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METHODS FOR DETERMINING THE CHEMICAL CHARACTERISTICS OF COD-LIVER OIL

(PARTS I AND II)

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Methods for Determining the Chemical Characteristics of Cod-liver Oil.

Part I. The Determination of the Iodine Number

By W. Wesley Stewart

Introduction

All oils have certain definite characteristics which can be used to identify the oil. These properities are also useful in grading an oil, as their values give some indication as to the conditions under which the oils have been prepared and also as to the quality of the oil obtained. For this reason it is necessary that methods are investigated which are suitable to determine the characteristics of cod-liver oil. These methods should be such that they are as time saving as possible, give results that can be checked and the accuracy of the method known.

The writer has investigated some of the methods that are found in the literature which are suitable to determine the iodine number and the acid value of cod-liver oil. The results of this investigation are given in this report.

The iodine number of an oil gives the number of grams of iodine absorbed by 100 grams of oil. Thus, if a cod-liver oil is reported to have an iodine number of 160, that means that 100 grams of oil absorbs 160 grams of iodine.

Cod-liver oil is a mixture of glycerides of many unsaturated acids. If iodine, in some suitable form, and the oil are mixed under favourable conditions, the iodine is absorbed. The iodine forms an addition product with the unsaturated glyceride. A simple case of the addition reaction can be illustrated thus:- $-\overset{|}{C}=\overset{|}{C}- + I_2 \longrightarrow -\overset{|}{\underset{I}{C}}-\overset{|}{\underset{I}{C}}-$
Therefore the iodine number gives a value of the degree of unsaturation of the glycerides and the unsaturated acids present in the oil.

The iodine number can indicate the quality of the oil, as if the cod-liver oil has been prepared from fresh livers in a sanitary manner, the iodine number of the oil should be high; but if the oil or liver has been exposed to conditions that promote oxidation the iodine number will be lower. Oxidation reduces the degree of unsaturation of the oil by the formation of saturated hydroxy and other oxidation compounds which reduces the quality of the cod-liver oil.

There are two well known volumetric methods for determining the iodine number of an oil, the Wijs method and the Hanus method. The Wijs method is recommended by the Committee of Analysis appointed the Director of Oil and Fat Research in England (1), also by the A.C.S. Committee on Analysis of Commercial Fats and Oils (2). The Hanus method is the official method of the A.O.A.C. (3).

These two volumetric methods were investigated for determining the iodine number of cod-liver oil as they are the ones that are most commonly used for the determination of this property of oil, although further work on this problem may well be carried out investigating some other methods which are more rapid to carry out or which may be better suited for determining the iodine number of cod-liver oil. In this respect a gravimetric method by Toms (4) which is based on the absorption of bromine vapour by the oil, may be well worth investigating. The writer made some rough experiments on this method which seemed to indicate that satisfactory results could be obtained by a method which is much less difficult than either of the volumetric methods. Unfortunately time did not permit a thorough investigation of this method.

Experimental Work

THE WIJS METHOD

Reagents Necessary

1. 0.IN Sodium thiosulphate which has been standardized by any convenient method.
2. 1% Starch solution for an indicator. I added 2 grams of soluble starch to 200 grams of boiling water.
3. 15% Potassium Iodide Solution (KI).
4. Wijs Solution.
5. 1.6% solution of Potassium dichromate to be used as a colour standard.

Preparation of Wijs Solution

Dissolve 13.0 grams of resublimed iodine in 1 litre of pure glacial acetic acid (99.5%), which does not show any reduction toward potassium dicromate and H_2SO_4. The solution may be heated to dissolve the iodine. Titrate a portion of this solution with 0.IN $Na_2S_2O_3$. This will give the halogen concentration of the original solution. Set aside about 25 cc. of the iodine acetic acid solution. The colour of this solution is dark brownish red which is characteristic of all solutions containing free iodine. Into the remainder of the iodine acetic acid solution pass washed and dry chlorine gas. (The gas was washed by bubbling it through concentrated H_2SO_4). The chlorine is passed into the solution until the original thiosulphate titration is just doubled. As the chlorine passes into the solution one can notice the colour changing from the reddish brown to a reddish orange. When the colour approaches the reddish orange, a sample of the solution is withdrawn and its colour matched in an ordinary pH comparator block with the colour of a 1.6% potassium dichromate solution. When the halogen content of the chlorinated solution is just double the halogen content of the original solution, the colour of the Wijs solution matches the colour of the 1.6% potassium dichromate solution. If an excess of chlorine passes into the solution this excess can be neutralized by adding some of the original solution which was set aside. When both colours match each other some of the Wijs solution is withdrawn in a pipette to which is added 15 cc. - 20cc. of 15% KI and 100 cc. of water, which has been boiled and cooled, and then titrated with 0.IN sodium

thiosulphate to see if the halogen content of the Wijs solution is exactly double the halogen content of the original solution.

In pipetting the solution it is advisable to use a long length of rubber tubing as a mouth piece, as Wijs solution (and Hamus) is very pungent and corrosive. (After using a pipette, air is blown through it to expel all the fumes and vapours).

The prepared Wijs solution should be kept in a dark place or in amber coloured glass stoppered bottles at a temperature about equal to the temperature of the room at the time of determining the I numbers. The solution deteriorates on standing and should not be used after more than one month old.

Preparation of the Sample of Oil

The reaction of the absorption of the iodine by the oil depends upon the concentration of the iodine present. In order that the reaction will go to completion a definite amount of iodine must be present in excess. The amount of Wijs solution used in each determination is 25 cc. Therefore a sample of oil must be used so that the excess iodine in the solution after the reaction is complete is about 50%,- 60% of the amount of iodine added in the 25 cc. of Wijs solution, that is, about 100% ; 150% of the amount of the iodine absorbed by the oil. It is therefore necessary that a preliminary estimation of the iodine value of the oil be determined by the method which is described later, so that the proper amount of oil is used for the accurate determination of the iodine number of the oil, so that in this determination the iodine that is added will have a concentration as stated above. The sample of oil is weighed in a small weighing bottle; by means of a small glass rod, which has also been weighed in the weighing bottle, the oil is dropped into a clean dry 500 cc. glass stoppered bottle which contains 15 - 20 cc. of chloroform. From the difference in the weight of the weighing bottle of oil before and after the oil has been added to the reaction bottle, the weight of the oil is calculated. It was found that by dropping the oil from the small glass rod, time was saved, as by counting the drops of oil added, a close estimate of the amount of oil being added was obtained.

Time of the Reaction

The iodine number of the oil that is obtained by this method depends on the time in which the sample of the oil is in contact with the Wijs solution. To obtain the maximum value, that is, when the saturation of the unsaturated compounds in the oil by the addition of the iodine is complete, it is necessary to determine the time of the reaction.

The time of the reaction of the Wijs method was determined by following the procedure which is given in the next section; but varying the length of time that the sample was allowed to stand in contact with the Wijs solution. The following results were obtained:-

Time	Iodine Number (Wijs Method)
½ hour	170.5
1 "	171.4
1½ hours	171.6
2 "	171.4
3 "	171.6

From these results it can be seen that the maximum value for the iodine number of cod-liver oil is reached in one hour when the Wijs method is used.

Procedure for Determining the Iodine Number of Cod-liver Oil by the Wijs Method

Add 25 cc. of Wijs solution to the sample from a pipette. Moisten the glass stopper with a drop of KI solution so that no iodine or chlorine is lost, but do not let any KI run down into the bottle. Allow the bottle to stand for one hour (the reaction is complete for cod-liver oil in this time) in a dark place at a uniform temperature, which should be about the same temperature as the air around the bench where the solution will be titrated. At the end of this time add 15 cc. of 15% KI and 100 cc. of distilled water, washing all the iodine from the stopper and sides of the bottle.

Titrate the excess iodine immediately with standard 0.1N $Na_2S_2O_3$; add quite rapidly and shake constantly. When the dark colour changes to a yellow add the starch as an indicator, then titrate to the iodine starch end point. Shake violently so that any iodine absorbed by the $CH.Cl_3$ will be taken up by the KI and this react with the $Na_2S_2O_3$. Run two blanks at the same time as determination following the above procedure with the exception of adding the oil to the solvent.

Method of Calculating the iodine Number by the Wijs Method

To illustrate the method of calculating the iodine number a sample set of observations are given.

Sample	$Na_2S_2O_3$ used to titrate the blanks	$Na_2S_2O_3$ used to titrate the excess iodine	Amt. of iodine absorbed in equivalents of $Na_2S_2O_3$	I No.
20.9904gms 20.8450 0.1454	50.10 cc.	33.90 1.58 32.32	50.10 cc. 32.32 17.78	171.3

Standardization of $Na_2S_2O_3$.
1 cc. of $Na_2S_2O_3$ equivalent to 0.01401 grams of iodine.

$$\text{Iodine number} = \frac{32.32 \text{ cc. } Na_2S_2O_3 \times 0.01401 \text{gm. I/cc. } Na_2S_2O_3 \times 100}{0.1454 \text{ gm. of oil}}$$

$$= 171.3$$

The error in the iodine number due to the reading of instruments is less than 0.3%.

THE HANUS METHOD

Preparation of the Hanus Solution

Dissolve 13.0 grams of resublimed iodine in 1 litre of glacial acetic acid (99.5%) which shows no reduction with dichromate acid H_2SO_4. The solution may be heated to dissolve the iodine but must be cold before adding bromine or titrating. Set aside 20-25 cc. of the original solution. Titrate the original solution with 0.1N $Na_2S_2O_3$ to find the halogen content. Add enough liquid bromine to exactly double the original halogen content, about 3 cc. of bromine are sufficient. Take a definite portion from the Hanus solution and add 15-20 cc. of 15% KI solution, and 100 cc. of water (which has been boiled and cooled), then titrate with 0.1N $Na_2S_2O_3$. The halogen content of the Hanus solution can be adjusted very easily by adding more bromine or original solution, according to what may be required.

The Hanus solution is kept under similar conditions as the Wijs solution, but it does not deteriorate so rapidly.

Preparation of the Sample of Oil

The method as outlined in the Wijs Method for preparing the sample is used for the Hanus Method.

Time of the Hanus Method

As in the Wijs Method the time of the reaction of the Hanus Method was determined following the method which is outlined in the next section. The following results were obtained.

Time	Iodine Number (Hanus Method)
½ hour	167.5
1 "	168.9
1½ hours	170.2
2 "	170.1
3 "	170.2

With the Hanus solution the maximum value of the iodine number of cod-liver oil is reached in 1½ hours.

Precedure for Determining the Iodine Number of Cod-liver Oil by the Hanus Method

The method is the same as in the Wijs method, except the time of reaction is longer, being 1½ hours in this case. Also, during the time of reaction the bottles containing the samples should be shaken occasionally, about once every 15 minutes.

Comparison of the Iodine Values of Cod-liver Oil as Obtained by the Wijs and the Hanus Methods

Stewart and Banerjea (5) have shown that in a comparison of these two methods the Wijs solution and the Hanus solution should have the same concentration of halogen; also that the halogen concentration of the final solution should be exactly double the concentration of the initial solution.

Two litres of N/10 iodine solution was prepared by dissolving 25.386 grams of iodine in 2 litres of glacial acetic acid. The halogen concentration of the solution was determined by titrating it with N/10 standard $Na_2S_2O_3$ solution. The halogen concentration of this initial iodine solution in terms of thiosulphate was: 10.00 cc. of iodine solution was equal to 10.05 cc. of the standard thio. solution.

From one litre of this initial iodine solution the Wijs solution was prepared by the method which has been given. The halogen concentration of the Wijs solution was adjusted so that it was exactly double the halogen concentration of the initial iodine solution. The halogen concentration of the Wijs solution given in terms of cc. of thiosulphate was 10.00 cc. of the Wijs solution equalled 20.08cc. of the standard thio. solution.

With the remaining litre of the initial iodine solution the Hanus solution was prepared in the manner described. The halogen concentration of the Hanus solution was adjusted so that it was exactly double the halogen concentration of the initial iodine solution. For the Hanus solution the halogen concentration was: 10.00 cc. of Hanus solution is equal to 20.10 cc. of the standard thio. solution.

The results obtained for the iodine number of a cod-liver oil by the Wijs method and the Hanus method, using the Wijs solution and a Hanus solution which have the same concentration of halogen prepared in this manner gave the following results:

Wijs Method	Hanus Method
1. 171.2	170.2
2. 171.3	170.1
3. 171.3	169.8
4. 171.4	170.1
Mean 171.3	170.0

The average deviation from the mean value in the Wijs method is less than 0.1%.

The average deviation from the mean value in the Hanus method is less than 0.10%.

In both methods the error in the iodine number due to observations is less than 0.3%.

The above results show that the Hanus method gives a lower value than the Wijs method. This is in agreement with some of the results in the literature on these methods (6), but Stewart and Banerjea (5) obtained the same value for the iodine number by these methods.

Discussion of the Results

The Wijs and the Hanus method were compared for determining the iodine number of cod-liver oil. It is found that the Wijs method gives a higher value for the iodine number than the Hanus method. The iodine number of cod-liver oil used has a value of 171.3 by the Wijs method and 170.0 for the Hanus method. Therefore in all cases when the iodine number of cod-liver oil is reported it is necessary that the method that has been used to determine this property be mentioned.

The Wijs method only requires one hour for the reaction to go to completion, while the Hanus method requires one and one half hours for the reaction to be completed.

The Hanus method has an advantage over the Wijs method in that the Hanus solution is easier to prepare.

Both methods are as easy to carry out and the accuracy in each is the same. The experimental error due to the observation of the readings is less than 0.3%. The average deviation from the mean value of the iodine number, determined from four consecutive results, using either method, is less than 0.1%.

Part I.

References

1. Eldson: Edible Oils and Fats (Benn.) 1926.
2. Ind. Eng. Chem. Vol.18 No. 12, 1346, 1926.
3. Official and Tentative Methods of Analysis American A.O.A.C.
4. Toms Analyst 53, 69, 1928.
5. Stewart and Banerjea Indian J. Med. Research Vol. 15, 687-94, 1928.
6. Kerr, R.H. J. Assoc. Off. Agr. Chem. 5, 178-9, 1922.

Methods for the Determination of the Acid Value of Cod-liver Oil

Fresh cod-liver oil that has been prepared by satisfactory methods has a small percentage of free fatty acids present. If the oil is exposed to conditions that promote hydrolysis of the glycerides, or the livers were not handled when fresh, the precentage of free fatty acids in the oil will be increased. Cod-liver oil is graded on the basis of the percentage of free fatty acids present, or the acid value of the oil. For this reason it is necessary to have established a method for determining this property rapidly, also the operator should be able to check the results and know the accuracy of the method.

The acidity of the oil can be determined by titrating the free fatty acids present with a standard alkali solution. The results can be reported as the precentage of free fatty acids present in the oil or as the acid value of the oil. If the results are reported as the percentage of free fatty acids, it is assumed that all the free fatty acid is Oleic acid. It has been suggested by the A.C.S. Committee on Analysis of Oil and Fats (1) that the results be recorded as the acid value of the oil. In this work all the results have been calculated as the acid value.

The acid value (2) of a fat or oil is a measure of the free fatty acids present, and is defined as the number of milligrammes of KOH required to neutralize the free fatty acid in 1 gram of fat or oil.

The usual method for determining this value is to weigh out a definite quantity of oil into a 250 cc. Erlenmeyer flask. Add about 50 cc. of 95% ethyl alcohol which has been freshly distilled over NaOH and neutralized to a faint shade of pink with the standard alkali solution, using phenolphthalein as the indicator. The mixture is gently boiled and shaken thoroughly to dissolve the fatty acids, then titrated while still hot with constant agitation with N/10 alcoholic or aqueous sodium hydroxide till the pink colour of the indicator, phenolphthalein, is permanent on shaking for 10 seconds.

This method was investigated and results could be obtained, but the operator had to become accustomed to the end point. This was not sharp, and as the colour of the solution was yellow this added difficulties in detecting the end point; another disadvantage in this method being that the solution was hot, which is uncomfortable to handle, also care must be taken that bumping does not occur when the solution is being heated which often happened resulting in the loss of the sample.

The Bureau of Standards (3) recommend dissolving the oil in 50 cc. of a mixture of equal parts of ethyl alcohol and C.P. benzene (thiophene free), which has been previously neutralized to a faint pink with the standard alkali using phenolphthalein as the indicator. The titration may be made at once without heating the solution.

This method suggested that alcohol and ether may be a suitable solvent instead of alcohol and benzene. Also the solvent may be prepared from denatured alcohol instead of 95% ethyl alcohol. The above method was investigated using these different solvents in the determination of the acid value of oil. Very satisfactory results were obtained as the end of the phenolphthalein in the cold solution is very sharp. These solvents are also better to use as the titration is carried out in a cold solution.

The error of the determination due to the observation of readings is less than 0.4%. The results that were obtained for the acid value agreed within the limit of this error, as the average deviation from a mean value of the acid value, as determined from four consecutive determinations (using the same solvent) is less than 0.1%.

In any of the methods used it was found that over a definite maximum weight of oil could not be used as a sample. The amount of oil used had to be small enough so that the NaOH used in the titration did not exceed 20 cc. A further addition of aqueous NaOH solution gives high acid values due to the tendency of the salt, formed in the neutralization of the weak acid, to hydrolyse..

To determine the maximum amount of oil that can be used, a rough determination of the acid value is made. From the result obtained it can be easily calculated how much oil can be used as a sample for the accurate determination of the acid value.

When the acid value of the oil is small it is obvious that the amount of the standard alkali used to titrate the free fatty acids in the oil will be small. The error introduced into the determination from reading the small difference in the graduation of the burette will greatly increase the experimental error. To overcome this, a very large sample of oil is necessary or a microburette may be used. It was found by using the microburette, to add the NaOH in the titration when the oil had a very small acid

value, as accurate results for the acid value could be obtained as when a large amount of NaOH is used to neutralize the free fatty acids in an oil with a high acid value.

Experimental Work

Preparation of Solutions

The free fatty acid in the oil was neutralized with N/10 NaCl solution which was standardized by the usual methods.

Solvents

The alcohols used are 95% ethyl alcohol and denatured alcohol. Both of these alcohols were freshly distilled over NaOH before using.

The benzene used in the alcohol benzene mixture was 90% benzene and benzene free from thiophene and sulphur compounds. These compounds were taken from the benzene by shaking it with concentrated H_2SO_4 and then washing with distilled water, finally drying the benzene over $CaCl_2$. The following solvents were used:

Denatured alcohol.
1:1 Denatured alcohol and ether.
1:1 Denatured alcohol and (90% benzene).
1:1 Denatured alcohol and benzene (thiophene free)

95% Ethyl alcohol
1:1 " " and ether.
1:1 " " and 90% benzene.
1:1 " " and benzene (thiophene free)

Before these solvents were used they were neutralized to a faint shade of pink with the standard alkali solution, using phenolphthalein as the indicator.

Indicator

Phenolphthalein was used as the indicator. This was added to the solvent, a concentration of 0.2 grams of phenolphthalein to 1 litre of solvent.

Preparation of Sample of Oil

The sample of oil was put into a weighing bottle and weighed. By means of a small glass rod which had been weighed in the sample of oil, drops of oil can be dropped into a 250 cc. Erlenmeyer flask. The difference in weight of the sample bottle of oil and the glass rod before and after the oil is added to the flask is naturally the weight of the sample of oil used for the determination. After some experience in weighing out the oil by this method, the approximate weight of the sample being taken is easily calculated by counting the drops of the oil, thus time is saved by this method as only two weighings are necessary for weighing out the proper amount of the oil as a sample for the determination.

Procedure

To the weighed sample of oil in the flask 50 cc. of the solvent is added. If the solvent is alcohol alone, the solution is heated to boiling and titrated with standard N/10 NaOH while still hot and with constant shaking. If the solvent is the mixture of alcohol and benzene or ether the solution is titrated cold with constant shaking. The end point is taken when the pink colour of phenolphthalein persists after shaking vigorously for 15 seconds. The amount of aqueous NaOH added should in no case exceed 20 cc. and the weight of the sample taken, so that the NaOH used to neutralize the free acid is less than this amount.

Results

To illustrate how the acid value is calculated from this method a sample set of observations are given as obtained when the solvent was denatured alcohol and ether.

Sample	N/10 NaOH used	Acid Value
46.910 grams	46.70 cc.	
38.220	35.38	
6.690	11.32	9.859

Standardization of NaOH

1 cc. of NaOH equivalent to 0.005825 grams of KOH
1 cc. " " " " 5.825 milligrammes of KOH

Calculation of the acid value of the oil.

$$\text{Acid Value} = \frac{11.32 \text{ cc. NaOH } 5.825 \text{ milligrammes KOH/cc.NaOH}}{6.690 \text{ grams of oil}}$$

$$= 9.859 \text{ milligrammes KOH grams of oil.}$$

At the same time the acid values of three other samples of the same oil was determined with the same solvent, the following values being obtained:

9.848; 9.860; 9.863;

Averaging these four values and obtaining the mean value of the acid value of the oil using denatured alcohol and ether as the solvent the following result is obtained.:

Acid Value	Deviation from the Mean Value
9.859	0.002
9.848	0.009
9.860	0.003
9.863	0.006
Mean 9.857	0.005

Average deviation from the mean value is about 0.05%.

Calculation of errors due to the observations.

$$\text{Acid Value} = \frac{11.32 \text{cc. NaOH } 5.855 \text{ millgr. KOH}}{6.690 \text{ grams of oil}}$$

cc.

Error in 11.32/NaOH -0.02 NaOH less than 0.2%, which makes an error in the acid value less than 0.2%.

Error in 5.855 milligrs., KOH less than 0.1% which makes an error in the acid value less than 0.1%.

Error in 6.690 grams of oil 0.001 gm. which is less than 0.015% which makes an error in the acid value less than 0.015%, which is negligible. Total error in the acid value due to experimental observation is less than 0.3%.

To compare these results with results obtained when the acid value is determined by the method using the hot denatured alcohol solution, the following set of results are given which have been obtained in a similar way.

TABLE II

Acid Value	Deviation from the Mean Value
9.888	0.009
9.857	0.022
9.890	0.012
9.882	0.003
Mean 9.879	0.012

Average deviation from the mean value is about 0.12%.

The average deviation from the mean value in Table II is larger than in Table I. This is no doubt due to the difficulty of determining the end point of the titration in the hot solution. The end point in the method using the cold solution is very sharp while the end point in the method using a hot solution is not very distinct as the colour of the solution makes it difficult to detect the first change to the pink colour of phenolphthalein in an alkaline medium. The error in the acid value due to the observations will be the same.

Table III gives the mean values for the acid value of cod-liver oil as determined by the methods already described. The mean values have been obtained in a similar manner as shown in the illustrated set of results.

The same lot of oil was used for all these determinations.

TABLE III

Solvent Used	Acid Value
Denatured Alcohol	9.879
" " and ether	9.857
" " " benzene (thio. free)	9.853
" " " 90% benzene	9.849
95% Ethyl alcohol	9.800
" " " ether	9.860
" " " benzene (thio. free)	9.846
" " " 90% benzene	9.822

From these results it will be noticed that the values of the acid value of cod-liver oil obtained when the titration is carried out in cold solution (that is using a solvent, a mixture of alcohol and ether or benzene) agree with each other better than those results obtained titrating in hot alcohol solution. This is no doubt due to the sharper end point in the cold solution method.

Use of the Microburette for Titrating the Free Fatty Acids in Oil with Small Acid Values

Table IV gives a comparison of the results obtained for the acid value of an oil by using a microburette for the titration and an ordinary burette.

TABLE IV

Microburette			Ordinary Burette		
Sample	NaOH cc.	Acid Value	Sample	NaOH	Acid Value
21.280 gm.	2.570	0.6699	19.195 gm.	2.31	0.6678
17.195	1.905	0.6676	10.320	1.38	0.7445
17.925	2.180	0.6646	15.695	1.82	0.6435

The results show that much better agreement for the acid value is seen when the microburette is used. It is also shown that to obtain the same accuracy in the experiment using the ordinary burette as when the microburette is used ten times the amount of oil must be used as a sample.

Discussion of the Results

From these results the best method for determining the acid value of cod-liver oil is to titrate the free fatty acids with standard alkali using a solvent of equal parts of alcohol and ether or benzene, instead of titrating the acids in a hot solution of alcohol. The end point with phenolphthalein in the cold solution is sharp. Denatured alcohol can be used as the solvent with satisfactory results instead of ethyl alcohol.

90% benzene gives as consistent results as C.P. benzene (thiophene free),.

The error in the value due to the observations is less than 0.3%.

The average deviation from the mean value, as determined from four consecutive determinations, does not vary more than 0.1% with the method for determining the acid value of cod-liver oil, using a solvent which is a mixture of alcohol and ether or benzene.

In determining the acid value of an oil with a low value the microburette can be used with advantage to add the standard alkali to the solution being titrated.

Part II

References

1. [illegible] Ind. Eng. Chem. 18, 12, 1346, 1926.
2. Eldson, Edible Oils and Fats. (Benn) 1926.
3. J. Ind. Eng. Chem. 14, 57, 1922.