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Ink Identification by High Performance Liquid Chromatography
Library Matching

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INK IDENTIFICATION BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY LIBRARY MATCHING

By

Marilyn L. Bagley

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ABSTRACT

INK IDENTIFICATION BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY LIBRARY MATCHING

By

Marilyn L. Bagley

Ink identifications have typically been performed by utilizing normal phase thin layer chromatography in both the initial screening step and the final identification step. This research focused on substituting high performance liquid chromatography (HPLC) as the final technique used in ink identifications. Forty-four ballpoint ink samples were analyzed by reversed phase high performance liquid chromatography. Using Waters Empower software, a processing method was developed with which to objectively analyze the ink chromatograms. Within each sample set of thirteen to seventeen known ink samples, a library was created of the resulting processed chromatograms. By processing an unknown sample of ink and comparing it to the processed chromatograms in the library for its respective sample set, a quantitative measure of the degree of correspondence of a sample to the library was obtained. Utilizing this quantitative measure, as well as visually inspecting the three-dimensional photo diode array printouts generated for each ink sample, it was shown that this method of HPLC ballpoint ink identification is quite effective.

ACKNOWLEDGEMENTS

I would first like to thank Speckin Forensic Laboratories for providing me with the ink samples from their ink library that permitted this research to occur. Also, I would like to thank Roger Bolhouse for his support and feedback throughout both the research and writing portions of this thesis project.

Throughout the time I have worked on this research project, I have been fortunate to receive immeasurable support from numerous sources. I would like to thank my advisor, Dr. Siegel, for his patience and suggestions throughout this research. To my friends and family, I want to thank you for listening to me when things weren't going as smoothly as I would have liked and for constantly telling me that it all would end someday. I truly appreciate the patience that my sisters, Natalie and Darlene, and my father exhibited when I would call from the chemistry lab full of frustration; they never failed to make me laugh before we hung up.

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1. INTRODUCTION

The forensic examination of ink has been used extensively over the years for the detection of various crimes and resolution of civil matters. For example, people attempt to back-date, alter or forge tax forms, wills, letters of authentication, mortgages, pre-nuptial agreements and other forms of legal documentation, and might very well succeed at their fraudulent acts were ink analysis not available. There are several ways inks can be analyzed varying from ink dating procedures to the detection of fluorescent date tags. The form of ink analysis focused on in this research, however, is that of ink identification; that is, the determination of the manufacturer and the formulation of a questioned ink.

In this research project, a variety of ballpoint pen inks were analyzed by high performance liquid chromatography (HPLC). A protocol already developed for the purpose of ink comparisons (determining if questioned ink "matches" ink from a suspect pen) was used to run known samples of forty-four ballpoint pen inks. These inks were either blue or black and represented twenty-one pen manufacturers. A processing method was created on the HPLC software to objectively analyze the ink samples by such parameters as peak retention time and peak area. Within each sample run, a library of the resulting spectra was then created and the processing method was used to process questioned samples and run them against the library in order to identify the questioned ink.

1.1 The Ballpoint Pen

Although the first patent for the ballpoint pen was obtained in 1888, it did not become popular until the late 1930s.[1] The ballpoint pen was presented to the American

public in the mid-1940s and was received with a great deal of enthusiasm. The pen of the 1940s, however, had several imperfections such as leaving large ink deposits on the paper and problems of skipping and directionality. By 1950, the majority of the imperfections had been resolved.[1]

1.2 Ink

Inks used in pre-1950 ballpoint pens were oil-based, using solvents such as mineral oil, linseed oil, recinoleic acid, methyl and ethyl esters of recinoleic acid, glycerine, monolicinoleate, coconut fatty acids, sorbital derivatives, and plasticizers.[1] The type of ink developed in 1950 by the Hungarian chemist Fran Seec created the new trend which has carried on into the formulas of today: glycol-based inks. Examples of solvents commonly used in glycol-based inks include ethylene glycol, 1,2-propylene glycol, 1,3-butylene glycol, hexylene glycol, octylene glycol, di and tri ethylene glycol, di propylene glycol, glycerin, phenoxyethylene glycols, benzyl alcohol, ethylene glycol monomethylether, and diethylene glycol monomethylether.[1]

Also included in the formulas of "modern" ballpoint inks are the dyes. Dyes based on copper phthalocyanine are popular since they are readily soluble and do not fade when exposed to light. The basic dyes used in the oil-based inks, methyl violet, Victoria blue, rhodamine red, Victoria green, and ausamine, are also popular for use in glycol-based inks; however, they must first be made into organic salts that are soluble in glycols.[1]

Additional ingredients are included in an ink's formula in order to impart desired characteristics. They include resins, acidic materials, surface active agents and viscosity adjusters. The resins, which can be either natural or synthetic, adjust the viscosity of the

ink, act as a ball lubricant, and have an effect on several physical properties of the ink including adhesiveness and elasticity. The acidic materials, typically fatty acids, serve a variety of functions including acting as a lubricant for the ball of the pen and in neutralizing the dyes. The wetting characteristics of an ink are adjusted by the surface active agents present. Also, other organic substances can be added to inhibit corrosion or aid in improving a dye's solubility in different solvents.[1]

1.3 The Value of Ink as Forensic Evidence

As stated earlier, ink can be a crucial part of a forensic document examination. Ink identifications, highlighted here since that is the focus of this research can be used as a portion of an ink analysis or can constitute the examination itself. In the first case, ink identification can be used as a step in a relative ink age determination. To determine the age of an ink using this technique, the sample of questioned age is compared to a sample of known age. One way this can be done is by identifying an entry on the same page as the questioned entry whose authenticity is unquestioned and is of the same formulation as the questioned entry. The second option is obtaining a sample of ink whose age is known by identifying the manufacturer and formulation of the questioned ink. A new mark is then made on the paper on which the questioned entry is written by a pen identified as having the same ink formulation as the questioned entry. Therefore, in cases where a lone ink entry on a page is to be dated using the relative ink age technique, it is imperative to identify the ink so a new mark can be made to which the questioned entry can be compared.

Also, ink identification can be used to determine the outcome of certain cases by itself. For example, if a questioned entry is made with an ink that was not commercially

available at the time the document was purportedly signed, it is clear that the document is not authentic. A slight variation to this use of ink identification is if an ink is identified as that produced by one of the manufacturers who participated in the fluorescent ink tagging program between the years 1975-1994. If that is the case, an additional procedure can be performed to see if any tags are indeed present.[1] (personal knowledge that it ended in 1994) The presence of a tag would determine the earliest year that document could have been prepared by determining the year of production of the ink that was used to make the questioned entry.

Thus the identification of an ink can and does play a crucial role in the forensic examination of a questioned document. Therefore, a quick and reliable method for ink identification is necessary.

1.4 Established Methods for Ink Identification

In the 1950s when analysis of ballpoint pen ink was in its infancy, Brown and Kirk experimented with horizontal paper chromatography for the purposes of ink identification. The researchers observed separation of dye components but only to the extent that the inks could be classified into broad groups, not individually identified.[2] Brown and Kirk then tried paper electrophoresis in an attempt to distinguish inks from one another for the purpose of ink identification. This method was able to further separate ink components that paper chromatography was unable to separate.[2]

In the 1960s, thin layer chromatography (TLC) was applied to ink analysis. It was determined that this method provided separation of dyes and other ink components far superior to that provided by paper chromatography.[3,4] Thin layer chromatography is the method primarily used for ink identifications by forensic ink examiners today.

To identify an ink using the TLC method, a small sample of the questioned ink (approximately four microplugs of ink ½ mm in diameter) is extracted using a strong solvent, typically pyridine for ballpoint inks. This questioned ink extract is then spotted onto a low-resolution, silica-coated chromatography sheet such as the plastic chromatography sheets produced by Eastman Kodak. After the strong solvent has evaporated, the sheet is developed in Solvent System 1 (ethyl acetate: ethanol: distilled water, 70:35:30). This results in a non-specific chromatogram that is compared against a library of low-resolution chromatograms of known inks. Any possible match to the questioned ink's chromatogram is identified and the known ink sample is obtained.

Samples are then taken from the possible known ink matches and their extracts are spotted alongside the questioned ink sample's extract on a glass-backed, silica-coated high performance thin layer chromatography plate (HPTLC). In this way many environmental factors that may cause differences in the final chromatogram are eliminated by running all of the samples on one plate. The HPTLC plate differs from the low-resolution plate by having a much smaller particle size of the stationary phase. Consequently, the resolution of the different components is much greater allowing for better separation of closely related compounds[4]. In addition, the smaller particle size of the stationary phase provided by HPTLC plates allows for smaller sample sizes to be utilized owing to the greater sensitivity of the technique.

This HPTLC plate is then developed in Solvent System 1. If necessary, an additional analysis can be performed to substantiate the results from the Solvent System I development by spotting an additional HPTLC plate with the known and questioned

samples' extracts and developing the plate in Solvent System 2 (n-butanol: ethanol: distilled water, 50:10:15) [1, 3, 4, 5]

Finally, if the previously mentioned HPTLC techniques are not able to eliminate all but one standard ink sample, spectrophotometry can be utilized. Using a spectrophotometer equipped to scan spots on TLC plates, the inks are scanned in the visible region at 550 nm with a xenon light source. The percent transmission of light through each band is recorded and compared relative to respective bands of the other samples. In other words, dye-ratios are calculated for the bands present and compared to the bands of the other like samples. [1, 3, 5]

1.5 High Performance Liquid Chromatography in Ink Analysis

In 1977, Colwell and Karger utilized normal phase HPLC to examine ballpoint inks. It was determined that since HPLC was more sensitive compared to other chromatography techniques used, it provides greater selectivity in distinguishing among different inks. They found that out of twenty-five blue ballpoint inks sampled, differences in dye components were distinguished in all samples.

Ratios were found to be useful in ink comparisons. In the visible region, HPLC could discriminate between dyes based on relative peak heights. Furthermore, if an ultraviolet detector were used, the vehicle components of the ink could also be analyzed by comparing the ratio of the UV-absorbent vehicle components to the dye components.[6]

Lyter disagreed with the latter analysis of Colwell and Karger. [7] He had performed his own experiments of ink analysis using the HPLC and arrived at different conclusions. Lyter utilized reversed phase chromatography but had limited his experiments to analyzing the dye components of the ink and their qualitative and

quantitative differences.[8] He claimed that the resins and organic acids present in the ink could not be analyzed since they could not be detected in concentrations corresponding to their amounts in the ink.[8] This fact could be explained by his determination of the following: while the paper type did not affect the characteristics of the resultant chromatogram, the paper type did affect the extractability of the ink.[7, 8] Thus, he felt Colwell and Karger's analysis of vehicle components was not reproducible since, owing to the differences in paper type extractability, false results could unwittingly be obtained. Also, since the vehicle components elute as unretained peaks, they are not specific enough to use in ratio comparisons and could lead to false results. Finally, dye components can also elute at 254 nm (the wavelength used by Colwell and Karger to analyze the vehicle components) and could thus interfere with the ratio calculations.[7]

Lyter's analysis of the dyes by HPLC permitted both qualitative and quantitative differences to be detected in the ten ink formulations he examined. Theoretically, pens from the same box of ink should contain identical ink formulations. There are instances, however, when slight differences occur between batches of ink of the same ink formulation. Demonstrating the specificity of the HPLC technique, Lyter was able to recognize quantitative differences between four different batches of the same ink formulation.[8]

The most recent research performed on ballpoint inks using the HPLC does not involve differentiating among different ink formulations. Instead, it involves the changes that ink undergoes as it ages that can be detected by HPLC. Andrasko has illustrated that certain non-lightfast dye components of ink, such as methyl violet and victoria blue, decompose over time. These decomposition byproducts appear as separate peaks in

chromatograms at 540nm that change quantitatively as the inks age or are exposed to light. In other words, the original component's peak gets smaller while the byproducts' peaks increase in size. These changes in components' concentrations can be depicted on ternary diagrams in which the percentages of components and byproducts are plotted with respect to one another.[9, 10]

The effect of Andrasko's research on ink differentiation and identification by HPLC is that an analyst must recognize the fact that some components of the ink will change with time and/or light exposure which may affect the HPLC chromatogram both qualitatively and quantitatively. With knowledge of this alteration process, however, such differences may be noted and dealt with accordingly during ink identifications.

1.6 Why Use the HPLC for Ink Identifications?

Although the current method of ink identification works acceptably, there are a few advantages to using the HPLC for ink identifications. For example, as noted by several authors of articles regarding HPLC and ink analysis, HPLC is a more specific method of ink identification with the ability to distinguish between those inks with similar TLC chromatograms and even different batches of the same ink formulation.[1, 4, 8] As with other forensic analyses such as drug identification, it is suggested that different forms of analyses be utilized for the preliminary screening steps and the identification step. Using normal phase TLC for both the preliminary screening step and the final identification step obviously works, but adding reversed phase HPLC as the alternative final step allows the ink to be subjected to an alternative environment, therefore providing results not as closely related to the screening step.

Furthermore, as also noted in previous research, HPLC can be used to determine quantitative differences between ink samples. Also of great importance is the fact that by using a computer program to search an ink library of the possible ink matches, a quantitative measurement of the degree of fit between the known and questioned ink samples is provided. There is no such measurement when identifying inks using the TLC method.

2. METHODS AND MATERIALS

2.1 Chemicals

The mobile phase in this project was 80:20 acetonitrile:water with an ion pairing reagent (Waters Pic® B-7 Low UV reagent, containing water, methanol, heptane sulfonic acid and phosphoric acid). Both the water and acetonitrile were HPLC grade. The mobile phase was degassed by vacuum filtration using a 0.50 um-pore, 47 mm-diameter filter (Alltech). The ion pairing reagent was utilized so that the ionic species of interest within the ink samples could be bound to counter ions to produce ion-pairs that were able to be analyzed.

2.2 Ink Samples

Ink samples for this research project were obtained from the ink library of Speckin Forensic Laboratories (Okemos, MI). No ink samples from outside the library were utilized since the goal of this research was to create a library of documented known inks. The ink samples from this library were all on white copy paper since colored paper would introduce additional dyes into the analysis.

Forty-four ballpoint inks (29 blue, 15 black) were selected from the SFL library and run in duplicate. Fourteen microplugs of each sample were taken and extracted into 25 microliters of mobile phase (80:20 acetonitrile:water with ion-pairing reagent as noted above). The samples were sonicated for thirty minutes to insure complete extraction of the ink into the mobile phase prior to analysis.

2.3 High Performance Liquid Chromatography

The samples were analyzed by a Waters HPLC system consisting of a Waters 600 Controller, gradient pump, Waters™ 717 Plus autosampler, and a Waters 996 Photodiode

Array Detector. The mobile phase was sparged with nitrogen twenty percent of the time. The reversed-phase column was manufactured by Waters (NovaPac® C_{18}, 3.9 x 150mm, 4 um spherical particles, 60 Å pore size). The samples were run using the "inkrev2" method (see Appendix A for details).

2.4 Processing Data with Waters Empower Software

In order to create an ink library, a processing method must first be developed. However, before developing a processing method, one must first derive a chromatogram. The manufacturers of the software recommend that a Max Plot chromatogram be derived as opposed to a chromatogram from a specific wavelength so that all the chromatographic peaks in the sample are viewed. The Max Plot chromatogram plots the maximum spectral absorbance at each time point. See Appendix B1 for details on creating the Max Plot chromatogram.

Using the Max Plot chromatogram, a processing method was then created. This processing method was used to process the ink samples and identify specific peaks in each sample based on such criteria as peak area and peak retention time. See Appendix B2 for details on creating a processing method using the Empower software.

Following processing of the ink samples by the processing method described above, the resulting spectra were added to libraries. See Appendix B3 for details on creating libraries and adding and matching spectra to existing libraries. Libraries were created of known inks by separating them into their respective runs. For example, the thirteen blue inks that were in the first run on January 16, 2003 were entered into one library and the three black inks from the first run were entered into another library. This

was repeated for each of the four runs performed, resulting in four separate blue ballpoint libraries and four separate black ballpoint libraries.

Those samples that were not identified to a satisfactory standard with this technique had an additional library created. In these cases, one sample was processed with the processing method and a library was created with its spectrum. The duplicate sample was then processed and run against the library with only its counterpart as a choice. This enabled a quantitative measure of how well the peaks measured against one another alone.

Reports were generated for the results of the library matching. The images in this thesis are presented in color. See Appendix B4 for how to create and print reports.

2.5 Thin Layer Chromatography

Thin layer chromatography was performed on the samples that were both not identified to a reasonable degree of certainty by HPLC and had similar photodiode array printouts as other ink samples. Five microplugs of each known ink were extracted with six microliters of pyridine. Four microliters of the extracted ink were spotted using a Camag Nanomat mechanical spotter onto a glass-backed, silica-coated, high resolution thin layer chromatography plate such as those manufactured by Merck. The pyridine was evaporated off by placing the plate in an 80° C oven for approximately thirty minutes. The plate was allowed to return to room temperature. The plate was then developed in Solvent System 1 (ethyl acetate: ethanol: distilled water, 70:35:30) for fifteen minutes.

3. RESULTS AND DISCUSSION

3.1 High Performance Liquid Chromatography

The majority of the inks (18 of 29 blue inks and 12 of 15 black inks) were correctly identified as the other sample of the duplicate sample pair when compared against the created library within their respective sample runs. Examples of this form of identification are shown in Figures 1 and 2.

There were some inks (10 of the remaining 11 blue inks and 3 of the remaining 3 black inks) that were identified, but not to any reasonable degree of certainty because, although the correct ink was listed as a possible match, too many other possible matches were proposed during the library search. An example of this form of identification is shown in Figure 3. In this situation, the examiner would have to further look at the three-dimensional photo diode array (PDA) printout and compare it to the other PDA printouts within that sample run before a positive identification could be made. Indeed, when the PDA printouts were compared for samples that fit into this category, inks that were identified but not to any reasonable degree of certainty, a positive identification was easily made in all but two cases, Senator B385 and Staedtler B384, which will be discussed below.

Finally there was the ink sample that was not able to be identified by the library search. An example of this lack of identification by library matching is shown in Figure 4. Again, in this case the examiner would have to compare the questioned PDA printout against the other known PDA printouts from that sample run.

There are several possible reasons for the weak identifications or lack of an identification by the library matching method. The most probable explanation is that the

software, in creating the library, identifies each individual peak within a sample. For example, in Figure 1, Bic B162 has seven peaks found against which the library is searched. The software does not recognize the PDA as a whole; instead it is broken up into individual pieces and the whole picture is never considered when library matching is performed. Furthermore, only the best fit for each individual peak is listed in the results of the matching. How this can cause problems in identifying inks is clear: there are often identical components of inks produced by different manufacturers. Methyl violet, for example, will theoretically appear the same in a HPLC chromatogram whether it is produced by Bic, Fisher, or another ink manufacturer. Therefore, the same peak will appear in similar locations in the chromatograms of different inks and could easily lead to misidentifications. Figure 5 illustrates the case of Papermate B68, an example of misidentification due to identifying individual peaks instead of the entire PDA as a whole. The ink composition of Papermate B68 is virtually identical to that of Papermate B376 (Figure 6), with the exception of the farthest peak to the right which is absent in Papermate B376. Three of the four peaks to which a match was made for Papermate B68 were misidentified as belonging to Papermate B376; the fourth, although labeled as Fisher B65, is correct as it was later shown by thin layer chromatography that Papermate B68 and Fisher B65 have identical ink compositions (see Section 3.2). However, if one were to examine the PDAs of Papermate B68 and Papermate B376, it would be readily obvious that the two inks are not the same.

Another explanation for the poor identification of select inks is the lack of retention of copper phthalocyanine in the HPLC environment used in this research. Per a conversation with Dr. Albert Lyter III who has previously conducted research on HPLC

analysis of ballpoint inks (references 7 and 8), it was learned that copper phthalocyanine either gets trapped in the reversed phase column (if a guard column is not present), or elutes too rapidly for detection. Therefore, as was the case with Senator B385 and Staedtler B384 (Figures 7 and 8), inks that differ only in the presence or absence of copper phthalocyanine will not be able to be distinguished with this library searching method, nor by the examination of the PDA printouts for each ink. Thin layer chromatography, however, will still be able to distinguish between the two inks (see Section 3.2).

There were also a few inks run multiple times with varying success rates in the library matching method. For example in Figures 4, 9, and 10, Pilot B103 was run three separate times with two different results: twice it was identified to a reasonably certain degree, and the third time it was misidentified (Pilot B103 wasn't listed as a possible match for any peak). Furthermore, when run against only its counterpart duplicate sample, no peak was identified. This last result is rather perplexing, as pictorially the PDAs of the duplicate samples look similar. However, the intensity of the peaks in the two samples (absorbance unit value) differs drastically. One possible explanation for this difference in intensity could be the weak extraction that was noted for this certain ink sample. It is noted that at its strongest peak, the absorbance value is a mere 0.04. Perhaps a small increase in extraction of one of the duplicate weak samples as compared to the other would create relatively large differences in peak area that could lead to misidentification or non-identification. New Bic and Tombo B-535 also were poorly identified in one run, and identified to a reasonably certain degree in another run.

In other samples that were not identified to a satisfactory degree, but that could be identified from the list of possible matches presented by the library search by comparing PDA printouts, the "questioned" sample was run against a library containing only its duplicate sample counterpart. This was done to gain a quantitative measure of the degree of fit for the peaks present in the samples. In the majority of cases, the number of peaks correctly identified increased when other inks with possible similar components were removed from the library and the resultant quantitative measurements indicated a good match. Figures 11 and 12 representing the ink Fisher B65 are illustrations of this marked improvement in identification and subsequent quantitative measurements. However, there were some cases in which the number of peaks identified as the correct ink increased but the quantitative measure of fit did not improve when the other samples were removed. Figures 13 and 14 representing Staedtler B384 illustrates this observation.

One other possible source of confusion when utilizing this library search method, which would be inherent in any type of ink identification process, is the fact that several of the pen manufacturers buy ink from either a general ink manufacturer or from other pen companies. This results in several pens from different pen manufacturers being filled with ink with identical composition. This would not lessen the ink library matching effectiveness, but would provide a source of concern as the ink could appear to be misidentified when it in fact is being correctly identified. This occurred during this research with numerous samples and is explained in Section 3.2.

Furthermore, a different sort of confusion could arise when an ink manufacturer maintains the same formula for their inks, but purchases the dyes from different suppliers. This could cause inks of the same formulation to appear spectrally different.

Figure 1: HPLC report for ink sample Bic B162D

SampleName Bic B162D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11603

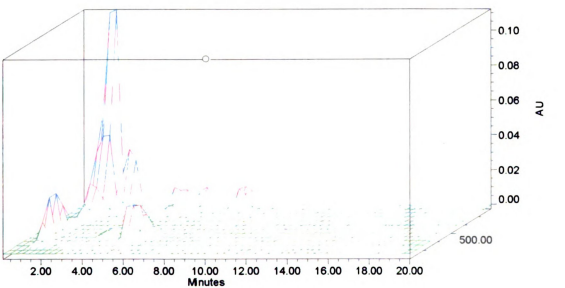
Date Acquired 1/17/2003 2:37:08 AM

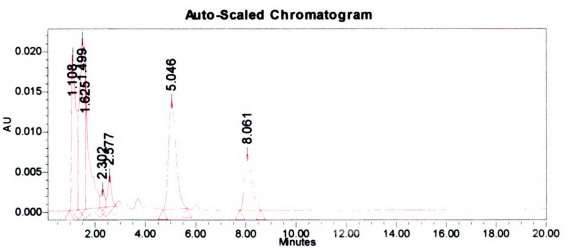
Acq Method Set inkrev2 method set

Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Bic B162D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.108	242620	20.01	18984
2	PDA MaxPlot (250nm-550nm)	1.499	317561	26.19	21382
3	PDA MaxPlot (250nm-550nm)	1.625	166238	13.71	17119
4	PDA MaxPlot (250nm-550nm)	2.302	23931	1.97	2271
5	PDA MaxPlot (250nm-550nm)	2.577	40485	3.34	3918
6	PDA MaxPlot (250nm-550nm)	5.046	276767	22.83	13481
7	PDA MaxPlot (250nm-550nm)	8.061	144942	11.95	6974

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.108			Bic B162-1	0.768	1.150
2		1.499			Bic B162-2	0.424	1.123
3		1.625			Bic B162-3	0.896	1.155
4		2.302					
5		2.577			Bic B162-5	3.984	2.083
6		5.046			Bic B162-6	0.998	1.514
7		8.061			Bic B162-7	0.601	1.647

Figure 2: HPLC report for ink sample Zebra B7D

SampleName Zebra B7D

Date Acquired 1/19/2003 7:53:29 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

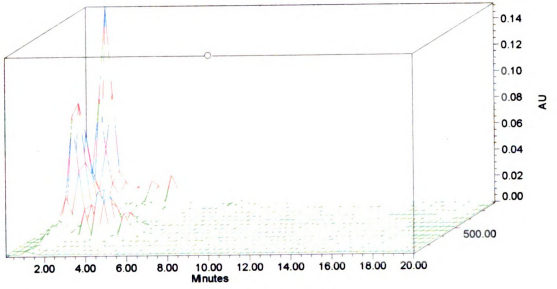
Run Time 20.00 Minutes

Processing Method Marilyn library 2103

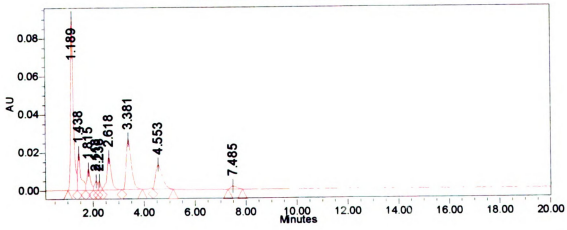
Sample Set Name marilyn 11903

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Zebra B7D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.189	681911	36.42	89772
2	PDA MaxPlot (250nm-550nm)	1.438	174379	9.31	19592
3	PDA MaxPlot (250nm-550nm)	1.815	107240	5.73	11068
4	PDA MaxPlot (250nm-550nm)	2.118	38864	2.08	4600
5	PDA MaxPlot (250nm-550nm)	2.238	28850	1.54	4653
6	PDA MaxPlot (250nm-550nm)	2.618	207498	11.08	17203
7	PDA MaxPlot (250nm-550nm)	3.381	367958	19.65	26256
8	PDA MaxPlot (250nm-550nm)	4.553	237240	12.67	12789
9	PDA MaxPlot (250nm-550nm)	7.485	28556	1.53	1630

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.189			Zebra B7-1	1.743	1.051
2		1.438			Zebra B7-2	0.617	1.152
3		1.815			Zebra B7-3	2.396	1.356
4		2.118			Zebra B7-4	2.243	2.378
5		2.238			Zebra B7-5	1.953	2.014
6		2.618			Zebra B7-6	0.529	1.444
7		3.381			Zebra B7-7	0.220	1.292
8		4.553			Zebra B7-8	0.405	1.519
9		7.485			Zebra B7-9	2.238	4.044

Figure 3: HPLC report for ink sample Bic B388D

SampleName Bic B388D

Date Acquired 1/17/2003 9:55:49 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

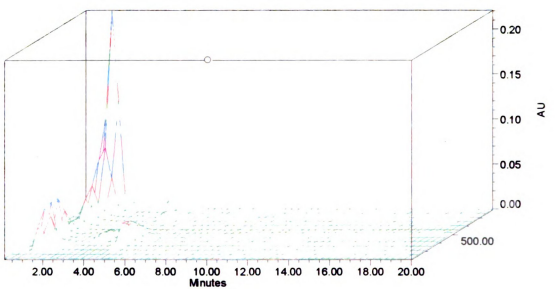
Run Time 20.00 Minutes

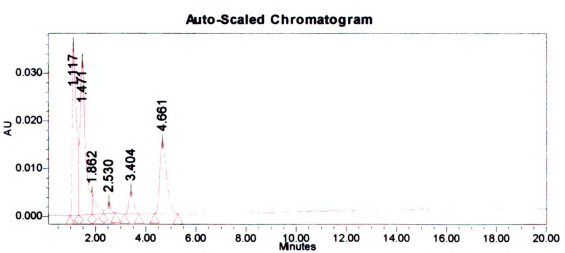
Processing Method Marilyn library 2103

Sample Set Name marilyn 11703

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Bic B388D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.117	410689	31.11	36415
2	PDA MaxPlot (250nm-550nm)	1.471	487187	36.90	32523
3	PDA MaxPlot (250nm-550nm)	1.862	45310	3.43	4383
4	PDA MaxPlot (250nm-550nm)	2.530	27470	2.08	2348
5	PDA MaxPlot (250nm-550nm)	3.404	62555	4.74	4776
6	PDA MaxPlot (250nm-550nm)	4.661	286934	21.74	15171

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.117			Bic B388-1	6.390	1.080
2		1.471			Bic B388-3	4.730	1.091
3		1.862			Tombo B535-1	8.032	1.445
4		2.530			Bic B388-5	7.737	2.789
5		3.404			Fisher B50-4	1.307	1.849
6		4.661			Papermate B376-7	0.655	1.389

Figure 4: HPLC report for ink sample Pilot B103D (2nd time run)

SampleName Pilot B103D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marily n 11903

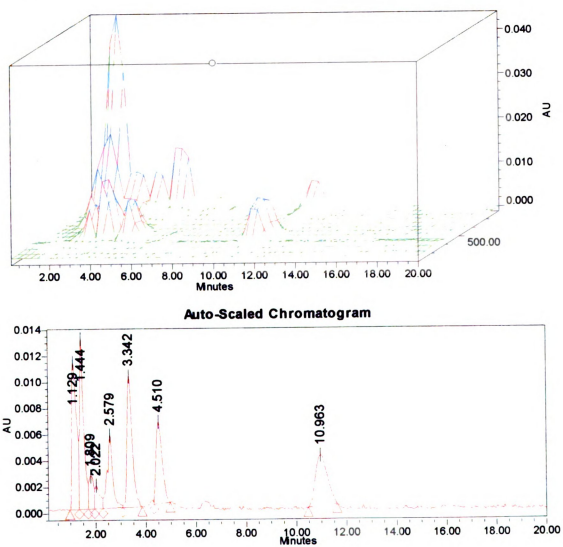
Date Acquired 1/19/2003 9:18:17 PM

Acq Method Set inkrev2 method set

Processing Method Marily n library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)



Sample Name Pilot B103D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.129	147918	18.14	11291
2	PDA MaxPlot (250nm-550nm)	1.444	145228	17.81	13083
3	PDA MaxPlot (250nm-550nm)	1.809	33125	4.06	2496
4	PDA MaxPlot (250nm-550nm)	2.022	25226	3.09	1758
5	PDA MaxPlot (250nm-550nm)	2.579	84761	10.40	5556
6	PDA MaxPlot (250nm-550nm)	3.342	144555	17.73	10024
7	PDA MaxPlot (250nm-550nm)	4.510	105909	12.99	6226
8	PDA MaxPlot (250nm-550nm)	10.963	128521	15.76	3858

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.129					
2		1.444			Itoya B194-2	7.514	12.038
3		1.809					
4		2.022					
5		2.579					
6		3.342			Cross B164E-6	6.422	17.963
7		4.510					
8		10.963					

Figure 5: HPLC report for ink sample Papermate B68D

SampleName Papermate B68D

Date Acquired 1/19/2003 6:49:53 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

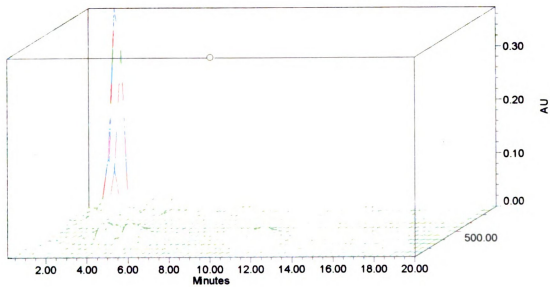
Run Time 20.00 Minutes

Processing Method Marilyn library 2103

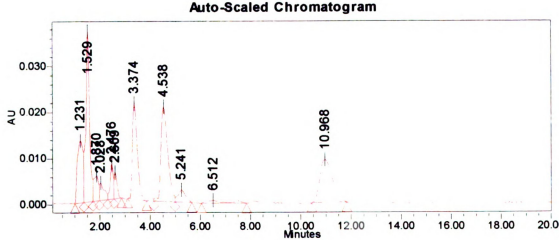
Sample Set Name marilyn 11903

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Papermate B68D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.231	208327	10.98	13409
2	PDA MaxPlot (250nm-550nm)	1.529	375218	19.78	36998
3	PDA MaxPlot (250nm-550nm)	1.870	72332	3.81	5519
4	PDA MaxPlot (250nm-550nm)	2.028	49920	2.63	3793
5	PDA MaxPlot (250nm-550nm)	2.476	64856	3.42	7553
6	PDA MaxPlot (250nm-550nm)	2.609	44550	2.35	5639
7	PDA MaxPlot (250nm-550nm)	3.374	279426	14.73	20739
8	PDA MaxPlot (250nm-550nm)	4.538	384641	20.28	20485
9	PDA MaxPlot (250nm-550nm)	5.241	54236	2.86	2576
10	PDA MaxPlot (250nm-550nm)	6.512	35392	1.87	616
11	PDA MaxPlot (250nm-550nm)	10.698	327674	17.26	9284

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.231			Fisher B65-1	6.695	14.586
2		1.529			Papermate B376E-2	3.862	6.086
3		1.870					
4		2.028					
5		2.476					
6		2.609					
7		3.374			Papermate B376E-6	6.450	16.903
8		4.538			Papermate B376E-7	8.108	21.963
9		5.241					
10		6.512					
11		10.698					

Figure 6: HPLC report for ink sample Papermate B376G

SampleName Papermate B376G

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marily n 11903

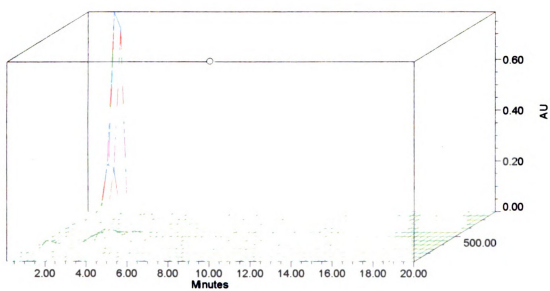
Date Acquired 1/20/2003 3:18:48 AM

Acq Method Set inkrev2 method set

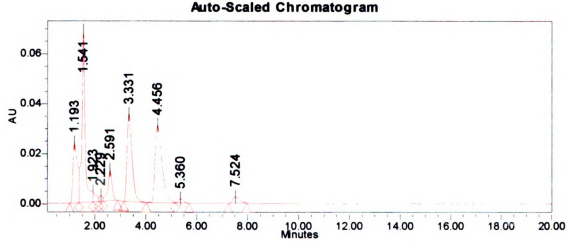
Processing Method Marily n library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Papermate B376G

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.193	299484	13.25	24172
2	PDA MaxPlot (250nm-550nm)	1.541	620990	27.47	68619
3	PDA MaxPlot (250nm-550nm)	1.923	33024	1.46	3992
4	PDA MaxPlot (250nm-550nm)	2.229	21558	0.95	2390
5	PDA MaxPlot (250nm-550nm)	2.591	140236	6.20	12278
6	PDA MaxPlot (250nm-550nm)	3.331	483771	21.40	35065
7	PDA MaxPlot (250nm-550nm)	4.456	588343	26.02	30968
8	PDA MaxPlot (250nm-550nm)	5.360	23559	1.04	1657
9	PDA MaxPlot (250nm-550nm)	7.524	49874	2.21	2596

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.193			Papermate B376E-1	3.587	1.163
2		1.541			Papermate B376E-2	0.201	1.035
3		1.923			Papermate B376E-3	5.868	2.054
4		2.229			Papermate B376E-4	2.071	2.601
5		2.591			Papermate B376E-5	0.981	1.890
6		3.331			Papermate B376E-6	0.622	1.320
7		4.456			Papermate B376E-7	0.419	1.350
8		5.360			Papermate B376E-8	3.490	5.328
9		7.524			Itoya B194-10	1.326	2.340

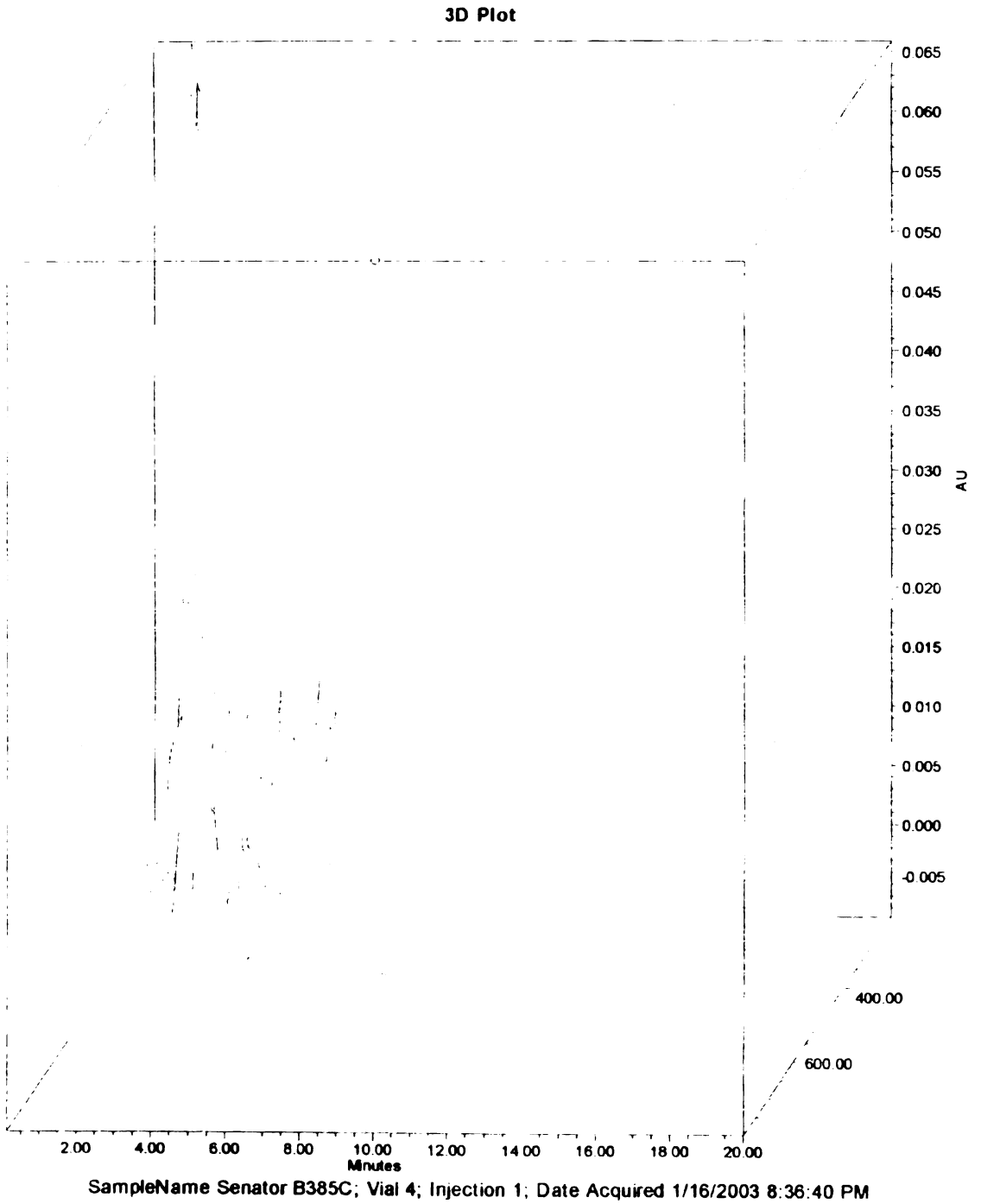


Figure 7: PDA printout for ink sample Senator B385C

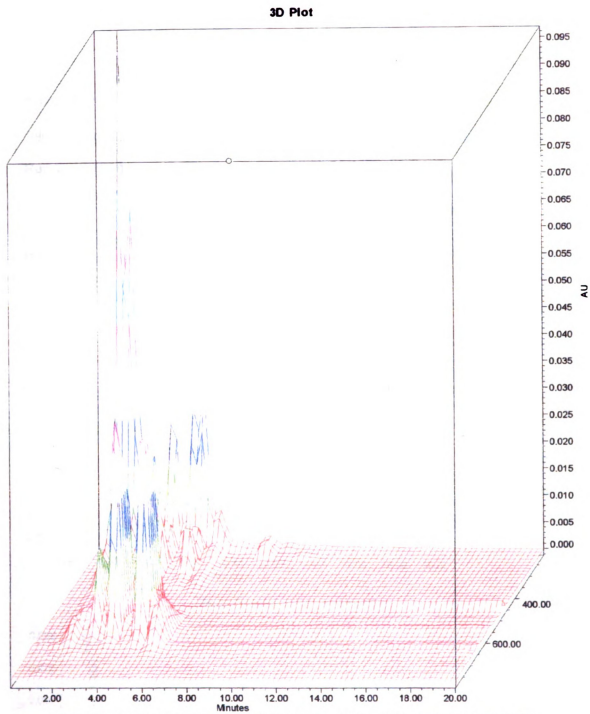


Figure 8: PDA printout for ink sample Staedtler B384C

Figure 9: HPLC report for ink sample Pilot B103D (1st time run)

SampleName Pilot B103D

Date Acquired 1/17/2003 8:31:01 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

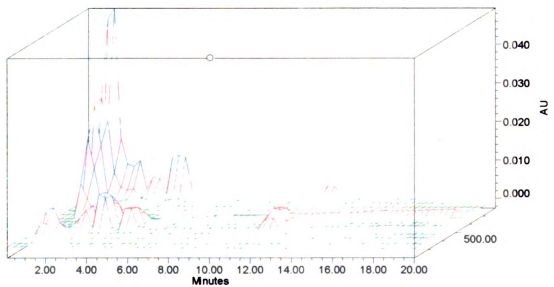
Run Time 20.00 Minutes

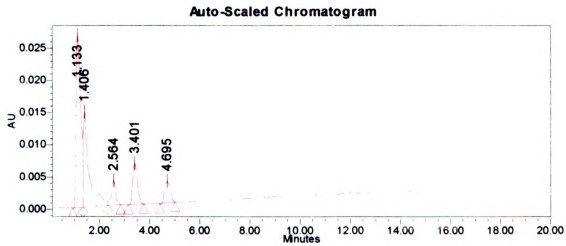
Processing Method Marilyn library 2103

Sample Set Name marilyn 11703

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Pilot B103D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.133	340040	44.90	26933
2	PDA MaxPlot (250nm-550nm)	1.406	238185	31.45	14835
3	PDA MaxPlot (250nm-550nm)	2.564	45586	6.02	3819
4	PDA MaxPlot (250nm-550nm)	3.401	83479	11.02	6376
5	PDA MaxPlot (250nm-550nm)	4.695	49986	6.60	3351

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.133			Pilot B103-1	1.947	2.794
2		1.406			Pilot B103-2	3.799	5.318
3		2.564					
4		3.401			Papermate B376-6	5.369	11.318
5		4.695					

Figure 10: HPLC report for ink sample Q6B (Pilot B103 3rd time run)

SampleName Q6B

Date Acquired 1/22/2003 1:22:21 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

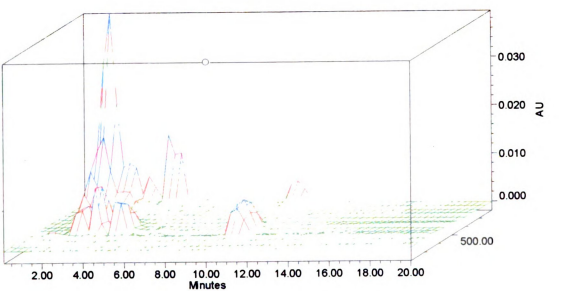
Run Time 20.00 Minutes

Processing Method Marilyn library 2103

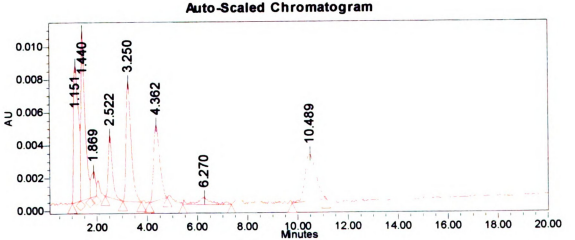
Sample Set Name marilyn 12103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Q6B (Pilot B103)

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.151	112454	19.73	8365
2	PDA MaxPlot (250nm-550nm)	1.440	112723	19.78	10246
3	PDA MaxPlot (250nm-550nm)	1.869	18896	3.32	1533
4	PDA MaxPlot (250nm-550nm)	2.522	41748	7.32	3778
5	PDA MaxPlot (250nm-550nm)	3.250	101534	17.81	7285
6	PDA MaxPlot (250nm-550nm)	4.362	77805	13.65	4611
7	PDA MaxPlot (250nm-550nm)	6.270	18281	3.21	444
8	PDA MaxPlot (250nm-550nm)	10.489	86526	15.18	2861

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.151			Pilot B103G-1	4.509	10.549
2		1.440			Pilot B103G-2	6.030	12.799
3		1.869					
4		2.522					
5		3.250			Papermate B376E-6	6.804	17.102
6		4.362					
7		6.270					
8		10.489					

Figure 11: HPLC report for ink sample Fisher B65D

SampleName Fisher B65D

Date Acquired 1/19/2003 6:07:29 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

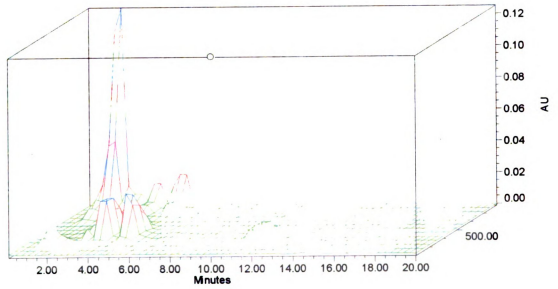
Run Time 20.00 Minutes

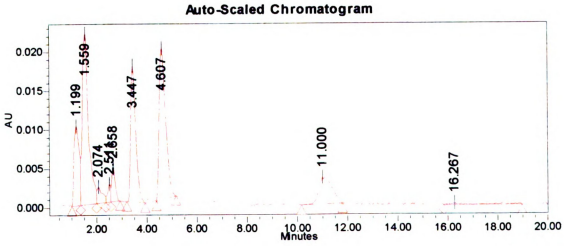
Processing Method Marily n library 2103

Sample Set Name marily n 11903

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Fisher B65D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.199	145522	10.75	10224
2	PDA MaxPlot (250nm-550nm)	1.559	375771	27.76	22000
3	PDA MaxPlot (250nm-550nm)	2.074	31508	2.33	2091
4	PDA MaxPlot (250nm-550nm)	2.511	19000	1.40	2301
5	PDA MaxPlot (250nm-550nm)	2.658	42557	3.14	4286
6	PDA MaxPlot (250nm-550nm)	3.447	244771	18.08	17468
7	PDA MaxPlot (250nm-550nm)	4.607	348524	25.75	19485
8	PDA MaxPlot (250nm-550nm)	11.000	126719	9.36	3430
9	PDA MaxPlot (250nm-550nm)	16.267	19335	1.43	330

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.199			Fisher B65-1	3.973	10.182
2		1.559			Fisher B65-2	2.664	7.676
3		2.074					
4		2.511					
5		2.658					
6		3.447			Cross B164E-6	3.875	9.588
7		4.607			Dupont B102E-6	5.618	10.838
8		11.000					
9		16.267					

Figure 12: HPLC report for ink sample Fisher B65D (own library)

SampleName Fisher B65D

Date Acquired 1/19/2003 6:07:29 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

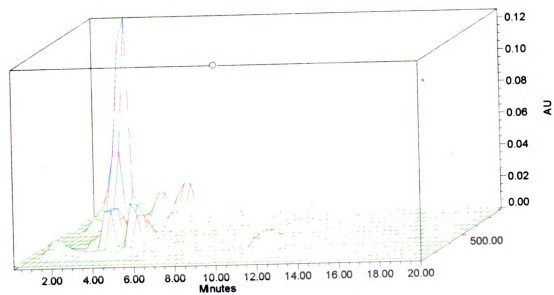
Run Time 20.00 Minutes

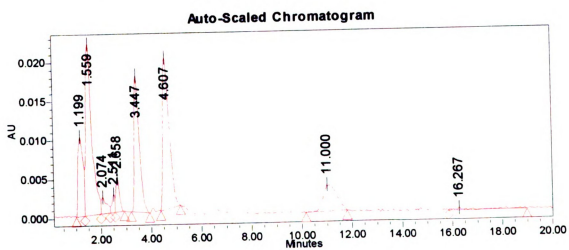
Processing Method Marily n library 2103

Sample Set Name marily n 11903

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Fisher B65D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.199	145522	10.75	10224
2	PDA MaxPlot (250nm-550nm)	1.559	375771	27.76	22000
3	PDA MaxPlot (250nm-550nm)	2.074	31508	2.33	2091
4	PDA MaxPlot (250nm-550nm)	2.511	19000	1.40	2301
5	PDA MaxPlot (250nm-550nm)	2.658	42557	3.14	4286
6	PDA MaxPlot (250nm-550nm)	3.447	244771	18.08	17468
7	PDA MaxPlot (250nm-550nm)	4.607	348524	25.75	19485
8	PDA MaxPlot (250nm-550nm)	11.000	126719	9.36	3430
9	PDA MaxPlot (250nm-550nm)	12.267	19335	1.43	330

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.199			Fisher 65-1	3.973	10.182
2		1.559			Fisher 65-2	2.664	7.676
3		2.074					
4		2.511					
5		2.658					
6		3.447			Fisher 65-6	4.263	12.280
7		4.607			Fisher 65-7	6.454	14.078
8		11.000					
9		12.267					

Figure 13: HPLC report for ink sample Staedtler B384D

SampleName Staettler B384D

Date Acquired 1/17/2003 9:13:25 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

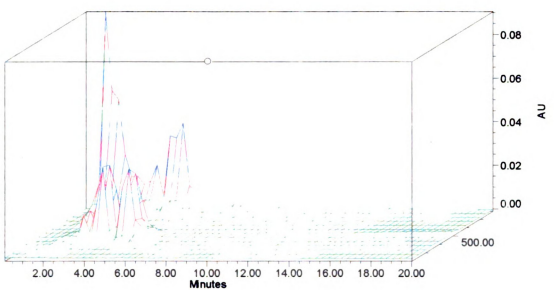
Run Time 20.00 Minutes

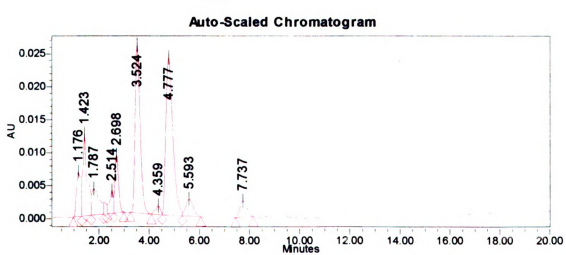
Processing Method Marily n library 2103

Sample Set Name marily n 11703

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Staedtler B384D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.176	84794	6.13	6772
2	PDA MaxPlot (250nm-550nm)	1.423	149196	10.78	12421
3	PDA MaxPlot (250nm-550nm)	1.787	82627	5.97	4018
4	PDA MaxPlot (250nm-550nm)	2.514	36908	2.67	3422
5	PDA MaxPlot (250nm-550nm)	2.698	87798	6.34	8783
6	PDA MaxPlot (250nm-550nm)	3.524	356502	25.76	25487
7	PDA MaxPlot (250nm-550nm)	4.359	18803	1.36	1355
8	PDA MaxPlot (250nm-550nm)	4.777	463155	33.46	23895
9	PDA MaxPlot (250nm-550nm)	5.593	54418	3.93	2580
10	PDA MaxPlot (250nm-550nm)	7.737	49882	3.60	2519

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.176			Staettler B384-1	9.989	1.324
2		1.423			Tombo B535-2	3.839	1.363
3		1.787			Staettler B384-3	4.566	1.896
4		2.514					
5		2.698			Fisher B50-3	2.439	1.799
6		3.524			Fisher B50-4	0.589	1.289
7		4.359					
8		4.777			Parker B176-9	3.105	2.292
9		5.593			Staettler B384-8	3.803	2.190
10		7.737			Papermate B376-8	4.937	7.106

Figure 14: HPLC report for ink sample Staedtler B384D (own library)

SampleName Staettler B384D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11703

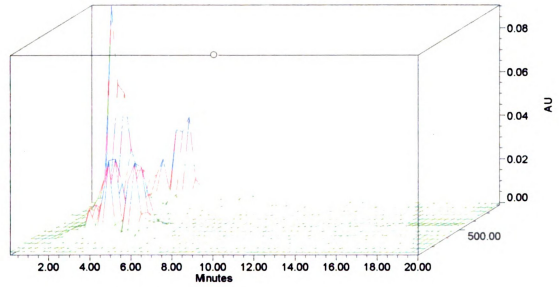
Date Acquired 1/17/2003 9:13:25 PM

Acq Method Set inkrev2 method set

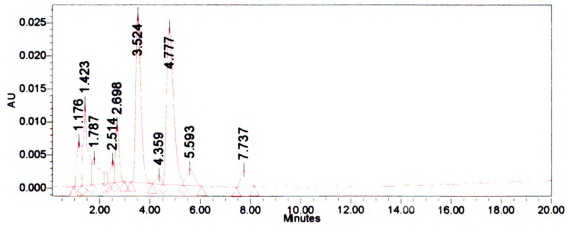
Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Staedtler B384D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

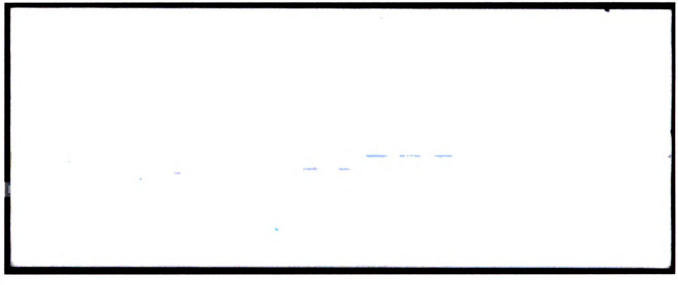
	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.176	84794	6.13	6772
2	PDA MaxPlot (250nm-550nm)	1.423	149196	10.78	12421
3	PDA MaxPlot (250nm-550nm)	1.787	82627	5.97	4018
4	PDA MaxPlot (250nm-550nm)	2.514	36908	2.67	3422
5	PDA MaxPlot (250nm-550nm)	2.698	87798	6.34	8783
6	PDA MaxPlot (250nm-550nm)	3.524	356502	25.76	25487
7	PDA MaxPlot (250nm-550nm)	4.359	18803	1.36	1355
8	PDA MaxPlot (250nm-550nm)	4.777	463155	33.46	23895
9	PDA MaxPlot (250nm-550nm)	5.593	54418	3.93	2580
10	PDA MaxPlot (250nm-550nm)	7.737	49882	3.60	2519

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.176			Staettler B384-1	9.989	1.324
2		1.423			Staettler B384-2	4.225	1.330
3		1.787			Staettler B384-3	4.566	1.896
4		2.514					
5		2.698			Staettler B384-5	6.830	1.659
6		3.524			Staettler B384-6	1.715	1.229
7		4.359					
8		4.777					
9		5.593			Staettler B384-8	3.803	2.190
10		7.737					

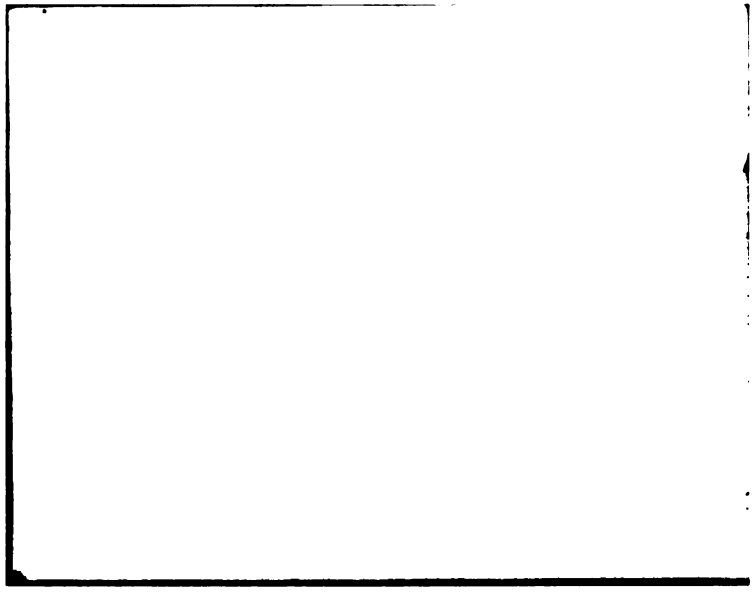
3.2 Thin Layer Chromatography

Those inks that were not able to be identified to a reasonable degree of certainty and whose PDAs showed great resemblance to others in their respective sample runs were run on a high resolution thin layer chromatography plate for comparison purposes. It was determined that Papermate B68, Fisher B65, Fisher B77 and Fisher B4 all had identical ink compositions. Mitsubishi B384 and Mitsubishi B385 were also shown to have identical ink compositions. Cross B164, Parker B176 and Formulabs B517 also have the same ink composition as one another. Finally, Bic B162, Bic B197 and Bic B388 were shown to share the same ink composition as one another. Furthermore, Senator B385 and Staedtler B384 whose PDAs were remarkably similar were shown to differ only by the presence of copper phthalocyanine in Staedtler B384 and its absence in Senator B385. See Figure 15 and Figure 15A. None of the black ball point inks that had similar PDA printouts were shown to have the same ink composition. See Figure 16.



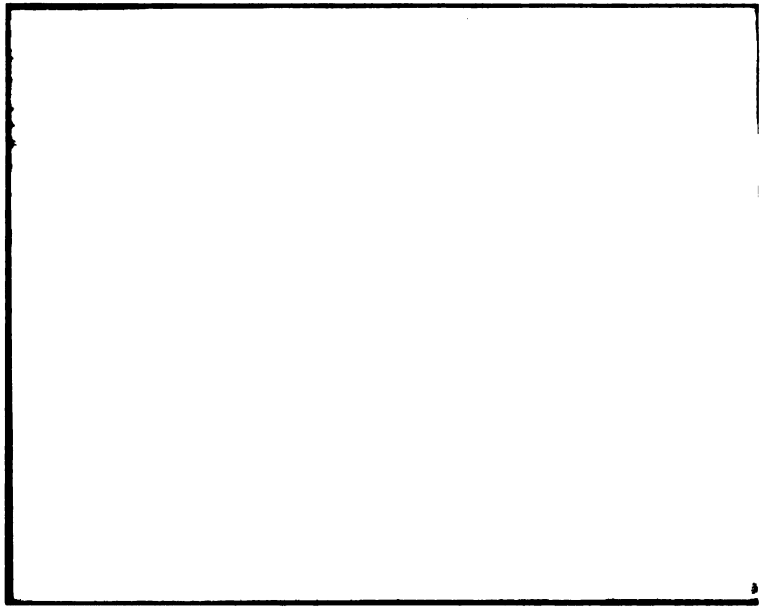
1. Papermate B68	6. Senator B385	11. Parker B176
2. Fisher B65	7. Staedtler B384	12. Formulabs B517
3. Papermate B376	8. Mitsubishi B394	13. Fisher B77
4. Bic B388	9. Mitsubishi B395	14. Fisher B4
5. Fisher B50	10. Cross B164	15. Pilot B103

Figure 15: Thin layer chromatography plate for similar blue ballpoint PDA samples.



1. Bic B162 2. Bic B197 3. Bic B388

Figure 15A: Thin layer chromatography plate for similar blue ballpoint PDA samples.



1. Pentel 623	**3. Staedtler B391**	**5. Eversharp 657**
2. Parker B174	**4. Dupont B113**	**6. Pilot B115**

Figure 16: Thin layer chromatography plate for similar black ballpoint PDA samples.

4. CONCLUSIONS AND FUTURE DIRECTION

The use of high performance liquid chromatography (HPLC) as the final step in ink identifications has been shown through this research to be highly effective. As stated earlier, the use of a reversed phase examination as the final step in the ink identification as opposed to an additional normal phase process provides much needed variation in the techniques utilized to produce the ink identification. Furthermore, both the increased specificity of the HPLC as compared to HPTLC and the quantitative measure of degree of fit provided by the library matching software allow for a more objective analysis and conclusion to be performed and attained.

Alterations to this technique, however, could drastically improve the results. For example, if software were developed to not only look at only the individual peaks in a chromatogram, but instead to examine the entire chromatogram, several misidentifications that occurred could be avoided. Also, if a HPLC environment were identified that would allow for the examination of copper phthalocyanine, a common ingredient in inks, a more inclusive analysis of the inks would be able to be performed and much confusion, and possible misidentification, could be eliminated.

Ink identifications are crucial to many questioned document cases. It is therefore imperative that a reproducible, reliable, and highly efficient technique be available. HPTLC and HPLC have been shown to meet these standards, and there are other techniques currently being developed that will further the science of ink identification. Capillary electrophoresis (CE) is a technique that is gaining popularity in the field of forensic science owing to its great versatility. The ability to easily alter the instrumentation and analysis environment on the CE greatly facilitates the analysis of

different kinds of ink (i.e. rollerball ink, ballpoint ink, felt tip ink) which are composed of vastly different components requiring different analytical techniques.[11] In addition, CE has been found to be more discriminating than either HPTLC or HPLC in the analysis of ink and provides greater resolving power than those techniques as well.[12] Furthermore, CE typically requires a much smaller sample size than HPTLC or HPLC. For example, using capillary zone capillary electrophoresis, Whiting was able to obtain consistent results differentiating between four ballpoint inks with sample sizes as small as 5mm of an ink line.[12]

Other forms of capillary electrophoresis have also been utilized in ballpoint ink analysis. Micellar electrokinetic capillary chromatography (MECC) was used by a group in the Netherlands to differentiate ballpoint inks that were indistinguishable by HPLC or HPTLC.[12] Capillary electrophoresis has also been paired with particle induced x-ray emission (PIXE) to obtain favorable results. Ballpoint ink samples that were not able to be differentiated by the capillary electrophoresis were shown by PIXE to possess a different copper: zinc ratio or additional metals not present in the other inks. Conversely, those samples that were not able to be differentiated by PIXE analysis exhibited different peak patterns in their electropherograms.[13]

Another method of ink differentiation analysis currently being pursued is that of field desorption mass spectrometry (FDMS). This method, too, uses a much smaller ink sample size than either HPLC or HPTLC: 1mm of an ink line. FDMS is a simple, quick method that has been shown to differentiate ballpoint inks by the identification and comparison of the basic dyes present in the inks. One notable disadvantage to this

technique, however, is that it is unable to differentiate between different dyes with identical molecular weights.[14]

As is obvious from the amount of research being pursued with the various techniques discussed, ballpoint ink differentiation and identification are extremely timely topics of research. With the HPLC method proposed by this research and the results it has provided, this author hopes to provide yet another building block on which improved methods of ballpoint ink identification analysis can be constructed.

APPENDICES

APPENDIX A

APPENDIX A

Instrument Method for inkrev 2

Instrument Method: inkrev2 instrument method

Stored: 2/25/2002 10:42:53 AM

Method Information

Comments	
Modified User	System
Locked	No
Method Id	5296
Method Version	12
Edit User	

996 PDA Instrument Setup

Type	996 PDA	Channel 1 Ratio Wavelength	254.0
Instrument Status	On	Channel 1 Threshold	0.001
Channel Name	996	Channel 1 Minimum Ratio	0.001
Start Wavelength	208.0	Channel 1 Maximum Ratio	100.000
End Wavelength	800.0	Channel 1 Filter Type	Hamming
Sampling Rate	1.0	Channel 1 Filter Response	0
Resolution	1.2	Channel 2 Mode	Off
Auto Exposure	Yes	Channel 2 Bandwidth	4.8
Lamp On	Yes	Channel 2 Wavelength	254.0
Interpolate 656 nm	Yes	Channel 2 Offset	0.000
Channel 1 Enable	Off	Channel 2 Ratio Wavelength	254.0
Channel 2 Enable	Off	Channel 2 Threshold	0.001
Exposure Time	15.00	Channel 2 Minimum Ratio	0.001
Filter Response	1	Channel 2 Maximum Ratio	100.000
Digital Filter Response	1.0	Channel 2 Filter Type	Hamming
Channel 1 Mode	Off	Channel 2 Filter Response	0
Channel 1 Bandwidth	4.8	Event Enable	On
Channel 1 Wavelength	254.0		
Channel 1 Offset	0.000		

996 PDA Event Table

	Time	Event Out Number	Event	Comments
1	22.00	Event Lamp	Off	

W600 Instrument Setup

Type	W600
Instrument Status	On
Channel Name	600 PRESS
Description	
Use channel monitor	Off
Monitor parameter	Pressure
Chart Parameter	%A
Head Volume	100
Pump Type	600E
Pump Mode	Isocratic
Flow	1.00
%A	100.0
%B	0.0
%C	0.0
%D	0.0
High Limit	4000
Low Limit	0
Sparge Rate	20
Sparge A	On
Sparge B	Off
Sparge C	Off
Sparge D	Off
Setpoint	0.0
High temp limit	25.0
Silk On	Off
Vacuum Degas On	Off
Switch 1	Off
Switch 2	Off
Switch 3	Off
Switch 4	Off
Use Events	Off
Solvent A	80:20 acetonitrile: H2O .005 heptanesulfonic acid + 0.025 acetic acid
Solvent B	
Solvent C	
Solvent D	

W717 Instrument Setup

Type	W717
Instrument Status	On
Use Temp	No
Setup	4.0
Heater Cooler	Not Installed

Channel 2 Wavelength	254.0
Channel 2 Offset	0.000
Channel 2 Ratio Wavelength	254.0
Channel 2 Threshold	0.001
Channel 2 Minimum Ratio	0.001
Channel 2 Maximum Ratio	100.000
Channel 2 Filter Type	Hamming
Channel 2 Filter Response	0
Event Enable	On

996 PDA Event Table

	Time	Event Out Number	Event	Comments
1	22.00	Event Lamp	Off	

W600 Instrument Setup

Type	W600
Instrument Status	On
Channel Name	600 PRESS
Description	
Use channel monitor	Off
Monitor parameter	Pressure
Chart Parameter	%A
Head Volume	100
Pump Type	600E
Pump Mode	Isocratic
Flow	1.00
%A	100.0
%B	0.0
%C	0.0
%D	0.0
High Limit	4000
Low Limit	0
Sparge Rate	20
Sparge A	On
Sparge B	Off
Sparge C	Off
Sparge D	Off
Setpoint	0.0
High temp limit	25.0
Silk On	Off
Vacuum Degas On	Off
Switch 1	Off
Switch 2	Off
Switch 3	Off
Switch 4	Off
Use Events	Off

APPENDIX B

APPENDIX B

Processing Data with Waters Empower Software

APPENDIX B.1

Deriving a Max Plot Chromatogram

To Derive a Max Plot Chromatogram:

1. Open the **Project** window
   - At the main menu, right click on the **Review Data** box.
   - Select **Review** from the context menu.
   - Select **Channels** from the cascade menu.
2. Select (double click) the sample you wish to build the processing method with. It is advantageous to select one with numerous peaks. If one of the samples run has an upward sloping baseline, select that sample with which to build the processing method.
   - It is necessary to use the sample with the high baseline, if present, because if you utilize a spectrum that does not have a high baseline to create a processing method and then try to utilize the processing method on a spectrum that does have a high baseline, the method will find a reduced number or no peaks. However if the reverse is done, creating the processing method with the high baseline spectrum and then analyzing samples without the high baseline, there are no adverse effects noted.
   - The numerous peaks characteristic is advantageous in that it provides a large variety of peaks from which to select a "narrowest peak" (a later step in building the processing method).
3. In the Review Main window, click the **Method Set** tool in the tool bar to bring the Method Set Editor into view.
4. Right click on the **Method Set tree** (in the window on the left of the screen); select **New** from the context menu and **Derived Channel** from the cascade menu.

5. From the Channel tab, select **PDA: Max Plot** from the drop-down menu.
6. Enter **250** for the start wavelength and **550** for the end wavelength in their respective text boxes.
    - This span was selected owing to previous research that illustrated the greatest diversity between ball point inks to occur at the wavelengths of 254 nm and 546 nm.[7] It is suggested by the software manufacturer to keep the wavelength range as small as possible, thus explaining the precise numbers selected here.
7. Click **OK** after the correct wavelength range has been selected.
8. Enter a name for the new derived channel in the dialog box which appears (for example, **MaxPlot250_550**), and click **OK**.

APPENDIX B.2

Building a PDA Processing Method

To Build a PDA Processing Method:

1. Click on the **Processing Method Wizard** icon in the tool bar.
2. Select **PDA** from the Processing Type drop-down menu, and click **OK**. The Peak Detection 1 page will appear.
3. On the Integration - Peak Detection 1 page, select the narrowest peak of interest; click **Next**.
    - Do not select the smallest, narrowest peak present in the spectrum; instead, select a peak that is of decent height (somewhat of a judgement call) and is slightly wider than the narrowest peak. This will allow the processing method to be more discriminatory in the peaks it identifies.
    - The peak width selected here was 30.00 seconds.
4. The Integration - Peak Detection 2 page appears next. This page allows you to set the peak threshold by selecting a portion of the baseline that has representative noise.
    - This is where the high baseline is a factor.
    - Zoom in on an area of the baseline that does not have peaks, but that is sloping upwards (if applicable, towards the right hand side of the spectrum). It may be necessary to zoom in several times to ensure that the baseline is indeed free of peaks.
    - The threshold selected in this case was 60.00 μV/sec.
    - Click **Next**.
5. The Integration - Peak Detection 3 page appears next. In this page, you are to select the portion of the chromatogram over which you would like the integration

performed. Using the mouse, select the entire chromatogram; dragging the box within the x- and y-axes. Click **Next.**

6. The Integration - Peak Detection 4 page appears next. This page allows you to discard peaks that are not of interest.
   - Click in the middle of the peak of interest; select either the **Minimum Height** or **Minimum Area** box. This sets the Minimum Area or Minimum Height to 95% of the smallest peak of interest.
   - A peak of area 18,000 μV*sec. was selected
   - Click **Next.**
7. The Calibration – General page appears next. Click **Next** on the following pages until you reach the PDA Purity/Matching page.
   - To the question: "Do you wish to perform peak purity testing on all peaks?", answer **No.**
   - To the question: "Do you wish to match spectra against PDA library spectra?", answer **Yes.**
8. The Processing Method Name page appears. In the Method Name text box, type the desired name, in this case "Marilyn library 2103". Click **Finish.**
9. It is also necessary to save the Method Set in which the Processing Method functions. To do this, simply go to **Save As**, select **Method Set** from the drop down window, and type in the desired name.

APPENDIX B.3

Creating a Library; Adding and Matching Spectra to an Existing Library

To Create and Add Spectra to the Library:

1. Return to the Project window (Step 1 under "To Derive a Max Plot Chromatogram"), and select the spectra you desire to have in your library. You may start with as many or few as you choose; you can always add more at later times. To select more than one, you must hold down the **Shift** key on the keyboard when clicking on the spectra name with the mouse. Click the **Review** tool.
2. Click the **3D Channels** tab at the bottom of the Review Main window.
3. Select **Open** from the File menu, and then select **Method Set.**
4. Select the desired method set (**Marilyn library 2103**); click **Open.**
5. The method set should automatically be applied to the sample. If not, click on the **Apply Method Set** tool in the upper tool bar.
6. Select **Library** from the Spectrum Review menu; select **New Library** from the cascade menu.
7. Name the new library; click on the **Create** button.
8. Again, select the **Library** option from the Spectrum Review menu; select **Add to library** _____ from the cascade menu.
9. The Add Spectrum to Library dialog box then appears.
1. In the Name text box enter the desired name of the identified peak. Each peak within the sample will be identified and will subsequently need some sort of label. For example, if it were the first peak identified from the sample Tombo B-535, I would name the peak "Tombo B-535-1", then "Tombo B-535-2", and so on. Click **OK.**

2. After all peaks from one sample are named, go to the 3D Channels table and select the next spectrum to be processed. Repeat steps 8 through 10.
3. Continue entering spectra into the library until finished.
4. Select **Exit** from the File menu.

To Match Spectra to an Existing Library:

1. Again, open the Project window (Step 1 under "To Derive a Max Plot Chromatogram").
2. Click on the "Method" tab that will then display all processing methods and method sets in the computer's memory. Click on the processing method that was used to create the library, and that will be used to process the unknown sample. In the library matching area, check the empty box next to the library created for this questioned sample. Ensure that no other box is checked.
3. Save these changes to the processing method.
4. Return to the Channels tab.
5. Select the spectrum you would like matched against the existing library. Click **Review**.
6. At the bottom of the Review Main window, click on the **3D Channels** tab.
7. Select **Open** from the File menu, and then **Method Set** from the cascade menu. Select **Marilyn library 2103** from the menu of existing method sets. Click **Open**.

8. Again, the processing method should automatically be applied to the sample. However, if it is not, click on the **Apply Method Set** tool. This will extract and process a Max Plot chromatogram for the spectrum selected.

9. Scroll the menu where 3D Channels is initially highlighted until you reach a tab entitled **Peaks.** This will display a table where the calculated values for the library matching are listed.

    - The Match Angle should be less than the Match Threshold to indicate a good match.

10. Save the results so that they can be printed in a report.

    - Select **Save** from the File menu, then **All.**

APPENDIX B.4

Creating and Printing Reports

To Create and Print Reports:

1. Return to the Project window (Step 1 under "To Derive a Max Plot Chromatogram").
2. Click the **Results** tab.
3. Select the data you wish to print; click **Preview/Report Publisher** under the Tools menu.
4. In the Open Report Method dialog box, create your report. A report for individual samples was created in this case by adding the following items to a blank report template: sample name, injection volume, run time, sample set name, processed channel description, date acquired, acquiring method set, processing method, channel name, 3D plot, auto-scaled chromatogram, peak results table, and PDA result table.
5. Save the result method.
6. After the Report Method has been saved, click the **Print** tool.

APPENDIX C

APPENDIX C

HPLC Reports for Blue Ball Point Inks That Were Identified to a Reasonable Degree of Certainty by Library Matching

APPENDIX C.1

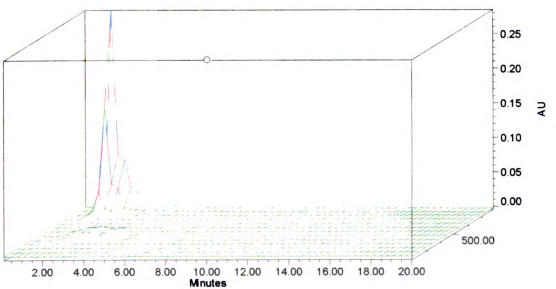
HPLC Reports for Blue Ball Point Inks That Were Identified to a Reasonable Degree of Certainty by Library Matching

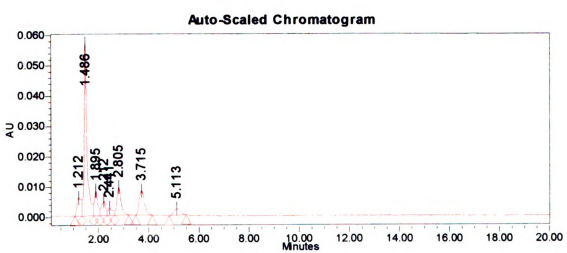
Sample Run 1

Figure 17: HPLC report for ink sample Russian Ink B426D

SampleName Russian Ink B426D	**Date Acquired 1/16/2003 9:40:16 PM**
Injection Volume 10.00 ul	**Acq Method Set inkrev2 method set**
Run Time 20.00 Minutes	**Processing Method Marilyn library 2103**
Sample Set Name marilyn 11603	**Channel Name MaxPlot250_550**

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)





Sample Name Russian Ink B426D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.212	73523	7.73	5964
2	PDA MaxPlot (250nm-550nm)	1.486	449822	47.27	57074
3	PDA MaxPlot (250nm-550nm)	1.895	72834	7.65	8299
4	PDA MaxPlot (250nm-550nm)	2.212	57234	6.02	4790
5	PDA MaxPlot (250nm-550nm)	2.441	33250	3.49	2591
6	PDA MaxPlot (250nm-550nm)	2.805	107663	11.31	9212
7	PDA MaxPlot (250nm-550nm)	3.715	117534	12.35	8087
8	PDA MaxPlot (250nm-550nm)	5.113	39656	4.17	2165

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.212			Russian Ink B426-1	0.440	1.224
2		1.486			Russian Ink B426-2	0.178	1.022
3		1.895			Russian Ink B426-3	1.006	1.103
4		2.212			Russian Ink B426-4	2.604	1.581
5		2.441			Russian Ink B426-5	8.371	1.827
6		2.805			Senator B385-4	2.980	1.940
7		3.715			Senator B385-5	0.888	1.493
8		5.113			Formulabs B517-11	1.988	2.479

Figure 18: HPLC report for ink sample Cross B164D

SampleName Cross B164D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marily n 11603

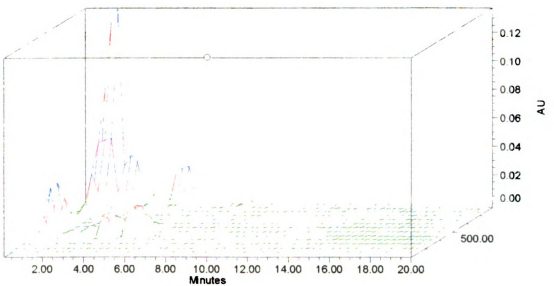
Date Acquired 1/16/2003 10:43:52 PM

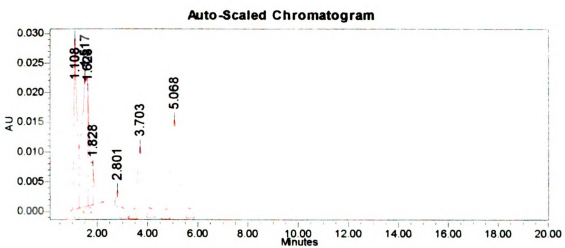
Acq Method Set inkrev2 method set

Processing Method Marily n library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Cross B164D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.108	249857	19.91	28649
2	PDA MaxPlot (250nm-550nm)	1.517	357626	28.50	21975
3	PDA MaxPlot (250nm-550nm)	1.628	119216	9.50	19312
4	PDA MaxPlot (250nm-550nm)	1.828	43258	3.45	6288
5	PDA MaxPlot (250nm-550nm)	2.801	24924	1.99	2669
6	PDA MaxPlot (250nm-550nm)	3.703	151753	12.09	10480
7	PDA MaxPlot (250nm-550nm)	5.068	308162	24.56	15073

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.108			Cross B164-1	0.778	1.111
2		1.517			Cross B164-2	0.481	1.186
3		1.628			Cross B164-3	0.431	1.197
4		1.828			Cross B164-3	5.016	1.498
5		2.801			Cross B164-4	2.380	3.185
6		3.703			Cross B164-5	4.567	1.528
7		5.068			Fisher B4-6	0.889	1.461

Figure 19: HPLC report for ink sample Papermate 622D

SampleName Papermate 622D

Date Acquired 1/16/2003 11:26:16 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

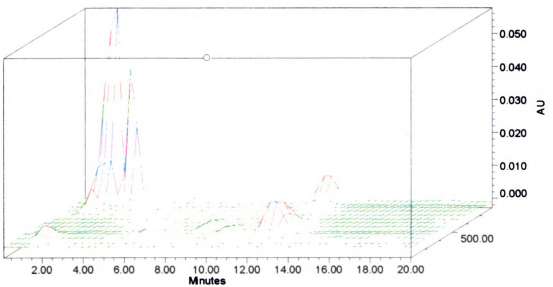
Run Time 20.00 Minutes

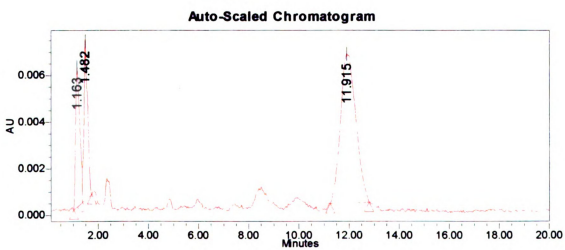
Processing Method Marilyn library 2103

Sample Set Name marilyn 11603

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Papermate 622D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.163	68832	16.70	5963
2	PDA MaxPlot (250nm-550nm)	1.482	69720	16.92	6857
3	PDA MaxPlot (250nm-550nm)	11.915	273590	66.38	6407

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.163			Papermate 622-1	6.074	12.567
2		1.482			Papermate 622-2	8.116	18.857
3		11.915					

Figure 20: HPLC report for ink sample Inoxcrom B10D

SampleName Inoxcrom B10D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11603

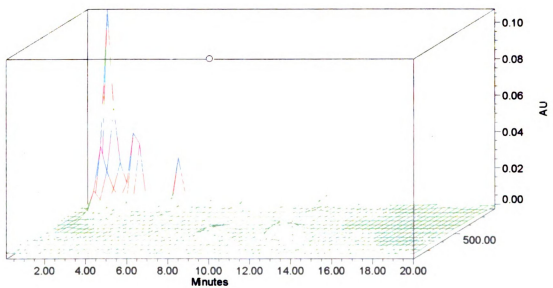
Date Acquired 1/17/2003 12:08:41 AM

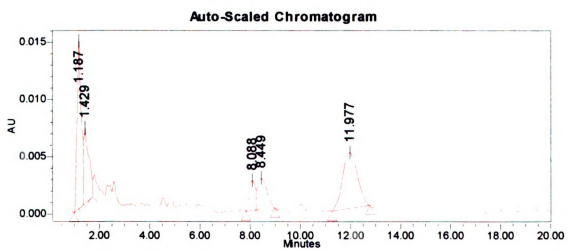
Acq Method Set inkrev2 method set

Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Inoxcrom B10D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.187	168135	29.30	14719
2	PDA MaxPlot (250nm-550nm)	1.429	91873	16.01	6593
3	PDA MaxPlot (250nm-550nm)	8.088	42559	7.42	2608
4	PDA MaxPlot (250nm-550nm)	8.449	69907	12.18	2728
5	PDA MaxPlot (250nm-550nm)	11.977	201402	35.10	4886

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.187			Inoxcrom B10-1	3.035	6.057
2		1.429			Inoxcrom B10-2	6.002	12.691
3		8.088					
4		8.449					
5		11.977					

Figure 21: HPLC report for ink sample Mont Blanc B106D

SampleName Mont Blanc B106D

Date Acquired 1/17/2003 1:12:19 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

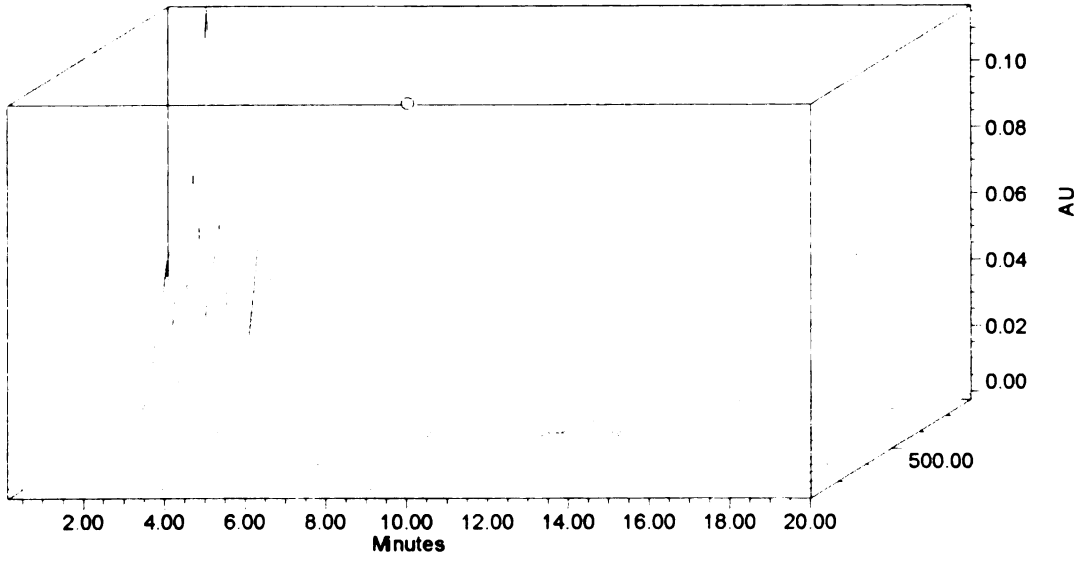
Run Time 20.00 Minutes

Processing Method Marilyn library 2103

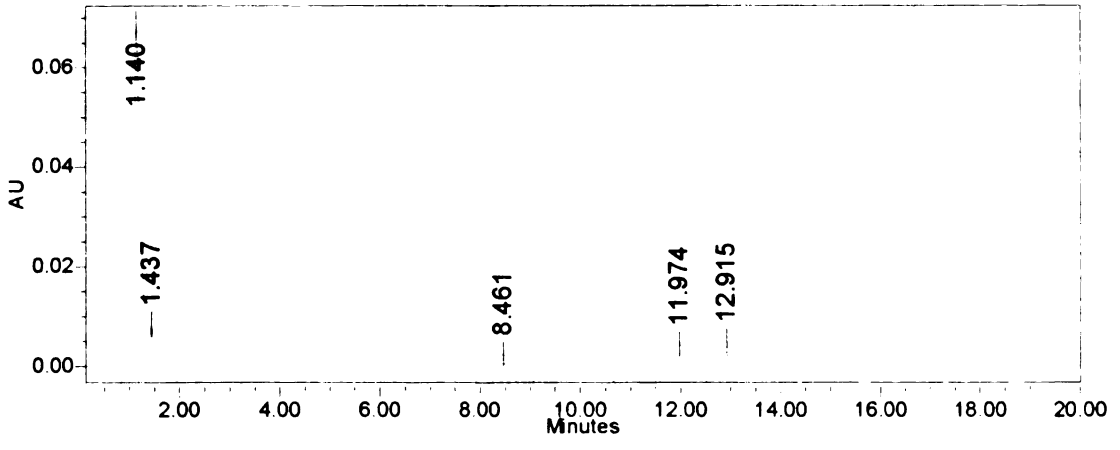
Sample Set Name marilyn 11603

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Mont Blanc B106D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.140	566640	54.90	68190
2	PDA MaxPlot (250nm-550nm)	1.437	66273	6.42	7190
3	PDA MaxPlot (250nm-550nm)	8.461	44523	4.31	1803
4	PDA MaxPlot (250nm-550nm)	11.974	157890	15.30	3885
5	PDA MaxPlot (250nm-550nm)	12.915	196829	19.07	4640

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.140			Mont Blanc B106-1	1.034	1.329
2		1.437			Mont Blanc B106-2	5.972	11.291
3		8.461					
4		11.974					
5		12.915			Formulabs B519-11	3.897	7.760

Figure 22: HPLC report for ink sample Bic B162D

SampleName Bic B162D

Date Acquired 1/17/2003 2:37:08 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

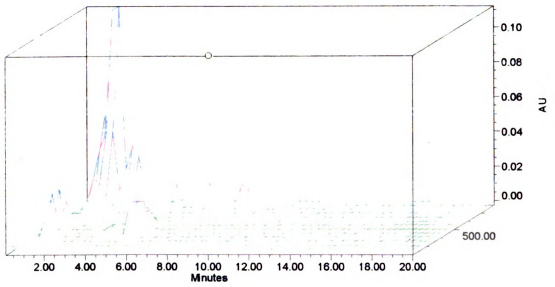
Run Time 20.00 Minutes

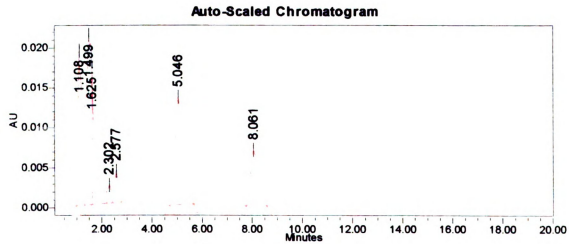
Processing Method Marilyn library 2103

Sample Set Name marilyn 11603

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Bic B162D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.108	242620	20.01	18984
2	PDA MaxPlot (250nm-550nm)	1.499	317561	26.19	21382
3	PDA MaxPlot (250nm-550nm)	1.625	166238	13.71	17119
4	PDA MaxPlot (250nm-550nm)	2.302	23931	1.97	2271
5	PDA MaxPlot (250nm-550nm)	2.577	40485	3.34	3918
6	PDA MaxPlot (250nm-550nm)	5.046	276767	22.83	13481
7	PDA MaxPlot (250nm-550nm)	8.061	144942	11.95	6974

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.108			Bic B162-1	0.768	1.150
2		1.499			Bic B162-2	0.424	1.123
3		1.625			Bic B162-3	0.896	1.155
4		2.302					
5		2.577			Bic B162-5	3.984	2.083
6		5.046			Bic B162-6	0.998	1.514
7		8.061			Bic B162-7	0.601	1.647

Figure 23: HPLC report for ink sample Dupont B102D

SampleName Dupont B102D

Date Acquired 1/17/2003 3:40:47 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

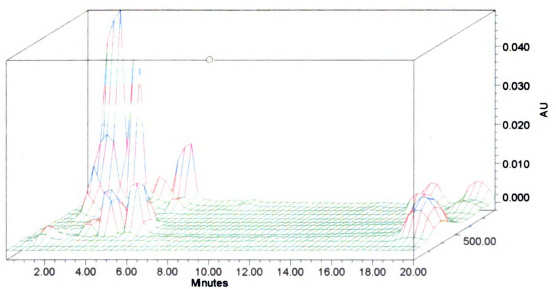
Run Time 20.00 Minutes

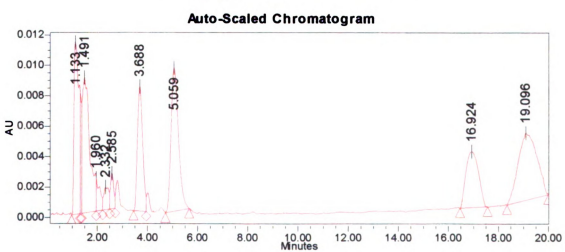
Processing Method Marily n library 2103

Sample Set Name marily n 11603

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Dupont B102D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.133	156928	14.62	11398
2	PDA MaxPlot (250nm-550nm)	1.491	185793	17.31	8881
3	PDA MaxPlot (250nm-550nm)	1.960	20893	1.95	2166
4	PDA MaxPlot (250nm-550nm)	2.332	21025	1.96	1483
5	PDA MaxPlot (250nm-550nm)	2.585	20716	1.93	2334
6	PDA MaxPlot (250nm-550nm)	3.688	117297	10.93	8182
7	PDA MaxPlot (250nm-550nm)	5.059	193387	18.02	9417
8	PDA MaxPlot (250nm-550nm)	16.924	128039	11.93	3661
9	PDA MaxPlot (250nm-550nm)	19.096	228953	21.34	4413

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.133			Dupont B102-1	3.406	1.325
2		1.491			Dupont B102-2	0.838	1.377
3		1.960			Dupont B102-2	7.951	2.242
4		2.332			Bic B162-4	6.054	2.001
5		2.585			Fisher B4-3	6.795	4.063
6		3.688			Dupont B102-5	0.795	1.774
7		5.059			Dupont B102-6	0.765	1.591
8		16.924			Dupont B102-7	1.048	2.181
9		19.096			Dupont B102-8	0.806	1.865

Figure 24: HPLC report for ink sample Formulabs B517D

SampleName Formulabs B517D

Date Acquired 1/17/2003 4:23:11 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

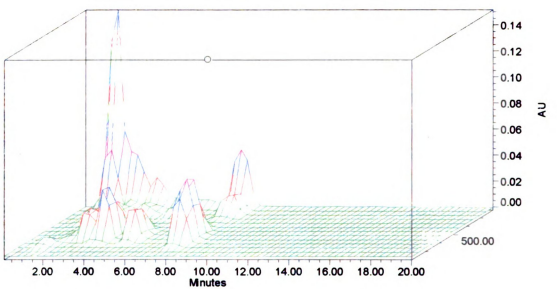
Run Time 20.00 Minutes

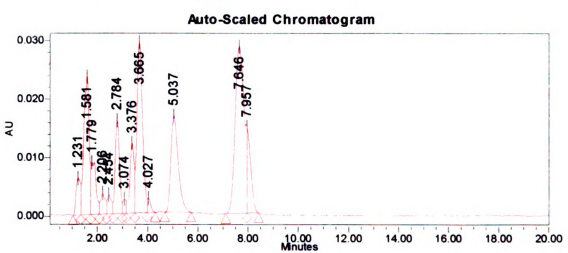
Processing Method Marily n library 2103

Sample Set Name marily n 11603

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Formulabs B517D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.231	75589	2.85	6331
2	PDA MaxPlot (250nm-550nm)	1.581	343716	12.95	23669
3	PDA MaxPlot (250nm-550nm)	1.779	128449	4.84	8876
4	PDA MaxPlot (250nm-550nm)	2.206	48294	1.82	3585
5	PDA MaxPlot (250nm-550nm)	2.454	36387	1.37	3263
6	PDA MaxPlot (250nm-550nm)	2.784	189057	7.12	16060
7	PDA MaxPlot (250nm-550nm)	3.074	20007	0.75	2489
8	PDA MaxPlot (250nm-550nm)	3.376	142441	5.37	11959
9	PDA MaxPlot (250nm-550nm)	3.665	443863	16.72	29224
10	PDA MaxPlot (250nm-550nm)	4.027	22556	0.85	2464
11	PDA MaxPlot (250nm-550nm)	5.037	338763	12.76	16448
12	PDA MaxPlot (250nm-550nm)	7.646	718598	27.07	28404
13	PDA MaxPlot (250nm-550nm)	7.957	147252	5.55	14658

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.231			Formulabs B517-1	1.304	1.953
2		1.581			Formulabs B517-2	0.412	1.257
3		1.779				7.368	2.191
4		2.206			Formulabs B517-4	1.738	2.948
5		2.454			Formulabs B517-5	2.125	3.391
6		2.784			Formulabs B517-6	2.401	1.448
7		3.074			Formulabs B517-7	3.140	4.220
8		3.376			Formulabs B517-8	0.928	1.819
9		3.665			Formulabs B517-9	0.340	1.349
10		4.027			Formulabs B517-10	2.811	4.330
11		5.037			Formulabs B517-11	0.407	1.557
12		7.646			Formulabs B517-12	0.199	1.226
13		7.957			Formulabs B517-13	0.365	1.491

Figure 25: HPLC report for ink sample Fisher B4D

SampleName Fisher B4D

Date Acquired 1/17/2003 5:26:50 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

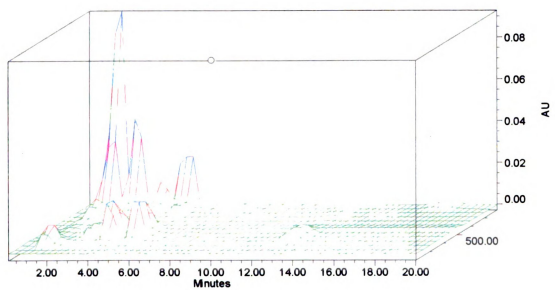
Run Time 20.00 Minutes

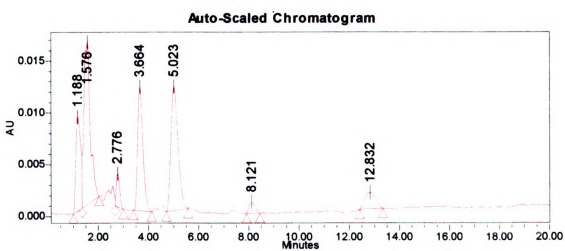
Processing Method Marily n library 2103

Sample Set Name marily n 11603

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Fisher B4D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.188	122811	13.53	9173
2	PDA MaxPlot (250nm-550nm)	1.576	274622	30.25	15733
3	PDA MaxPlot (250nm-550nm)	2.776	29909	3.29	3212
4	PDA MaxPlot (250nm-550nm)	3.664	175068	19.29	11965
5	PDA MaxPlot (250nm-550nm)	5.023	236983	26.11	11965
6	PDA MaxPlot (250nm-550nm)	8.121	18988	2.09	1087
7	PDA MaxPlot (250nm-550nm)	12.832	49355	5.44	1561

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.188			Fisher B4-1	1.001	1.466
2		1.576			Fisher B4-2	0.519	1.396
3		2.776			Fisher B4-4	1.745	3.345
4		3.664			Fisher B4-5	0.551	1.539
5		5.023			Fisher B4-6	1.478	1.533
6		8.121					
7		12.832			Formulabs B519-11	1.665	2.902

Figure 26: HPLC report for ink sample Formulabs B519D

SampleName Formulabs B519D

Date Acquired 1/17/2003 6:09:14 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

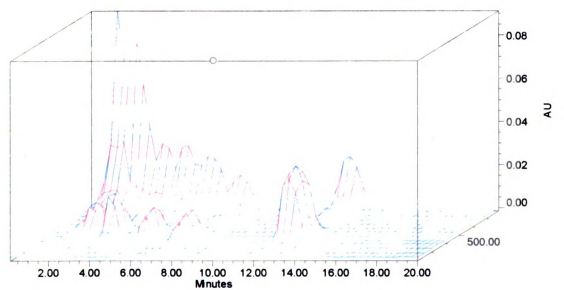
Run Time 20.00 Minutes

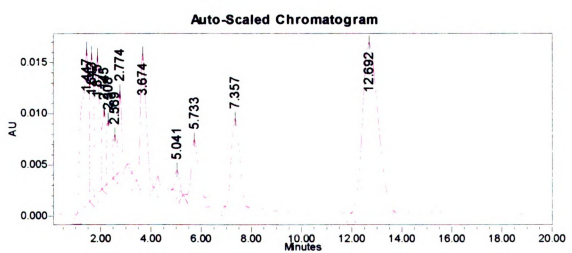
Processing Method Marilyn library 2103

Sample Set Name marilyn 11603

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Formulabs B519D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.447	290390	13.87	15197
2	PDA MaxPlot (250nm-550nm)	1.643	135034	6.45	14326
3	PDA MaxPlot (250nm-550nm)	1.875	183769	8.78	13534
4	PDA MaxPlot (250nm-550nm)	2.145	79438	3.79	7531
5	PDA MaxPlot (250nm-550nm)	2.308	76328	3.64	6149
6	PDA MaxPlot (250nm-550nm)	2.569	36924	1.76	4090
7	PDA MaxPlot (250nm-550nm)	2.774	73556	3.51	7847
8	PDA MaxPlot (250nm-550nm)	3.674	194483	9.29	12657
9	PDA MaxPlot (250nm-550nm)	5.041	26322	1.26	2097
10	PDA MaxPlot (250nm-550nm)	5.733	92609	4.42	5484
11	PDA MaxPlot (250nm-550nm)	7.357	197550	9.43	8537
12	PDA MaxPlot (250nm-550nm)	12.692	707718	33.80	16521

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.447			Formulabs B519-2	3.912	2.052
2		1.643			Formulabs B519-3	1.201	2.187
3		1.875			Formulabs B519-4	8.933	2.151
4		2.145			Formulabs B519-5	3.958	2.717
5		2.308			Formulabs B519-6	2.313	2.942
6		2.569			Formulabs B519-6	8.270	3.719
7		2.774			Formulabs B519-7	2.320	3.835
8		3.674			Formulabs B519-8	3.356	2.794
9		5.041			Bic B162-6	9.046	9.568
10		5.733			Formulabs B519-9	3.874	4.388
11		7.357			Formulabs B519-10	2.178	4.028
12		12.692			Formulabs B519-11	1.012	2.270

APPENDIX C.2

HPLC Reports for Blue Ball Point Inks That Were Identified to a Reasonable Degree of Certainty by Library Matching

Sample Run 2

Figure 27: HPLC report for ink sample Pilot B103D

SampleName Pilot B103D

Date Acquired 1/17/2003 8:31:01 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

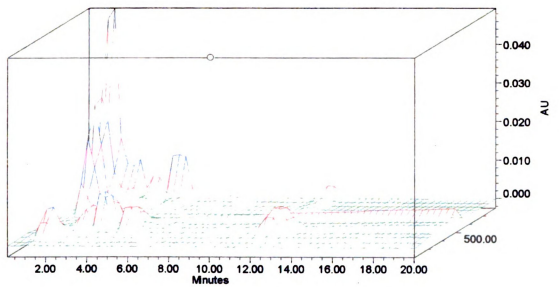
Run Time 20.00 Minutes

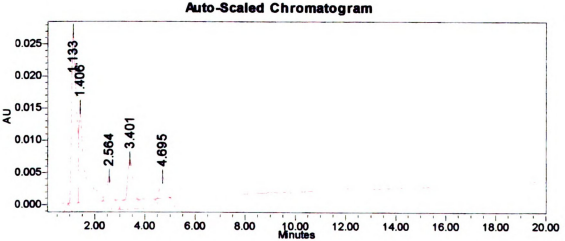
Processing Method Marilyn library 2103

Sample Set Name marilyn 11703

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)





Sample Name Pilot B103D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.133	340040	44.90	26933
2	PDA MaxPlot (250nm-550nm)	1.406	238185	31.45	14835
3	PDA MaxPlot (250nm-550nm)	2.564	45586	6.02	3819
4	PDA MaxPlot (250nm-550nm)	3.401	83479	11.02	6376
5	PDA MaxPlot (250nm-550nm)	4.695	49986	6.60	3351

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.133			Pilot B103-1	1.947	2.794
2		1.406			Pilot B103-2	3.799	5.318
3		2.564					
4		3.401			Papermate B376-6	5.369	11.318
5		4.695					

Figure 28: HPLC report for ink sample Mitsubishi B395D

SampleName Mitsubishi B395D

Date Acquired 1/18/2003 1:27:49 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

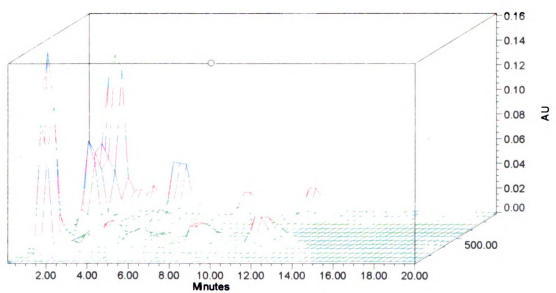
Run Time 20.00 Minutes

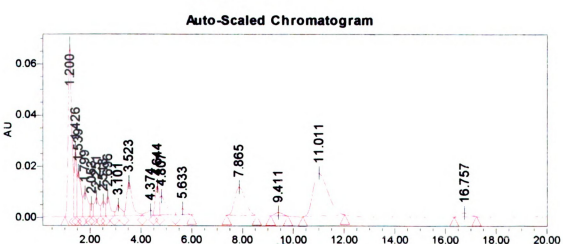
Processing Method Marily n library 2103

Sample Set Name marily n 11703

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Mitsubishi B395D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.200	649939	21.33	67929
2	PDA MaxPlot (250nm-550nm)	1.426	149438	4.90	26159
3	PDA MaxPlot (250nm-550nm)	1.539	187495	6.15	17756
4	PDA MaxPlot (250nm-550nm)	1.799	124620	4.09	9432
5	PDA MaxPlot (250nm-550nm)	2.053	39185	1.29	5035
6	PDA MaxPlot (250nm-550nm)	2.251	92729	3.04	7383
7	PDA MaxPlot (250nm-550nm)	2.518	60956	2.00	5940
8	PDA MaxPlot (250nm-550nm)	2.696	87300	2.86	7686
9	PDA MaxPlot (250nm-550nm)	3.101	60233	1.98	4262
10	PDA MaxPlot (250nm-550nm)	3.523	200338	6.57	13053
11	PDA MaxPlot (250nm-550nm)	4.374	32902	1.08	1911
12	PDA MaxPlot (250nm-550nm)	4.644	118270	3.88	11411
13	PDA MaxPlot (250nm-550nm)	4.807	132572	4.35	7440
14	PDA MaxPlot (250nm-550nm)	5.633	44531	1.46	2267
15	PDA MaxPlot (250nm-550nm)	7.865	315483	10.35	11010
16	PDA MaxPlot (250nm-550nm)	9.411	27096	0.89	1263
17	PDA MaxPlot (250nm-550nm)	11.011	676972	22.22	16633
18	PDA MaxPlot (250nm-550nm)	16.757	47216	1.55	1469

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.200			Mitsubishi B395-1	2.928	3.388
2		1.426			Mitsubishi B395-2	6.281	6.222
3		1.539					
4		1.799			Mitsubishi B395-3	7.083	8.091
5		2.053			Fisher B50-1	9.224	7.704
6		2.251			Mitsubishi B395-3	9.995	7.801
7		2.518					
8		2.696					
9		3.101			Mitsubishi B395-3	8.618	10.005
10		3.523					
11		4.374					
12		4.644			Mitsubishi B395-5	2.803	5.311
13		4.807					
14		5.633					
15		7.865					
16		9.411					
17		11.011					
18		16.757					

Figure 29: HPLC report for ink sample Parker B176D

SampleName Parker B176D

Date Acquired 1/18/2003 3:56:16 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

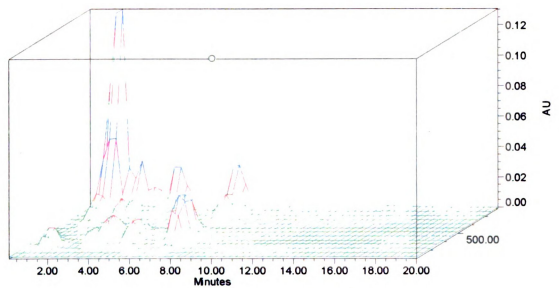
Run Time 20.00 Minutes

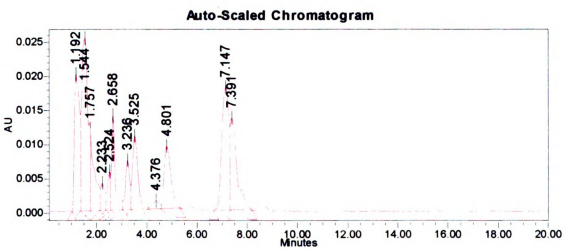
Processing Method Marilyn library 2103

Sample Set Name marilyn 11703

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Parker B176D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.192	279003	13.20	20140
2	PDA MaxPlot (250nm-550nm)	1.544	433846	20.52	25406
3	PDA MaxPlot (250nm-550nm)	1.757	132631	6.27	12023
4	PDA MaxPlot (250nm-550nm)	2.233	46426	2.20	4010
5	PDA MaxPlot (250nm-550nm)	2.524	51119	2.42	5657
6	PDA MaxPlot (250nm-550nm)	2.658	131991	6.24	13841
7	PDA MaxPlot (250nm-550nm)	3.236	84894	4.02	7251
8	PDA MaxPlot (250nm-550nm)	3.525	163404	7.73	10786
9	PDA MaxPlot (250nm-550nm)	4.376	22068	1.04	1220
10	PDA MaxPlot (250nm-550nm)	4.801	171581	8.12	9098
11	PDA MaxPlot (250nm-550nm)	7.147	354430	16.76	17969
12	PDA MaxPlot (250nm-550nm)	7.391	242926	11.49	13463

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.192			Parker B176-1	6.865	1.321
2		1.544			Parker B176-2	8.502	1.434
3		1.757			Parker B176-3	8.115	1.793
4		2.233			Parker B176-4	4.454	2.754
5		2.524			Parker B176-5	4.342	2.972
6		2.658			Parker B176-6	2.201	1.428
7		3.236			Parker B176-7	2.326	2.762
8		3.525			Staettler B384-6	3.820	1.806
9		4.376					
10		4.801			Bic B388-7	3.481	2.006
11		7.147			Parker B176-10	0.830	1.519
12		7.391					

Figure 30: HPLC report for ink sample Papermate B225D

SampleName Papermate B225D

Date Acquired 1/18/2003 8:53:14 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

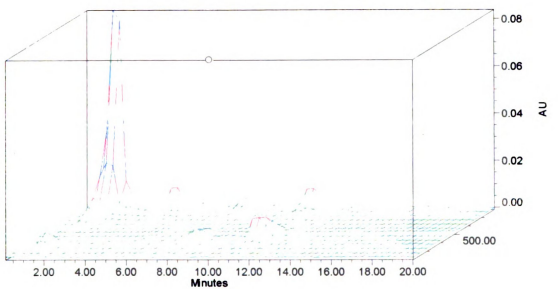
Run Time 20.00 Minutes

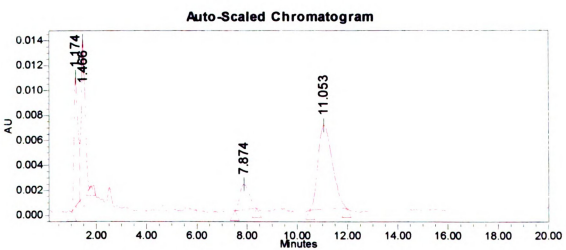
Processing Method Marily n library 2103

Sample Set Name marily n 11703

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Papermate B225D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.174	112295	19.78	10398
2	PDA MaxPlot (250nm-550nm)	1.466	137537	24.22	12647
3	PDA MaxPlot (250nm-550nm)	7.874	53151	9.36	2035
4	PDA MaxPlot (250nm-550nm)	11.053	264809	46.64	6751

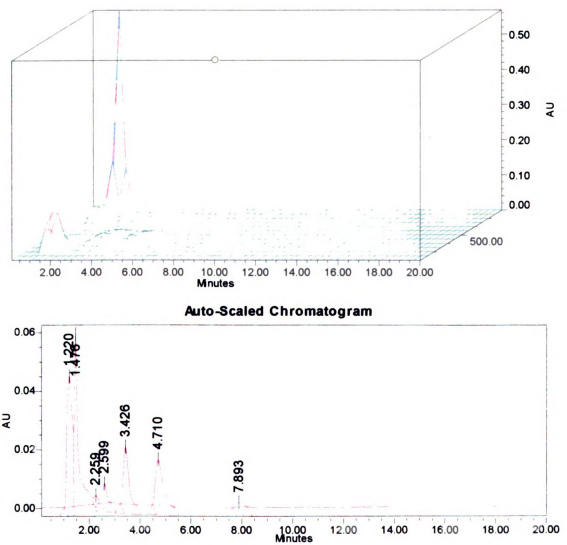
PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.174			Papermate B225-1	5.529	5.550
2		1.466					
3		7.874					
4		11.053					

Figure 31: HPLC report for ink sample Papermate B376D

SampleName Papermate B376D	Date Acquired 1/18/2003 9:35:38 AM
Injection Volume 10.00 ul	Acq Method Set inkrev2 method set
Run Time 20.00 Minutes	Processing Method Marily n library 2103
Sample Set Name marily n 11703	Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Sample Name Papermate B376D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.220	645246	32.77	44778
2	PDA MaxPlot (250nm-550nm)	1.476	629640	31.97	58379
3	PDA MaxPlot (250nm-550nm)	2.259	30799	1.56	2973
4	PDA MaxPlot (250nm-550nm)	2.599	80827	4.10	6744
5	PDA MaxPlot (250nm-550nm)	3.426	263243	13.37	19478
6	PDA MaxPlot (250nm-550nm)	4.710	293050	14.88	15658
7	PDA MaxPlot (250nm-550nm)	7.893	26406	1.34	1465

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.220			Papermate B376-1	1.059	1.084
2		1.476			Papermate B376-2	0.699	1.041
3		2.259			Papermate B376-4	1.749	2.337
4		2.599			Papermate B376-5	2.447	1.881
5		3.426			Staettler B384-6	0.986	1.310
6		4.710			Papermate B376-7	1.553	1.431
7		7.893			Papermate B376-8	4.232	6.474

APPENDIX C.3

HPLC Reports for Blue Ball Point Inks That Were Identified to a Reasonable Degree of Certainty by Library Matching

Sample Run 3

Figure 32: HPLC report for ink sample Cross B164G

SampleName Cross B164G

Date Acquired 1/19/2003 5:25:05 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

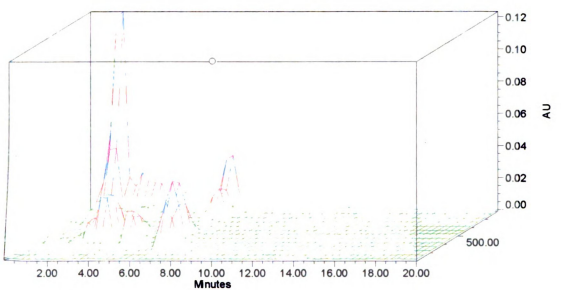
Run Time 20.00 Minutes

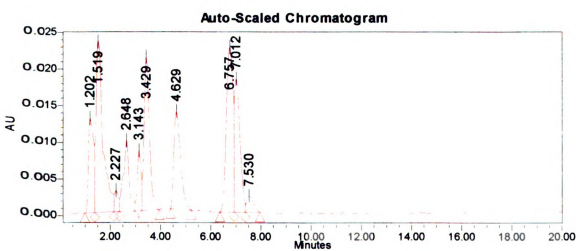
Processing Method Marilyn library 2103

Sample Set Name marilyn 11903

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Cross B164G

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.202	179373	8.22	12999
2	PDA MaxPlot (250nm-550nm)	1.519	450222	20.62	23485
3	PDA MaxPlot (250nm-550nm)	2.227	31413	1.44	2892
4	PDA MaxPlot (250nm-550nm)	2.648	156582	7.17	9732
5	PDA MaxPlot (250nm-550nm)	3.143	86181	3.95	8262
6	PDA MaxPlot (250nm-550nm)	3.429	307701	14.09	21016
7	PDA MaxPlot (250nm-550nm)	4.629	247632	11.34	13305
8	PDA MaxPlot (250nm-550nm)	6.757	405324	18.57	22484
9	PDA MaxPlot (250nm-550nm)	7.012	278548	12.76	18191
10	PDA MaxPlot (250nm-550nm)	7.530	40231	1.84	2184

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.202			Sheaffer B166-1	3.745	1.433
2		1.519			Cross B164E	1.423	1.295
3		2.227			Cross B164E	3.341	2.710
4		2.648			Cross B164E	1.487	1.617
5		3.143			Cross B164E	1.911	2.032
6		3.429			Cross B164E	0.607	1.436
7		4.629			Cross B164E	0.840	1.622
8		6.757			Cross B164E	0.448	1.264
9		7.012			Cross B164E	0.916	1.332
10		7.530			Cross B164E	5.143	4.580

Figure 33: HPLC report for ink sample Itoya B194D

SampleName Itoya B194D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11903

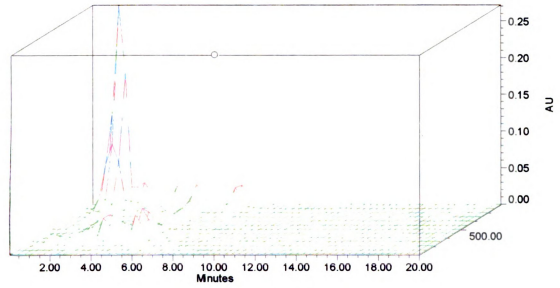
Date Acquired 1/19/2003 8:35:53 PM

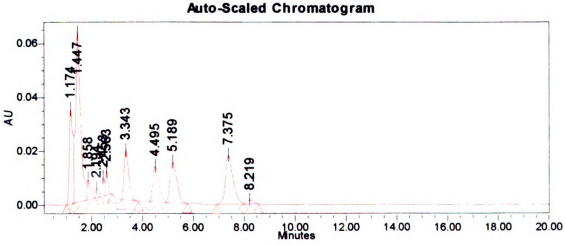
Acq Method Set inkrev2 method set

Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Itoya B194D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.174	355916	13.74	35381
2	PDA MaxPlot (250nm-550nm)	1.447	835779	32.26	63734
3	PDA MaxPlot (250nm-550nm)	1.858	87323	3.37	7455
4	PDA MaxPlot (250nm-550nm)	2.194	33460	1.29	3545
5	PDA MaxPlot (250nm-550nm)	2.453	54295	2.10	6989
6	PDA MaxPlot (250nm-550nm)	2.583	62742	2.42	8783
7	PDA MaxPlot (250nm-550nm)	3.343	240929	9.30	18537
8	PDA MaxPlot (250nm-550nm)	4.495	229238	8.85	13299
9	PDA MaxPlot (250nm-550nm)	5.189	283711	10.95	15140
10	PDA MaxPlot (250nm-550nm)	7.375	380960	14.70	18274
11	PDA MaxPlot (250nm-550nm)	8.219	26781	1.03	1375

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.174			Itoya B194-1	1.851	1.167
2		1.447			Itoya B194-2	2.974	1.118
3		1.858			Itoya B194-3	2.284	1.948
4		2.194			Itoya B194-4	2.908	3.164
5		2.453			Itoya B194-5	2.587	2.711
6		2.583			Itoya B194-6	2.167	2.873
7		3.343			Itoya B194-7	0.908	1.957
8		4.495			Itoya B194-8	1.533	2.397
9		5.189			Itoya B194-9	0.959	1.499
10		7.375			Itoya B194-10	0.377	1.466
11		8.219			Tombo B535E-9	3.440	4.648

Figure 34: HPLC report for ink sample Sheaffer B166D

SampleName Sheaffer B166D

Date Acquired 1/19/2003 10:21:54 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

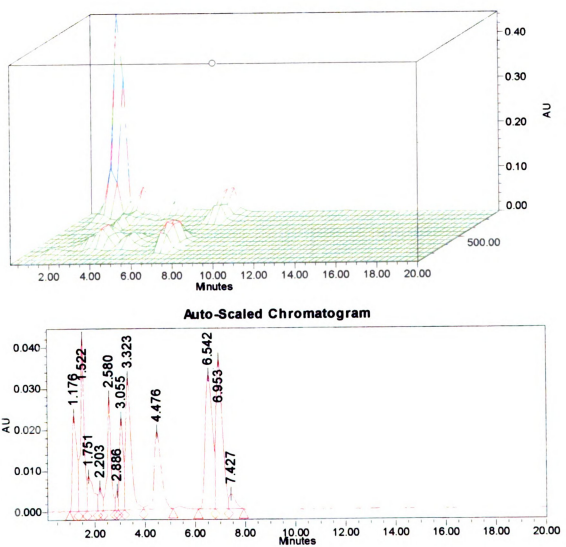
Run Time 20.00 Minutes

Processing Method Marilyn library 2103

Sample Set Name marilyn 11903

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Sample Name Sheaffer B166D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.176	279115	7.60	23225
2	PDA MaxPlot (250nm-550nm)	1.522	419308	11.42	42092
3	PDA MaxPlot (250nm-550nm)	1.751	149424	4.07	8414
4	PDA MaxPlot (250nm-550nm)	2.203	58192	1.59	5601
5	PDA MaxPlot (250nm-550nm)	2.580	284517	7.75	27585
6	PDA MaxPlot (250nm-550nm)	2.886	32410	0.88	4651
7	PDA MaxPlot (250nm-550nm)	3.055	230052	6.27	22267
8	PDA MaxPlot (250nm-550nm)	3.323	484834	13.21	32072
9	PDA MaxPlot (250nm-550nm)	4.476	374220	10.20	18778
10	PDA MaxPlot (250nm-550nm)	6.542	649799	17.70	32567
11	PDA MaxPlot (250nm-550nm)	6.953	644405	17.56	36207
12	PDA MaxPlot (250nm-550nm)	7.427	64075	1.75	3624

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.176			Sheaffer B166-1	1.451	1.563
2		1.522			Sheaffer B166-2	2.253	1.326
3		1.751			Sheaffer B166-3	2.748	2.287
4		2.203			Sheaffer B166-4	2.587	3.067
5		2.580			Sheaffer B166-5	0.640	1.382
6		2.886					
7		3.055			Sheaffer B166-6	2.478	2.282
8		3.323			Tombo B535E-6	1.998	1.941
9		4.476			Papermate B376E-7	2.623	2.086
10		6.542			Sheaffer B166-9	0.883	1.721
11		6.953			Sheaffer B166-10	1.658	1.818
12		7.427			Cross B164E-10	5.205	5.537

Figure 35: HPLC report for ink sample Mitsubishi B394D

SampleName Mitsubishi B394D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11903

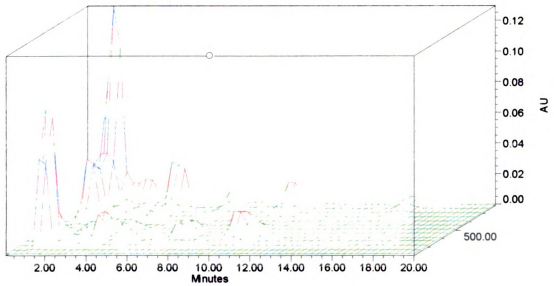
Date Acquired 1/19/2003 11:04:18 PM

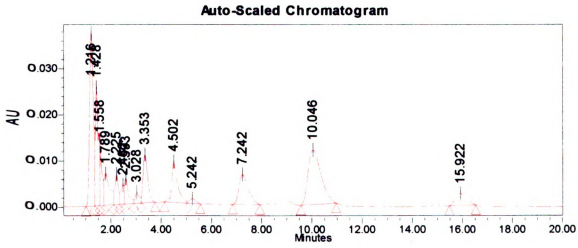
Acq Method Set inkrev2 method set

Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Mitsubishi B394D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.216	383612	19.68	37602
2	PDA MaxPlot (250nm-550nm)	1.428	216732	11.12	25678
3	PDA MaxPlot (250nm-550nm)	1.558	74578	3.83	13701
4	PDA MaxPlot (250nm-550nm)	1.789	111319	5.71	6907
5	PDA MaxPlot (250nm-550nm)	2.225	61164	3.14	6556
6	PDA MaxPlot (250nm-550nm)	2.482	37938	1.95	4176
7	PDA MaxPlot (250nm-550nm)	2.593	59219	3.04	5539
8	PDA MaxPlot (250nm-550nm)	3.028	28148	1.44	2384
9	PDA MaxPlot (250nm-550nm)	3.353	136777	7.02	10409
10	PDA MaxPlot (250nm-550nm)	4.502	142804	7.33	8846
11	PDA MaxPlot (250nm-550nm)	5.242	18556	0.95	988
12	PDA MaxPlot (250nm-550nm)	7.242	169654	8.70	6488
13	PDA MaxPlot (250nm-550nm)	10.046	423380	21.72	11805
14	PDA MaxPlot (250nm-550nm)	15.922	85428	4.38	2565

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.216			Mitsubishi B394-1	0.583	1.660
2		1.428			Mitsubishi B394-2	2.443	3.343
3		1.558			Mitsubishi B394-3	2.186	4.858
4		1.789			Mitsubishi B394-4	4.001	4.800
5		2.225			Mitsubishi B394-5	1.919	4.066
6		2.482					
7		2.593			Mitsubishi B394-6	7.631	14.221
8		3.028			Mitsubishi B394-7	5.600	10.272
9		3.353					
10		4.502			Mitsubishi B394-9	1.372	3.426
11		5.242					
12		7.242					
13		10.046					
14		15.922					

Figure 36: HPLC report for ink sample Papermate B376G

SampleName Papermate B376G

Date Acquired 1/20/2003 3:18:48 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

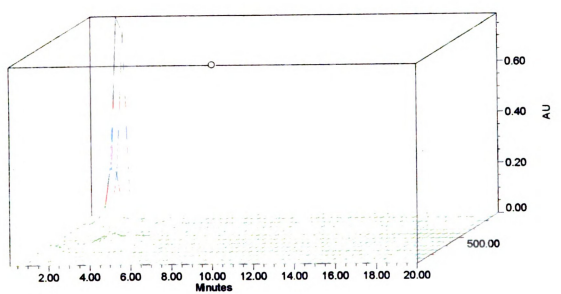
Run Time 20.00 Minutes

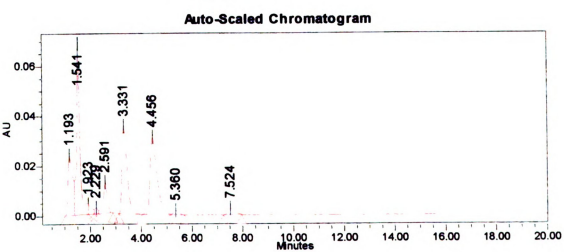
Processing Method Marilyn library 2103

Sample Set Name marilyn 11903

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)





Sample Name Papermate B376G

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.193	299484	13.25	24172
2	PDA MaxPlot (250nm-550nm)	1.541	620990	27.47	68619
3	PDA MaxPlot (250nm-550nm)	1.923	33024	1.46	3992
4	PDA MaxPlot (250nm-550nm)	2.229	21558	0.95	2390
5	PDA MaxPlot (250nm-550nm)	2.591	140236	6.20	12278
6	PDA MaxPlot (250nm-550nm)	3.331	483771	21.40	35065
7	PDA MaxPlot (250nm-550nm)	4.456	588343	26.02	30968
8	PDA MaxPlot (250nm-550nm)	5.360	23559	1.04	1657
9	PDA MaxPlot (250nm-550nm)	7.524	49874	2.21	2596

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.193			Papermate B376E-1	3.587	1.163
2		1.541			Papermate B376E-2	0.201	1.035
3		1.923			Papermate B376E-3	5.868	2.054
4		2.229			Papermate B376E-4	2.071	2.601
5		2.591			Papermate B376E-5	0.981	1.890
6		3.331			Papermate B376E-6	0.622	1.320
7		4.456			Papermate B376E-7	0.419	1.350
8		5.360			Papermate B376E-8	3.490	5.328
9		7.524			Itoya B194-10	1.326	2.340

Figure 37: HPLC report for ink sample Tombo B535G

SampleName Tombo B535G

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11903

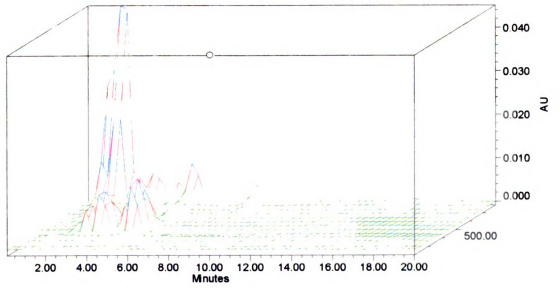
Date Acquired 1/20/2003 2:36:24 AM

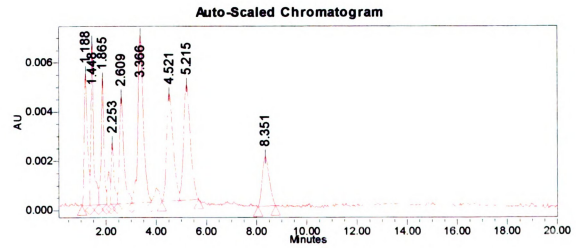
Acq Method Set inkrev2 method set

Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Tombo B535G

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.188	47232	9.10	5389
2	PDA MaxPlot (250nm-550nm)	1.448	48795	9.40	6672
3	PDA MaxPlot (250nm-550nm)	1.865	39874	7.68	5132
4	PDA MaxPlot (250nm-550nm)	2.253	19045	3.67	2495
5	PDA MaxPlot (250nm-550nm)	2.609	52663	10.15	4356
6	PDA MaxPlot (250nm-550nm)	3.366	103405	19.92	6812
7	PDA MaxPlot (250nm-550nm)	4.521	79855	15.39	4344
8	PDA MaxPlot (250nm-550nm)	5.215	88438	17.04	4685
9	PDA MaxPlot (250nm-550nm)	8.351	39697	7.65	2014

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.188			Peak 1	2.983	1.724
2		1.448			Tombo B535E-1	0.784	1.492
3		1.865			Tombo B535E-3	0.621	1.413
4		2.253			Tombo B535E-4	3.473	3.040
5		2.609			Tombo B535E-5	3.120	2.607
6		3.366			Tombo B535E-6	1.702	2.000
7		4.521			Papermate B376E-7	2.446	2.297
8		5.215			Tombo B535E-8	0.724	1.665
9		8.351			Tombo B535E-9	2.807	4.218

Figure 38: HPLC report for ink sample Dupont B102G

SampleName Dupont B102G

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11903

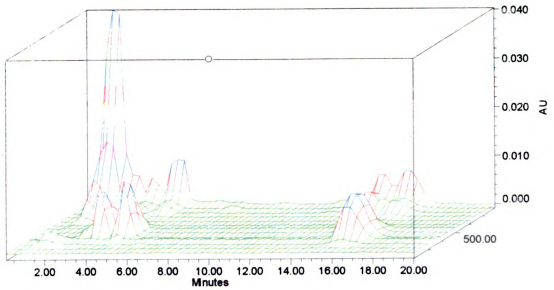
Date Acquired 1/20/2003 1:32:45 AM

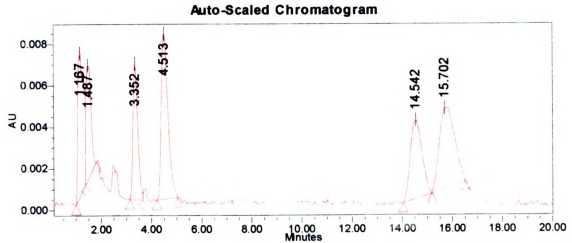
Acq Method Set inkrev2 method set

Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Dupont B102G

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.167	108751	15.32	6944
2	PDA MaxPlot (250nm-550nm)	1.487	79850	11.25	5536
3	PDA MaxPlot (250nm-550nm)	3.352	87449	12.32	6555
4	PDA MaxPlot (250nm-550nm)	4.513	146442	20.63	7988
5	PDA MaxPlot (250nm-550nm)	14.542	122686	17.28	3800
6	PDA MaxPlot (250nm-550nm)	15.702	164661	23.20	3890

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.167			Dupont B102E-1	1.093	1.238
2		1.487			Dupont B102E-2	0.970	1.284
3		3.352			Dupont B102E-5	1.514	1.815
4		4.513			Dupont B102E-6	1.768	1.622
5		14.542			Dupont B102E-7	2.545	2.059
6		15.702			Dupont B102E-8	2.711	1.795

APPENDIX C.4

HPLC Reports for Blue Ball Point Inks That Were Identified to a Reasonable Degree of Certainty by Library Matching

Sample Run 4

Figure 39: HPLC report for ink sample Q1B (New Bic)

SampleName Q1B

Date Acquired 1/21/2003 9:29:08 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

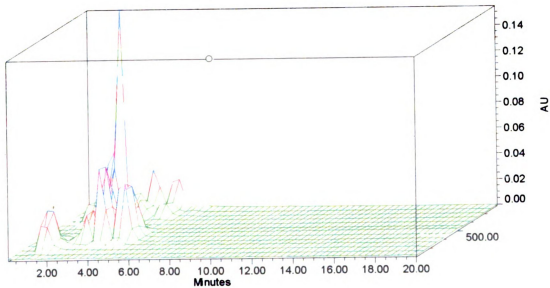
Run Time 20.00 Minutes

Processing Method Marily n library 2103

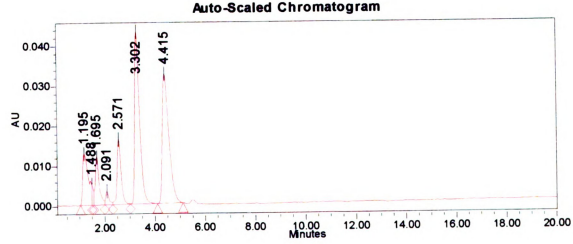
Sample Set Name marily n 12103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Q1B (New Bic)

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.195	203290	11.60	12908
2	PDA MaxPlot (250nm-550nm)	1.488	21634	1.23	5135
3	PDA MaxPlot (250nm-550nm)	1.695	129633	7.40	11991
4	PDA MaxPlot (250nm-550nm)	2.091	31917	1.82	3437
5	PDA MaxPlot (250nm-550nm)	2.571	179184	10.22	16265
6	PDA MaxPlot (250nm-550nm)	3.302	593831	33.88	43109
7	PDA MaxPlot (250nm-550nm)	4.415	593338	33.85	32360

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.195			Papermate B376E-1	5.044	1.225
2		1.488			New Bic C-2	4.908	1.409
3		1.695			New Bic C-3	0.507	1.129
4		2.091					
5		2.571			New Bic C-4	1.448	1.588
6		3.302			New Bic C-5	0.340	1.230
7		4.415			New Bic C-6	0.490	1.273

Figure 40: HPLC report for ink sample Q2B (Bic B162)

SampleName Q2B

Date Acquired 1/21/2003 10:11:33 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

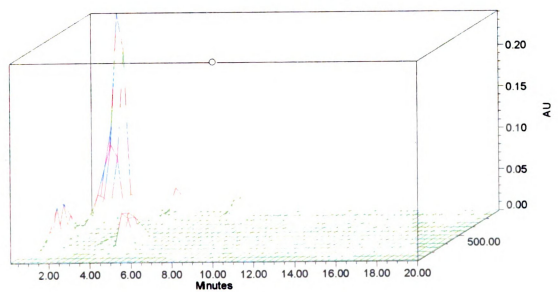
Run Time 20.00 Minutes

Processing Method Marilyn library 2103

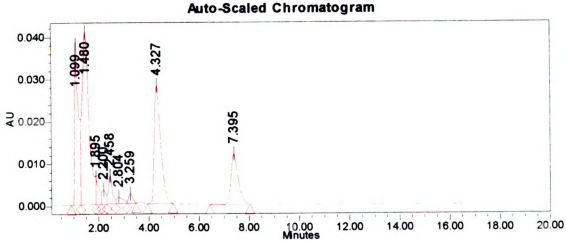
Sample Set Name marilyn 12103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Q2B (Bic B162)

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.099	394274	18.41	38403
2	PDA MaxPlot (250nm-550nm)	1.480	780040	36.42	40931
3	PDA MaxPlot (250nm-550nm)	1.895	52151	2.44	6325
4	PDA MaxPlot (250nm-550nm)	2.200	37548	1.75	3466
5	PDA MaxPlot (250nm-550nm)	2.458	72539	3.39	6650
6	PDA MaxPlot (250nm-550nm)	2.804	28458	1.33	1547
7	PDA MaxPlot (250nm-550nm)	3.259	25221	1.18	2236
8	PDA MaxPlot (250nm-550nm)	4.327	501659	23.42	27990
9	PDA MaxPlot (250nm-550nm)	7.395	249688	11.66	12048

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.099			Bic B162E-1	0.866	1.167
2		1.480			Bic B162E-2	0.293	1.128
3		1.895					
4		2.200			Bic B162E-3	1.581	3.021
5		2.458			Bic B162E-4	0.834	2.405
6		2.804			Bic B162E-5	2.633	5.526
7		3.259			Formulabs B517E-8	5.845	4.654
8		4.327			Papermate B376E-7	1.519	1.563
9		7.395			Bic B162E-7	0.561	1.755

Figure 41: HPLC report for ink sample Q3B (Papermate B376)

SampleName Q3B

Date Acquired 1/21/2003 10:53:57 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

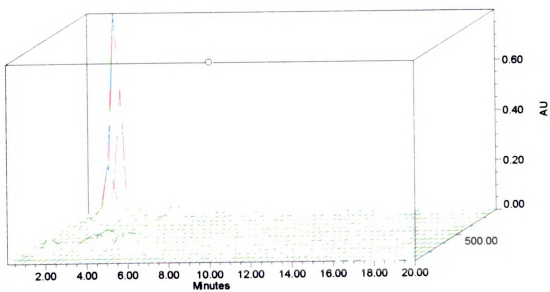
Run Time 20.00 Minutes

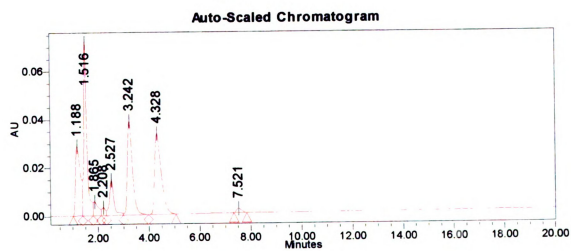
Processing Method Marily n library 2103

Sample Set Name marily n 12103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Q3B (Papermate B376)

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.188	383343	15.69	28882
2	PDA MaxPlot (250nm-550nm)	1.516	601483	24.62	72390
3	PDA MaxPlot (250nm-550nm)	1.865	78944	3.23	5733
4	PDA MaxPlot (250nm-550nm)	2.208	32812	1.34	3261
5	PDA MaxPlot (250nm-550nm)	2.527	179074	7.33	14563
6	PDA MaxPlot (250nm-550nm)	3.242	532268	21.78	38871
7	PDA MaxPlot (250nm-550nm)	4.328	609957	24.96	33643
8	PDA MaxPlot (250nm-550nm)	7.521	25644	1.05	1778

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.188			Papermate B376 E-	1.019	1.180
2		1.516			Papermate B376 E-	0.243	1.053
3		1.865			Papermate B376 E-	2.843	2.209
4		2.208			Papermate B376 E-	6.571	3.113
5		2.527			Papermate B376 E-	7.260	2.161
6		3.242			Formulabs B517E-8	1.546	1.296
7		4.328			Formulabs B517E-10	1.100	1.415
8		7.521			Bic B162E-7	2.240	3.072

Figure 42: HPLC report for ink sample Q5B (Formulabs B517)

SampleName Q5B

Date Acquired 1/22/2003 12:39:57 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

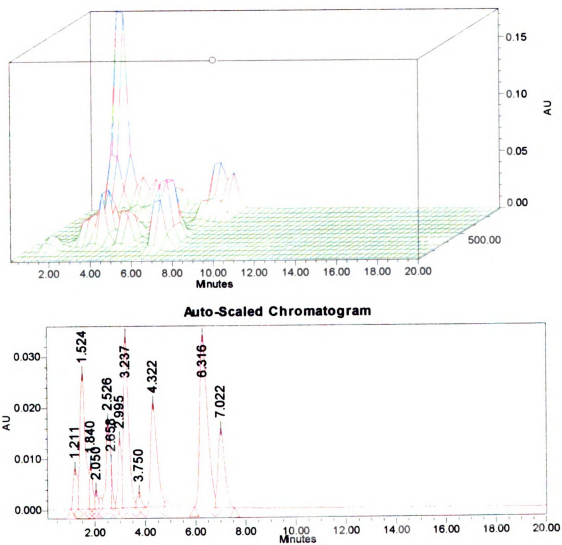
Run Time 20.00 Minutes

Processing Method Marilyn library 2103

Sample Set Name marilyn 12103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)



Sample Name Q5B (Formulabs B517)

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.211	94603	3.34	7931
2	PDA MaxPlot (250nm-550nm)	1.524	393821	13.89	26542
3	PDA MaxPlot (250nm-550nm)	1.840	76243	2.69	8837
4	PDA MaxPlot (250nm-550nm)	2.050	29043	1.02	3708
5	PDA MaxPlot (250nm-550nm)	2.526	201856	7.12	17201
6	PDA MaxPlot (250nm-550nm)	2.658	28305	1.00	9135
7	PDA MaxPlot (250nm-550nm)	2.995	134415	4.74	13654
8	PDA MaxPlot (250nm-550nm)	3.237	468295	16.52	33708
9	PDA MaxPlot (250nm-550nm)	3.750	34345	1.21	2984
10	PDA MaxPlot (250nm-550nm)	4.322	360564	12.72	20331
11	PDA MaxPlot (250nm-550nm)	6.316	728628	25.70	33765
12	PDA MaxPlot (250nm-550nm)	7.022	285321	10.06	15506

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.211			Papermate B376E-1	1.770	1.471
2		1.524			Formulabs B517E-2	0.723	1.242
3		1.840			Formulabs B517E-3	1.399	1.545
4		2.050			Formulabs B517E-4	3.278	2.703
5		2.526			Formulabs B517E-6	1.389	1.529
6		2.658					
7		2.995			Formulabs B517E-7	1.179	1.615
8		3.237			Formulabs B517E-8	0.402	1.280
9		3.750			Formulabs B517E-9	2.740	3.684
10		4.322			Formulabs B517E-10	0.479	1.452
11		6.316			Formulabs B517E-12	0.192	1.182
12		7.022			Formulabs B517E-13	0.551	1.573

Figure 43: HPLC report for ink sample Q6B (Pilot B103)

SampleName Q6B

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marily n 12103

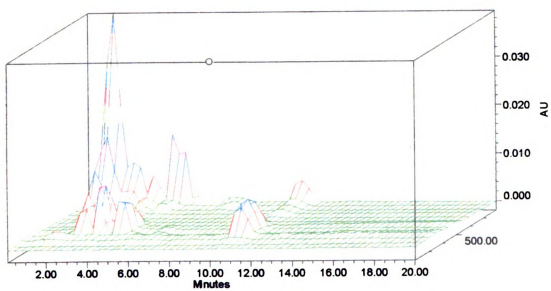
Date Acquired 1/22/2003 1:22:21 AM

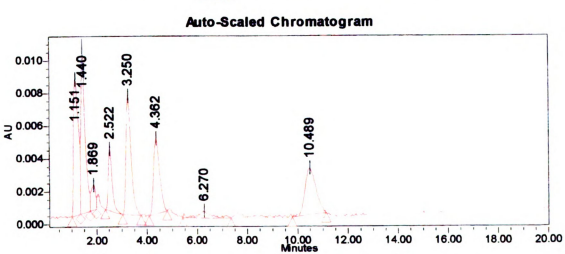
Acq Method Set inkrev2 method set

Processing Method Marily n library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)





Sample Name Q6B (Pilot B103)

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.151	112454	19.73	8365
2	PDA MaxPlot (250nm-550nm)	1.440	112723	19.78	10246
3	PDA MaxPlot (250nm-550nm)	1.869	18896	3.32	1533
4	PDA MaxPlot (250nm-550nm)	2.522	41748	7.32	3778
5	PDA MaxPlot (250nm-550nm)	3.250	101534	17.81	7285
6	PDA MaxPlot (250nm-550nm)	4.362	77805	13.65	4611
7	PDA MaxPlot (250nm-550nm)	6.270	18281	3.21	444
8	PDA MaxPlot (250nm-550nm)	10.489	86526	15.18	2861

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.151			Pilot B103G-1	4.509	10.549
2		1.440			Pilot B103G-2	6.030	12.799
3		1.869					
4		2.522					
5		3.250			Papermate B376E-6	6.804	17.102
6		4.362					
7		6.270					
8		10.489					

Figure 44: HPLC report for ink sample Q7B (Papermate 622)

SampleName Q7B

Date Acquired 1/22/2003 2:26:00 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

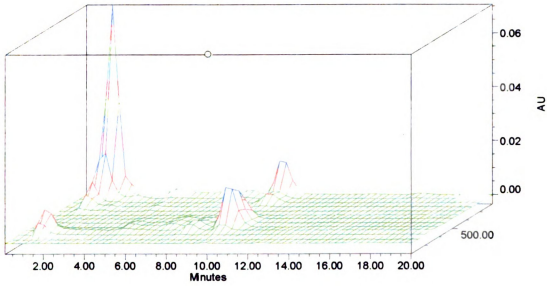
Run Time 20.00 Minutes

Processing Method Marilyn library 2103

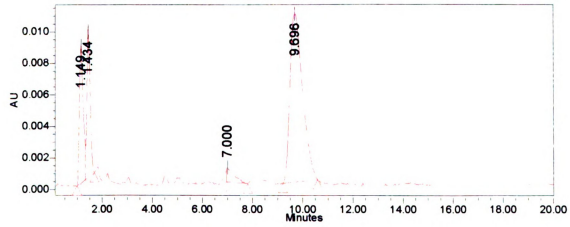
Sample Set Name marilyn 12103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Q7B (Papermate 622)

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.149	91998	16.16	8719
2	PDA MaxPlot (250nm-550nm)	1.434	87424	15.36	9394
3	PDA MaxPlot (250nm-550nm)	7.000	18057	3.17	915
4	PDA MaxPlot (250nm-550nm)	9.696	371865	65.31	10666

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.149			Papermate 622E-1	3.418	5.993
2		1.434			Papermate 622E-2	8.581	11.427
3		7.000					
4		9.696					

APPENDIX D

APPENDIX D

HPLC Reports for Black Ball Point Inks That Were Identified to a Reasonable Degree of Certainty by Library Matching

APPENDIX D.1

HPLC Reports for Black Ball Point Inks That Were Identified to a Reasonable Degree of Certainty by Library Matching

Sample Run 1

Figure 45: HPLC report for ink sample Lindy B159D

SampleName Lindy B159D

Date Acquired 1/17/2003 1:54:43 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

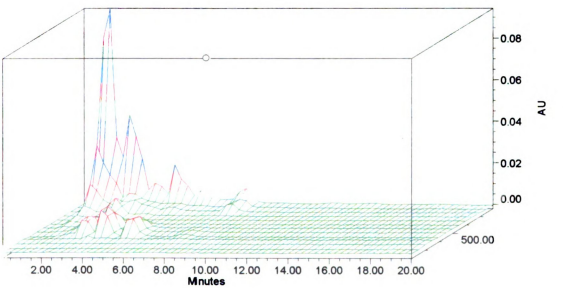
Run Time 20.00 Minutes

Processing Method Marilyn library 2103

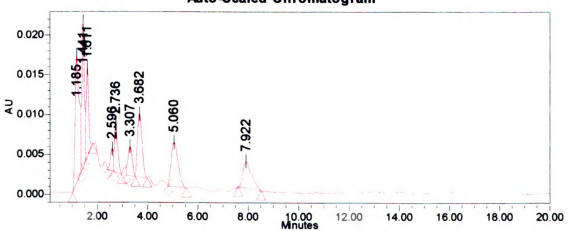
Sample Set Name marilyn 11603

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Lindy B159D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.185	179268	22.80	16075
2	PDA MaxPlot (250nm-550nm)	1.441	125523	15.96	18270
3	PDA MaxPlot (250nm-550nm)	1.611	77756	9.89	11241
4	PDA MaxPlot (250nm-550nm)	2.596	23117	2.94	2812
5	PDA MaxPlot (250nm-550nm)	2.736	53176	6.76	6079
6	PDA MaxPlot (250nm-550nm)	3.307	44433	5.65	3648
7	PDA MaxPlot (250nm-550nm)	3.682	99890	12.70	7980
8	PDA MaxPlot (250nm-550nm)	5.060	104263	13.26	5550
9	PDA MaxPlot (250nm-550nm)	7.922	78862	10.03	3309

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.185			Lindy B159-1	1.145	1.479
2		1.441			Lindy B159-2	0.604	1.484
3		1.611			Lindy B159-3	2.020	2.201
4		2.596			Lindy B159-4	9.426	5.254
5		2.736			Lindy B159-5	1.395	1.814
6		3.307					
7		3.682			Lindy B159-7	0.930	1.852
8		5.060			Lindy B159-8	0.987	2.073
9		7.922			Lindy B159-8	8.151	4.022

Figure 46: HPLC report for ink sample Cross B13D

SampleName Cross B13D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11603

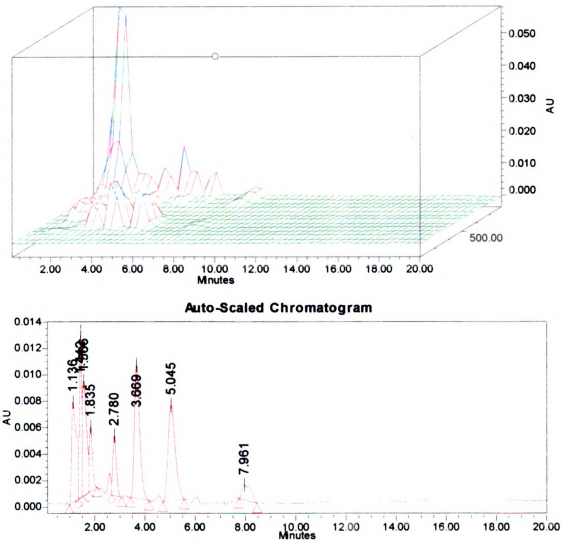
Date Acquired 1/17/2003 6:51:38 AM

Acq Method Set inkrev2 method set

Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)



Sample Name Cross B13D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.136	100075	14.56	7708
2	PDA MaxPlot (250nm-550nm)	1.442	75637	11.00	12521
3	PDA MaxPlot (250nm-550nm)	1.566	101159	14.71	8676
4	PDA MaxPlot (250nm-550nm)	1.835	41577	6.05	4892
5	PDA MaxPlot (250nm-550nm)	2.780	45535	6.62	4560
6	PDA MaxPlot (250nm-550nm)	3.669	148477	21.60	10116
7	PDA MaxPlot (250nm-550nm)	5.045	144653	21.04	7238
8	PDA MaxPlot (250nm-550nm)	7.961	30344	4.41	1137

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.136			Cross B13-1	2.550	1.375
2		1.442			Cross B13-2	1.662	1.257
3		1.566			Cross B13-3	2.167	1.389
4		1.835			Cross B13-4	1.770	2.306
5		2.780			Cross B13-5	4.347	2.237
6		3.369			Cross B13-6	0.556	1.554
7		5.045			Cross B13-7	0.600	1.712
8		7.961			Cross B13-8	3.099	4.272

Figure 47: HPLC report for ink sample Parker B174D

SampleName Parker B174D

Date Acquired 1/17/2003 7:55:20 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

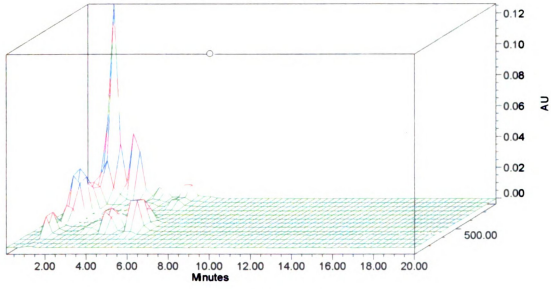
Run Time 20.00 Minutes

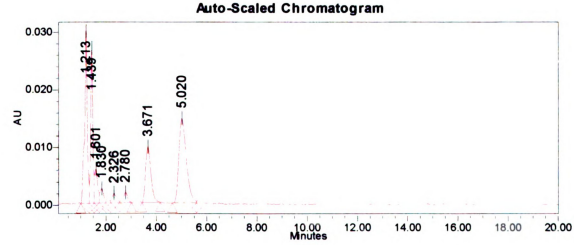
Processing Method Marily n library 2103

Sample Set Name marily n 11603

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)





Sample Name Parker B174D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.213	223270	23.62	30118
2	PDA MaxPlot (250nm-550nm)	1.439	158544	16.77	26713
3	PDA MaxPlot (250nm-550nm)	1.601	49848	5.27	5958
4	PDA MaxPlot (250nm-550nm)	1.830	26707	2.82	2558
5	PDA MaxPlot (250nm-550nm)	2.326	20592	2.18	1657
6	PDA MaxPlot (250nm-550nm)	2.780	20337	2.15	1772
7	PDA MaxPlot (250nm-550nm)	3.671	141576	14.98	9656
8	PDA MaxPlot (250nm-550nm)	5.020	304532	32.21	14696

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.213			Parker B174-1	1.503	1.115
2		1.439			Parker B174-2	0.380	1.055
3		1.601			Parker B174-3	0.485	1.317
4		1.830			Parker B174-4	3.554	1.747
5		2.326			Parker B174-5	0.526	1.527
6		2.780			Parker B174-6	7.126	3.904
7		3.671			Parker B174-7	0.687	1.536
8		5.020			Parker B174-8	0.420	1.340

APPENDIX D.2

HPLC Reports for Black Ball Point Inks That Were Identified to a Reasonable Degree of Certainty by Library Matching

Sample Run 2

Figure 48: HPLC report for ink sample Eversharp 657

SampleName Eversharp 657

Date Acquired 1/18/2003 5:21:05 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

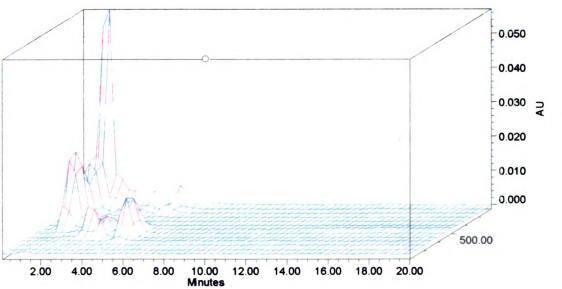
Run Time 20.00 Minutes

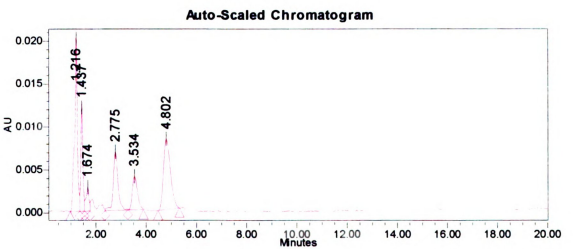
Processing Method Marilyn library 2103

Sample Set Name marilyn 11703

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Eversharp 657

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.216	154977	28.05	20152
2	PDA MaxPlot (250nm-550nm)	1.437	69934	12.66	12154
3	PDA MaxPlot (250nm-550nm)	1.674	23002	4.16	2811
4	PDA MaxPlot (250nm-550nm)	2.775	88678	16.05	6796
5	PDA MaxPlot (250nm-550nm)	3.534	56970	10.31	3935
6	PDA MaxPlot (250nm-550nm)	4.802	158858	28.76	8222

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.216			Eversharp 657-1	7.499	1.180
2		1.437			Eversharp 657-2	1.015	1.176
3		1.674			Staettler B391-2	4.144	1.863
4		2.775			Eversharp 657-3	8.421	2.752
5		3.534			Eversharp 657-4	2.046	2.529
6		4.802			Eversharp 657-5	0.620	1.687

Figure 49: HPLC report for ink sample Staedtler B391D

SampleName Staettler B391D

Date Acquired 1/18/2003 6:24:44 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

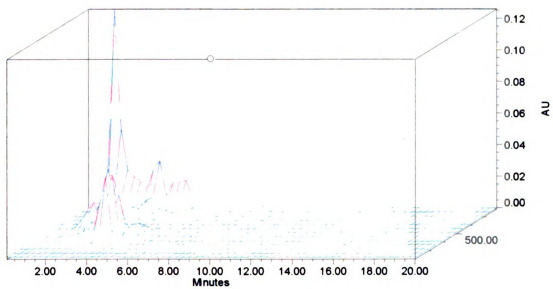
Run Time 20.00 Minutes

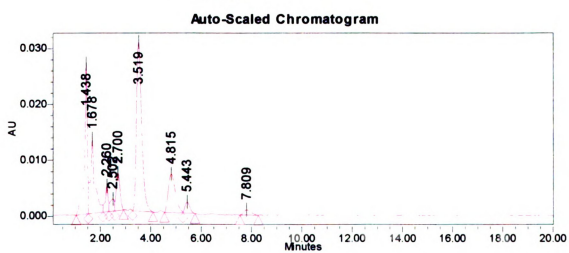
Processing Method Marily n library 2103

Sample Set Name marily n 11703

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Staedtler B391D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.438	202988	18.07	26970
2	PDA MaxPlot (250nm-550nm)	1.678	164266	14.62	13351
3	PDA MaxPlot (250nm-550nm)	2.260	35656	3.17	4614
4	PDA MaxPlot (250nm-550nm)	2.502	26642	2.37	2169
5	PDA MaxPlot (250nm-550nm)	2.700	69143	6.15	6661
6	PDA MaxPlot (250nm-550nm)	3.519	442257	39.36	30338
7	PDA MaxPlot (250nm-550nm)	4.815	135952	12.10	6912
8	PDA MaxPlot (250nm-550nm)	5.443	27436	2.44	1998
9	PDA MaxPlot (250nm-550nm)	7.809	19265	1.71	917

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.438			Staettler B391-1	0.321	1.140
2		1.678			Staettler B391-2	0.790	1.322
3		2.260			Staettler B391-3	1.651	1.955
4		2.502			Staettler B391-4	2.523	3.585
5		2.700			Staettler B391-5	0.774	2.014
6		3.519			Eversharp 657-4	1.074	2.001
7		4.815			Staettler B391-7	2.509	1.791
8		5.443			Staettler B391-8	2.876	3.854
9		7.809			Papermate B183-9	6.565	7.333

Figure 50: HPLC report for ink sample Papermate B183D

SampleName Papermate B183D

Date Acquired 1/18/2003 7:49:32 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

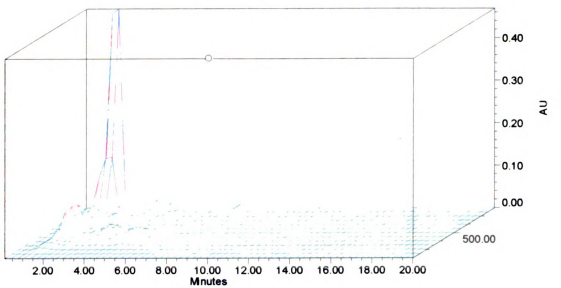
Run Time 20.00 Minutes

Processing Method Marilyn library 2103

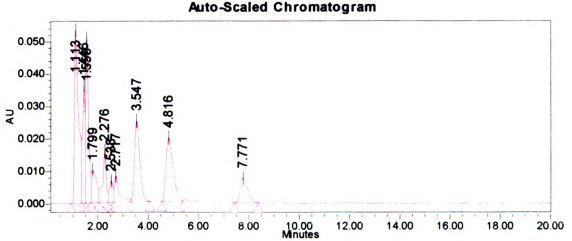
Sample Set Name marilyn 11703

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Papermate B183D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.113	590592	22.37	52810
2	PDA MaxPlot (250nm-550nm)	1.446	245010	9.28	36126
3	PDA MaxPlot (250nm-550nm)	1.558	406411	15.40	50957
4	PDA MaxPlot (250nm-550nm)	1.799	141233	5.35	10137
5	PDA MaxPlot (250nm-550nm)	2.276	164345	6.23	15950
6	PDA MaxPlot (250nm-550nm)	2.538	65908	2.50	6593
7	PDA MaxPlot (250nm-550nm)	2.717	116309	4.41	8176
8	PDA MaxPlot (250nm-550nm)	3.547	361851	13.71	24892
9	PDA MaxPlot (250nm-550nm)	4.816	390313	14.79	19675
10	PDA MaxPlot (250nm-550nm)	7.771	157660	5.97	7588

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.113			Papermate B183-1	8.517	1.167
2		1.446			Papermate B183-2	1.468	1.092
3		1.558			Papermate B183-3	2.427	1.061
4		1.799			Papermate B183-4	6.129	1.420
5		2.276			Papermate B183-5	2.644	1.498
6		2.538			Fisher B111-5	6.299	2.460
7		2.717			Pilot B113-3	9.942	2.179
8		3.547			Eversharp 657-4	2.774	2.052
9		4.816			Eversharp 657-5	6.216	1.646
10		7.771			Papermate B183-9	0.470	1.583

APPENDIX D.3

HPLC Reports for Black Ball Point Inks That Were Identified to a Reasonable Degree of Certainty by Library Matching

Sample Run 3

Figure 51: HPLC report for ink sample Zebra B7D

SampleName Zebra B7D

Date Acquired 1/19/2003 7:53:29 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

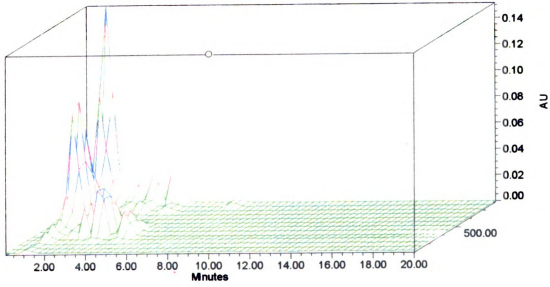
Run Time 20.00 Minutes

Processing Method Marilyn library 2103

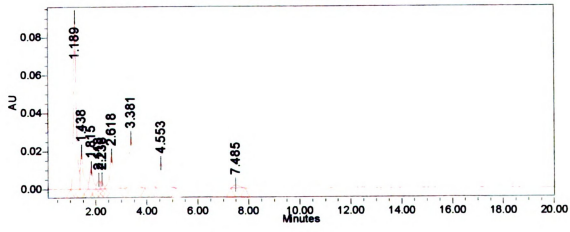
Sample Set Name marilyn 11903

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Zebra B7D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.189	681911	36.42	89772
2	PDA MaxPlot (250nm-550nm)	1.438	174379	9.31	19592
3	PDA MaxPlot (250nm-550nm)	1.815	107240	5.73	11068
4	PDA MaxPlot (250nm-550nm)	2.118	38864	2.08	4600
5	PDA MaxPlot (250nm-550nm)	2.238	28850	1.54	4653
6	PDA MaxPlot (250nm-550nm)	2.618	207498	11.08	17203
7	PDA MaxPlot (250nm-550nm)	3.381	367958	19.65	26256
8	PDA MaxPlot (250nm-550nm)	4.553	237240	12.67	12789
9	PDA MaxPlot (250nm-550nm)	7.485	28556	1.53	1630

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.189			Zebra B7-1	1.743	1.051
2		1.438			Zebra B7-2	0.617	1.152
3		1.815			Zebra B7-3	2.396	1.356
4		2.118			Zebra B7-4	2.243	2.378
5		2.238			Zebra B7-5	1.953	2.014
6		2.618			Zebra B7-6	0.529	1.444
7		3.381			Zebra B7-7	0.220	1.292
8		4.553			Zebra B7-8	0.405	1.519
9		7.485			Zebra B7-9	2.238	4.044

Figure 52: HPLC report for ink sample Parker B458D

SampleName Parker B458D

Date Acquired 1/19/2003 11:46:42 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

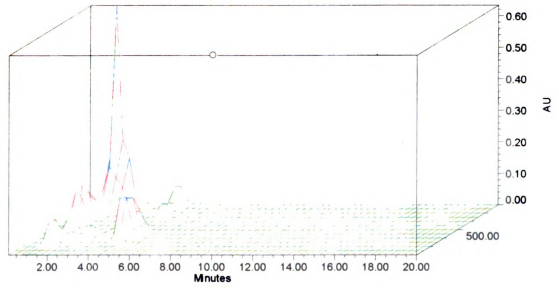
Run Time 20.00 Minutes

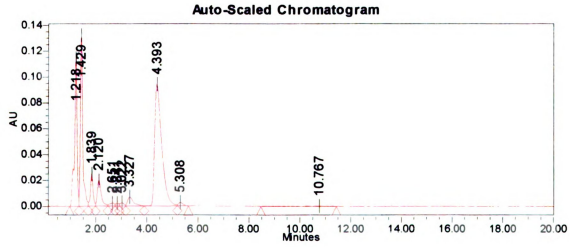
Processing Method Marilyn library 2103

Sample Set Name marilyn 11903

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Parker B458D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.218	804147	19.70	114338
2	PDA MaxPlot (250nm-550nm)	1.429	838305	20.54	133745
3	PDA MaxPlot (250nm-550nm)	1.839	174386	4.27	24796
4	PDA MaxPlot (250nm-550nm)	2.120	212519	5.21	19787
5	PDA MaxPlot (250nm-550nm)	2.651	30401	0.74	2401
6	PDA MaxPlot (250nm-550nm)	2.841	18817	0.46	2150
7	PDA MaxPlot (250nm-550nm)	3.022	27098	0.66	2485
8	PDA MaxPlot (250nm-550nm)	3.327	111092	2.72	6946
9	PDA MaxPlot (250nm-550nm)	4.393	1808874	44.32	94129
10	PDA MaxPlot (250nm-550nm)	5.308	32211	0.79	2547
11	PDA MaxPlot (250nm-550nm)	10.767	23656	0.58	290

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.218			Parker B458-1	0.343	1.066
2		1.429			Parker B458-2	1.179	1.049
3		1.839			Parker B458-3	0.864	1.180
4		2.120			Parker B458-4	3.304	1.664
5		2.651			Parker B458-5	6.494	4.897
6		2.841					
7		3.022					
8		3.327			Parker B458-4	4.330	2.484
9		4.393			Parker B458-7	0.424	1.164
10		5.308			Parker B458-8	3.778	5.377
11		10.767					

APPENDIX D.4

HPLC Reports for Black Ball Point Inks That Were Identified to a Reasonable Degree of Certainty by Library Matching

Sample Run 4

Figure 53: HPLC report for ink sample Q4B (Pentel 623)

SampleName Q4B

Date Acquired 1/21/2003 11:57:33 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

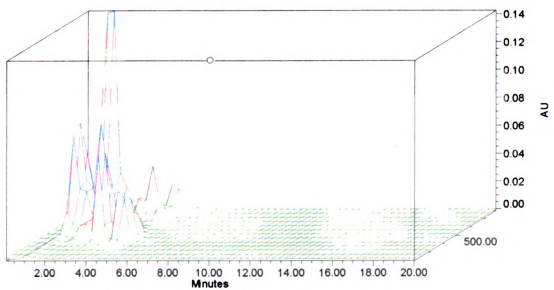
Run Time 20.00 Minutes

Processing Method Marily n library 2103

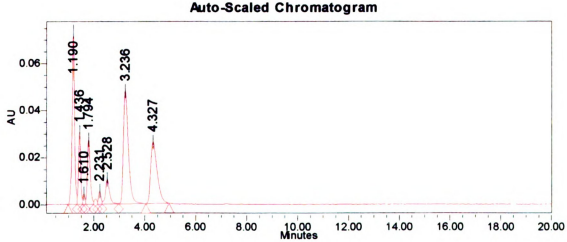
Sample Set Name marily n 12103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Q4B (Pentel 623)

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.190	488134	22.38	73361
2	PDA MaxPlot (250nm-550nm)	1.436	179132	8.21	30790
3	PDA MaxPlot (250nm-550nm)	1.610	24138	1.11	4499
4	PDA MaxPlot (250nm-550nm)	1.794	214850	9.85	27598
5	PDA MaxPlot (250nm-550nm)	2.231	36563	1.68	5592
6	PDA MaxPlot (250nm-550nm)	2.528	118513	5.43	10503
7	PDA MaxPlot (250nm-550nm)	3.236	652532	29.92	48034
8	PDA MaxPlot (250nm-550nm)	4.327	466783	21.41	26156

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.190			Pentel 623E-1	0.246	1.077
2		1.436			Pentel 623-2	0.210	1.103
3		1.610			Pentel 623-3	3.003	2.200
4		1.794			Pentel 623-4	1.043	1.269
5		2.231			Pentel 623-5	1.297	1.940
6		2.528			Pentel 623-6	0.835	1.906
7		3.236			Pentel 623-7	0.218	1.208
8		4.327			Pentel 623-8	0.297	1.356

Figure 54: HPLC report for ink sample Q8B (Bic B396)

SampleName Q8B

Date Acquired 1/22/2003 3:08:24 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

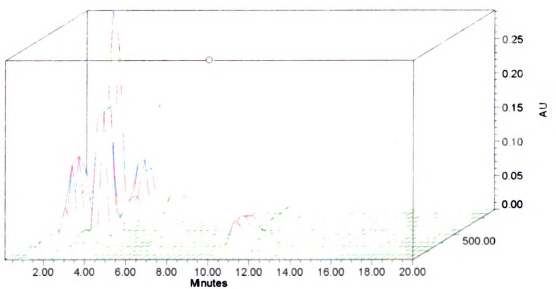
Run Time 20.00 Minutes

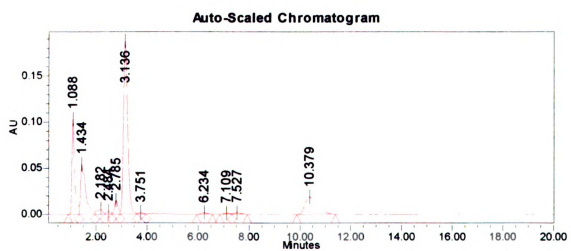
Processing Method Marilyn library 2103

Sample Set Name marilyn 12103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Q8B (Bic B396)

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.088	771538	16.31	103742
2	PDA MaxPlot (250nm-550nm)	1.434	750879	15.87	55265
3	PDA MaxPlot (250nm-550nm)	2.182	85257	1.80	5752
4	PDA MaxPlot (250nm-550nm)	2.484	39086	0.83	3523
5	PDA MaxPlot (250nm-550nm)	2.785	148917	3.15	15073
6	PDA MaxPlot (250nm-550nm)	3.136	2172813	45.93	189366
7	PDA MaxPlot (250nm-550nm)	3.751	23257	0.49	1725
8	PDA MaxPlot (250nm-550nm)	6.234	31544	0.67	1788
9	PDA MaxPlot (250nm-550nm)	7.109	23628	0.50	1312
10	PDA MaxPlot (250nm-550nm)	7.527	37623	0.80	1927
11	PDA MaxPlot (250nm-550nm)	10.379	646388	13.66	18869

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.088			Bic B396E-1	0.175	1.199
2		1.434			Bic B396-2	3.768	8.997
3		2.182					
4		2.484					
5		2.785			Bic B396E-6	8.833	31.699
6		3.136			Bic B396-7	0.774	3.553
7		3.751					
8		6.234					
9		7.109					
10		7.527					
11		10.379					

Figure 55: HPLC report for ink sample Q9B (Cross B13)

SampleName Q9B

Date Acquired 1/22/2003 3:50:48 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

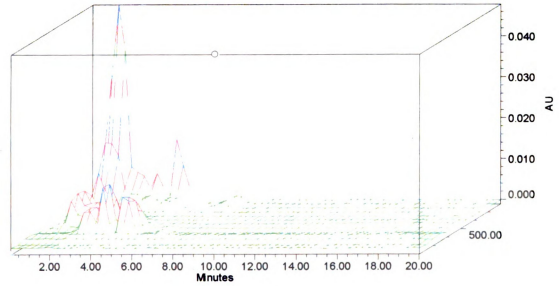
Run Time 20.00 Minutes

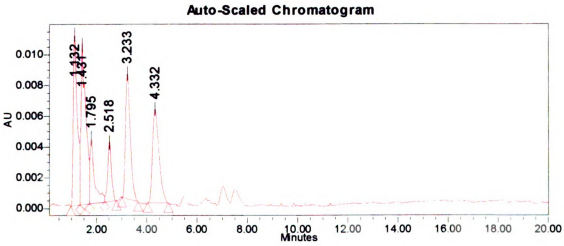
Processing Method Marily n library 2103

Sample Set Name marily n 12103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Q9B (Cross B13)

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.132	123385	21.45	11237
2	PDA MaxPlot (250nm-550nm)	1.431	141086	24.53	10472
3	PDA MaxPlot (250nm-550nm)	1.795	52840	9.19	4239
4	PDA MaxPlot (250nm-550nm)	2.518	40694	7.07	3875
5	PDA MaxPlot (250nm-550nm)	3.233	107940	18.77	8187
6	PDA MaxPlot (250nm-550nm)	4.332	109241	18.99	6087

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.132			Cross B13E-1	2.117	1.199
2		1.431			Cross B13E-2	0.527	1.149
3		1.795			Cross B13E-3	1.670	1.456
4		2.518			Cross B13E-4	7.327	2.132
5		3.233			Pentel 623E-6	4.238	1.622
6		4.332			Staettler B387-10	5.561	1.861

Figure 56: HPLC report for ink sample Pentel 623D

SampleName Pentel 623D

Date Acquired 1/22/2003 5:36:51 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

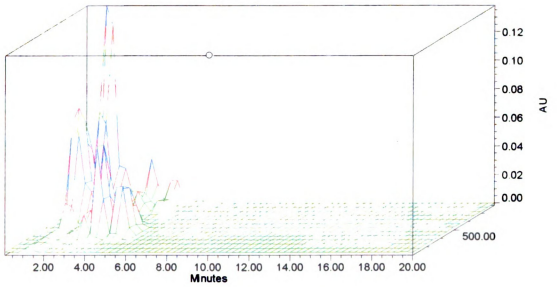
Run Time 20.00 Minutes

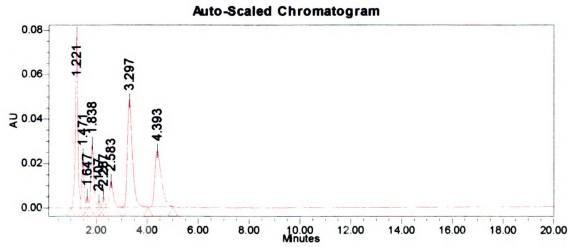
Processing Method Marily n library 2103

Sample Set Name marily n 12103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Pentel 623D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.221	518598	23.50	77552
2	PDA MaxPlot (250nm-550nm)	1.471	137948	6.25	23209
3	PDA MaxPlot (250nm-550nm)	1.647	30759	1.39	5278
4	PDA MaxPlot (250nm-550nm)	1.838	222835	10.10	28542
5	PDA MaxPlot (250nm-550nm)	2.107	23945	1.08	2945
6	PDA MaxPlot (250nm-550nm)	2.287	32114	1.46	5022
7	PDA MaxPlot (250nm-550nm)	2.583	136362	6.18	11827
8	PDA MaxPlot (250nm-550nm)	3.297	656373	29.74	48298
9	PDA MaxPlot (250nm-550nm)	4.393	448068	20.30	25181

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.221			Pentel 623-1	1.085	1.054
2		1.471			Staettler B387-1	4.986	1.102
3		1.647			Pentel 623-3	2.668	1.980
4		1.838			Pentel 623-4	0.641	1.251
5		2.107					
6		2.287			Pentel 623-5	1.830	1.895
7		2.583			Pentel 623-6	0.906	1.604
8		3.297			Pentel 623-7	0.178	1.141
9		4.393			Pentel 623-8	0.208	1.240

Figure 57: HPLC report for ink sample Bic B396D

SampleName Bic B396D

Date Acquired 1/22/2003 6:19:15 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

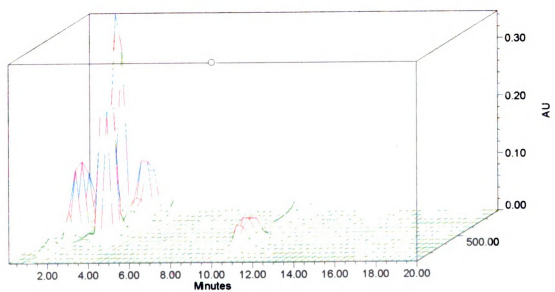
Run Time 20.00 Minutes

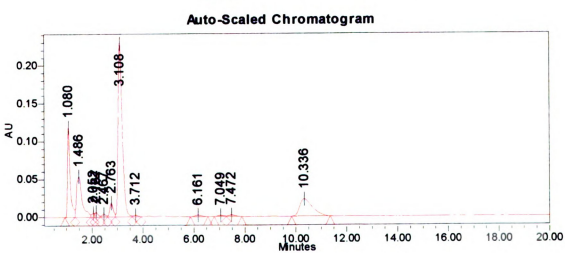
Processing Method Marily n library 2103

Sample Set Name marily n 12103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Bic B396D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.080	873841	15.74	118574
2	PDA MaxPlot (250nm-550nm)	1.486	817377	14.72	53492
3	PDA MaxPlot (250nm-550nm)	2.052	39574	0.71	5094
4	PDA MaxPlot (250nm-550nm)	2.167	55616	1.00	6274
5	PDA MaxPlot (250nm-550nm)	2.467	43401	0.78	3872
6	PDA MaxPlot (250nm-550nm)	2.763	176928	3.19	18291
7	PDA MaxPlot (250nm-550nm)	3.108	2619713	47.18	229896
8	PDA MaxPlot (250nm-550nm)	3.712	27542	0.50	2064
9	PDA MaxPlot (250nm-550nm)	6.161	37420	0.67	2077
10	PDA MaxPlot (250nm-550nm)	7.049	27044	0.49	1537
11	PDA MaxPlot (250nm-550nm)	7.472	51151	0.74	2078
12	PDA MaxPlot (250nm-550nm)	10.336	792415	14.27	22905

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.080			Bic B396E-1	0.191	1.208
2		1.486			Bic B396E-2	3.681	11.206
3		2.052					
4		2.167					
5		2.467					
6		2.763			Peak 7	8.093	30.798
7		3.108			Bic B396-7	0.746	3.531
8		3.712					
9		6.161					
10		7.049					
11		7.472					
12		10.336			Bic B396-13	8.626	39.332

Figure 58: HPLC report for ink sample Fisher B536G

SampleName Fisher B536G

Date Acquired 1/22/2003 8:05:16 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

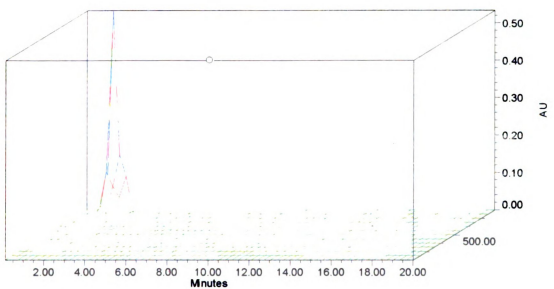
Run Time 20.00 Minutes

Processing Method Marilyn library 2103

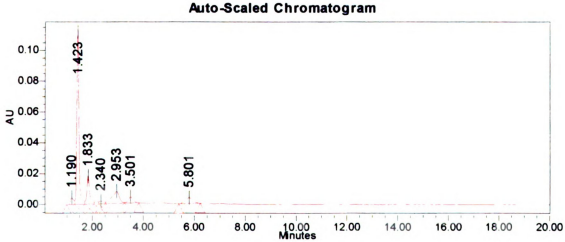
Sample Set Name marilyn 12103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Fisher B536G

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.190	40753	3.55	4525
2	PDA MaxPlot (250nm-550nm)	1.423	656150	57.12	111907
3	PDA MaxPlot (250nm-550nm)	1.833	136486	11.88	18302
4	PDA MaxPlot (250nm-550nm)	2.340	22044	1.92	1823
5	PDA MaxPlot (250nm-550nm)	2.953	161623	14.07	7972
6	PDA MaxPlot (250nm-550nm)	3.501	51862	4.52	3904
7	PDA MaxPlot (250nm-550nm)	5.801	79724	6.94	3747

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.190			Fisher B536E-1	3.529	1.742
2		1.423			Fisher B536E-2	0.061	1.025
3		1.833			Fisher B536E-3	0.358	1.098
4		2.340			Fisher B536E-4	2.544	3.590
5		2.953			Fisher B536E-5	1.073	2.171
6		3.501			Fisher B536E-6	1.028	2.298
7		5.801			Fisher B536E-7	1.473	2.433

Figure 59: HPLC report for ink sample Staedtler B387D

SampleName Staettler B387D

Date Acquired 1/22/2003 8:47:40 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

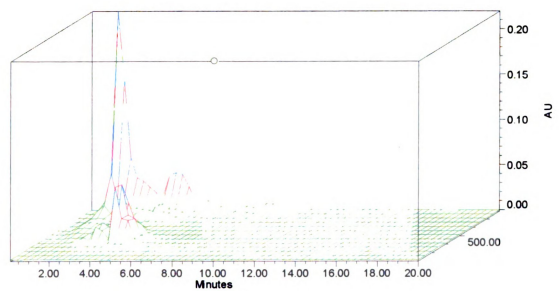
Run Time 20.00 Minutes

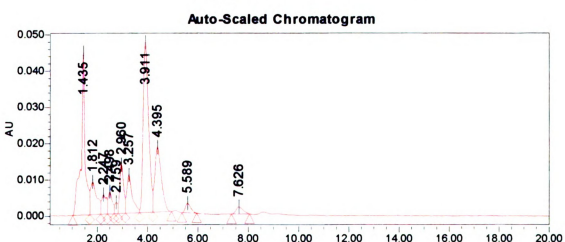
Processing Method Marily n library 2103

Sample Set Name marily n 12103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Staedtler B387D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.435	517034	22.84	44503
2	PDA MaxPlot (250nm-550nm)	1.812	160525	7.09	8963
3	PDA MaxPlot (250nm-550nm)	2.247	72431	3.20	5323
4	PDA MaxPlot (250nm-550nm)	2.498	69741	3.08	6067
5	PDA MaxPlot (250nm-550nm)	2.759	28240	1.25	3054
6	PDA MaxPlot (250nm-550nm)	2.960	144105	6.37	13535
7	PDA MaxPlot (250nm-550nm)	3.257	163372	7.22	10500
8	PDA MaxPlot (250nm-550nm)	3.911	709575	31.35	47016
9	PDA MaxPlot (250nm-550nm)	4.395	323022	14.27	17861
10	PDA MaxPlot (250nm-550nm)	5.589	38342	1.69	2634
11	PDA MaxPlot (250nm-550nm)	7.626	36991	1.63	1945

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.435			Staettler B387-1	1.882	1.116
2		1.812			Staettler B387-2	1.632	1.568
3		2.247			Staettler B387-3	2.624	2.004
4		2.498			Staettler B387-5	2.709	2.102
5		2.759			Staettler B387-6	3.545	2.432
6		2.960			Staettler B387-7	3.424	1.899
7		3.257			Staettler B387-8	4.240	2.317
8		3.911			Staettler B387-9	1.073	1.374
9		4.395			Staettler B387-10	2.316	1.853
10		5.589			Staettler B387-11	2.962	4.189
11		7.626			Cross B13E-8	3.046	4.295

APPENDIX E

APPENDIX E

HPLC Reports for Blue Ball Point Inks That Were Not Identified to a Reasonable Degree of Certainty, but Were Listed as Possible Matches by Library Matching

APPENDIX E.1

HPLC Reports for Blue Ball Point Inks That Were Not Identified to a Reasonable Degree of Certainty, but Were Listed as Possible Matches by Library Matching

Sample Run 1

Figure 60: HPLC report for ink sample Bic B197D

SampleName Bic B197D

Date Acquired 1/16/2003 8:15:28 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

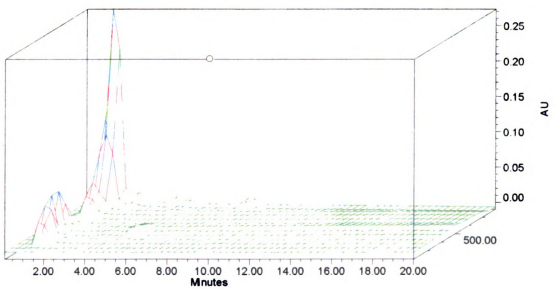
Run Time 20.00 Minutes

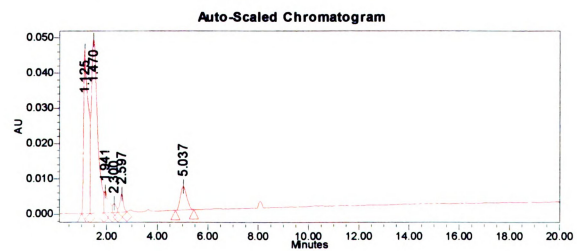
Processing Method Marilyn library 2103

Sample Set Name marilyn 11603

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Bic B197D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.125	576098	33.82	46081
2	PDA MaxPlot (250nm-550nm)	1.470	858272	50.39	49519
3	PDA MaxPlot (250nm-550nm)	1.941	76902	4.52	6110
4	PDA MaxPlot (250nm-550nm)	2.300	25314	1.49	2597
5	PDA MaxPlot (250nm-550nm)	2.597	50281	2.95	5175
6	PDA MaxPlot (250nm-550nm)	5.037	116381	6.83	6650

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.125			Bic B162-1	4.472	1.137
2		1.470			Bic B197-2	1.929	1.042
3		1.941					
4		2.300					
5		2.597					
6		5.037			Formulabs B517-11	3.438	1.693

Figure 61: HPLC report for ink sample Senator B385D

SampleName Senator B385D

Date Acquired 1/16/2003 8:57:52 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

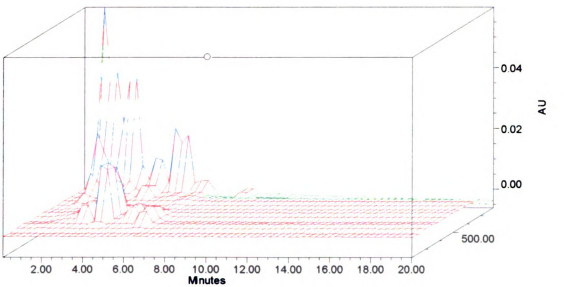
Run Time 20.00 Minutes

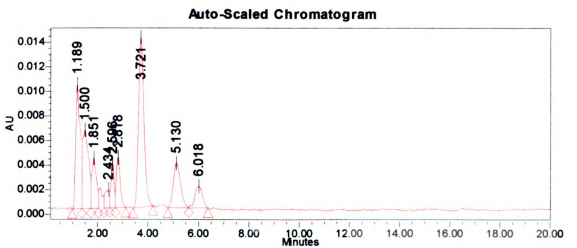
Processing Method Marilyn library 2103

Sample Set Name marilyn 11603

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Senator B385D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.189	125509	18.12	10175
2	PDA MaxPlot (250nm-550nm)	1.500	109170	15.76	6425
3	PDA MaxPlot (250nm-550nm)	1.851	51310	7.41	4099
4	PDA MaxPlot (250nm-550nm)	2.434	18309	2.64	1511
5	PDA MaxPlot (250nm-550nm)	2.596	30675	4.43	3616
6	PDA MaxPlot (250nm-550nm)	2.818	43361	6.26	4097
7	PDA MaxPlot (250nm-550nm)	3.721	206095	29.76	13869
8	PDA MaxPlot (250nm-550nm)	5.130	72381	10.45	3624
9	PDA MaxPlot (250nm-550nm)	6.018	35689	5.15	1760

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.189			Senator B385-1	3.221	1.344
2		1.500			Dupont B102-2	6.866	1.594
3		1.851			Cross B164-3	9.074	1.755
4		2.434					
5		2.596			Bic B162-5	7.553	2.474
6		2.818			Russian Ink B426-6	2.728	2.127
7		3.721			Dupont B102-5	0.858	1.642
8		5.130					
9		6.018			Senator B385-7	2.150	2.397

Figure 62: HPLC report for ink sample New Bic D

SampleName New Bic D

Date Acquired 1/17/2003 8:37:44 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

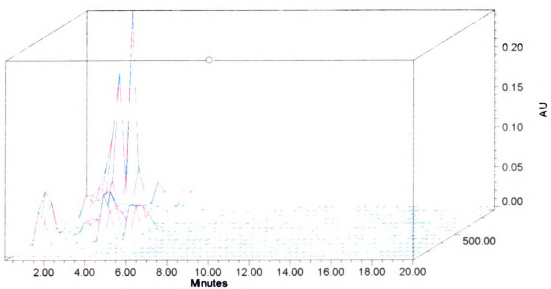
Run Time 20.00 Minutes

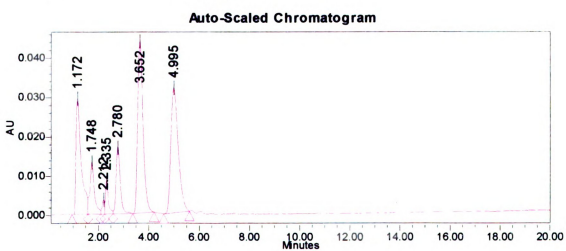
Processing Method Marily n library 2103

Sample Set Name marily n 11603

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name New Bic D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.172	428371	19.70	29372
2	PDA MaxPlot (250nm-550nm)	1.748	163091	7.50	13234
3	PDA MaxPlot (250nm-550nm)	2.212	23031	1.06	3629
4	PDA MaxPlot (250nm-550nm)	2.335	68283	3.14	8679
5	PDA MaxPlot (250nm-550nm)	2.780	196164	9.02	16963
6	PDA MaxPlot (250nm-550nm)	3.652	647928	29.80	43722
7	PDA MaxPlot (250nm-550nm)	4.995	647286	29.77	31824

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.172			New Bic-1	4.751	1.202
2		1.748			New Bic-2	1.190	1.124
3		2.212					
4		2.335			Bic B162-4	7.499	1.355
5		2.780			Senator B385-4	3.052	1.885
6		3.652			Formulabs B517-9	0.597	1.278
7		4.995			Formulabs B517-11	1.072	1.423

APPENDIX E.2

HPLC Reports for Blue Ball Point Inks That Were Not Identified to a Reasonable Degree of Certainty, but Were Listed as Possible Matches by Library Matching

Sample Run 2

Figure 63: HPLC report for ink sample Staedtler B384D

SampleName Staettler B384D

Date Acquired 1/17/2003 9:13:25 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

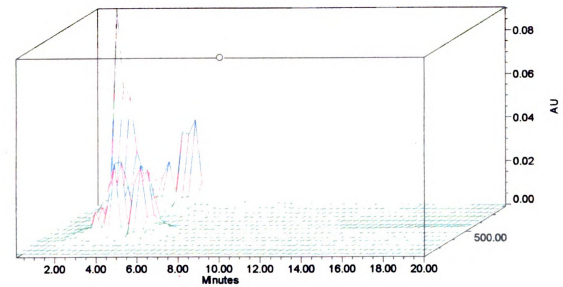
Run Time 20.00 Minutes

Processing Method Marily n library 2103

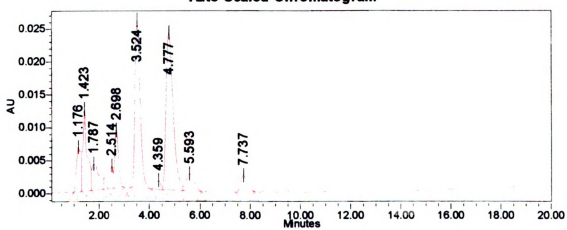
Sample Set Name marily n 11703

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Staedtler B384D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.176	84794	6.13	6772
2	PDA MaxPlot (250nm-550nm)	1.423	149196	10.78	12421
3	PDA MaxPlot (250nm-550nm)	1.787	82627	5.97	4018
4	PDA MaxPlot (250nm-550nm)	2.514	36908	2.67	3422
5	PDA MaxPlot (250nm-550nm)	2.698	87798	6.34	8783
6	PDA MaxPlot (250nm-550nm)	3.524	356502	25.76	25487
7	PDA MaxPlot (250nm-550nm)	4.359	18803	1.36	1355
8	PDA MaxPlot (250nm-550nm)	4.777	463155	33.46	23895
9	PDA MaxPlot (250nm-550nm)	5.593	54418	3.93	2580
10	PDA MaxPlot (250nm-550nm)	7.737	49882	3.60	2519

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.176			Staettler B384-1	9.989	1.324
2		1.423			Tombo B535-2	3.839	1.363
3		1.787			Staettler B384-3	4.566	1.896
4		2.514					
5		2.698			Fisher B50-3	2.439	1.799
6		3.524			Fisher B50-4	0.589	1.289
7		4.359					
8		4.777			Parker B176-9	3.105	2.292
9		5.593			Staettler B384-8	3.803	2.190
10		7.737			Papermate B376-8	4.937	7.106

Figure 64: HPLC report for ink sample Bic B388D

SampleName Bic B388D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marily n 11703

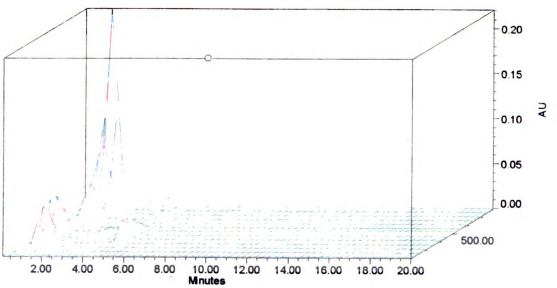
Date Acquired 1/17/2003 9:55:49 PM

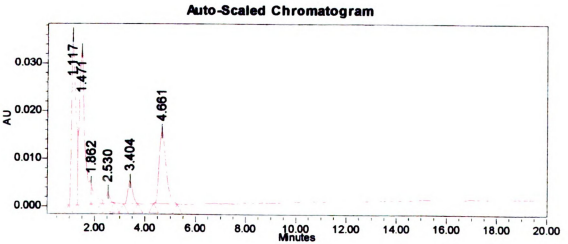
Acq Method Set inkrev2 method set

Processing Method Marily n library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)





Sample Name Bic B388D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.117	410689	31.11	36415
2	PDA MaxPlot (250nm-550nm)	1.471	487187	36.90	32523
3	PDA MaxPlot (250nm-550nm)	1.862	45310	3.43	4383
4	PDA MaxPlot (250nm-550nm)	2.530	27470	2.08	2348
5	PDA MaxPlot (250nm-550nm)	3.404	62555	4.74	4776
6	PDA MaxPlot (250nm-550nm)	4.661	286934	21.74	15171

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.117			Bic B388-1	6.390	1.080
2		1.471			Bic B388-3	4.730	1.091
3		1.862			Tombo B535-1	8.032	1.445
4		2.530			Bic B388-5	7.737	2.789
5		3.404			Fisher B50-4	1.307	1.849
6		4.661			Papermate B376-7	0.655	1.389

Figure 65: HPLC report for ink sample Fisher B50D

SampleName Fisher B50D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11703

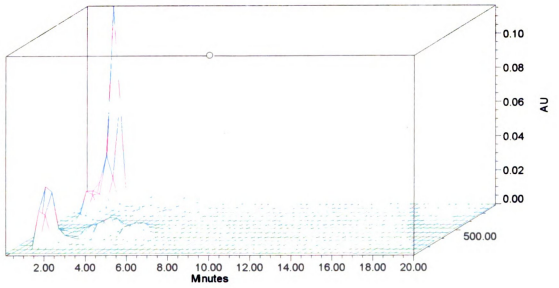
Date Acquired 1/17/2003 10:59:25 PM

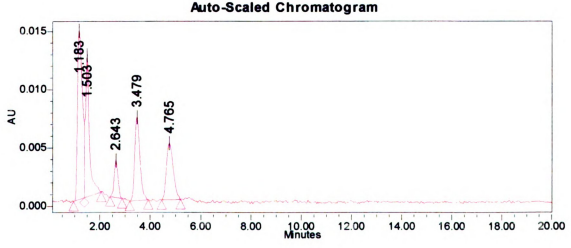
Acq Method Set inkrev2 method set

Processing Method Marily n library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Fisher B50D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.183	196708	35.19	14572
2	PDA MaxPlot (250nm-550nm)	1.503	133772	23.93	12215
3	PDA MaxPlot (250nm-550nm)	2.643	33519	6.00	3183
4	PDA MaxPlot (250nm-550nm)	3.479	104058	18.62	7172
5	PDA MaxPlot (250nm-550nm)	4.765	90881	16.26	4841

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.183			Fisher B50-1	1.844	1.139
2		1.503			Papermate B376-2	0.948	1.054
3		2.643			Tombo B535-3	3.370	3.303
4		3.479			Papermate B376-6	0.818	1.585
5		4.765			Parker B176-9	2.848	2.552

Figure 66: HPLC report for ink sample Tombo B535D

SampleName Tombo B535D

Date Acquired 1/18/2003 2:10:14 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

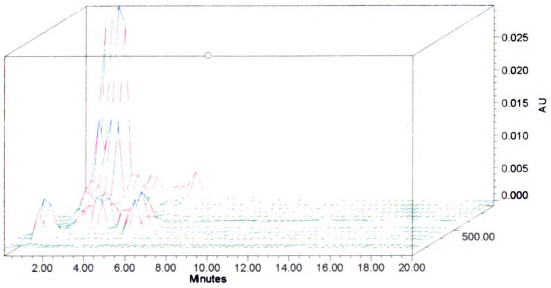
Run Time 20.00 Minutes

Processing Method Marilyn library 2103

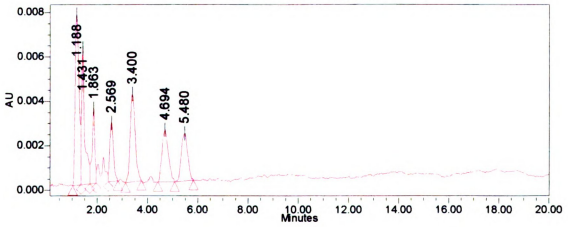
Sample Set Name marilyn 11703

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Tombo B535D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.188	83179	25.80	7765
2	PDA MaxPlot (250nm-550nm)	1.431	52016	16.13	6099
3	PDA MaxPlot (250nm-550nm)	1.863	25488	7.91	3355
4	PDA MaxPlot (250nm-550nm)	2.569	27121	8.41	2650
5	PDA MaxPlot (250nm-550nm)	3.400	55410	17.19	3958
6	PDA MaxPlot (250nm-550nm)	4.694	41071	12.74	2344
7	PDA MaxPlot (250nm-550nm)	5.480	38114	11.82	2139

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.188			Tombo B535-1	1.283	1.286
2		1.431			Tombo B535-2	0.500	1.288
3		1.863			Bic B388-4	9.933	1.497
4		2.569			Fisher B50-3	4.761	2.719
5		3.400			Fisher B50-4	0.995	1.994
6		4.694			Staettler B384-7	2.391	2.616
7		5.480			Staettler B384-8	6.135	2.222

APPENDIX E.3

HPLC Reports for Blue Ball Point Inks That Were Not Identified to a Reasonable Degree of Certainty, but Were Listed as Possible Matches by Library Matching

Sample Run 3

Figure 67: HPLC report for ink sample Fisher B65D

SampleName Fisher B65D

Date Acquired 1/19/2003 6:07:29 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

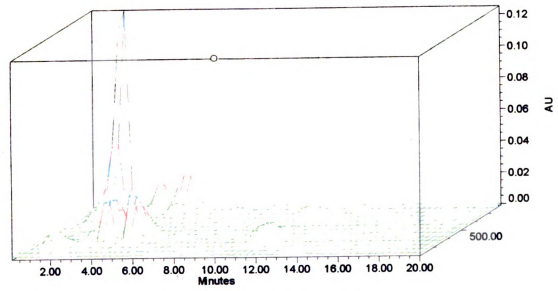
Run Time 20.00 Minutes

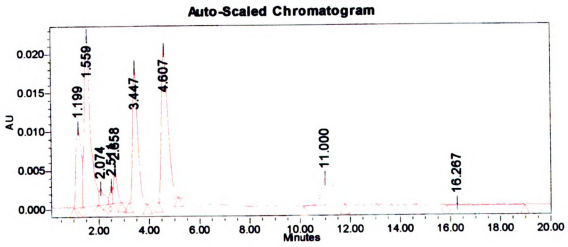
Processing Method Marily n library 2103

Sample Set Name marily n 11903

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Fisher B65D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.199	145522	10.75	10224
2	PDA MaxPlot (250nm-550nm)	1.559	375771	27.76	22000
3	PDA MaxPlot (250nm-550nm)	2.074	31508	2.33	2091
4	PDA MaxPlot (250nm-550nm)	2.511	19000	1.40	2301
5	PDA MaxPlot (250nm-550nm)	2.658	42557	3.14	4286
6	PDA MaxPlot (250nm-550nm)	3.447	244771	18.08	17468
7	PDA MaxPlot (250nm-550nm)	4.607	348524	25.75	19485
8	PDA MaxPlot (250nm-550nm)	11.000	126719	9.36	3430
9	PDA MaxPlot (250nm-550nm)	16.267	19335	1.43	330

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.199			Fisher B65-1	3.973	10.182
2		1.559			Fisher B65-2	2.664	7.676
3		2.074					
4		2.511					
5		2.658					
6		3.447			Cross B164E-6	3.875	9.588
7		4.607			Dupont B102E-6	5.618	10.838
8		11.000					
9		16.267					

Figure 68: HPLC report for ink sample Papermate B68D

SampleName Papermate B68D

Date Acquired 1/19/2003 6:49:53 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

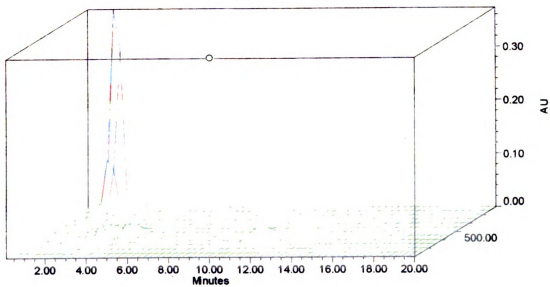
Run Time 20.00 Minutes

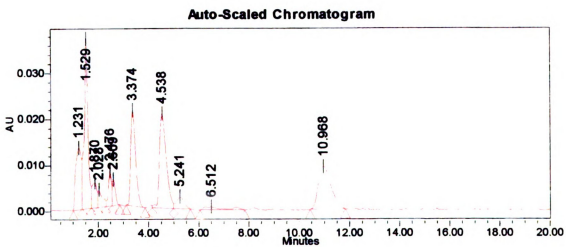
Processing Method Marily n library 2103

Sample Set Name marily n 11903

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Papermate B68D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.231	208327	10.98	13409
2	PDA MaxPlot (250nm-550nm)	1.529	375218	19.78	36998
3	PDA MaxPlot (250nm-550nm)	1.870	72332	3.81	5519
4	PDA MaxPlot (250nm-550nm)	2.028	49920	2.63	3793
5	PDA MaxPlot (250nm-550nm)	2.476	64856	3.42	7553
6	PDA MaxPlot (250nm-550nm)	2.609	44550	2.35	5639
7	PDA MaxPlot (250nm-550nm)	3.374	279426	14.73	20739
8	PDA MaxPlot (250nm-550nm)	4.538	384641	20.28	20485
9	PDA MaxPlot (250nm-550nm)	5.241	54236	2.86	2576
10	PDA MaxPlot (250nm-550nm)	6.512	35392	1.87	616
11	PDA MaxPlot (250nm-550nm)	10.698	327674	17.26	9284

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.231			Fisher B65-1	6.695	14.586
2		1.529			Papermate B376E-2	3.862	6.086
3		1.870					
4		2.028					
5		2.476					
6		2.609					
7		3.374			Papermate B376E-6	6.450	16.903
8		4.538			Papermate B376E-7	8.108	21.963
9		5.241					
10		6.512					
11		10.698					

Figure 69: HPLC report for ink sample Fisher B77D

SampleName Fisher B77D

Date Acquired 1/20/2003 12:50:22 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

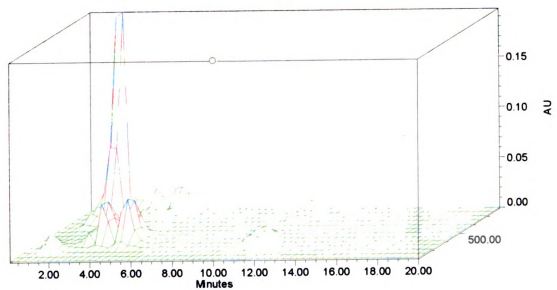
Run Time 20.00 Minutes

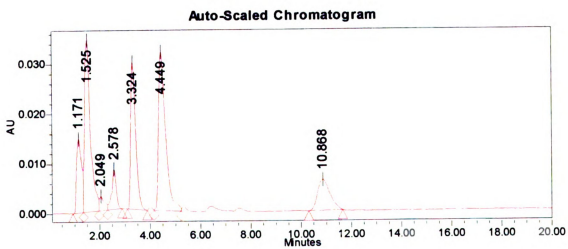
Processing Method Marilyn library 2103

Sample Set Name marilyn 11903

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Fisher B77D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.171	206145	9.63	14843
2	PDA MaxPlot (250nm-550nm)	1.525	556938	26.02	34595
3	PDA MaxPlot (250nm-550nm)	2.049	41924	1.96	2863
4	PDA MaxPlot (250nm-550nm)	2.578	97976	4.58	7955
5	PDA MaxPlot (250nm-550nm)	3.324	405089	18.92	29548
6	PDA MaxPlot (250nm-550nm)	4.449	621606	29.04	31789
7	PDA MaxPlot (250nm-550nm)	10.868	211009	9.86	6169

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.171			Fisher B77-1	4.063	9.483
2		1.525			Fisher B77-2	3.634	8.161
3		2.049					
4		2.578			Papermate B376E-5	9.436	23.794
5		3.324			Papermate B376E-6	3.670	9.017
6		4.449			Papermate B376E-7	3.762	10.347
7		10.868					

APPENDIX F

APPENDIX F

HPLC Reports for Black Ball Point Inks That Were Not Identified to a Reasonable Degree of Certainty, but Were Listed as Possible Matches by Library Matching

APPENDIX F.1

HPLC Reports for Black Ball Point Inks That Were Not Identified to a Reasonable Degree of Certainty, but Were Listed as Possible Matches by Library Matching

Sample Run 2

Figure 70: HPLC report for ink sample Fisher B111D

SampleName Fisher B111D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11703

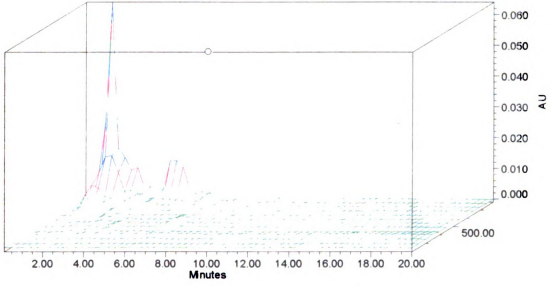
Date Acquired 1/17/2003 11:41:49 PM

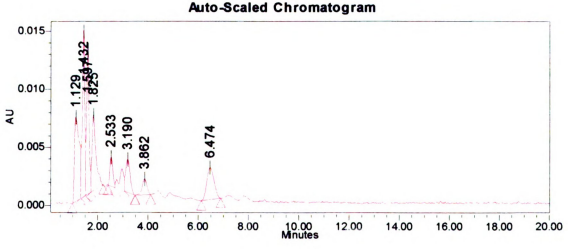
Acq Method Set inkrev2 method set

Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Fisher B111D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.129	95159	20.00	7272
2	PDA MaxPlot (250nm-550nm)	1.432	94941	19.96	14284
3	PDA MaxPlot (250nm-550nm)	1.597	86408	18.16	12448
4	PDA MaxPlot (250nm-550nm)	1.825	70535	14.83	6490
5	PDA MaxPlot (250nm-550nm)	2.533	20793	4.37	2518
6	PDA MaxPlot (250nm-550nm)	3.190	34877	7.33	2833
7	PDA MaxPlot (250nm-550nm)	3.862	18140	3.81	1359
8	PDA MaxPlot (250nm-550nm)	6.474	54917	11.54	2733

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.129			Fisher B111-1	4.729	1.506
2		1.432			Pilot B115-2	2.001	1.218
3		1.597			Fisher B111-3	6.968	1.654
4		1.825			Fisher B111-4	4.735	1.702
5		2.533			Dupont B113-4	8.305	3.573
6		3.190					
7		3.862					
8		6.474					

Figure 71: HPLC report for ink sample Dupont B113D

SampleName Dupont B113D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11703

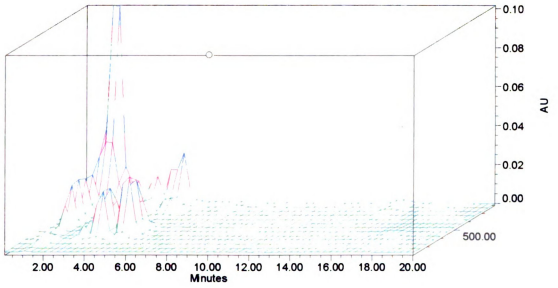
Date Acquired 1/18/2003 12:24:13 AM

Acq Method Set inkrev2 method set

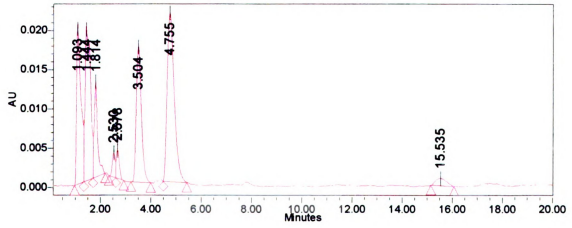
Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Dupont B113D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.093	245392	17.50	20568
2	PDA MaxPlot (250nm-550nm)	1.444	292630	20.87	19792
3	PDA MaxPlot (250nm-550nm)	1.814	114477	8.17	12124
4	PDA MaxPlot (250nm-550nm)	2.530	25106	1.79	3123
5	PDA MaxPlot (250nm-550nm)	2.678	29771	2.12	3563
6	PDA MaxPlot (250nm-550nm)	3.504	245604	17.52	17247
7	PDA MaxPlot (250nm-550nm)	4.755	420049	29.96	21525
8	PDA MaxPlot (250nm-550nm)	15.535	28919	2.06	926

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.093			Dupont B113-1	1.575	1.155
2		1.444			Dupont B113-2	0.613	1.163
3		1.814			Fisher B111-4	7.075	1.571
4		2.530			Dupont B113-4	7.095	3.225
5		2.678			Staettler B391-5	5.649	2.405
6		3.504			Dupont B113-6	0.360	1.395
7		4.755			Pilot B115-8	0.450	1.298
8		15.535			Dupont B113-8	4.877	6.942

Figure 72: HPLC report for ink sample Pilot B115D

SampleName Pilot B115D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11703

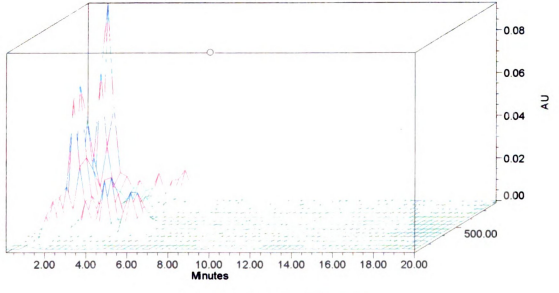
Date Acquired 1/18/2003 4:38:41 AM

Acq Method Set inkrev2 method set

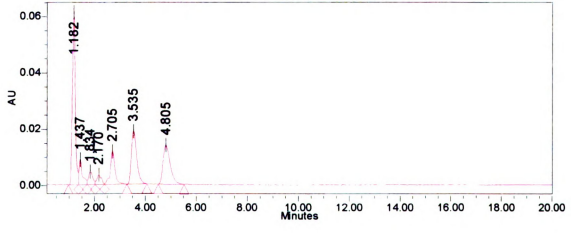
Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Pilot B115D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.182	491082	36.00	62020
2	PDA MaxPlot (250nm-550nm)	1.437	79131	5.80	8951
3	PDA MaxPlot (250nm-550nm)	1.834	53327	3.91	4632
4	PDA MaxPlot (250nm-550nm)	2.170	43203	3.17	3489
5	PDA MaxPlot (250nm-550nm)	2.705	148292	10.87	11655
6	PDA MaxPlot (250nm-550nm)	3.535	276129	20.24	18809
7	PDA MaxPlot (250nm-550nm)	4.805	272802	20.00	13914

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.182			Pilot B115-1	1.737	1.057
2		1.437			Pilot B115-2	1.224	1.208
3		1.834			Pilot B115-3	4.981	1.647
4		2.170			Pilot B115-3	2.293	2.473
5		2.705			Pilot B115-5	1.052	1.478
6		3.535			Dupont B113-6	0.561	1.352
7		4.805			Dupont B113-7	0.378	1.356

APPENDIX G

APPENDIX G

HPLC Reports for Blue Ball Point Inks That Were Not Identified

APPENDIX G.1

HPLC Reports for Blue Ball Point Inks That Were Not Identified

Sample Run 3

Figure 73: HPLC report for ink sample Pilot B103D

SampleName Pilot B103D

Date Acquired 1/19/2003 9:18:17 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

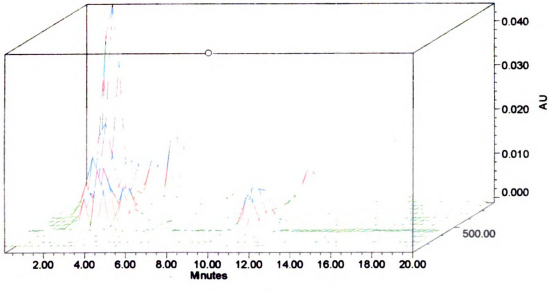
Run Time 20.00 Minutes

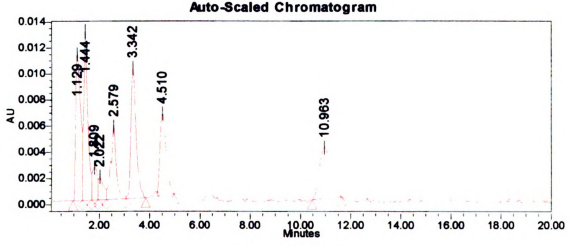
Processing Method Marilyn library 2103

Sample Set Name marilyn 11903

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Pilot B103D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.129	147918	18.14	11291
2	PDA MaxPlot (250nm-550nm)	1.444	145228	17.81	13083
3	PDA MaxPlot (250nm-550nm)	1.809	33125	4.06	2496
4	PDA MaxPlot (250nm-550nm)	2.022	25226	3.09	1758
5	PDA MaxPlot (250nm-550nm)	2.579	84761	10.40	5556
6	PDA MaxPlot (250nm-550nm)	3.342	144555	17.73	10024
7	PDA MaxPlot (250nm-550nm)	4.510	105909	12.99	6226
8	PDA MaxPlot (250nm-550nm)	10.963	128521	15.76	3858

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.129					
2		1.444			Itoya B194-2	7.514	12.038
3		1.809					
4		2.022					
5		2.579					
6		3.342			Cross B164E-6	6.422	17.963
7		4.510					
8		10.963					

APPENDIX H

APPENDIX H

HPLC Reports for Blue Ball Point Inks That Were Run Against Only Their Counterparts in a Library

APPENDIX H.1

HPLC Reports for Blue Ball Point Inks That Were Run Against Only Their Counterparts in a Library

Sample Run 1

Figure 74: HPLC report for ink sample Bic B197D (own library)

SampleName Bic B197D

Date Acquired 1/16/2003 8:15:28 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

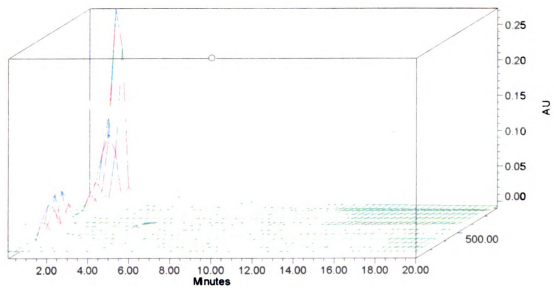
Run Time 20.00 Minutes

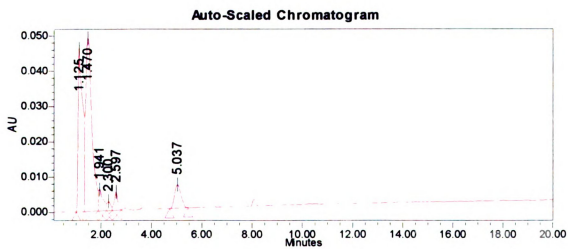
Processing Method Marilyn library 2103

Sample Set Name marilyn 11603

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Bic B197D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.125	576098	33.82	46081
2	PDA MaxPlot (250nm-550nm)	1.470	858272	50.39	49519
3	PDA MaxPlot (250nm-550nm)	1.941	76902	4.52	6110
4	PDA MaxPlot (250nm-550nm)	2.300	25314	1.49	2597
5	PDA MaxPlot (250nm-550nm)	2.597	50281	2.95	5175
6	PDA MaxPlot (250nm-550nm)	5.037	116381	6.83	6650

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.125			Bic B197-1	9.750	1.059
2		1.470			Bic B197-2	1.929	1.042
3		1.941					
4		2.300					
5		2.597					
6		5.037			Bic B197-3	6.379	2.262

Figure 75: HPLC report for ink sample Senator B385D (own library)

SampleName Senator B385D

Date Acquired 1/16/2003 8:57:52 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

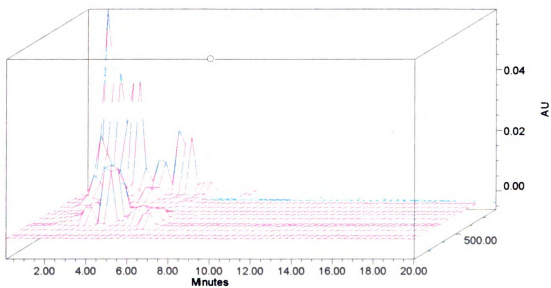
Run Time 20.00 Minutes

Processing Method Marily n library 2103

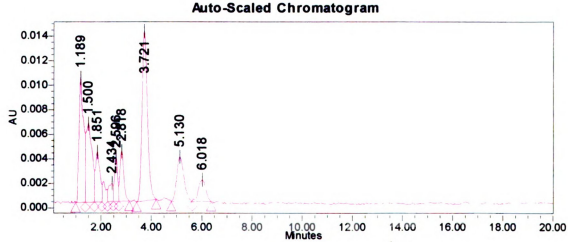
Sample Set Name marily n 11603

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Senator B385D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.189	125509	18.12	10175
2	PDA MaxPlot (250nm-550nm)	1.500	109170	15.76	6425
3	PDA MaxPlot (250nm-550nm)	1.851	51310	7.41	4099
4	PDA MaxPlot (250nm-550nm)	2.434	18309	2.64	1511
5	PDA MaxPlot (250nm-550nm)	2.596	30675	4.43	3616
6	PDA MaxPlot (250nm-550nm)	2.818	43361	6.26	4097
7	PDA MaxPlot (250nm-550nm)	3.721	206095	29.76	13869
8	PDA MaxPlot (250nm-550nm)	5.130	72381	10.45	3624
9	PDA MaxPlot (250nm-550nm)	6.018	35689	5.15	1760

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.189			Senator B385-1	3.221	1.344
2		1.500					
3		1.851					
4		2.434					
5		2.596					
6		2.818			Senator B385-4	3.081	2.362
7		3.721			Senator B385-5	0.982	1.337
8		5.130					
9		6.018			Senator B385-7	2.150	2.397

Figure 76: HPLC report for ink sample New Bic D (own library)

SampleName New Bic D

Date Acquired 1/17/2003 8:37:44 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

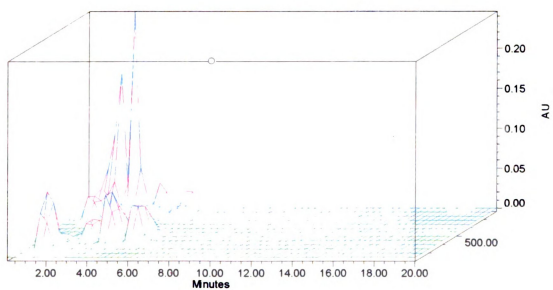
Run Time 20.00 Minutes

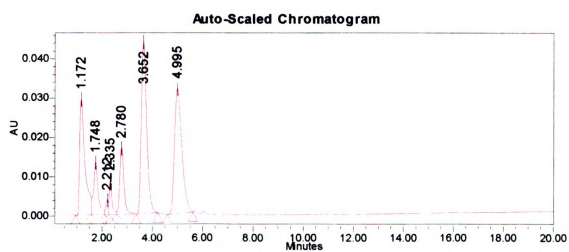
Processing Method Marilyn library 2103

Sample Set Name marilyn 11603

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name New Bic D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.172	428371	19.70	29372
2	PDA MaxPlot (250nm-550nm)	1.748	163091	7.50	13234
3	PDA MaxPlot (250nm-550nm)	2.212	23031	1.06	3629
4	PDA MaxPlot (250nm-550nm)	2.335	68283	3.14	8679
5	PDA MaxPlot (250nm-550nm)	2.780	196164	9.02	16963
6	PDA MaxPlot (250nm-550nm)	3.652	647928	29.80	43722
7	PDA MaxPlot (250nm-550nm)	4.995	647286	29.77	31824

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.172			New Bic-1	4.751	1.202
2		1.748			New Bic-2	1.190	1.124
3		2.212					
4		2.335					
5		2.780					
6		3.652			New Bic-4	0.844	1.252
7		4.995			New Bic-5	1.773	1.324

APPENDIX H.2

HPLC Reports for Blue Ball Point Inks That Were Run Against Only Their Counterparts in a Library

Sample Run 2

Figure 77: HPLC report for ink sample Staedtler B384D (own library)

SampleName Staettler B384D

Date Acquired 1/17/2003 9:13:25 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

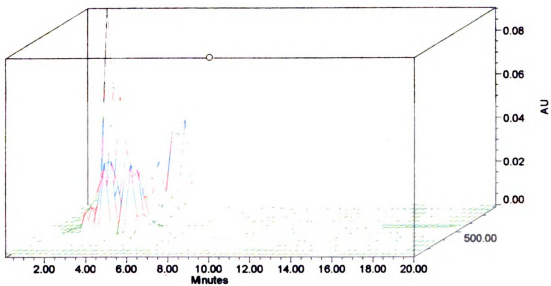
Run Time 20.00 Minutes

Processing Method Marily n library 2103

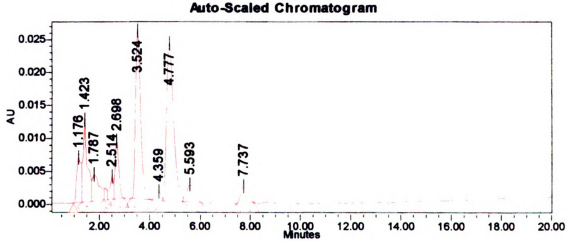
Sample Set Name marily n 11703

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Staedtler B384D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.176	84794	6.13	6772
2	PDA MaxPlot (250nm-550nm)	1.423	149196	10.78	12421
3	PDA MaxPlot (250nm-550nm)	1.787	82627	5.97	4018
4	PDA MaxPlot (250nm-550nm)	2.514	36908	2.67	3422
5	PDA MaxPlot (250nm-550nm)	2.698	87798	6.34	8783
6	PDA MaxPlot (250nm-550nm)	3.524	356502	25.76	25487
7	PDA MaxPlot (250nm-550nm)	4.359	18803	1.36	1355
8	PDA MaxPlot (250nm-550nm)	4.777	463155	33.46	23895
9	PDA MaxPlot (250nm-550nm)	5.593	54418	3.93	2580
10	PDA MaxPlot (250nm-550nm)	7.737	49882	3.60	2519

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.176			Staettler B384-1	9.989	1.324
2		1.423			Staettler B384-2	4.225	1.330
3		1.787			Staettler B384-3	4.566	1.896
4		2.514					
5		2.698			Staettler B384-5	6.830	1.659
6		3.524			Staettler B384-6	1.715	1.229
7		4.359					
8		4.777					
9		5.593			Staettler B384-8	3.803	2.190
10		7.737					

Figure 78: HPLC report for ink sample Bic B388D (own library)

SampleName Bic B388D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11703

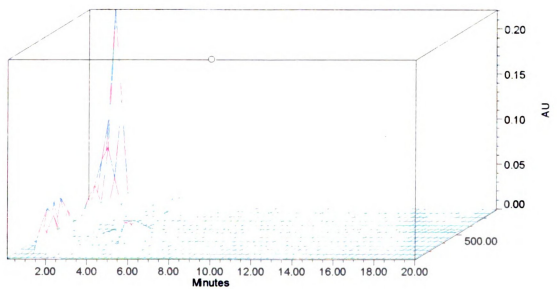
Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)

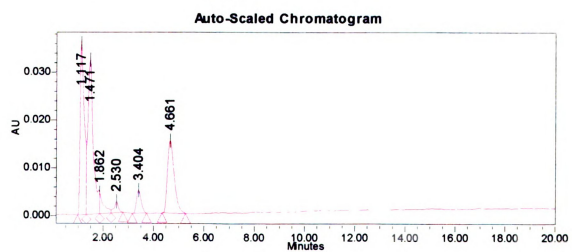
Date Acquired 1/17/2003 9:55:49 PM

Acq Method Set inkrev2 method set

Processing Method Marilyn library 2103

Channel Name MaxPlot250_550





Sample Name Bic B388D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.117	410689	31.11	36415
2	PDA MaxPlot (250nm-550nm)	1.471	487187	36.90	32523
3	PDA MaxPlot (250nm-550nm)	1.862	45310	3.43	4383
4	PDA MaxPlot (250nm-550nm)	2.530	27470	2.08	2348
5	PDA MaxPlot (250nm-550nm)	3.404	62555	4.74	4776
6	PDA MaxPlot (250nm-550nm)	4.661	286934	21.74	15171

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.117			Bic B388-1	6.390	1.080
2		1.471			Bic B388-3	4.730	1.091
3		1.862					
4		2.530			Bic B388-5	7.737	2.789
5		3.404			Bic B388-6	1.313	2.061
6		4.661					

Figure 79: HPLC report for ink sample Fisher B50D (own library)

SampleName Fisher B50D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11703

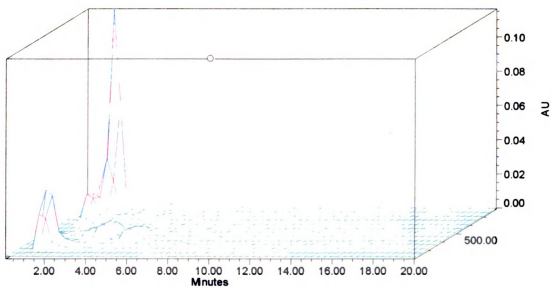
Date Acquired 1/17/2003 10:59:25 PM

Acq Method Set inkrev2 method set

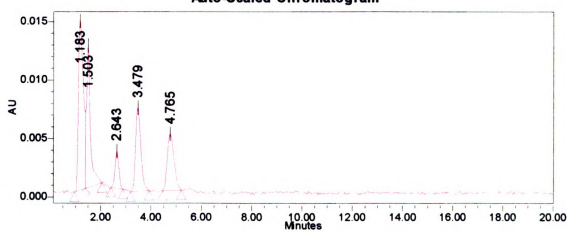
Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Fisher B50D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.183	196708	35.19	14572
2	PDA MaxPlot (250nm-550nm)	1.503	133772	23.93	12215
3	PDA MaxPlot (250nm-550nm)	2.643	33519	6.00	3183
4	PDA MaxPlot (250nm-550nm)	3.479	104058	18.62	7172
5	PDA MaxPlot (250nm-550nm)	4.765	90881	16.26	4841

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.183			Fisher B50-1	1.844	1.139
2		1.503			Fisher B50-2	0.950	1.072
3		2.643			Fisher B50-3	8.136	2.317
4		3.479			Fisher B50-4	0.832	1.573
5		4.765					

Figure 80: HPLC report for ink sample Mitsubishi B395D (own library)

SampleName Mitsubishi B395D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11703

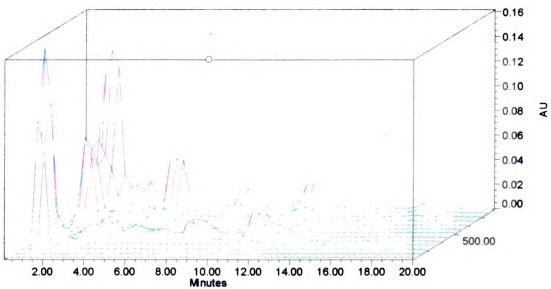
Date Acquired 1/18/2003 1:27:49 AM

Acq Method Set inkrev2 method set

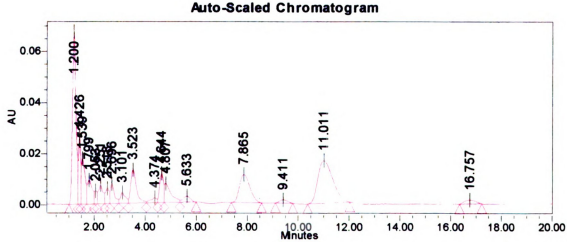
Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Mitsubishi B395D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.200	649939	21.33	67929
2	PDA MaxPlot (250nm-550nm)	1.426	149438	4.90	26159
3	PDA MaxPlot (250nm-550nm)	1.539	187495	6.15	17756
4	PDA MaxPlot (250nm-550nm)	1.799	124620	4.09	9432
5	PDA MaxPlot (250nm-550nm)	2.053	39185	1.29	5035
6	PDA MaxPlot (250nm-550nm)	2.251	92729	3.04	7383
7	PDA MaxPlot (250nm-550nm)	2.518	60956	2.00	5940
8	PDA MaxPlot (250nm-550nm)	2.696	87300	2.86	7686
9	PDA MaxPlot (250nm-550nm)	3.101	60233	1.98	4262
10	PDA MaxPlot (250nm-550nm)	3.523	200338	6.57	13053
11	PDA MaxPlot (250nm-550nm)	4.374	32902	1.08	1911
12	PDA MaxPlot (250nm-550nm)	4.644	118270	3.88	11411
13	PDA MaxPlot (250nm-550nm)	4.807	132572	4.35	7440
14	PDA MaxPlot (250nm-550nm)	5.633	44531	1.46	2267
15	PDA MaxPlot (250nm-550nm)	7.865	315483	10.35	11010
16	PDA MaxPlot (250nm-550nm)	9.411	27096	0.89	1263
17	PDA MaxPlot (250nm-550nm)	11.011	676972	22.22	16633
18	PDA MaxPlot (250nm-550nm)	16.757	47216	1.55	1469

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.200			Mitsubishi B395-1	2.928	3.388
2		1.426			Mitsubishi B395-2	6.281	6.222
3		1.539					
4		1.799			Mitsubishi B395-3	7.083	8.091
5		2.053			Mitsubishi B395-1	9.317	9.180
6		2.251			Mitsubishi B395-3	9.995	7.801
7		2.518					
8		2.696					
9		3.101			Mitsubishi B395-3	8.618	10.005
10		3.523					
11		4.374					
12		4.644			Mitsubishi B395-4	2.803	5.311
13		4.807					
14		5.633					
15		7.865					
16		9.411					
17		11.011					
18		16.757					

Figure 81: HPLC report for ink sample Parker B176D (own library)

SampleName Parker B176D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11703

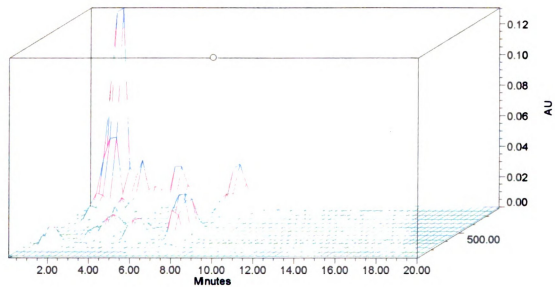
Date Acquired 1/18/2003 3:56:16 AM

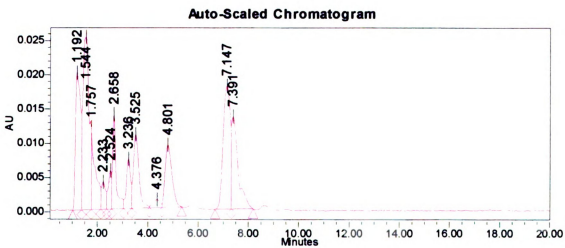
Acq Method Set inkrev2 method set

Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Parker B176D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.192	279003	13.20	20140
2	PDA MaxPlot (250nm-550nm)	1.544	433846	20.52	25406
3	PDA MaxPlot (250nm-550nm)	1.757	132631	6.27	12023
4	PDA MaxPlot (250nm-550nm)	2.233	46426	2.20	4010
5	PDA MaxPlot (250nm-550nm)	2.524	51119	2.42	5657
6	PDA MaxPlot (250nm-550nm)	2.658	131991	6.24	13841
7	PDA MaxPlot (250nm-550nm)	3.236	84894	4.02	7251
8	PDA MaxPlot (250nm-550nm)	3.525	163404	7.73	10786
9	PDA MaxPlot (250nm-550nm)	4.376	22068	1.04	1220
10	PDA MaxPlot (250nm-550nm)	4.801	171581	8.12	9098
11	PDA MaxPlot (250nm-550nm)	7.147	354430	16.76	17969
12	PDA MaxPlot (250nm-550nm)	7.391	242926	11.49	13463

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.192			Parker B176-1	6.865	1.321
2		1.544			Parker B176-2	8.502	1.434
3		1.757			Parker B176-3	8.115	1.793
4		2.233			Parker B176-4	4.454	2.754
5		2.524			Parker B176-5	4.342	2.972
6		2.658			Parker B176-6	2.201	1.428
7		3.236			Parker B176-7	2.326	2.762
8		3.525			Parker B176-8	4.120	2.424
9		4.376					
10		4.801			Parker B176-9	5.112	2.633
11		7.147			Parker B176-10	0.830	1.519
12		7.391					

Figure 82: HPLC report for ink sample Tombo B535D (own library)

SampleName Tombo B535D

Date Acquired 1/18/2003 2:10:14 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

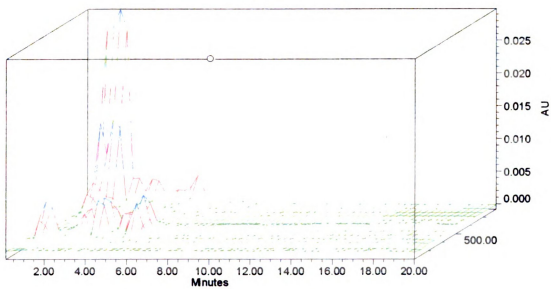
Run Time 20.00 Minutes

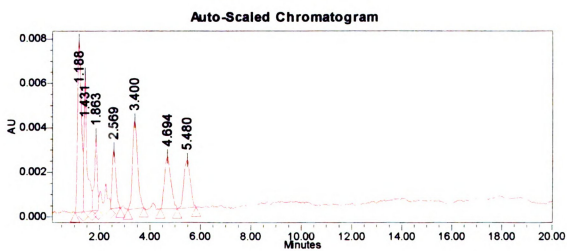
Processing Method Marilyn library 2103

Sample Set Name marilyn 11703

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)





Sample Name Tombo B535D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.188	83179	25.80	7765
2	PDA MaxPlot (250nm-550nm)	1.431	52016	16.13	6099
3	PDA MaxPlot (250nm-550nm)	1.863	25488	7.91	3355
4	PDA MaxPlot (250nm-550nm)	2.569	27121	8.41	2650
5	PDA MaxPlot (250nm-550nm)	3.400	55410	17.19	3958
6	PDA MaxPlot (250nm-550nm)	4.694	41071	12.74	2344
7	PDA MaxPlot (250nm-550nm)	5.480	38114	11.82	2139

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.188			Tombo B535-1	1.283	1.286
2		1.431			Tombo B535-2	0.500	1.288
3		1.863					
4		2.569			Tombo B535-3	8.908	3.571
5		3.400			Tombo B535-4	3.929	2.651
6		4.694			Tombo B535-5	5.776	3.842
7		5.480					

APPENDIX H.3

HPLC Reports for Blue Ball Point Inks That Were Run Against Only Their Counterparts in a Library

Sample Run 3

Figure 83: HPLC report for ink sample Papermate B68D

SampleName Papermate B68D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11903

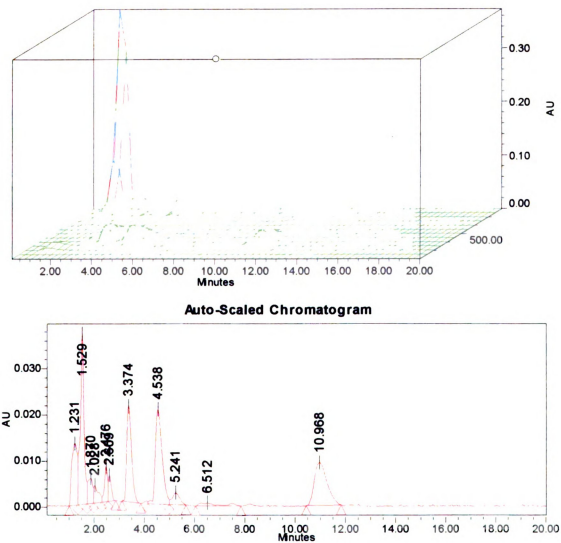
Date Acquired 1/19/2003 6:49:53 PM

Acq Method Set inkrev2 method set

Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Sample Name Papermate B68D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.231	208327	10.98	13409
2	PDA MaxPlot (250nm-550nm)	1.529	375218	19.78	36998
3	PDA MaxPlot (250nm-550nm)	1.870	72332	3.81	5519
4	PDA MaxPlot (250nm-550nm)	2.028	49920	2.63	3793
5	PDA MaxPlot (250nm-550nm)	2.476	64856	3.42	7553
6	PDA MaxPlot (250nm-550nm)	2.609	44550	2.35	5639
7	PDA MaxPlot (250nm-550nm)	3.374	279426	14.73	20739
8	PDA MaxPlot (250nm-550nm)	4.538	384641	20.28	20485
9	PDA MaxPlot (250nm-550nm)	5.241	54236	2.86	2576
10	PDA MaxPlot (250nm-550nm)	6.512	35392	1.87	616
11	PDA MaxPlot (250nm-550nm)	10.968	327674	17.28	9284

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.231					
2		1.529			Papermate B68-2	3.951	8.519
3		1.870					
4		2.028					
5		2.476					
6		2.609					
7		3.374			Papermate B68-7	7.816	25.703
8		4.538					
9		5.241					
10		6.512					
11		10.968					

Figure 84: HPLC report for ink sample Pilot B103D (2nd run, own library)

SampleName Pilot B103D

Date Acquired 1/19/2003 9:18:17 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

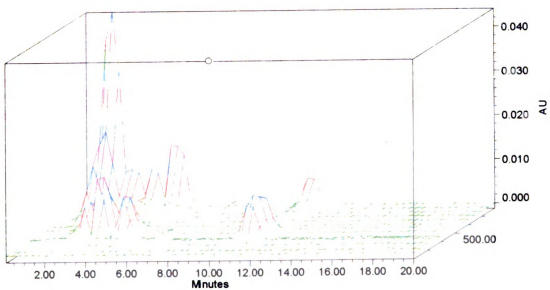
Run Time 20.00 Minutes

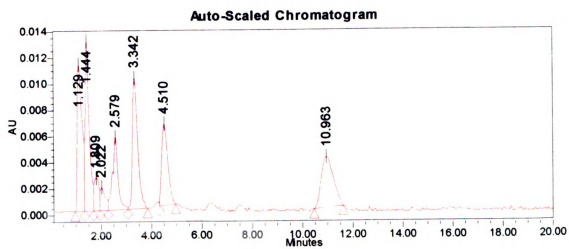
Processing Method Marilyn library 2103

Sample Set Name marilyn 11903

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Pilot B103D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.129	147918	18.14	11291
2	PDA MaxPlot (250nm-550nm)	1.444	145228	17.81	13093
3	PDA MaxPlot (250nm-550nm)	1.809	33125	4.06	2496
4	PDA MaxPlot (250nm-550nm)	2.022	25226	3.09	1758
5	PDA MaxPlot (250nm-550nm)	2.579	84761	10.40	5556
6	PDA MaxPlot (250nm-550nm)	3.342	144555	17.73	10024
7	PDA MaxPlot (250nm-550nm)	4.510	105909	12.99	6226
8	PDA MaxPlot (250nm-550nm)	10.963	128521	15.76	3858

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.129					
2		1.444					
3		1.809					
4		2.022					
5		2.579					
6		3.342					
7		4.510					
8		10.963					

Figure 85: HPLC report for ink sample Fisher B65D (own library)

SampleName Fisher B65D

Date Acquired 1/19/2003 6:07:29 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

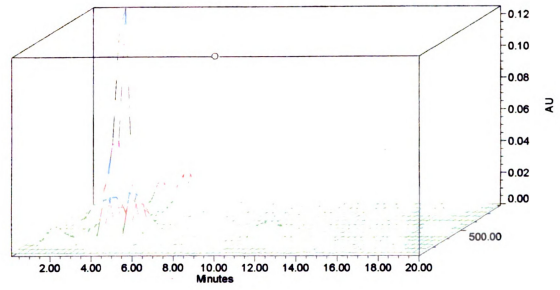
Run Time 20.00 Minutes

Processing Method Marilyn library 2103

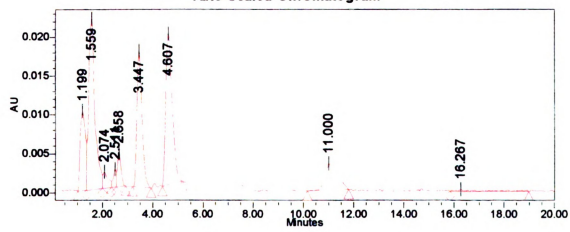
Sample Set Name marilyn 11903

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Fisher B65D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.199	145522	10.75	10224
2	PDA MaxPlot (250nm-550nm)	1.559	375771	27.76	22000
3	PDA MaxPlot (250nm-550nm)	2.074	31508	2.33	2091
4	PDA MaxPlot (250nm-550nm)	2.511	19000	1.40	2301
5	PDA MaxPlot (250nm-550nm)	2.658	42557	3.14	4286
6	PDA MaxPlot (250nm-550nm)	3.447	244771	18.08	17468
7	PDA MaxPlot (250nm-550nm)	4.607	348524	25.75	19485
8	PDA MaxPlot (250nm-550nm)	11.000	126719	9.36	3430
9	PDA MaxPlot (250nm-550nm)	12.267	19335	1.43	330

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.199			Fisher 65-1	3.973	10.182
2		1.559			Fisher 65-2	2.664	7.676
3		2.074					
4		2.511					
5		2.658					
6		3.447			Fisher 65-6	4.263	12.280
7		4.607			Fisher 65-7	6.454	14.078
8		11.000					
9		12.267					

Figure 86: HPLC report for ink sample Fisher B77D (own library)

SampleName Fisher B77D

Date Acquired 1/20/2003 12:50:22 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

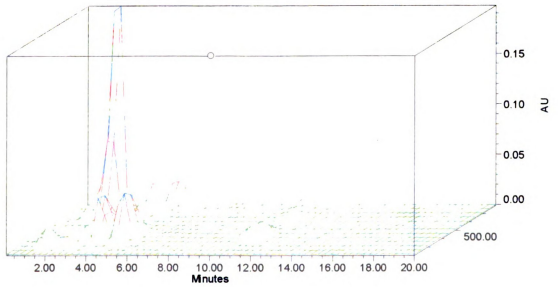
Run Time 20.00 Minutes

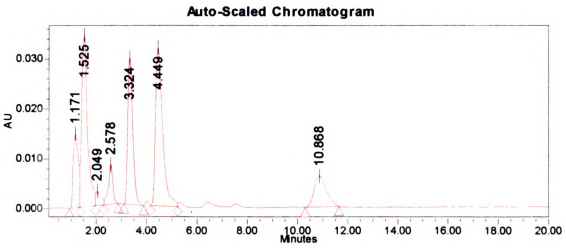
Processing Method Marilyn library 2103

Sample Set Name marilyn 11903

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Fisher B77D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.171	206145	9.63	14843
2	PDA MaxPlot (250nm-550nm)	1.525	556938	26.02	34595
3	PDA MaxPlot (250nm-550nm)	2.049	41924	1.96	2863
4	PDA MaxPlot (250nm-550nm)	2.578	97976	4.58	7955
5	PDA MaxPlot (250nm-550nm)	3.324	405089	18.92	29548
6	PDA MaxPlot (250nm-550nm)	4.449	621606	29.04	31789
7	PDA MaxPlot (250nm-550nm)	10.868	211009	9.86	6169

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.171			Fisher B77-1	4.063	9.483
2		1.525			Fisher B77-2	3.634	8.161
3		2.049					
4		2.578					
5		3.324			Fisher B77-5	4.854	12.056
6		4.449			Fisher B77-6	5.990	14.129
7		10.868					

APPENDIX I

APPENDIX I

HPLC Reports for Black Ball Point Inks That Were Run Against Only Their Counterparts in a Library

APPENDIX I.1

HPLC Reports for Black Ball Point Inks That Were Run Against Only Their Counterparts in a Library

Sample Run 2

Figure 87: HPLC report for ink sample Dupont B113D (own library)

SampleName Dupont B113D

Date Acquired 1/18/2003 12:24:13 AM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

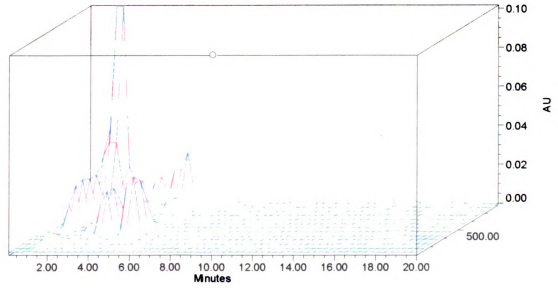
Run Time 20.00 Minutes

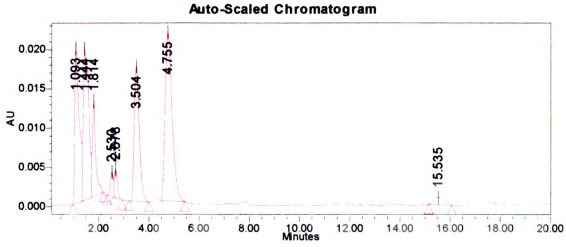
Processing Method Marilyn library 2103

Sample Set Name marilyn 11703

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot (250.0 nm to 550.0 nm)





Sample Name Dupont 113D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.093	245392	17.50	20568
2	PDA MaxPlot (250nm-550nm)	1.444	292630	20.87	19792
3	PDA MaxPlot (250nm-550nm)	1.814	114477	8.17	12124
4	PDA MaxPlot (250nm-550nm)	2.530	25106	1.79	3123
5	PDA MaxPlot (250nm-550nm)	2.678	29771	2.12	3563
6	PDA MaxPlot (250nm-550nm)	3.504	245604	17.52	17247
7	PDA MaxPlot (250nm-550nm)	4.755	420049	29.96	21525
8	PDA MaxPlot (250nm-550nm)	15.535	28919	2.06	926

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.093			Dupont B113-1	1.575	1.155
2		1.444			Dupont B113-2	0.613	1.163
3		1.814			Dupont B113-3	7.306	1.465
4		2.530			Dupont B113-4	7.095	3.225
5		2.678			Dupont B113-5	5.870	2.769
6		3.504			Dupont B113-6	0.360	1.395
7		4.755			Dupont B113-7	1.670	1.297
8		15.535			Dupont B113-8	4.877	6.942

Figure 88: HPLC report for ink sample Eversharp 657

SampleName Eversharp 657

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11703

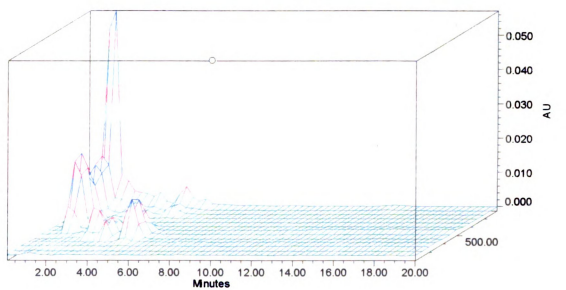
Date Acquired 1/18/2003 5:21:05 AM

Acq Method Set inkrev2 method set

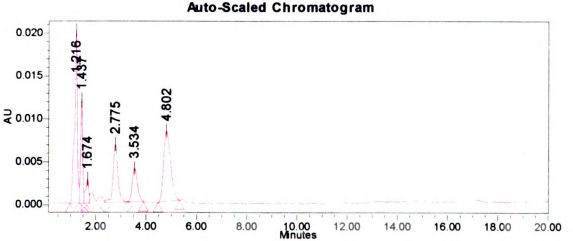
Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Eversharp 657

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.216	154977	28.05	20152
2	PDA MaxPlot (250nm-550nm)	1.437	69934	12.66	12154
3	PDA MaxPlot (250nm-550nm)	1.674	23002	4.16	2811
4	PDA MaxPlot (250nm-550nm)	2.775	88678	16.05	6796
5	PDA MaxPlot (250nm-550nm)	3.534	56970	10.31	3935
6	PDA MaxPlot (250nm-550nm)	4.802	158858	28.76	8222

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.216			Eversharp 657-1	7.499	1.180
2		1.437			Eversharp 657-2	1.015	1.176
3		1.674					
4		2.775			Eversharp 657-3	8.421	2.752
5		3.534			Eversharp 657-4	2.046	2.529
6		4.802			Eversharp 657-5	0.620	1.687

Figure 89: HPLC report for ink sample Fisher B111D (own library)

SampleName Fisher B111D

Date Acquired 1/17/2003 11:41:49 PM

Injection Volume 10.00 ul

Acq Method Set inkrev2 method set

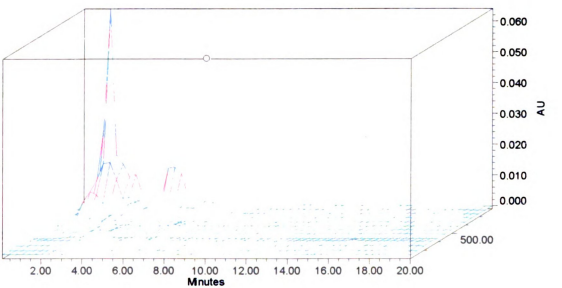
Run Time 20.00 Minutes

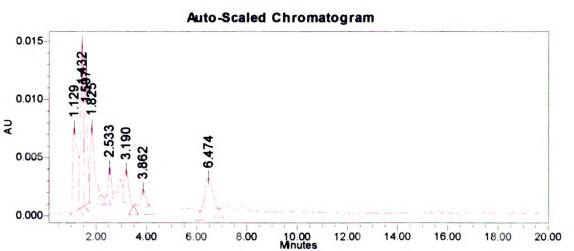
Processing Method Marily n library 2103

Sample Set Name marily n 11703

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)





Sample Name Fisher B111D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.129	95159	20.00	7272
2	PDA MaxPlot (250nm-550nm)	1.432	94941	19.96	14284
3	PDA MaxPlot (250nm-550nm)	1.597	86408	18.16	12448
4	PDA MaxPlot (250nm-550nm)	1.825	70535	14.83	6490
5	PDA MaxPlot (250nm-550nm)	2.533	20793	4.37	2518
6	PDA MaxPlot (250nm-550nm)	3.190	34877	7.33	2833
7	PDA MaxPlot (250nm-550nm)	3.862	18140	3.81	1359
8	PDA MaxPlot (250nm-550nm)	6.474	54917	11.54	2733

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.129			Fisher B111-1	4.729	1.506
2		1.432			Fisher B111-2	4.756	1.221
3		1.597			Fisher B111-3	6.968	1.654
4		1.825			Fisher B111-4	4.735	1.702
5		2.533					
6		3.190					
7		3.862					
8		6.474					

Figure 90: HPLC report for ink sample Pilot B115D (own library)

SampleName Pilot B115D

Injection Volume 10.00 ul

Run Time 20.00 Minutes

Sample Set Name marilyn 11703

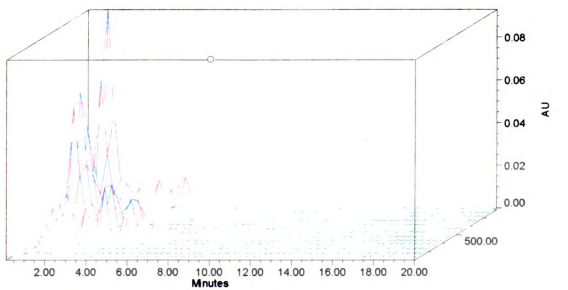
Date Acquired 1/18/2003 4:38:41 AM

Acq Method Set inkrev2 method set

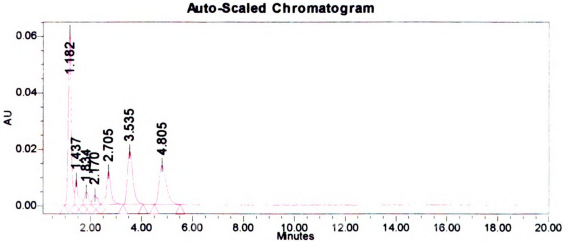
Processing Method Marilyn library 2103

Channel Name MaxPlot250_550

Processed Channel Descr. PDA MaxPlot
(250.0 nm to 550.0 nm)



Auto-Scaled Chromatogram



Sample Name Pilot B115D

Processed Channel: PDA MaxPlot (250.0 nm to 550.0 nm)

	Processed Channel	Retention Time (min)	Area	% Area	Height
1	PDA MaxPlot (250nm-550nm)	1.182	491082	36.00	62020
2	PDA MaxPlot (250nm-550nm)	1.437	79131	5.80	8951
3	PDA MaxPlot (250nm-550nm)	1.834	53327	3.91	4632
4	PDA MaxPlot (250nm-550nm)	2.170	43203	3.17	3489
5	PDA MaxPlot (250nm-550nm)	2.705	148292	10.87	11655
6	PDA MaxPlot (250nm-550nm)	3.535	276129	20.24	18809
7	PDA MaxPlot (250nm-550nm)	4.805	272802	20.00	13914

PDA Result Table

	Name	RT	Purity 1 Angle	Purity 1 Threshold	Match 1 Spect. Name	Match 1 Angle	Match 1 Threshold
1		1.182			Pilot B115-1	1.737	1.057
2		1.437			Pilot B115-2	1.224	1.208
3		1.834			Pilot B115-3	4.981	1.647
4		2.170			Pilot B115-4	2.293	2.473
5		2.705			Pilot B115-5	1.052	1.478
6		3.535			Pilot B115-6	0.576	1.286
7		4.805			Pilot B115-7	2.920	1.353

List of References

1. Brunelle, Richard L. and Reed, Robert W., Forensic Examination of Ink and Paper, Charles C. Thomas: Springfield, Illinois, 1984.

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