21	U	Thick Gel Super Glue	11/10/99	10/23/99
22	V	Elmers Super Glue	11/17/99	11/4/99
23	W	Elmers Wonder Bond Plus Super Glue	10/29/99	8/27/99
24	X	Cran High Performance Future Glue	10/23/99	8/27/99
25	Y	Super Bonder Super Glue	10/21/99	8/27/99
26	Z	Instant Krazy Glue Gel	11/3/99	9/3/99
27	AA	Instant Krazy Glue Advanced Formula Gel	11/10/99	11/4/99
28	BB	Sally Hansen Hypo-Allergenic Nail Glue	10/19/99	9/3/99
29	CC	Jonel Fast Setting Nail Glue	11/10/99	11/4/99
30	DD	Sally Hansen Professional Gel Glue	11/12/99	11/4/99
31	EE	Nail Fetish Brush-on Nail Glue	10/19/99	9/3/99
32	FF	5 Second Nail Glue	10/22/99	9/3/99
33	GG	Loctite 414	10/22/99	9/8/99
34	HH	Nailene Nail Glue (Super Glue)	10/23/99	9/8/99
35	II	Jonel Instant Nail Glue	10/23/99	9/8/99
36	JJ	Professional Solutions Fix-a-Nail Brush-on Glue	10/21/99	9/8/99
37	KK	Loctite 495 Instant Adhesive	11/12/99	11/4/99
38	LL	Sally Hansen Superhold Nail Glue	11/1/99	9/14/99
39	MM	Nailene Professional Nail Glue	11/10/99	11/4/99
40	NN	Kiss Professional Nail Glue	10/23/99	9/15/99
41	OO	Cosmar Ultra-Bond Nail Glue	11/17/99	9/15/99
42	PP	Loctite Hard Evidence	11/19/99	11/4/99
43	QQ	Permatex Super Glue Gel	11/15/99	9/22/99
44	RR	Instant Krazy Glue - Wood Formula	10/27/99	9/22/99
45	SS	Lee Instant Nail Glue	10/21/99	9/22/99
46	TT	Nailene Ultra Quick Nail Glue	11/1/99	9/22/99
47	UU	Sally Hansen 2000 lb Professional Strength Nail Glue	11/8/99	9/22/99
48	VV	Fing'rs Instant Nail Glue	10/27/99	9/22/99
49	WW	Pro 10 Quick Tite Super Glue for Nails	10/23/99	9/22/99
50	XX	Pro 10 Professional Nail Glue	11/15/99	9/22/99

REVIEW OF LITERATURE

Several articles have dealt with the analysis of adhesives through a variety of methods. Pyrolysis-gas chromatography (PGC) has been one such method used in the past to analyze adhesive-class evidence (3,4). One other method mentioned in a paper was the use of "size exclusion chromatography" to detect traces of nitrocellulose (5). This may sometimes be found in trace amounts among some adhesives. Electrically conductive adhesives have also been analyzed utilizing methods of Fourier transform mass spectroscopy pyrolysis (FTMS), Auger electron spectroscopy (AES), and photo-electron spectroscopy (XPS) (6).

Many papers have mentioned FTIR spectrophotometry, or some derivation of it, in the analysis of adhesives as well. FTIR has been used to analyze adhesives found on the backs of stamps (7, 8), anaerobic sealants and adhesives (9), toners and adhesives (10), and adhesives found in packaging materials (11, 12). Attenuated total reflection Fourier transform infrared spectrophotometry (ATR FTIR) has been utilized in the analysis of water-based adhesives (13) and surface regions of various adhesives, sealants, and coatings (14). Adhesives have also been analyzed through a method using FTIR-Raman spectroscopy (15).

Two articles have specifically dealt with the topics of IR and adhesive analysis. The first of these appeared in 1966 and utilized a variety of analytical methods, including spot tests, chromatography, PGC, along with IR to examine, and successfully distinguish adhesive classes (16). In 1974, a paper was published that analyzed 179 commercial adhesives using both IR and PGC in an attempt to differentiate them from one another (17). In both of these studies, the adhesives examined were distinguishable, but were not subject to Fourier transform or computer library searching. This lead the way to Jeffery Kindig's thesis, which, as mentioned before, served as the basis for this thesis.

MATERIALS AND METHODS

Fifty commercial cyanoacrylate glues were purchased for this research. All samples were obtained from local drug stores, hardware stores, or department stores. Most of the samples purchased were name brand samples and should be easily obtainable throughout the United States. As previously mentioned, samples ranged from general-purpose cyanoacrylate glues and gels to salon quality professional nail glues. In this paper, all samples will be referred to as "cyanoacrylate glues." A list of the glues and their drying dates is given in Table 1.

Individual samples were prepared by spreading the cyanoacrylate glue onto a clean, glass slide using a wooden applicator stick. The samples were air dried as thin as possible on the slide, both for ease of analysis and to simulate actual usage of the glue. Dried samples were used because, more often than not, cyanoacrylate glue evidence would appear in a lab in a dried form, and because a dry sample was much more practical to work with than a "wet" sample. All slides were labeled with an alphabetic "sample letter" (A through XX) for identification. The samples were allowed to dry for at least two days, although it was determined that all samples were ready for analysis in less than 24 hours after they were prepared.

As mentioned before, when Jeffery Kindig produced his thesis results, he used a diamond anvil cell in conjunction with an infrared microscope. For this research, it was the original intention to use a diamond cell as well, especially given its effectiveness in analyzing small, pure samples. However, in the analysis of cyanoacrylate glues, it was intended to use the diamond cell as a stand alone accessory.

The instrument used for analysis of the cyanoacrylate glues was a Nicolet Model 460 "Protégé." OMNIC 5.1 software was used for data collection, spectral analysis, and library creation. For all samples, the parameters were set to 300 scans, with a resolution of 2. The final format for each sample was set to absorbance, and no corrections were made to the spectra saved. The spectra had absorbances ranging from .5 to 2.0.

As previously mentioned, it was the original intention of this project to use the diamond anvil cell to collect the spectra. This process produced spectra, but unfortunately did not produce the sharp peaks needed for an effective database. For some reason, peaks in the fingerprint region of the spectra appeared rounded. This was possibly due to the transparent, crystalline nature of cyanoacrylate glue, most likely allowing too much light to pass through the sample. This did not produce the quality of spectra useful for the adhesive database, and could possibly interfere with an effective spectral library search.

In order to more effectively produce quality spectra, a new method of preparing the samples was utilized. The samples were still dried on individual slides and allowed to sit for at least two days. Once dry, the cyanoacrylate glue was carefully scraped off the slide with a scalpel and mixed with dry potassium bromide (KBr). This mixture was then amalgamated in a Wig-L-Bug™

amalgamator, and the mixed sample was pressed into a potassium bromide pellet.

At the beginning of each day, an atmospheric reference spectrum was obtained in order to account for the levels of water and carbon dioxide present in the room. These reference scans consisted of 300 scans run with the bench cover open. The sample spectra were then obtained by running 300 scans of the background, which consisted of just the purged sample compartment. The sample KBr pellet was then placed in the compartment, where it was allowed to purge for five to ten minutes. 300 scans of the sample were then run and the background interferograms were automatically subtracted. This method produced much clearer, sharper peaks, and provided spectra of a much higher quality.

In order to account for any variations in spectra due to drying time, one of the samples was run several times over a twenty-day period. No significant variation in spectral peaks was observed. Also, one dried sample was run several times to test for reproducibility. As with the drying test, no significant variations were seen in the final spectra.

To test for variation among different batches, or "lots" of the same brand of cyanoacrylate, five "lot" samples were run. These samples consisted of five samples of the same cyanoacrylate brand, but originating from different tubes with different "lot" numbers. It was determined that there were essentially no discernible differences between the spectra produced by these samples.

In addition to the collection of the fifty spectra for the Nicolet database, ten test samples were run in order to test the practicality and usefulness of an exclusive cyanoacrylate glue spectral library. These samples were randomly chosen and prepared as described above. Fifty scans of the samples and their backgrounds were run and then saved to be compared to the saved fifty sample spectra. 50 scans were chosen because peak resolution was well defined, and, considering that all library samples were run at 300 scans, 50 scans would act to test the "minimal capabilities" of the library. The results of the ten “test” samples are described in the “Results and Discussion” section of this thesis.

RESULTS AND DISCUSSION

Once each spectrum was collected, it was assigned a file name and saved to submit to Nicolet. Information on each spectrum was then entered into a database to be sent along with the spectra. The database contained the following information: brand name of the sample, sample file name, atmospheric reference file name, date collected, manufacturer, contact information for the manufacturer, UPC code, re-order number of the glue, lot number, method of collection (which was a potassium bromide pellet in all cases), and active ingredient of the sample (some form of cyanoacrylate in all cases). All of this information allows for accurate identification of each sample, and may later prove very useful in study replication or when new cyanoacrylate glues and other adhesives are added to the database.

In addition to recording the information for Nicolet, a prototype library was internally created of the fifty cyanoacrylate glue samples. This was accomplished using the library manager applications available on the OMNIC software. Each sample spectrum was put into the library after adjusting the baseline using the "automatic baseline correct" option. The library was set up at a resolution of 2, with a spectral format of "absorbance." The wavenumber regions between 400 cm-1 and 4000 cm-1 were set as the frequency limits. All spectra can be found in APPENDIX A. This was the library used to run searches on the ten test spectra previously mentioned.

It should be noted that for many spectral libraries, the spectra are deresolved to a resolution of 4, 8, or sometimes 16 wavenumber resolution before being put into a database. This is often done in order to save space in the library. For this research, however, the resolution was kept at 2 due to the similar nature of the cyanoacrylate glue samples. To deresolve the samples would have made it nearly impossible to distinguish one sample from another in a library search.

Upon inspection of the fifty spectra, it can be seen that, for the most part, the cyanoacrylate glue samples are very similar. All show the most prominent peak at wavenumber of around 1750. All samples also show peak patterns in the 3000 area. Peaks are also found in the spectral fingerprint region between the wavenumbers of around 1600 to 700. This is to be expected due to the fact that all samples contain cyanoacrylate.

The samples analyzed in this research can essentially be divided into two categories - cyanoacrylate glues and cyanoacrylate glue gels. While all samples show similarities, the gel samples show much higher intensities in the 1400 to 1000 region. This is most likely due to additives in the product that create the more viscous properties of the gel. As seen in Appendix A, most of the gel samples exhibit very similar spectra, with only slight variations of peak intensity in the fingerprint region.

The cyanoacrylate glue samples, like the gel samples, are also very similar, but showing variation in the fingerprint region as well. These variations also consist of differences in peak intensity in the region of 1600 to 700. A noted exception, also seen in Kindig's research, is Sample - A, Instant Krazy Glue - Skin Guard Formula. In this sample, there is a characteristic peak at around 3000. This is most likely attributed to the ingredients in the product which prevent bonding to skin.

The ten test samples produced fairly good results considering the similar nature of the cyanoacrylate glue samples analyzed. Of the ten samples run, 3 hit as the first match in the database. Of those that did not match as number 1, many of the hits occurred within very small percentages of what the actual sample was. A complete listing of the test samples, their hit number, and their match percentages can be seen in Table 2. While this many not allow for a conclusive individualization of cyanoacrylate brands, it helps to include or exclude possible brands, and will certainly distinguish cyanoacrylate glues from another adhesive class.

TABLE 2

Sample Number	Slide Letter	Sample Name	"Hit" Number	Match Percentage	% off from Actual Sample
5	E	Pacer Tech "High Performance" Future Glue	3	98.36%	0.22%
13	M	Ross Super Glue	18	88.43%	3.47%
14	N	Power Poxy Super Glue	4	68.47%	17.86%
15	O	Meijer Super Glue (Kwik-Fix)	1	55.57%	0.00%
27	AA	Instant Krazy Glue Advanced Formula Gel	2	94.64%	0.56%
35	II	Jonel Instant Nail Glue	6	96.39%	1.23%
41	OO	Cosmar Ultra-Bond Nail Glue	1	84.14%	0.00%
42	PP	Loctite Hard Evidence	19	92.88%	5.77%
44	RR	Instant Krazy Glue - Wood Formula	6	96.91%	1.10%
48	VV	Fing'rs Instant Nail Glue	1	95.43%	0.00%
		Average	6.1	87.12%	3.02%

CONCLUSION

The forensic science value of a comprehensive adhesives database can clearly be demonstrated by the research performed on the category of cyanoacrylate glues. The creation and use of a spectral library consisting of only one type of adhesive, in this case cyanoacrylate-based glues, shows that such a tool has practical use in the analysis of adhesive evidence. Although many of the samples show very similar spectral patterns, tests of the database clearly show that, while there may not be an exact match every time, brands can sometimes be identified. Even when a library hit is wrong, it is, in most cases within less than 3 percent of the true sample.

It is possible that differences in absorbance among samples may account for some of the discrepancies in match percentage, especially considering the chemical similarities between the cyanoacrylate samples. This does not, however, negate the usefulness of the spectral library. This library can be used effectively to draw correlations among samples, not absolute conclusions. The information complied here can still be used as a powerful tool in evaluating the nature of adhesive evidence in question.

The results of this study also indicate that there is further cause to continue the creation of an adhesive database. More complex adhesives than those studied here may well prove to show much more variation among classifications. While cements and white glues may dry to the clear color of cyanoacrylate glues, their spectra are different from cyanoacrylate glues, and most likely have similar variations within their own adhesive type. Further additions to the database will allow for better forensic investigation of adhesive evidence by including or excluding possible glues or other evidence found at the scene. Adhesive class could be easily be determined, and, as demonstrated in this research, possible adhesive brand individualization.

The results of this cyanoacrylate glue research should prompt continued spectral collection of other adhesive classes. As mentioned previously, there are seemingly countless categories of adhesives, and a wide variety of brands within those categories. While a comprehensive library may never truly be complete, further research and additions to an adhesives database would give forensic scientists another powerful tool in forensic casework and lend more credibility to the evidentiary value of adhesive evidence.

There are also other avenues to pursue in adhesive research in general. Studies could easily be generated that deal with drying time of a variety of adhesives depending on solvent properties of the class of adhesive in question. While probably not a practical study in the arena of cyanoacrylate glues, this type of research may have some merit with glues and other adhesives that take a long time to dry. This has practical application in giving a possible time frame of when the adhesive evidence was applied. Studies could also be developed to test how contaminated samples may affect adhesive spectra.

In future adhesive research, other FTIR sampling techniques could also be evaluated. While using a diamond anvil cell in this particular study proved to be ineffective, it may be very practical in the analysis of other adhesive classes.

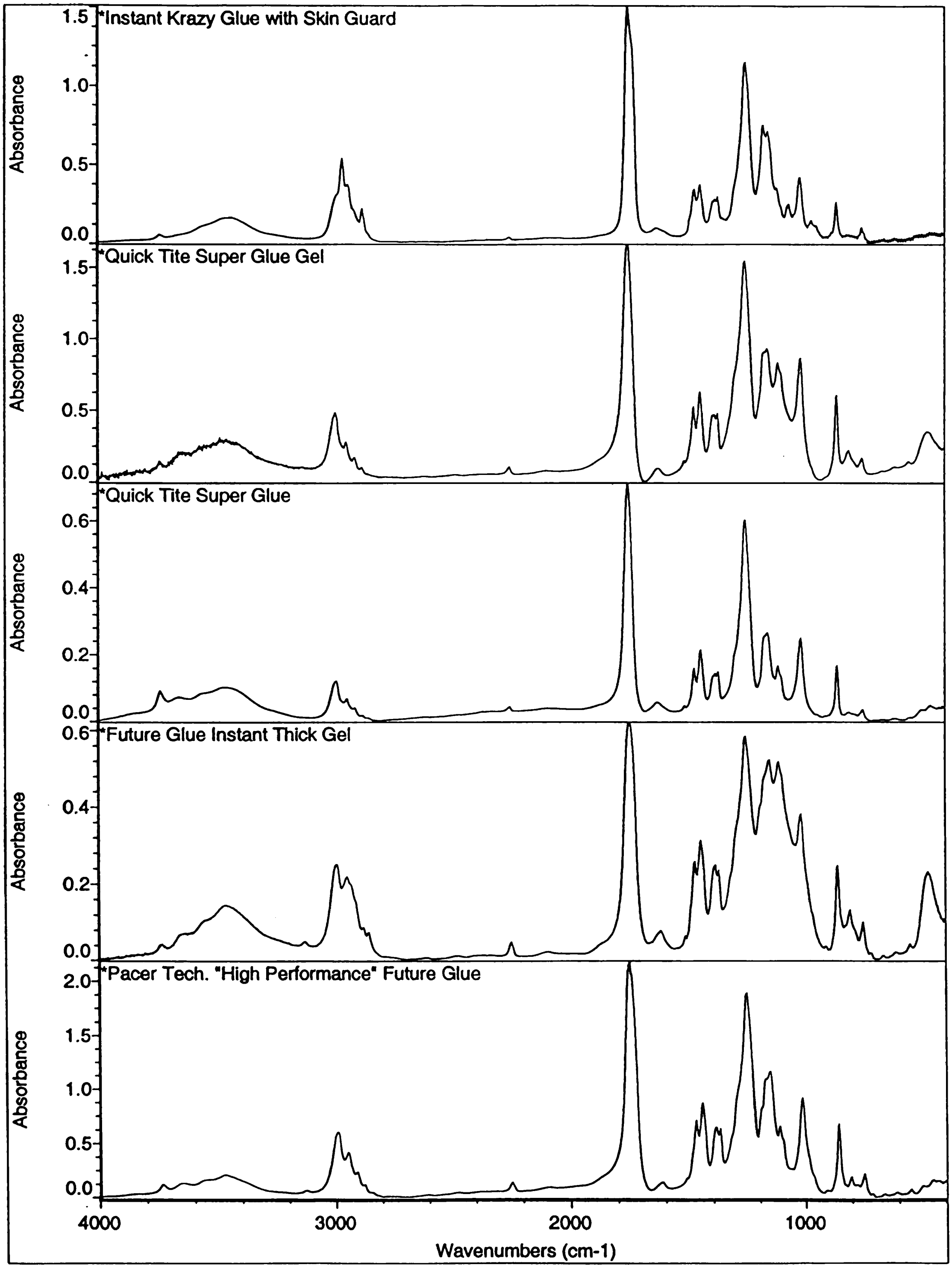
Kindig showed that an infrared microscope can be very effective, but further research may indicate better methods for analyzing various categories of adhesives to obtain FTIR spectra. Attenuated total reflectance (ATR) may be very useful for certain tapes and thin adhesive films on the surface of evidence.

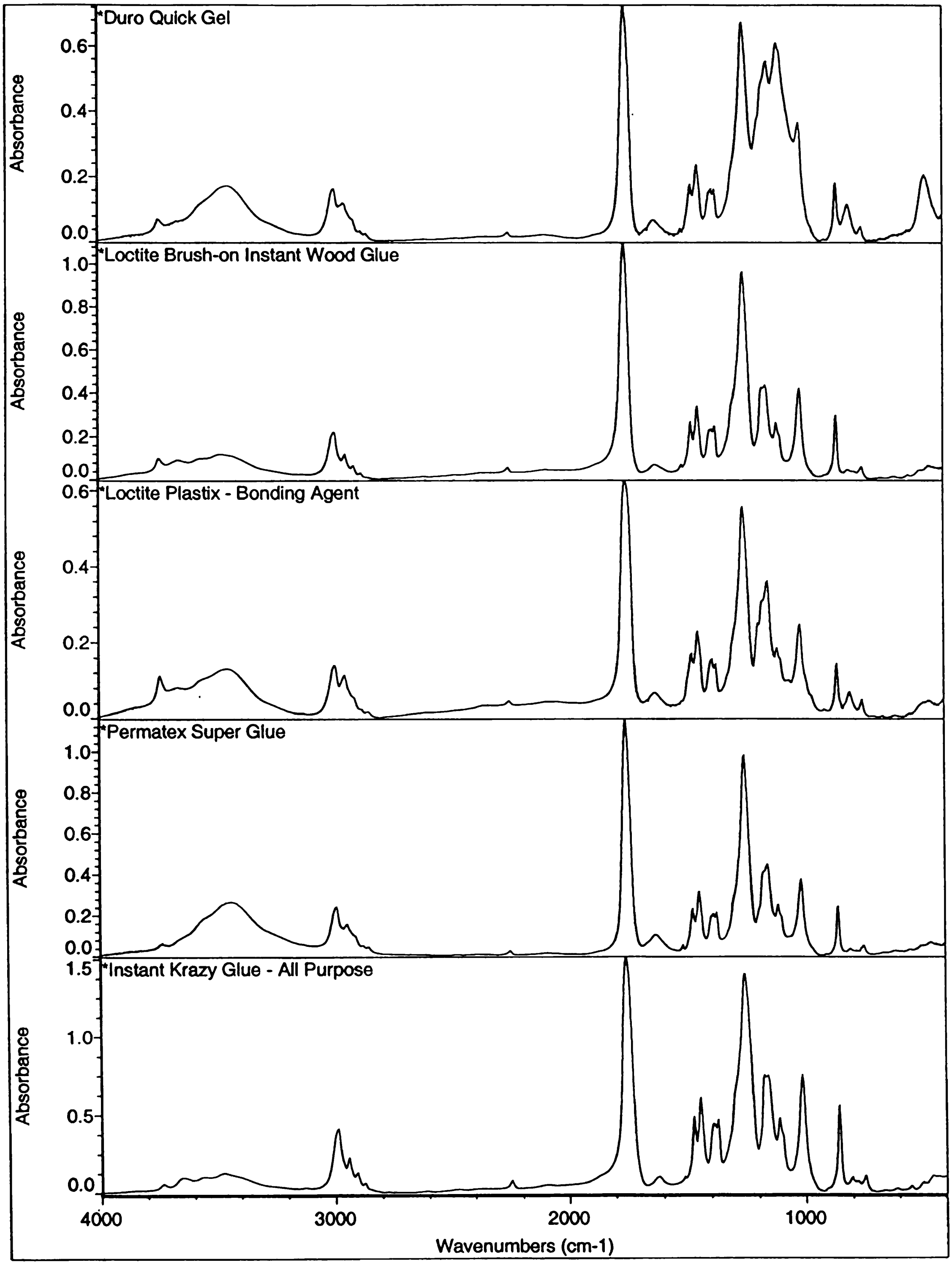
Finally, other instrumental methods of analysis could be used to evaluate adhesive evidence. Techniques such as Pyrolysis Gas Chromatography, and even GC-MS, could give valuable information about the composition of adhesive-class evidence. This could lead the way to other adhesive libraries and add more information to the body of knowledge concerning adhesive evidence.

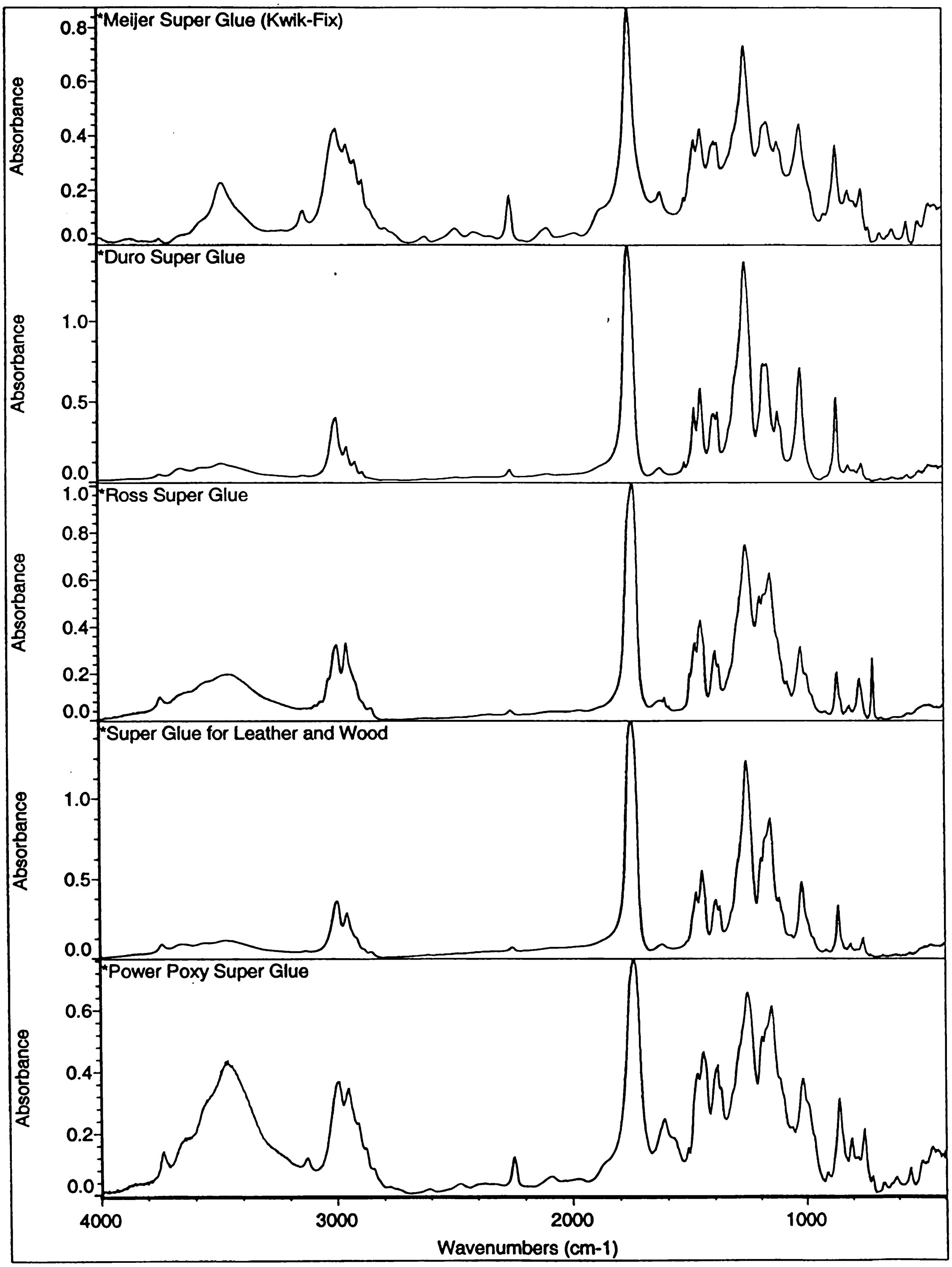
APPENDICES

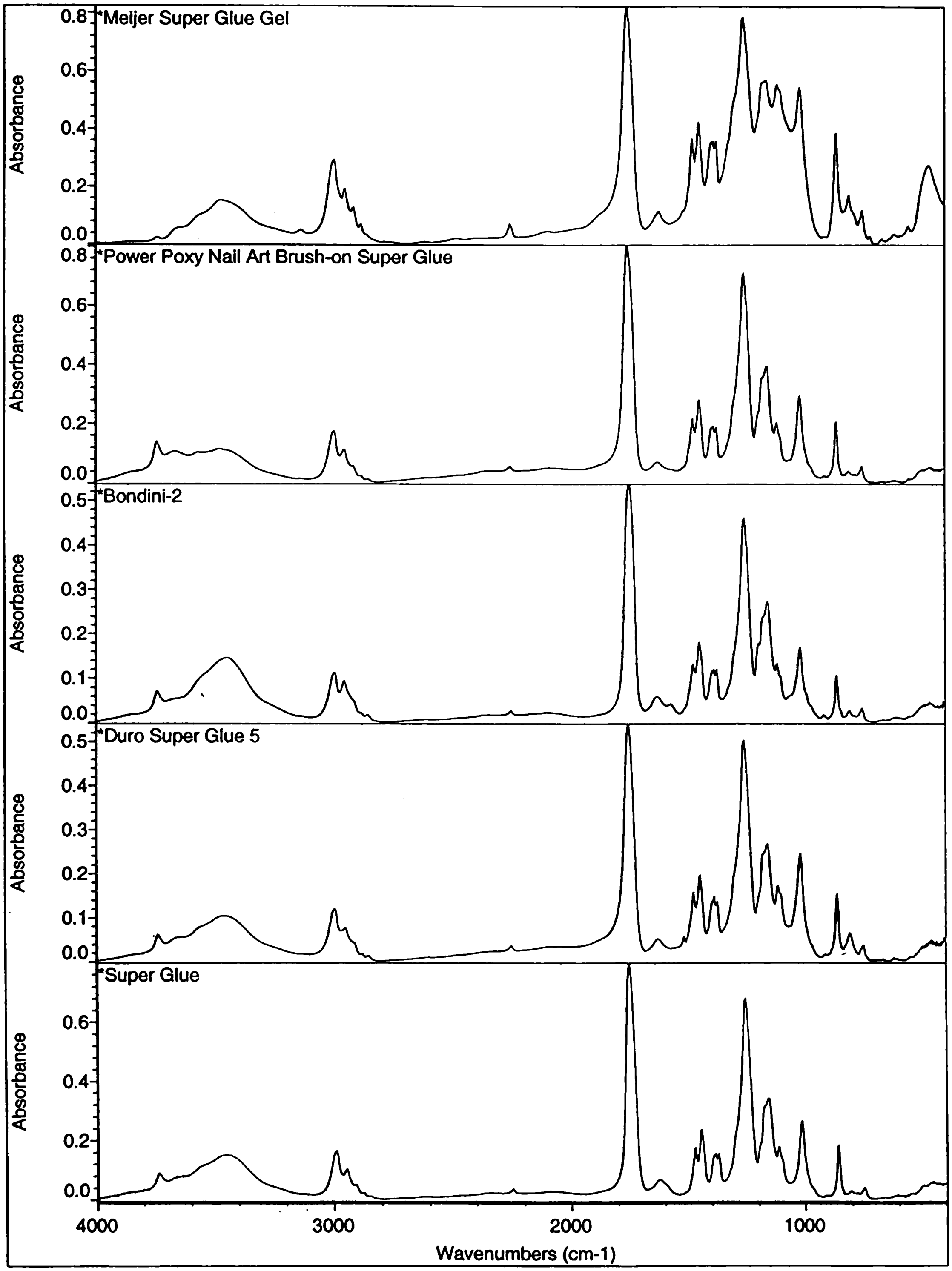
APPENDIX A

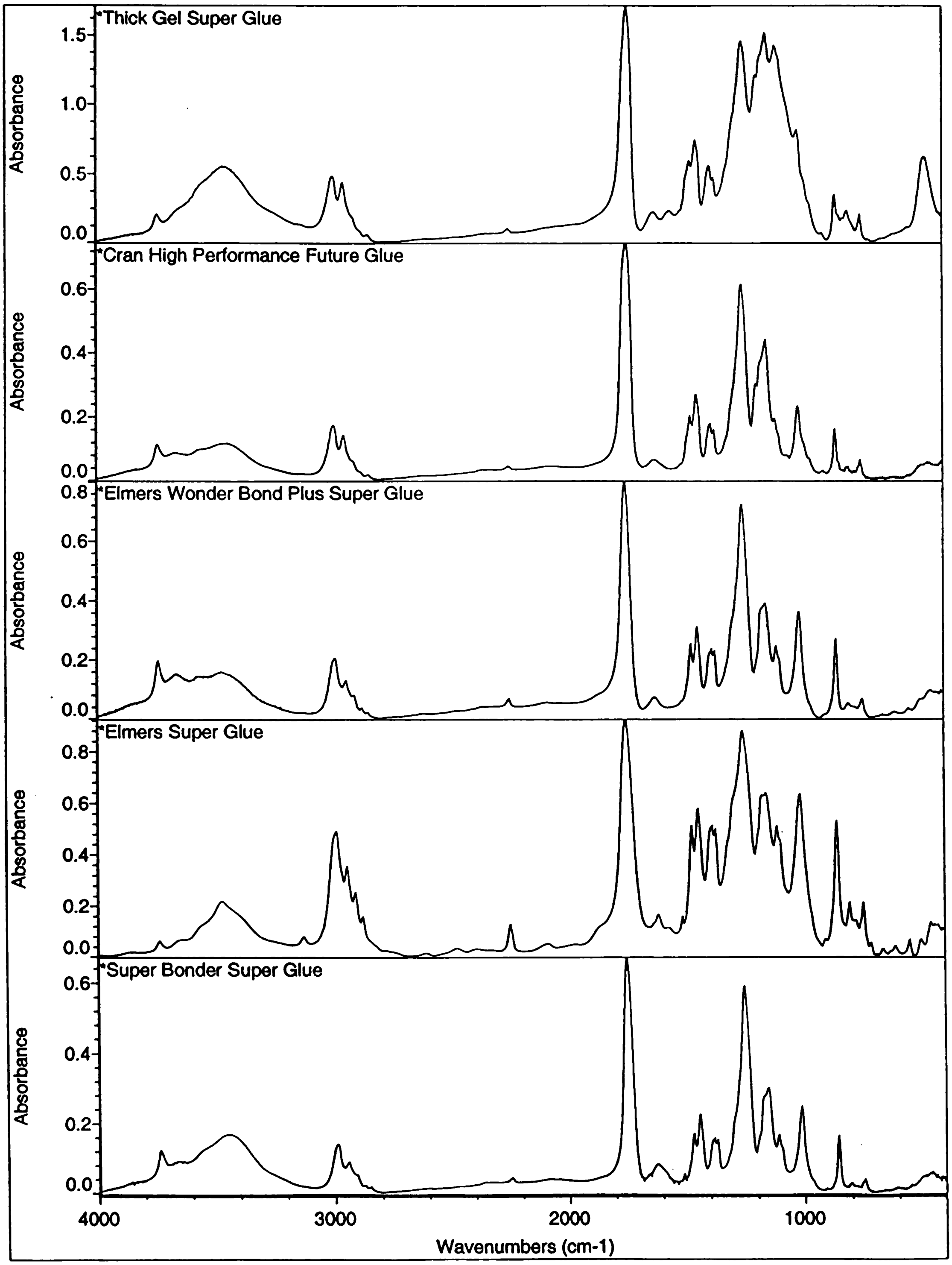
Cyanoacrylate Glue FTIR Spectra Included in the Library

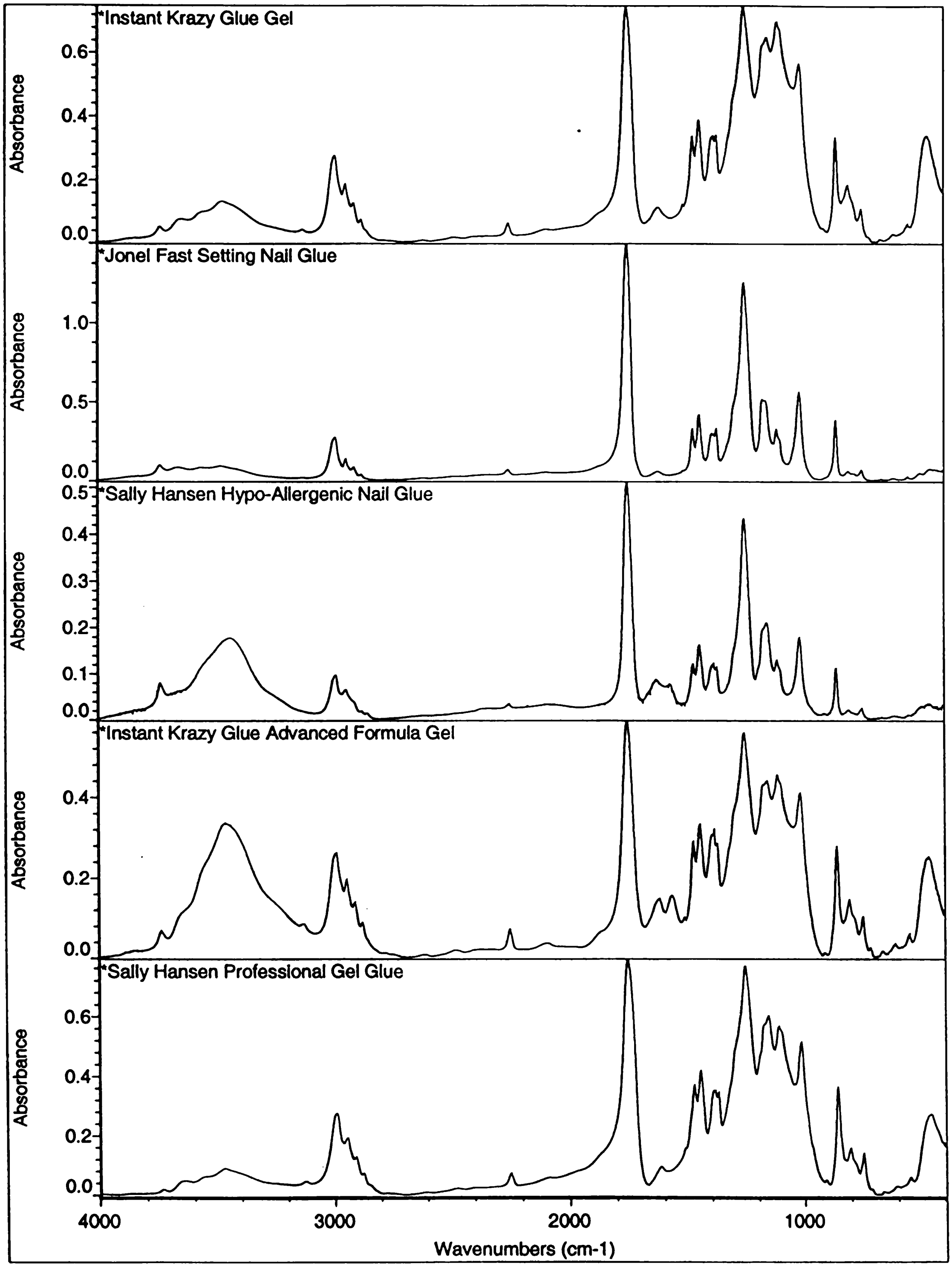

*Instant Krazy Glue with Skin Guard
*Quick Tite Super Glue Gel
*Quick Tite Super Glue
*Future Glue Instant Thick Gel
*Pacer Tech. "High Performance" Future Glue
Absorbance
Wavenumbers (cm-1)
4000
3000
2000
1000

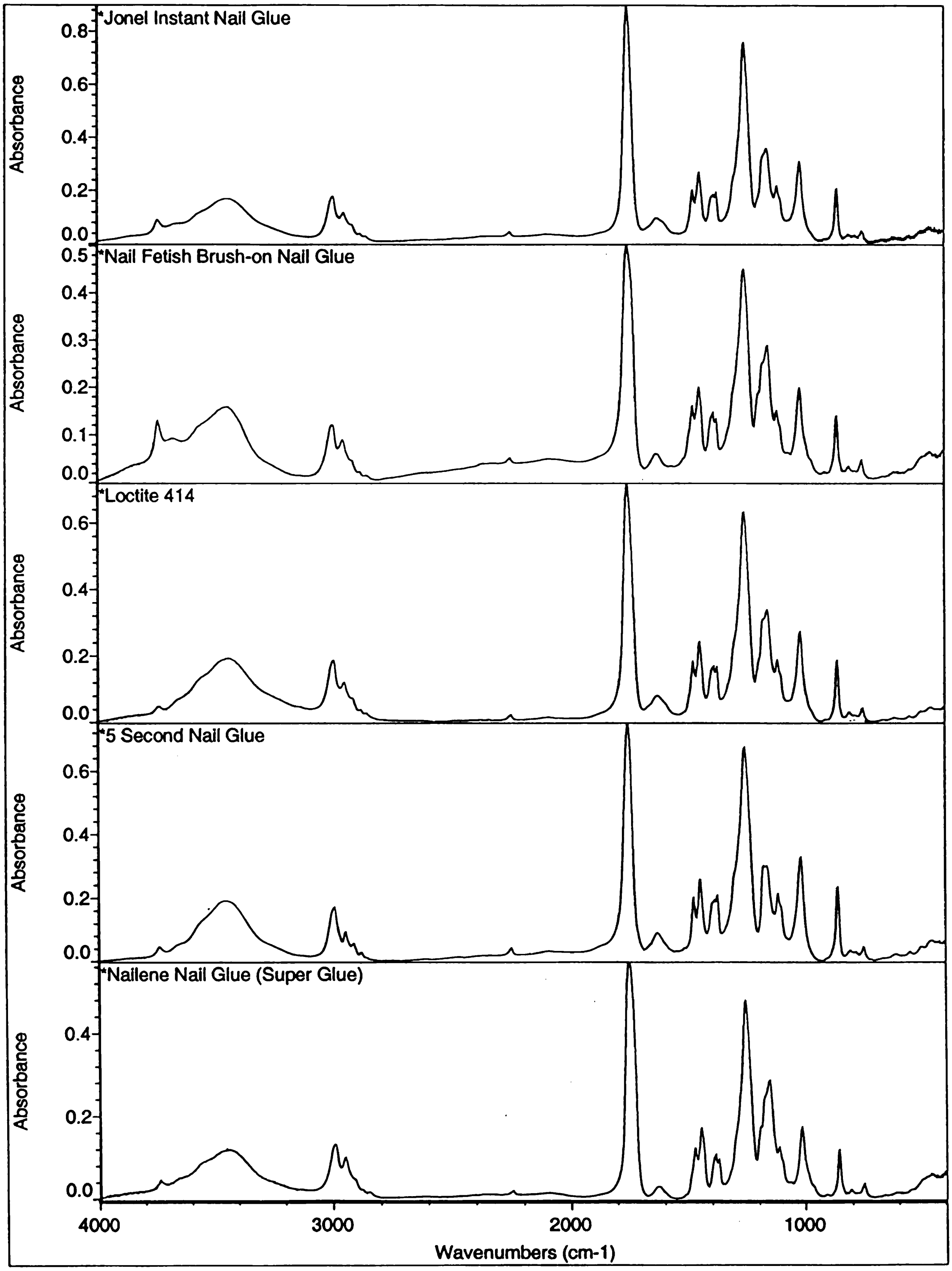

*Duro Quick Gel
*Loctite Brush-on Instant Wood Glue
*Loctite Plastix - Bonding Agent
*Permatex Super Glue
*Instant Krazy Glue - All Purpose
Absorbance
Wavenumbers (cm-1)
4000
3000
2000
1000

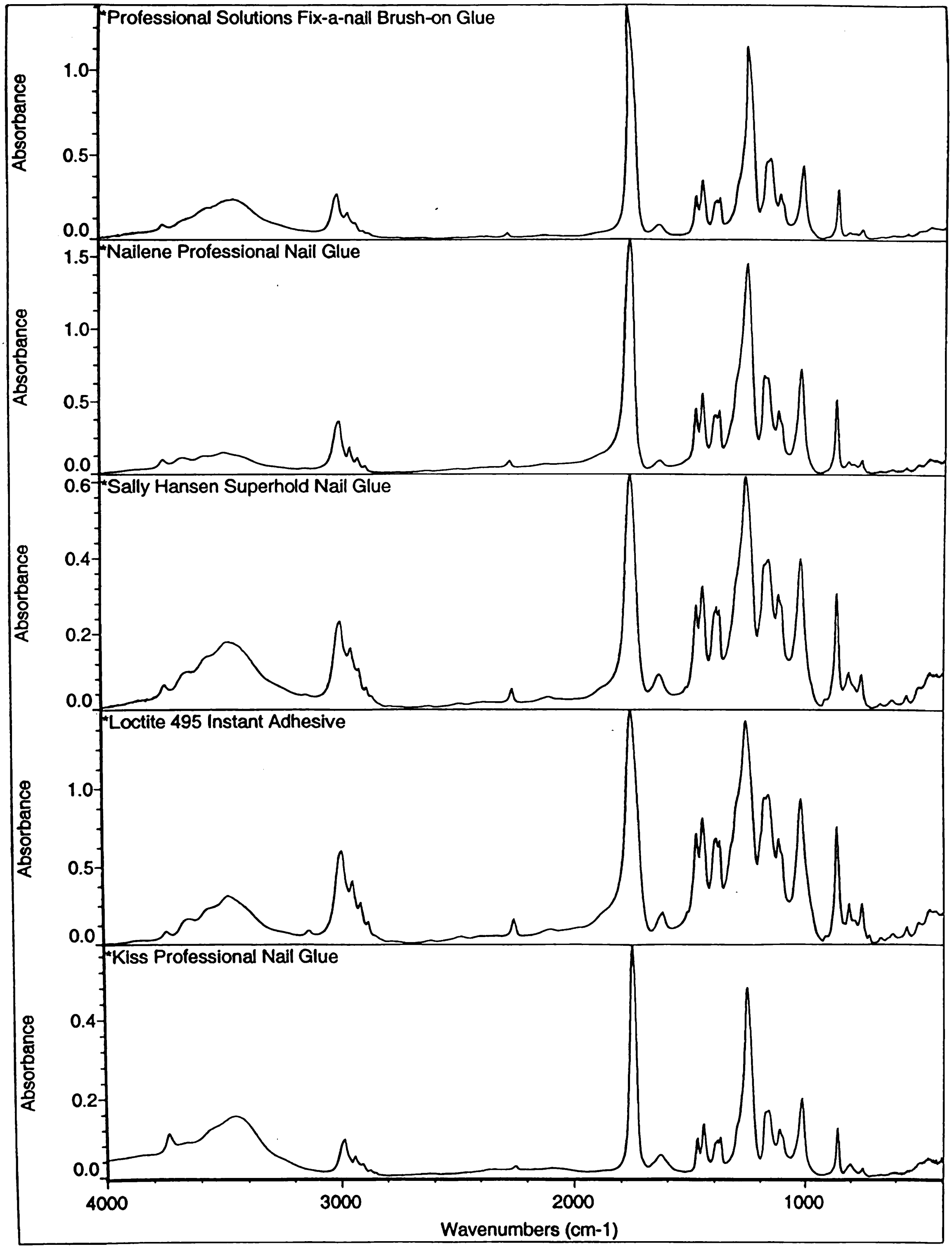

*Meijer Super Glue (Kwik-Fix)
*Duro Super Glue
*Ross Super Glue
*Super Glue for Leather and Wood
*Power Poxy Super Glue
Absorbance
0.0
0.2
0.4
0.6
0.8
0.5
1.0
4000
3000
2000
1000
Wavenumbers (cm-1)


*Meijer Super Glue Gel
*Power Poxy Nail Art Brush-on Super Glue
*Bondini-2
*Duro Super Glue 5
*Super Glue
Absorbance
Wavenumbers (cm-1)
4000
3000
2000
1000

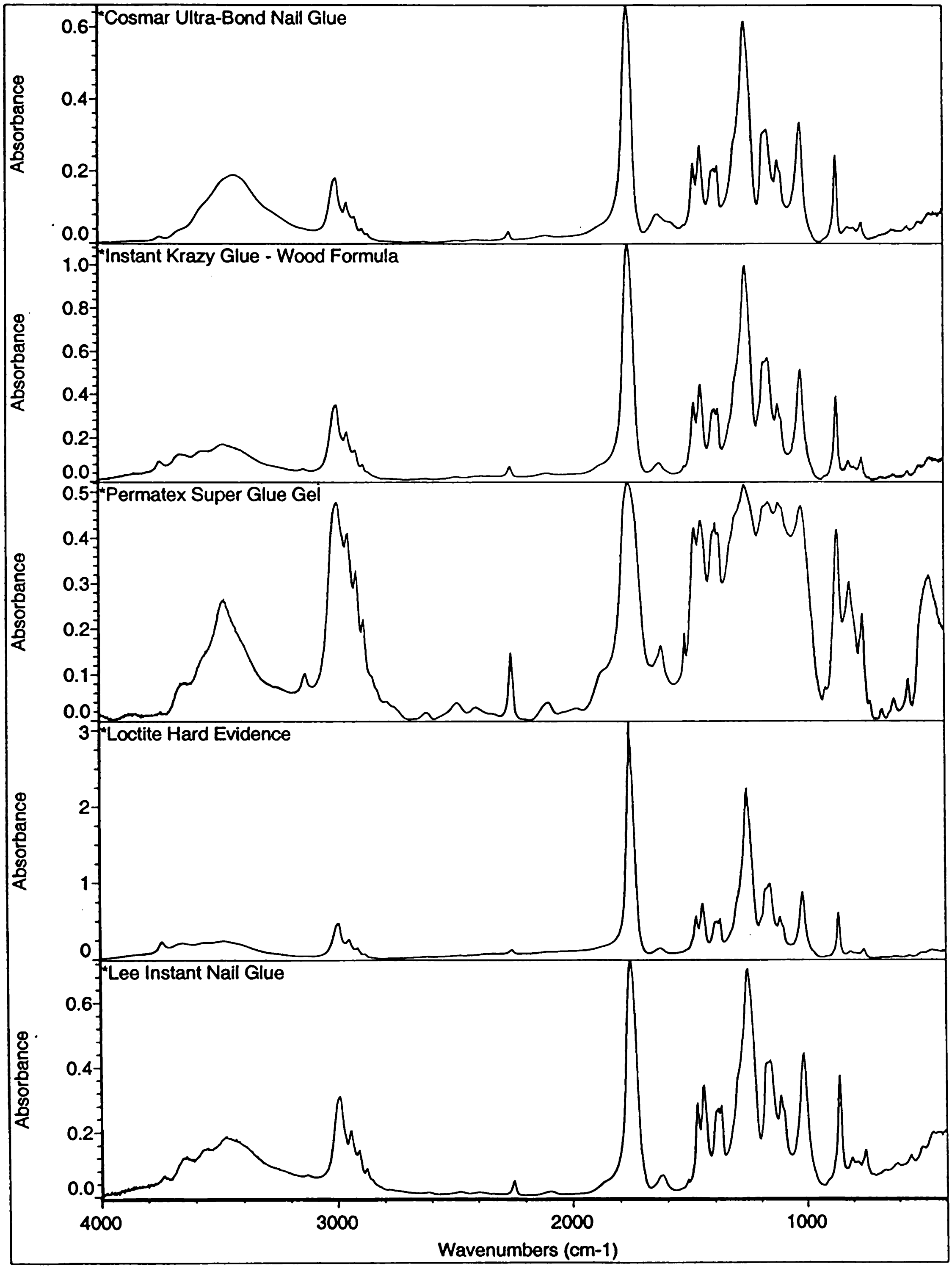

*Thick Gel Super Glue
*Cran High Performance Future Glue
*Elmers Wonder Bond Plus Super Glue
*Elmers Super Glue
*Super Bonder Super Glue
Absorbance
1.5
1.0
0.5
0.0
0.6
0.4
0.2
0.8
4000
3000
2000
1000
Wavenumbers (cm-1)

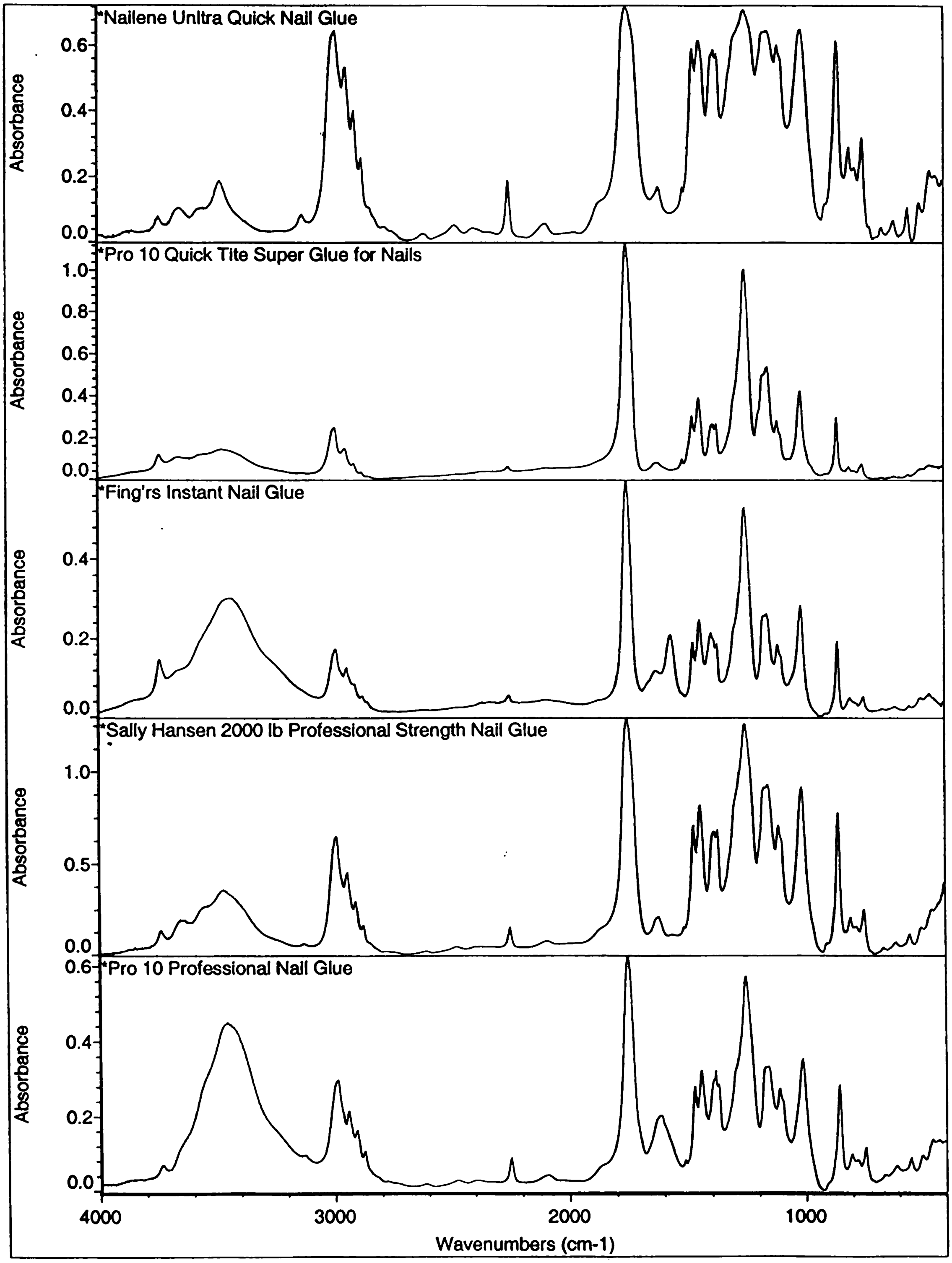

*Instant Krazy Glue Gel
*Jonel Fast Setting Nail Glue
*Sally Hansen Hypo-Allergenic Nail Glue
*Instant Krazy Glue Advanced Formula Gel
*Sally Hansen Professional Gel Glue
Absorbance
Wavenumbers (cm-1)
4000
3000
2000
1000


*Jonel Instant Nail Glue
*Nail Fetish Brush-on Nail Glue
*Loctite 414
*5 Second Nail Glue
*Nailene Nail Glue (Super Glue)
Absorbance
Wavenumbers (cm-1)
4000
3000
2000
1000



*Professional Solutions Fix-a-nail Brush-on Glue
*Nailene Professional Nail Glue
*Sally Hansen Superhold Nail Glue
*Loctite 495 Instant Adhesive
*Kiss Professional Nail Glue
Absorbance
Wavenumbers (cm-1)
4000
3000
2000
1000


*Cosmar Ultra-Bond Nail Glue
*Instant Krazy Glue - Wood Formula
*Permatex Super Glue Gel
*Loctite Hard Evidence
*Lee Instant Nail Glue
Absorbance
Wavenumbers (cm-1)
4000
3000
2000
1000



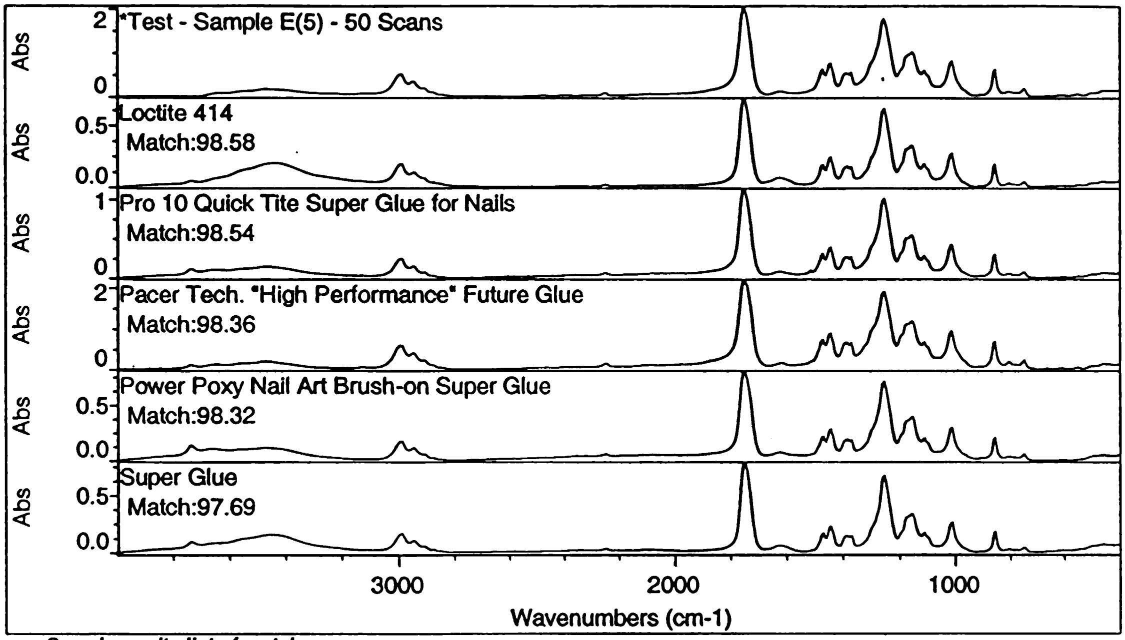
*Nailene Unltra Quick Nail Glue
*Pro 10 Quick Tite Super Glue for Nails
*Fing'rs Instant Nail Glue
*Sally Hansen 2000 lb Professional Strength Nail Glue
*Pro 10 Professional Nail Glue
Absorbance
Wavenumbers (cm-1)
4000
3000
2000
1000

APPENDIX B

Match "Hits" of Ten Test Samples

Test of Sample E - Pacer Tech. "High Performance" Future Glue

Search results for: *Test - Sample E(5) - 50 Scans
Date: Tue Jan 11 15:22:51 2000
Search algorithm: Correlation
Regions searched: 3999.70-400.16

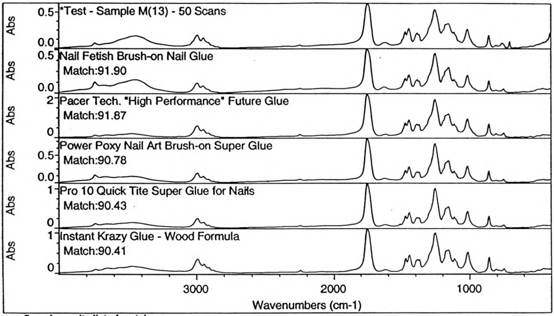


Search results list of matches

	Index	Match	Compound Name	Library Name
1	15	98.58	Loctite 414	KBr
2	44	98.54	Pro 10 Quick Tite Super Glue for Nails	KBr
3	40	98.36	Pacer Tech. "High Performance" Future Glue	KBr
4	27	98.32	Power Poxy Nail Art Brush-on Super Glue	KBr
5	26	97.69	Super Glue	KBr
6	29	97.30	Duro Super Glue 5	KBr
7	24	97.28	Elmers Wonder Bond Plus Super Glue	KBr
8	34	97.24	Duro Super Glue	KBr
9	6	97.19	Instant Krazy Glue - Wood Formula	KBr
10	36	97.03	Loctite Brush-on Instant Wood Glue	KBr

Test of Sample M - Ross Super Glue

Search results for: *Test - Sample M(13) - 50 Scans
Date: Wed Jan 19 15:28:49 2000
Search algorithm: Correlation
Regions searched: 3999.70-400.16

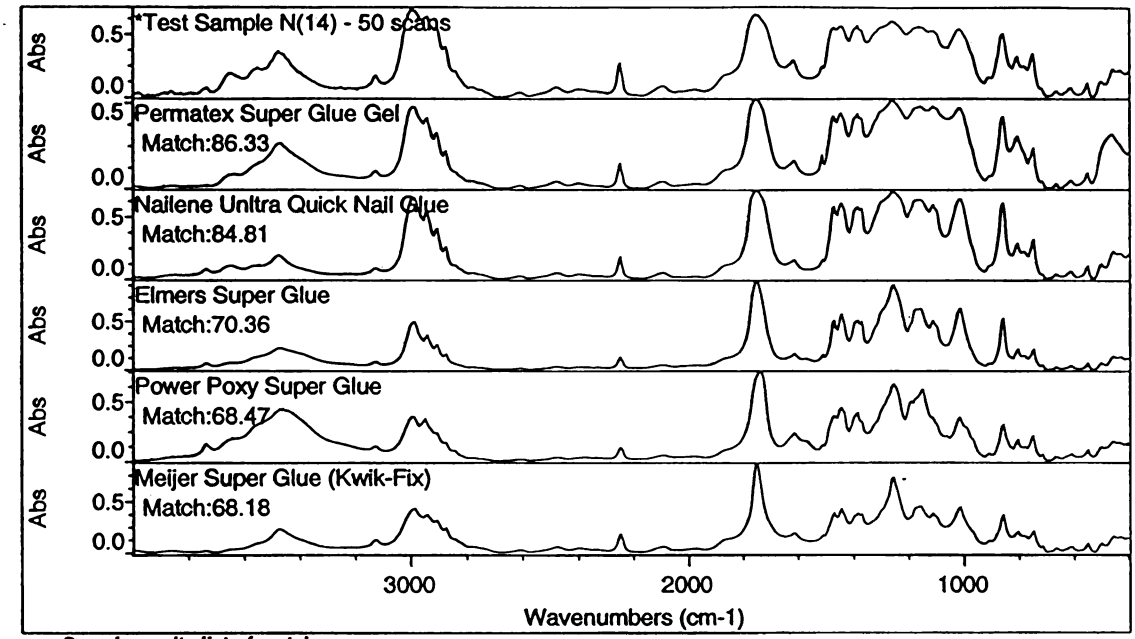


Search results list of matches

	Index	Match	Compound Name	Library Name
1	17	91.90	Nail Fetish Brush-on Nail Glue	KBr
2	40	91.87	Pacer Tech. "High Performance" Future Glue	KBr
3	27	90.78	Power Poxy Nail Art Brush-on Super Glue	KBr
4	44	90.43	Pro 10 Quick Tite Super Glue for Nails	KBr
5	6	90.41	Instant Krazy Glue - Wood Formula	KBr
6	15	90.34	Loctite 414	KBr
7	24	90.18	Elmers Wonder Bond Plus Super Glue	KBr
8	33	89.98	Super Glue for Leather and Wood	KBr
9	34	89.73	Duro Super Glue	KBr
10	29	89.41	Duro Super Glue 5	KBr
11	14	89.34	Nailene Nail Glue (Super Glue)	KBr
12	10	89.32	Sally Hansen Superhold Nail Glue	KBr
13	35	89.11	Instant Krazy Glue - All Purpose	KBr
14	37	89.09	Loctite Plastix - Bonding Agent	KBr
15	26	89.07	Super Glue	KBr
16	28	88.99	Bondini-2	KBr
17	23	88.88	Cran High Performance Future Glue	KBr
18	32	88.43	Ross Super Glue	KBr
19	11	88.29	Loctite 495 Instant Adhesive	KBr
20	45	88.08	Sally Hansen Professional Gel Glue	KBr

Test of Sample N - Power Poxy Super Glue

Search results for: *Test Sample N(14) - 50 scans
Date: Fri Jan 14 15:48:47 2000
Search algorithm: Correlation
Regions searched: 3999.70-400.16

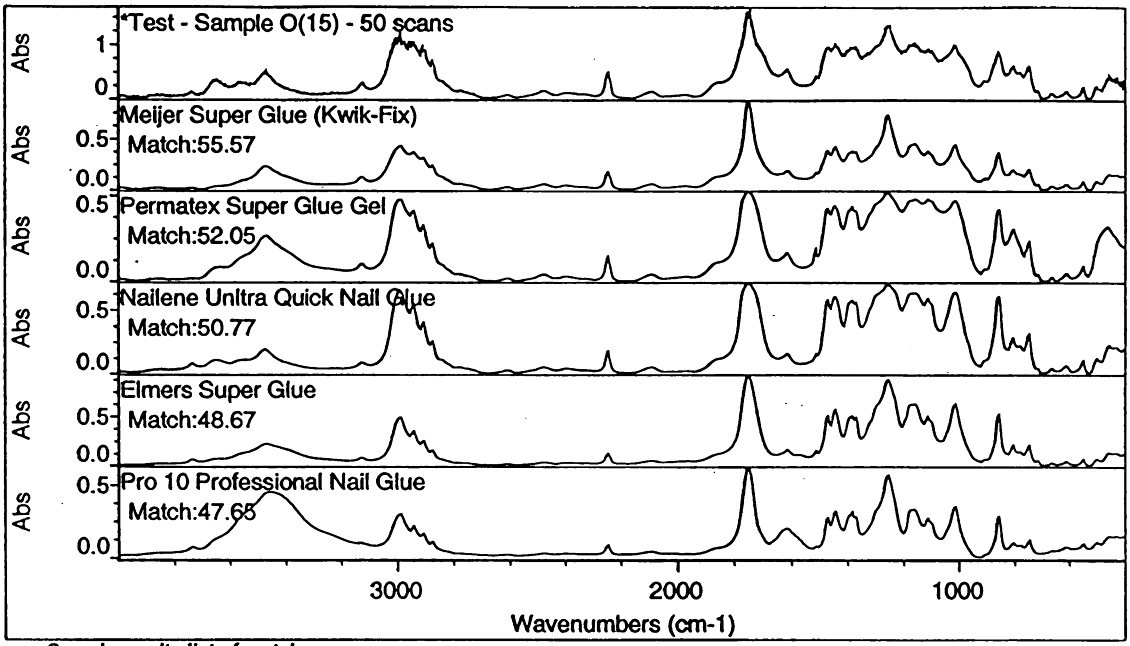


Search results list of matches

	Index	Match	Compound Name	Library Name
1	47	86.33	Permatex Super Glue Gel	KBr
2	4	84.81	Nailene Unltra Quick Nail Glue	KBr
3	48	70.36	Elmers Super Glue	KBr
4	31	68.47	Power Poxy Super Glue	KBr
5	50	68.18	Meijer Super Glue (Kwik-Fix)	KBr
6	3	64.03	Sally Hansen 2000 lb Professional Strength Nail Glue	KBr
7	11	63.07	Loctite 495 Instant Adhesive	KBr
8	20	62.28	Instant Krazy Glue Advanced Formula Gel	KBr
9	46	61.31	Pro 10 Professional Nail Glue	KBr
10	45	59.94	Sally Hansen Professional Gel Glue	KBr

Test of Sample O - Meijer Super Glue (Kwik-Fix)

Search results for: *Test - Sample O(15) - 50 scans
Date: Tue Jan 11 15:24:02 2000
Search algorithm: Correlation
Regions searched: 3999.70-400.16

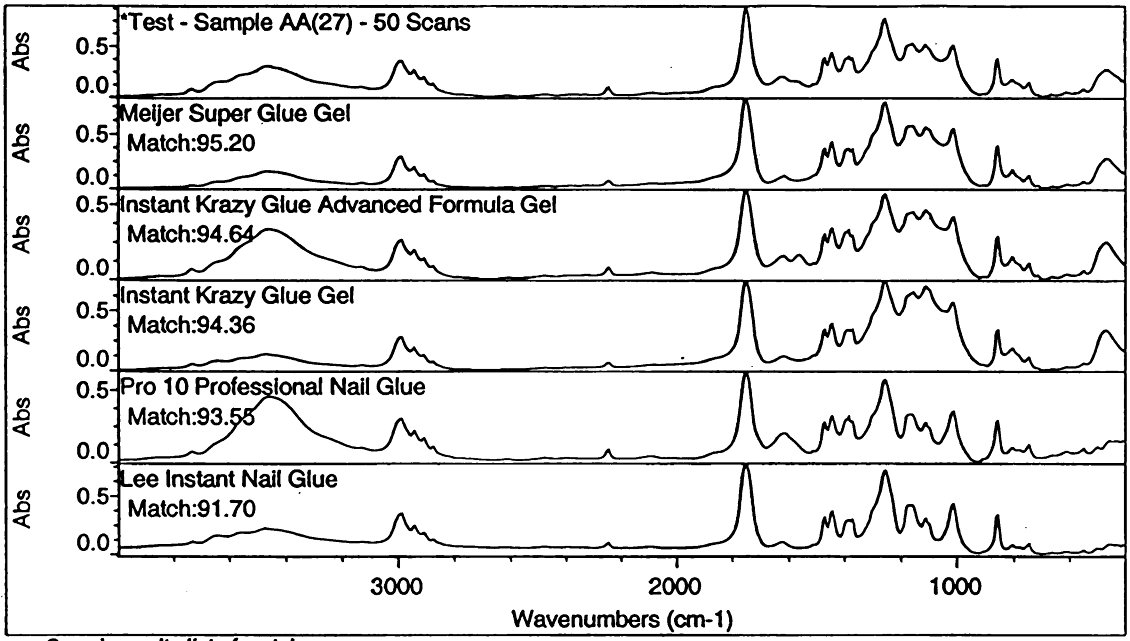


Search results list of matches

	Index	Match	Compound Name	Library Name
1	50	55.57	Meijer Super Glue (Kwik-Fix)	KBr
2	47	52.05	Permatex Super Glue Gel	KBr
3	4	50.77	Nailene Unltra Quick Nail Glue	KBr
4	48	48.67	Elmers Super Glue	KBr
5	46	47.65	Pro 10 Professional Nail Glue	KBr
6	31	47.60	Power Poxy Super Glue	KBr
7	20	47.06	Instant Krazy Glue Advanced Formula Gel	KBr
8	11	46.11	Loctite 495 Instant Adhesive	KBr
9	30	46.04	Meijer Super Glue Gel	KBr
10	45	45.19	Sally Hansen Professional Gel Glue	KBr

Test of Sample AA - Instant Krazy Glue Advanced Formula Gel

Search results for: *Test - Sample AA(27) - 50 Scans
Date: Tue Jan 11 15:31:09 2000
Search algorithm: Correlation
Regions searched: 3999.70-400.16

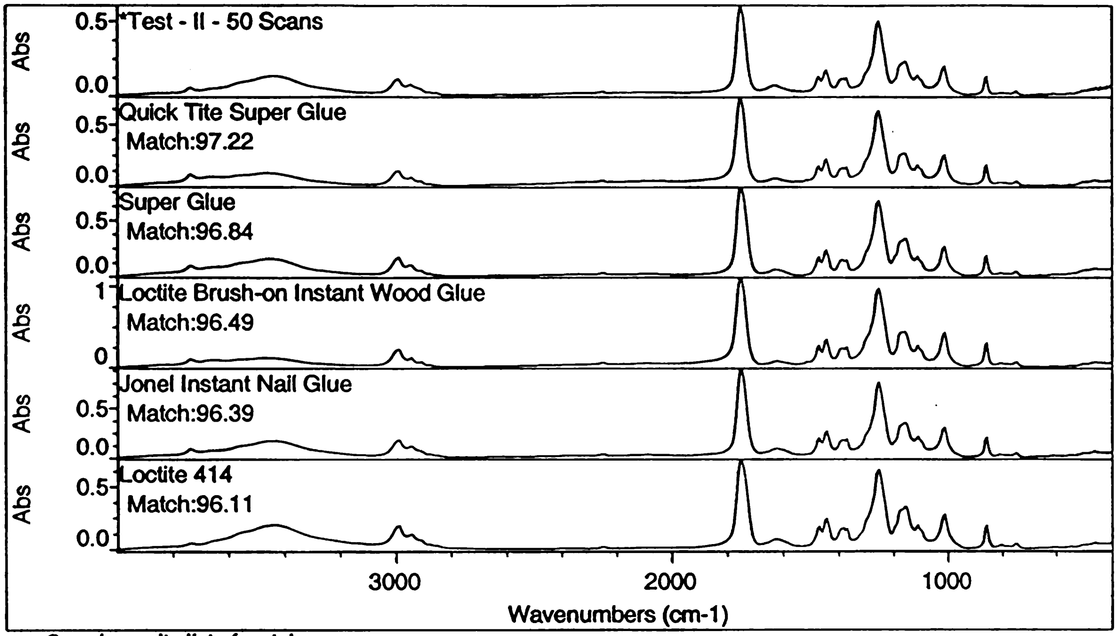


Search results list of matches

	Index	Match	Compound Name	Library Name
1	30	95.20	Meijer Super Glue Gel	KBr
2	20	94.64	Instant Krazy Glue Advanced Formula Gel	KBr
3	21	94.36	Instant Krazy Glue Gel	KBr
4	46	93.55	Pro 10 Professional Nail Glue	KBr
5	5	91.70	Lee Instant Nail Glue	KBr
6	16	91.53	5 Second Nail Glue	KBr
7	49	91.28	Cosmar Ultra-Bond Nail Glue	KBr
8	10	91.21	Sally Hansen Superhold Nail Glue	KBr
9	45	91.07	Sally Hansen Professional Gel Glue	KBr
10	24	91.05	Elmers Wonder Bond Plus Super Glue	KBr

Test of Sample II - Jonel Instant Nail Glue

Search results for: *Test - II - 50 Scans
Date: Tue Jan 11 15:26:51 2000
Search algorithm: Correlation
Regions searched: 3999.70-400.16

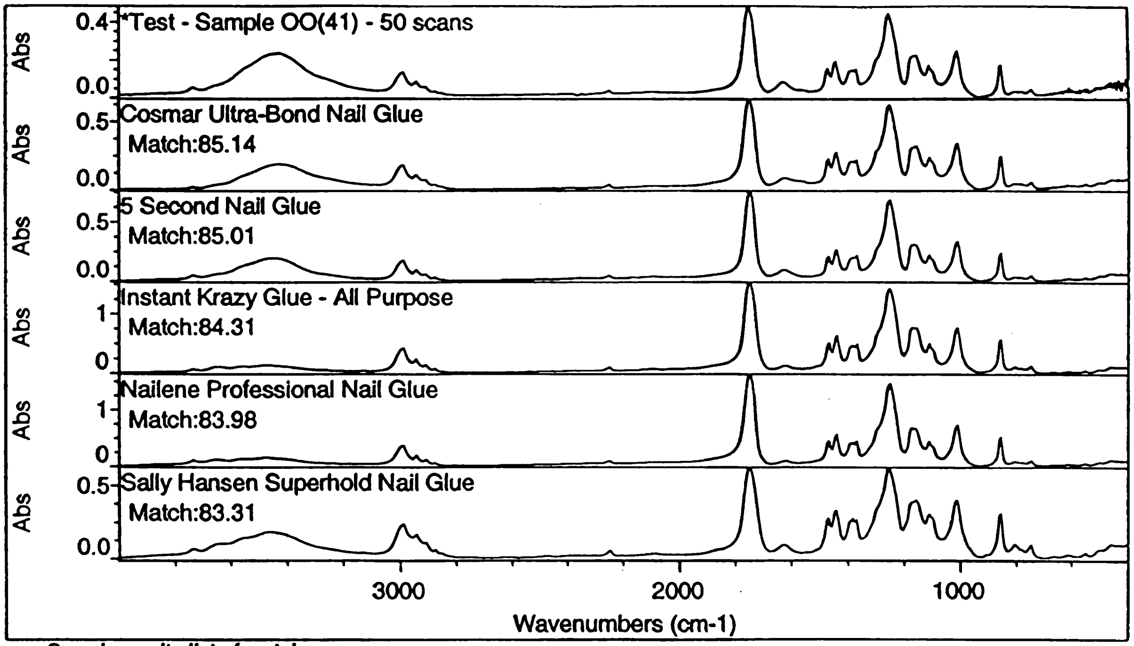


Search results list of matches

	Index	Match	Compound Name	Library Name
1	12	97.62	Professional Solutions Fix-a-nail Brush-on Glu	KBr
2	38	97.45	Permatex Super Glue	KBr
3	42	97.22	Quick Tite Super Glue	KBr
4	26	96.84	Super Glue	KBr
5	36	96.49	Loctite Brush-on Instant Wood Glue	KBr
6	13	96.39	Jonel Instant Nail Glue	KBr
7	15	96.11	Loctite 414	KBr
8	18	96.07	Jonel Fast Setting Nail Glue	KBr
9	8	95.29	Kiss Professional Nail Glue	KBr
10	44	95.15	Pro 10 Quick Tite Super Glue for Nails	KBr

Test of sample OO - Cosmar Ultra-Bond Nail Glue

Search results for: *Test - Sample OO(41) - 50 scans
Date: Tue Jan 11 15:28:31 2000
Search algorithm: Correlation
Regions searched: 3999.70-400.16

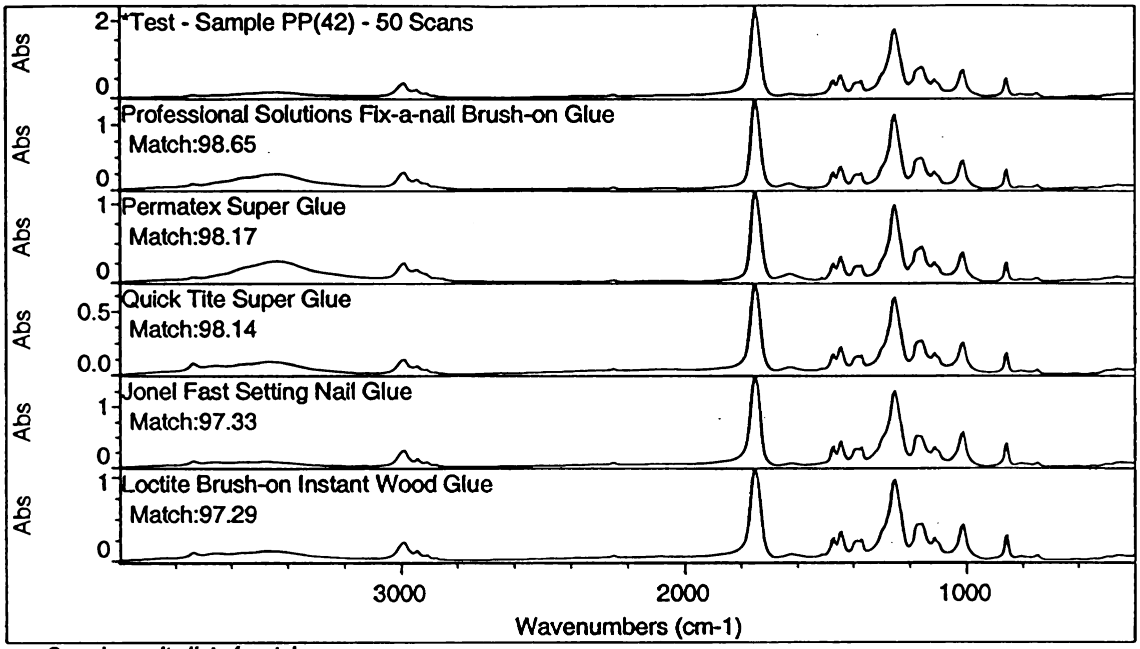


Search results list of matches

	Index	Match	Compound Name	Library Name
1	49	85.14	Cosmar Ultra-Bond Nail Glue	KBr
2	16	85.01	5 Second Nail Glue	KBr
3	35	84.31	Instant Krazy Glue - All Purpose	KBr
4	9	83.98	Nailene Professional Nail Glue	KBr
5	10	83.31	Sally Hansen Superhold Nail Glue	KBr
6	36	83.27	Loctite Brush-on Instant Wood Glue	KBr
7	34	83.21	Duro Super Glue	KBr
8	24	83.01	Elmers Wonder Bond Plus Super Glue	KBr
9	5	82.90	Lee Instant Nail Glue	KBr
10	2	82.86	Fing'rs Instant Nail Glue	KBr

Test of Sample PP - Loctite Hard Evidence

Search results for: *Test - Sample PP(42) - 50 Scans
Date: Wed Jan 19 15:29:35 2000
Search algorithm: Correlation
Regions searched: 3999.70-400.16

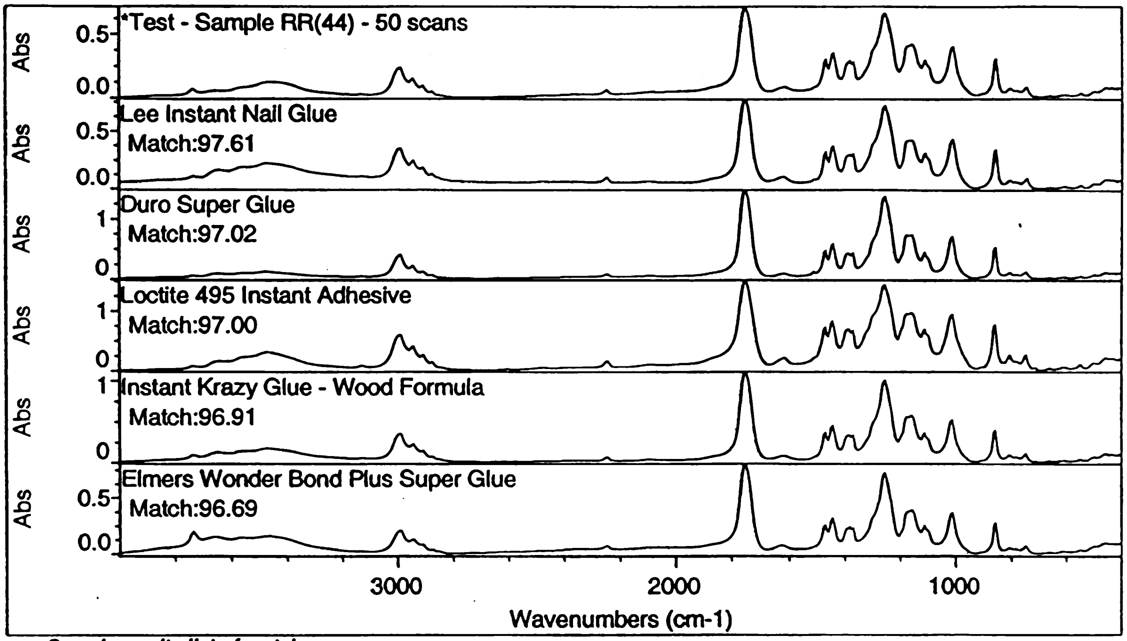


Search results list of matches

	Index	Match	Compound Name	Library Name
1	12	98.65	Professional Solutions Fix-a-nail Brush-on Glue	KBr
2	38	98.17	Permatex Super Glue	KBr
3	42	98.14	Quick Tite Super Glue	KBr
4	18	97.33	Jonel Fast Setting Nail Glue	KBr
5	36	97.29	Loctite Brush-on Instant Wood Glue	KBr
6	13	97.00	Jonel Instant Nail Glue	KBr
7	26	96.99	Super Glue	KBr
8	8	96.90	Kiss Professional Nail Glue	KBr
9	15	96.12	Loctite 414	KBr
10	19	95.98	Sally Hansen Hypo-Allergenic Nail Glue	KBr
11	22	95.38	Super Bonder Super Glue	KBr
12	16	95.20	5 Second Nail Glue	KBr
13	44	95.16	Pro 10 Quick Tite Super Glue for Nails	KBr
14	27	94.26	Power Poxy Nail Art Brush-on Super Glue	KBr
15	29	93.84	Duro Super Glue 5	KBr
16	9	93.70	Nailene Professional Nail Glue	KBr
17	2	93.27	Fing'rs Instant Nail Glue	KBr
18	24	93.23	Elmers Wonder Bond Plus Super Glue	KBr
19	7	92.88	Loctite Hard Evidence	KBr
20	34	92.66	Duro Super Glue	KBr

Test of Sample RR - Instant Krazy Glue - Wood Formula

Search results for: *Test - Sample RR(44) - 50 scans
Date: Wed Jan 12 15:33:32 2000
Search algorithm: Correlation
Regions searched: 3999.70-400.16

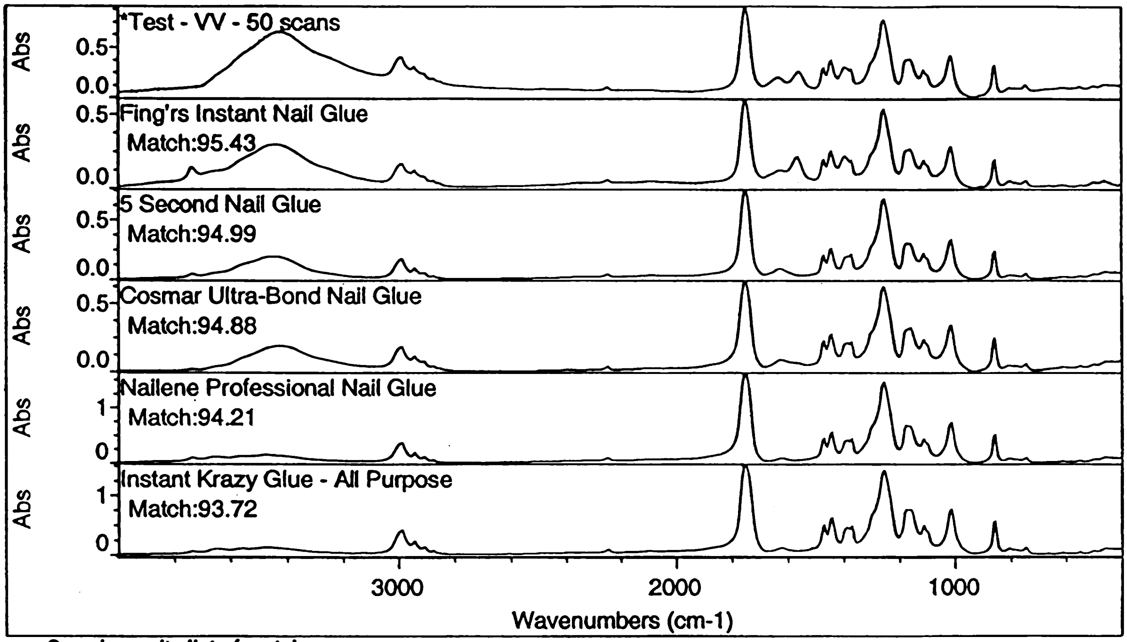


Search results list of matches

	Index	Match	Compound Name	Library Name
1	10	98.01	Sally Hansen Superhold Nail Glue	KBr
2	35	97.63	Instant Krazy Glue - All Purpose	KBr
3	5	97.61	Lee Instant Nail Glue	KBr
4	34	97.02	Duro Super Glue	KBr
5	11	97.00	Loctite 495 Instant Adhesive	KBr
6	6	96.91	Instant Krazy Glue - Wood Formula	KBr
7	24	96.69	Elmers Wonder Bond Plus Super Glue	KBr
8	49	96.57	Cosmar Ultra-Bond Nail Glue	KBr
9	3	95.57	Sally Hansen 2000 lb Professional Strength Na Glue	KBr
10	9	95.32	Nailene Professional Nail Glue	KBr

Test of Sample VV - Fing'rs Instant Nail Glue

Search results for: *Test - VV - 50 scans
Date: Tue Jan 11 15:29:17 2000
Search algorithm: Correlation
Regions searched: 3999.70-400.16



Search results list of matches

	Index	Match	Compound Name	Library Name
1	2	95.43	Fing'rs Instant Nail Glue	KBr
2	16	94.99	5 Second Nail Glue	KBr
3	49	94.88	Cosmar Ultra-Bond Nail Glue	KBr
4	9	94.21	Nailene Professional Nail Glue	KBr
5	35	93.72	Instant Krazy Glue - All Purpose	KBr
6	36	93.70	Loctite Brush-on Instant Wood Glue	KBr
7	18	93.51	Jonel Fast Setting Nail Glue	KBr
8	34	92.97	Duro Super Glue	KBr
9	42	92.90	Quick Tite Super Glue	KBr
10	24	92.34	Elmers Wonder Bond Plus Super Glue	KBr

LIST OF REFERENCES

LIST OF REFERENCES

1 Kindig J. The development of a FTIR spectral library of commercial adhesives. Michigan State University 1997; 39 pages.

2 Bloomfield LA. Working knowledge - instant glue. Scientific American 1999 Jun; 280(6):104.

3 Wheals BB. Analytical pyrolysis techniques in forensic science. Journal of Applied Pyrolysis 1981; 2(4):277-92.

4 Challinor JM. Forensic applications of pyrolysis capillary gas chromatography. Forensic Science International 1983; 21(3):269-85.

5 Lloyd JBF. Detection and differentiation of nitrocellulose traces of forensic science interest with reductive-mode electrochemical detection at a pendant mercury-drop electrode coupled with size-exclusion chromatography. Analytical Chemistry 1984 Sept; 56(11):1907-12.

6 Gaynes MA, Matienzo LJ, Zimmerman JA, Vanhart D. Analysis and characterization of electrically conductive adhesives. Materials Research Society Symposium Proceedings 445 (Electronic Packaging Materials Science IX) 1997; 139-151.

7 Poslusny M, Daugherty KE. Nondestructive adhesive analysis on stamps by Fourier transform infrared spectroscopy. Applied Spectroscopy 1988 Nov-Dec; 42(8):1466-9.

8 Wang JH. A versatile analytical method of identifying adhesive on stamps by specular-reflectance Fourier transform infrared spectroscopy. Applied Spectroscopy 1990 Mar-Apr; 44(3):447-50.

9 Leonard RG, Brennan M, Quigley K, Heatley D. Analysis of anerobic sealants and adhesives. Analytical Proceedings 1992 Sept; 29(9):393-6

10 Lennard CJ, Mazzella WD. Simple combined technique for the analysis of toners and adhesives. Journal of the Forensic Science Society 1991 Jul-Sep; 31(3):365-71.

11 Sachdev HS, Reed GD. Spectroscopic analysis of illicit drugs and their containment materials. Spectroscopy World 1990 Sep-Oct; 2(5) 27-8, 30-2.

12 Mandanis A. Identification of packaging material constituents. Analusis 1993 Jun; 21(5):M22-M26.

13 Fenner RA. Analysis of water-based adhesives using internal reflectance and curve-fitting. Applied Spectroscopy 1984 Jan-Feb; 38(1):84-6.

14 Ishida, H. Attenuated Total Reflection Fourier Transform Infrared Spectroscopy (ATR FTIR): A Useful Tool for Molecular Analysis of Adhesives, Sealants, and Coatings. Case Western Reserve University. 1996 Adhesive and Sealant Council International Conference, Volume 1, pp. 521-534 (TM3).

15 Nishio, E. Structural evaluation of adhesion layers by FT-IR/Raman Spectroscopy. Nippon Setchaku Gakkai 1996; 16(3), 36-39.

16 Caldwell BB, Smith M. The comparison and identification of adhesives on questioned documents. Journal of Forensic Sciences 1966 Jan; 11(1):28-42.

17 Noble W, Wheals BB, Whitehouse MJ. The characterization of adhesives by pyrolysis gas chromatography and infrared spectroscopy. Forensic Science 1974; 3:163-74.