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NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report

on

The Characteristics of Petroleum Thinners Available Commercially for Organic Protective Coatings.

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WASHINGTON, D.C.

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INTRODUCTION

(a) Authorization

1. This study was authorized by Project Order No. 31/39 of 30 June 1938.

(b) Statement of Problem

2. Part of the problem, as authorized, should consist of a study of the most satisfactory and adaptable solvents and solvent combinations for use with the improved and recently developed resins rapidly becoming available. This report will discuss some of the methods for studying these solvents and solvent mixtures with reference to their quantitative constitution.

(c) Known Facts Bearing on the Problem

3. A high solvency paint thinner of petroleum origin is usually a hydrocarbon mixture consisting largely of aromatic hydrocarbons, smaller percentages of aliphatic and naphthenic hydrocarbons, and less than one per cent of unsaturates. Many methods to determine the percentage of each constituent have been advanced, but most of these are tedious if accurate within one per cent. Some of these methods are used in this report and suggested alterations to increase the speed of the determination are suggested. The methods are then applied to commercial paint thinners that are available at the present time.

(d) Original Work Done at this Laboratory

4. Previously this Laboratory has written a report on "The Qualitative Identification of Various Functional Groups Present in Aviation Gasoline," known as Naval Research Laboratory Report No. P-1394, dated 30 September 1937. This report describes in detail the most accurate methods for the detection of the various functional groups likely to be found in aviation gasoline. The sensitivity of the chemical reactions involved is described in Naval Research Laboratory Report No. P-1499. In connection with this work the ultra-violet and infra-red spectroscopic characteristics of the various groups have been studied and the information so obtained compared with that from the chemical examination. For a summary and comparison of the two methods, attention is directed to Naval Research Laboratory Report No. P-1500, which points out the respective advantages of each method. These same methods may be applied to any hydrocarbon mixture. However, as only qualitative results are obtained, these tests are only applicable to the present problem in so far as they indicate the type of hydrocarbon present.

METHODS

5. A typical petroleum distillate suitable for use as a solvent in varnish and lacquer formulations may be assumed to consist of four groups or types of compounds, namely, aliphatic, aromatic, naphthenic, and unsaturated hydrocarbons. Methods employed for the detection and separation of each group are herein described.

(a) Unsaturated Hydrocarbons

6. Qualitative tests on unsaturates were made as described in Naval Research Laboratory Report No. P-1394. When unsaturated compounds were shown to be present a modification of the Francis[1] method for the estimation of unsaturated hydrocarbons was used. For the removal[2] of the unsaturated compounds a sample is cooled to -12°C. and brominated under strictly controlled conditions. The unsaturates form dibromides and tetra-bromides which have boiling points sufficiently high that the hydrocarbons may be removed by distillation without any great difficulty.

(b) Aromatic Hydrocarbons

7. For the separation of the aromatic fraction the hydrocarbon mixture can be extracted with liquid sulfur dioxide at temperatures of -35° to -40°C. The apparatus used in this work was designed and described by Leslie[5]. This method provides a continuous process and may be operated at length without interruption. Leslie states that there is little separation of naphthenes by the use of this method. The separation of aromatics is fairly complete. However, a minimum of 2 per cent of the ring compounds remains[6]. Where it is desired to recover even this last trace the method of Mair and White[6] may be used to an advantage. Their procedure is to absorb the remaining aromatic compounds with silica gel from which they may be completely recovered.

8. For the estimation of aromatic content without its separation a modification of the method of Tizard and Marshall[3] based upon the difference in aniline points sppears to be the most satisfactory. In the case of the aromatic hydrocarbons occurring in petroleum distillates, the aniline points of the individual members all lie below 32°F. and as a result the amount of lowering of the aniline point of a paraffin hydrocarbon is proportional to the amount of aromatic hydrocarbon held in solution. For example, a given amount of benzene dissolved in normal-hexane will lower the aniline point of the latter about the same as an equal amount of toluene or xylene.

(c) Naphthenic Hydrocarbons

9. After the removal of unsaturates and aromatics by the foregoing methods, there remains a mixture of naphthenes and paraffins. It is proposed to remove the cyclic naphthenes by the

method of Danalia, Andrei, and Melinescu[7] by vaporizing the hydrocarbon mixture and passing the vapors over a nickel catalyst at 350°C. This dehydrogenates the cyclic compounds, thereby making them susceptible to the reactions of the aromatic groups. They are then removed from the mixture of aliphatics by the methods described for the removal of aromatics.

(d) Aliphatic Hydrocarbons

10. At this point the mixture contains only aliphatic compounds with traces of impurities from the other groups. The mixture is washed with concentrated H_2SO_4 and H_2SO_4 - HNO_3 until tests show it to be free from unsaturates and aromatics. It is finally washed with water and dried over $CaCl_2$. The final purification is made by distillation.

11. The methods herein mentioned as applicable to the hydrocarbon mixtures under observation are described in detail in the appendix. Also included are the description and results of various experiments designed to prove the validity and reliability of these methods. These methods were applied to ten commercial products as described in the introduction.

DATA OBTAINED

12. The collected data are given in Table I. The different references given as numbers 1, 2 or 3 were found in the scientific literature and printed information from manufacturers.

13. The aniline point is the temperature at which an equal volume of anhydrous aniline and unknown shows a cloudiness due to separation of the components. The higher the aniline point the more aliphatic is the nature of the solvent.

14. Mixed aniline point is the temperature at which a cloudiness appears in a mixture of 50 per cent anhydrous aniline, 25 per cent of a reference aliphatic hydrocarbon, and 25 per cent of the unknown. This value is readily taken and especially so when the unknown contains 50 per cent or more aromatic hydrocarbons.

15. Per cent aromatics - by liquid SO_2. The method used is that described by Leslie[5] and does not remove naphthenes. The method by mixed aniline point is described in detail in the appendix. This value is probably high due to the presence of naphthenes in the solvent.

16. Unsaturates. The bromine number is defined as the centigrams of bromine consumed per gram of sample. This value was converted into the per cent diisobutylene (chosen as a reference material C_8H_{16}).

17. Bomb oxidation. One hundred (100) cc of the sample were placed in a bomb and the oxygen pressure was increased to 100 pounds at 25°C. This bomb was then placed in a bath at 100°C. for a period of 24 hours. The induction period is that time, in hours, required to show a drop of one pound in pressure. The gum was determined by the ASTM designation D.381-34T before and after oxidation. Of the samples studied, No. 10 is the only one showing any gumming tendency.

DISCUSSION OF DATA OBTAINED

18. From the data available it can be said that the amount of unsaturates in a thinner can be determined readily. Table I shows that the per cent unsaturates is small except with No. 10. Number 10 is a high boiling hydrocarbon mixture and may have other compounds present that react with bromine. This sample also shows more gum (before and after oxidation) than the others.

19. The determination of the aromatic content with any accuracy is questionable. The use of sulfuric acid has a tendency to remove some of the aliphatics as well and therefore may read high[9]. The liquid SO_2 method has a tendency to be low, leaving two per cent or more of the aromatics in the insoluble portion. Liquid SO_2 does not remove naphthenes or aliphatics but does have a tendency to remove some of the unsaturated hydrocarbons.

20. A mixed aniline point method can be used qualitatively for the per cent aromatics, but the results will be higher than the liquid SO_2 should any appreciable percentage of naphthenes be present. To show this the following values can be cited:

(1) Aniline point, hexane	67.3°C.
(2) Aniline point, hexane 20 cc + cyclohexane 5 cc	58.9
(3) Aniline point, hexane 20 cc + benzene 5 cc	44.5
(4) Aniline point, hexane 20 cc + cyclohexane 2.5 cc + benzene 2.5 cc	51.6

The drop in aniline point is 8.4°C. for 5 cc of cyclohexane in comparison to a drop of 22.8°C. for benzene. The cyclohexane shows only 37 per cent of the effect of the same per cent of benzene. For the mixture No. 4 given above, the calculated aniline point from No. 2 and No. 3 should be 51.7°C. and it was actually determined as 51.6°C. Therefore any method using the aniline point determination would show an increased percentage of aromatics due to the presence of naphthenes.

21. A mixed aniline point method was used in estimating the per cent aromatics in the solvents studied. In the appendix details of the method will be found. Plate 1 shows that aromatics, when added to a non-aromatic hydrocarbon, produce a constant drop

Table I

DATA ON PAINT THINNERS.

Thinner No.	1	2	3	4	5	6	7	8	9	10
Gravity - NRL	0.865	0.823	0.823	0.828	0.854	0.877	0.792	0.817	0.835	0.889
Lit. #1				0.797	0.855	0.897	0.795		0.846	
Lit. #2				0.821	0.858	0.884				
Lit. #3							0.792	0.806	0.844	0.891
Unsaturation -										
Bromine No.	0.71	0.11	1.50	0.16	0.16	0.28	0.14	0.06	0.09	2.62
Calculated as per cent diisobutylene	0.92	0.14	1.89	0.20	0.20	0.36	0.18	0.08	0.12	3.35
Bomb oxidation -										
Induction period, hours		20	16	24+	22	22	24+	24+	12.14	16
Pressure drop, lbs./sq.in.		1	2	0	1	1	0	0	2	2
Preformed gum, mgr.		0.0	0.4	1.0	0.8	2.0	0.0	1.4	0.0	18.8
Preformed and potential gum, mgr.		0.0	3.0	3.8	4.0	5.6	0.0	1.6	0.6	24.8
Aniline point, °C.	Below -16	9.8	27.1	Below -16	Below -16	Below -16	4.4	-10.5	-5.8	1.5
°C. Lit. #3							6.1	2.2	-6.7	-12.2
Mixed aniline point -										
With hexane 67.3°C.	12.4	31.4	45.1	22.4	15.8	20.0	37.3	30.7	31.1	32.5
Lit. #2 with mineral spirits				26.7	17.2	23.3				
Per cent aromatic:										
Liquid SO_2		59.0	34.1	67.3	79.7	78.0	50.5	61.2	53.8	49.7
Mixed aniline points	94.2	61.9	39.9	77.2	84.2	78.0	55.9	64.9	63.7	59.9
Lit. #2				73	92	89				

Table I (Continued)

Thinner No.	1	2	3	4	5	6	7	8	9	10
Distillation –										
Final B.P. °F. Lit. #2				275	346	410				
Lit. #3							270	340	400	500
Initial point °F.		239	315	214	275	345	200	242	308	374
50% point °F.		276	340	235	307	369	220	274	332	422
90% point °F.		307	367	259	329	391	237	297	358	466
Dry point °F.		342	394	280	342	410	258	355	379	490 (decomp.
Flash point °F.		55	107	35	83	133	22.25	54	105	155

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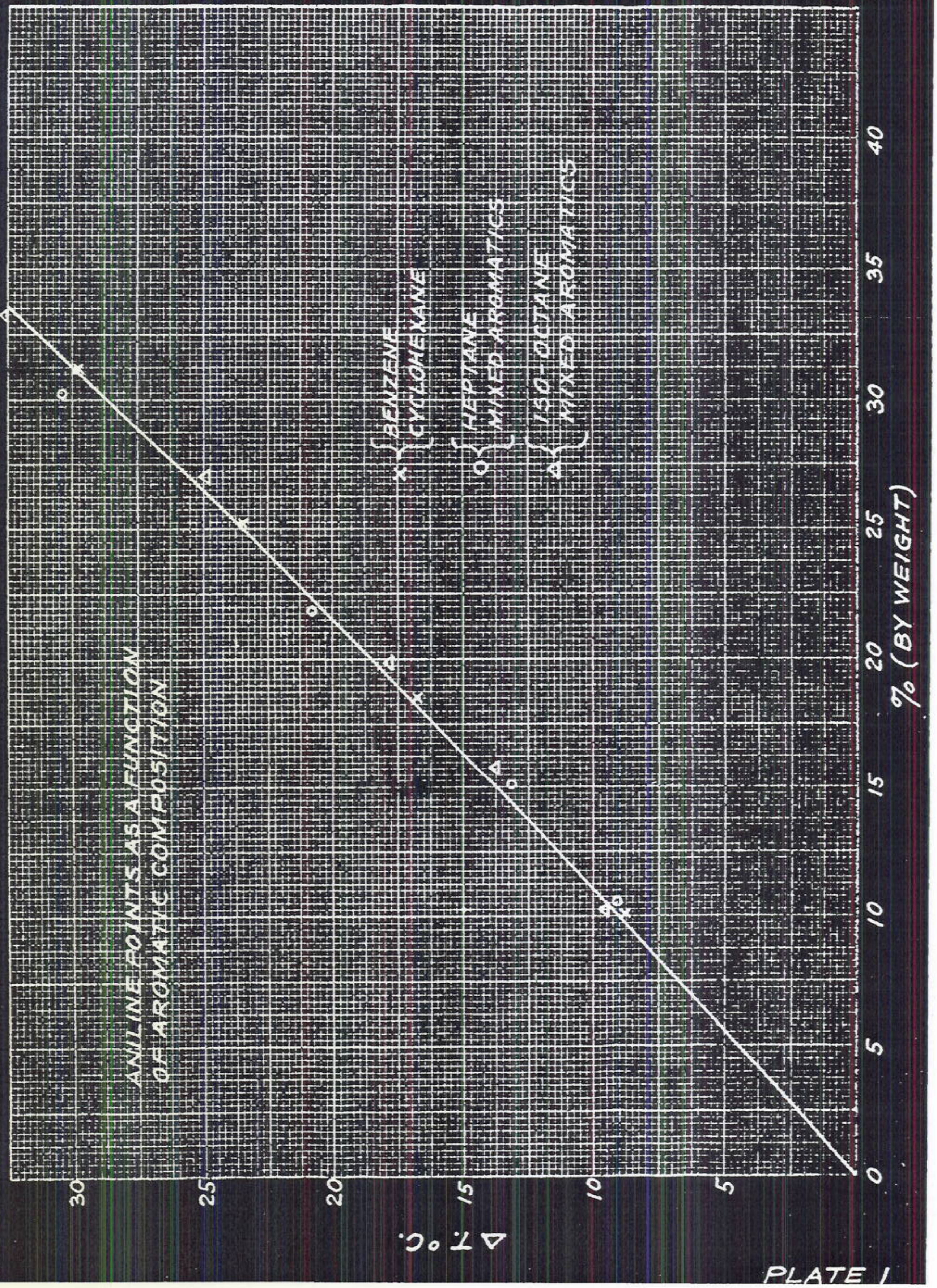

PLATE I

APPENDIX

DETAILS OF THE METHODS EMPLOYED IN THE EXAMINATION OF HYDROCARBON MIXTURES.

1. Unsaturated Hydrocarbons. The modification of the Francis method used in these studies involves the bromination of the unsaturates in the sample by the liberation of the bromine from KBr - $KBrO_3$ in acid solution, according to the equation:

$$KBrO_3 + 5KBr + 3H_2SO_4 = 3K_2SO_4 + 3Br_2 + 3H_2O.$$

The excess bromine produced is titrated with a standard solution of sodium thiosulphate. The solutions required for this determination are as follows:

(1) Potassium bromide - bromate - one-half normal.
(2) Sodium thiosulphate - fifth normal.
(3) Potassium iodide-saturated solution.
(4) Sulfuric acid - 10% solution saturated with KBr.
(5) Starch solution.

Twenty cc of the 10 per cent H_2SO_4 saturated with KBr is added to a glass-stoppered Erlenmeyer flask. Five cc of the sample is pipetted in very rapidly with the flask remaining closed as much as possible. The sample is titrated with KBr - $KBrO_3$ solution until there is an appearance of a permanent light yellow color. One cc is added in excess. After each addition of the titer, the flask is quickly stoppered and shaken vigorously with care taken to open the flask as infrequently as possible. After a permanent color has been obtained and the 1 cc excess added, the flask is shaken vigorously for two minutes. Five cc of saturated potassium iodide solution is added and the iodine liberated is titrated with the standard thiosulphate, using starch solution as the indicator. The bromine number in centigrams of bromine per gram of sample is given by the equation:

$$N = \frac{0.0799 \text{ x normality x net cc KBr - } KBrO_3 \text{ x } 100}{5 \text{ x density of sample}}$$

2. If the molecular weight of the unsaturates be known, actual percentage present may be calculated by the expression:

$$\text{Per cent} = \frac{MN}{160}$$

where M is the molecular weight and N is the bromine number from above. In the examination of a natural product such as a distillate of petroleum, the molecular weight of the unsaturates is unknown. The method described here serves to give the relative unsaturation in one sample as compared to another or to a standard.

3. To check this method, a solution of diisobutylene and benzene was prepared by dissolving 15 cc of the material in 125 cc of benzene. This represented a solution containing 9.11 per cent unsaturates by weight. The following percentages were found by actual experiment: (1) 9.59 per ccnt; (2) 9.00 per cent; (3) 9.58 per cent; mean, 9.39 per cent; theory, 9.11 per cent.

4. A known solution containing 9.20 per cent diisobutylene by weight in toluene was prepared. The following results were obtained by actual experiment: (1) 9.52 per cent; (2) 9.40 per cent; mean, 9.46 per cent; theory, 9.20 per cent.

5. It was thought that the organic peroxides which often are present in hydrocarbon mixtures containing unsaturated compounds, might possibly interfere with the reaction upon which the Francis method depends. To get some idea as to the effect of these peroxides, two known solutions were prepared. One of these was made up with freshly distilled diisobutylene showing a negative test for peroxides and the other contained diisobutylene that was distilled 18 months previously and gave a strong positive test for peroxides. These solutions were designated as Known No. 2 and Known No. 2A, respectively.

Set of Known Mixtures

Substance	Known No. 2	Known No. 2A
Isooctane	50 cc	50 cc
Diisobutylene	20 cc (containing peroxide)	20 cc (peroxide free)
Cyclohexane	10 cc	10 cc
Heptane	70 cc	70 cc
Per cent unsaturates by weight	13.88	13.88

Analyses of the above were as follows:

Sample	Per Cent Unsaturates Known No. 2	Known No. 2A
1	13.91	13.92
2	14.07	13.62
3	13.93	14.18
Mean	13.97	13.91
Theory	13.88	13.88

6. For the removal of the unsaturated compounds[2], a sample is cooled to -12°C. contained in a 3-neck liter flask equipped with a stirring device, a thermometer and a bromine burette. The bromine is added at such a rate that the temperature does not rise above -5°C. The rate of addition is also governed by the intensity of the characteristic yellow color imparted by the bromine. If the concentration and temperature are not held extremely low, bromination of some of the aromatics will occur. Addition of the bromine is continued until the yellow color becomes permanent. The excess bromine present is then removed by adding saturated potassium iodide solution to react with the bromine. The liberated iodine is taken out by the addition of saturated sodium thiosulphate solution which completely clarifies the entire mixture. The heavy aqueous layer containing the inorganic salts is separated and the hydrocarbon layer dried over $CaCl_2$. Due to the instability of the bromides at high temperature, the reaction mixture is fractionated under reduced pressure to separate the bromide fraction from the lower boiling hydrocarbons. The residual bromide fraction may be decomposed by the method of Gladstone and Tribe[8] by use of the zinc-copper couple and 90 per cent ethyl alcohol. After isolation, the olefins are cut into various fractions according to boiling points and the individual substances are identified by the physical constants and finally by the preparation of suitable derivatives. The di-olefins may be separated from the mono-olefins by the use of the maleic anhydride as described in Naval Research Laboratory Report No. P-1394, Appendix A.

7. Aromatic Hydrocarbons. For the estimation of the aromatic content a revision of the method of Tizard and Marshall[3] based upon the difference in aniline points was employed. Tizard and Marshall have proposed the method for the estimation of aromatic hydrocarbons based upon the difference in aniline points of the hydrocarbon mixture before and after washing with 98 per cent sulfuric acid. This method assumes that all of the aromatic compounds are removed by shaking with 98 per cent sulfuric acid and at the same time no naphthenic or aliphatic substances are affected. This possibly holds true between certain limits, but 98 per cent sulfuric acid in some cases has been shown to leave behind as much as 5 per cent of the aromatics present, sufficient to introduce considerable error. This fact was emphasized in the case of mixtures containing considerable amounts of aromatic substances, say beyond 20 per cent. Tizard and Marshall recommend their method only for mixtures containing less than 30 per cent aromatic compounds and show that it gives better results for concentrations between 15 and 25 per cent.

8. Although Tizard and Marshall claim that the lowering of the aniline point expressed in degrees Centigrade is equal to the percentage of aromatics actually present, this was found to be untrue in the range from 0 to 30 per cent aromatics. Tilitsheyew and Dumskaya[4], through a number of experiments, found

it necessary to apply the following equation:

$$X = Kd$$

where X = per cent aromatics
K = constant
d = aniline point lowering in degrees Centigrade.

The value of K was found to depend upon the concentration of the aromatic fraction in the hydrocarbon mixture, as follows:

0 to 10 per cent, $K = 1.2$
10 to 20 per cent, $K = 1.15$
20 to 30 per cent, $K = 1.1$
30 to - per cent, $K = 1.0$

9. The materials examined in this investigation were shown to contain from 40 to 91 per cent aromatics. Consequently an improved method was sought which would give accurate results for these higher concentrations. Solutions of various aromatic hydrocarbons in several aliphatic and naphthenic compounds were prepared in known concentrations varying from 5 to 35%. Aniline points were taken for all of these mixtures and it was shown that the lowering of the aniline point, ΔT, below that of the pure non-aromatic hydrocarbon was always proportional to the concentration of the ring compounds in the solution, regardless of the initial aniline point of the pure solvent. For example, the aniline point of hexane was found to be 67.3°C. and that of cyclohexane 30.1°C. Yet when equal amounts of benzene or xylene were mixed with equal amounts of each solvent by weight, ΔT was the same in each case. Furthermore, it was shown for solutions of benzene in hexane; mixtures of toluene, xylene, and benzene in heptane and cyclohexane, that the aniline point lowering is directly proportional to the percentage by weight of the aromatic component. The experimental data follow:

Composition	Aniline Point	$^\circ\Delta T$	% Aromatics (by weight) As Added (Theoretical)
1. Cyclohexane ($d = 0.779$)	30.1°C.		0.00
2. 5 cc Benzene 50 cc Cyclohexane	21.2	8.9	10.18
3. 10 cc Benzene 50 cc Cyclohexane	13.3	16.8	18.50
4. 15 cc Benzene 50 cc Cyclohexane	6.7	23.4	25.30
5. 20 cc Benzene 50 cc Cyclohexane	0.4	29.7	31.20

(Continued)

(Continued)

Composition	Aniline Point	° ΔT	% Aromatics (by weight) As Added (Theoretical)
6. Heptane (d = .684)	62.9°C		0.00
7. 100 cc Heptane 10 cc Mixed aromatics	53.8	9.1	10.60
8. 100 cc Heptane 15 cc Mixed aromatics	49.7	13.2	15.05
9. 100 cc Heptane 25 cc Mixed aromatics	42.1	20.8	21.82
10. 50 cc Heptane 20 cc Mixed aromatics	32.5	30.4	30.21
11. Isooctane (d = 0.702)	72.5		0.00
12. 100 cc Isooctane 10 cc Mixed aromatics	62.9	9.6	10.26
13. 100 cc Isooctane 15 cc Mixed aromatics	58.7	13.8	15.87
14. 100 cc Isooctane 20 cc Mixed aromatics	54.6	17.9	19.92
15. 100 cc Isooctane 30 cc Mixed aromatics	47.5	25.0	27.16
16. 100 cc Isooctane 50 cc Mixed aromatics	39.9	32.6	33.22

10. These data showing ΔT as a function of the composition were plotted and all points were found to lie very closely on a common curve as shown on Plate 1. With this standard curve as a reference, the composition of the unknown thinners was determined by the following procedure: A series of solutions of the unknown mixture is prepared with pure hexane. The concentration of the unknown in the solution should vary from 10 to 50 per cent over the range that produces an aniline point lowering from 4 to 35°C. The aniline point of each solution is taken and from these data a curve is obtained showing ΔT as a function of the percentage of unknown in the solution. This curve is similar to the standard curve and lies just beneath it when plotted on the same coordinate. If the unknown mixture happens to be 100 per cent aromatic, its curve should coincide with the standard. Likewise, its relative position below the standard depends upon the concentration of the aromatics in

the unknown. Finally, the actual amount of aromatic substances in the unknown may be computed by dividing Δ T for the unknown by Δ T for the standard for any common value of the abscissa.

11. The separation of the aromatic fraction can best be effected by extraction with liquid sulfur dioxide at temperatures around -35° to -40°C. A suitable apparatus has been designed by Leslie[5] which is most convenient for this operation. The process is continuous and gives a good separation. After sulfur dioxide extraction a test for aromatics may still be positive in the residue. However, this amount is small and may be conveniently removed completely by washing alternately with concentrated H_2SO_4 and H_2SO_4 - HNO_3 mixture. For a complete separation and recovery of aromatic portion, resort may be had to adsorption by silica gel as suggested by Mair and White[6].

12. For testing the accuracy of these methods for the estimation of aromatic hydrocarbons in other hydrocarbons, known blends were made and all data in this work are considered in per cent composition <u>by weight</u>.

13. In order to determine the error involved in the sulfur dioxide extractions, blend No. 1 was prepared from a variety of all types of hydrocarbons to contain 41.8 per cent aromatics by weight. The following percentages were obtained by actual experiment:

Run No.	Per Cent Aromatics
1	37.50
2	39.60
3	40.70
4	40.20
Mean	39.5
Theory	41.8

It is noted that the actual amount of aromatic material present is greater by an average of 2.3 per cent than that shown by the analyses. Using the revised aniline point method, this Known gave a value of 41.2 per cent for the aromatic content, instead of 41.8 per cent. The experimental data follow:

Hexane	Blend No. 1	Aniline Point
25 cc	-	67.3
25	5 cc	60.0
25	10	54.7
25	15	50.6
25	20	47.4
25	25	44.7

From the curve given in Plate 1 the average aromatic content was 41.2 per cent. The density of hexane was 0.660 and Blend No. 1, 0.774.

14. To test the method of Tizard and Marshall[3] two Knowns, numbers 3 and 4, were made up as follows:

Composition	Known No. 3	Known No. 4
Benzene	10 cc	10 cc
Toluene	10	10
Heptane	175	90
Aniline point, heptane	63.2°C.	63.2°C.
Aniline point, blend	52.50°C.	44.3°C.
°ΔT	10.7°C.	18.9°C.
% Aromatics:		
By weight, calculated	12.6	21.9
Tizard and Marshall	10.7	18.9
Using correction factor (1.15)	12.3	21.7
Using curve #1	12.1	20.7

15. Thirty cc of Known No. 3 were shaken for one-half hour with 90 cc of 98 per cent H_2SO_4. The layer of hydrocarbon was separated, washed with 30 per cent potassium hydroxide, and finally with water. After drying for two hours over sticks of solid potassium hydroxide the aniline point was found to be 62.94°C. as compared to 63.2°C. for pure heptane. This shows that the aromatic portion can be removed but it is troublesome, especially where the aromatic content is 40 per cent or more.

16. The data upon which the aromatic content of the thinners was determined as given in column 3 of Table II follow:

Solution No.	Amount of Thinner in 25 cc Hexane	Aniline Point	Mean of % Aromatics Calculated from A.P.
	Thinner #1 (Density 0.865)		
1	2.5 cc	58.0°C.	
2	5.0	50.3	
3	10.0	37.9	
4	15.0	27.8	
5	20.0	19.6	
6	25.0	12.4	94.2
	Thinner #2 (Density 0.823)		
1	2.5 cc	60.8°C.	
2	5.0	55.6	
3	10.0	47.2	
4	15.0	40.7	
5	20.0	35.5	
6	25.0	31.4	61.9

(Continued)

(Continued)

Solution No.	Amount of Thinner in 25 cc Hexane	Aniline Point	Mean of % Aromatics Calculated from A.P.
	Thinner #3 (Density 0.823)		
1	2.5 cc	62.6°C.	
2	5.0	59.8	
3	10.0	54.3	
4	15.0	50.4	
5	20.0	47.5	
6	25.0	45.1	39.9
	Thinner #4 (Density 0.828)		
1	2.5 cc	59.1°C.	
2	5.0	52.8	
3	10.0	42.0	
4	15.0	33.9	
5	20.0	27.1	
6	25.0	22.4	77.2
	Thinner #5 (Density 0.854)		
1	2.5 cc	58.4°C.	
2	5.0	50.9	
3	10.0	39.1	
4	15.0	29.5	
5	20.0	22.0	
6	25.0	15.8	84.2
	Thinner #6 (Density 0.877)		
1	2.5 cc	58.8°C.	
2	5.0	52.1	
3	10.0	40.7	
4	15.0	32.2	
5	20.0	24.8	
6	25.0	20.0	78.07
	Thinner #7 (Density 0.792)		
1	2.5 cc	61.8°C.	
2	5.0	57.4	
3	10.0	50.1	
4	15.0	44.8	
5	20.0	40.7	
6	25.0	37.3	55.9

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Solution No.	Amount of Thinner in 25 cc Hexane	Aniline Point	Mean of % Aromatics Calculated from A.P.
	Thinner #8 (Density 0.817)		
1	2.5 cc	60.5°C.	
2	5.0	55.2	
3	10.0	46.9	
4	15.0	40.1	
5	20.0	34.9	
6	25.0	30.7	64.9
	Thinner #9 (Density 0.835)		
1	2.5 cc	60.5°C.	
2	5.0	55.3	
3	10.0	46.6	
4	15.0	40.2	
5	20.0	35.0	
6	25.0	31.1	63.7
	Thinner #10 (Density 0.889)		
1	2.5 cc	60.7°C.	
2	5.0	55.7	
3	10.0	47.6	
4	15.0	41.3	
5	20.0	36.7	
6	25.0	32.5	59.9

17. The sources of material used in this investigation are as follows:

Sample No. 1 - Glyptal Thinner.
General Electric Co.

Sample No. 2 - Thinner No. T-S-11 "A".
Shell Development Corporation.

Sample No. 3 - Thinner No. A.
Socony Vacuum Oil Co.

Sample No. 4 - Solvesso No. 1.

Sample No. 5 - Solvesso No. 2.

Sample No. 6 - Solvesso No. 3.

Standard Oil Co. of N.J.

Sample No. 7 - Solvsol 19/27.

Sample No. 8 - Solvsol 24/34.

Sample No. 9 - Solvsol 30/40.

Sample No. 10 - Solvsol 40/50.

Tidewater Associated Oil Co.

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