

QUANTITATIVE ANALYTICAL METHODS FOR THE STUDY OF PEROXIDE FORMATION IN ETHER.*

BY R. VAN WINKLE AND W. G. CHRISTIANSEN.

During the many years devoted to ether research by our laboratories extensive work has been carried out in the development of quantitative analytical procedure which could be relied upon to give quick and accurate results. The work has been carried on by various investigators¹ and the procedures given in this paper are the final approved technique which to date under innumerable different conditions have met with no objection.

DETERMINATION OF ACTIVE (PEROXIDE) OXYGEN IN ETHER.

The basis of our method is an application of the U. S. P. peroxide test and the fact that the peroxides in ether decompose in an acid medium to hydrogen peroxide. The latter reacts quantitatively with a soluble iodide and the free iodine liberated is titrated with standard thiosulphate in a solvent miscible with both ether and water, namely, alcohol. Starch cannot be used as an indicator and consequently the end-point is a change from the yellow iodine color to a colorless solution. At first this end-point gives some difficulty but to one experienced in this analysis it is quite perceptible.

Method.—A 125-cc. flint glass-stoppered bottle is thoroughly swept out with nitrogen; 50 cc. of 1-1 alcohol and water from which oxygen is removed by evacuation and which has been kept under nitrogen, is added, followed by 10 cc. of the ether to be analyzed. Five cc. of 1-1 hydrochloric acid are added and then 0.25 Gm. of thoroughly dried cadmium potassium iodide. During the addition of the liquid materials a stream of nitrogen is kept playing around the orifice of the bottle. After the addition of the iodide, the bottle is stoppered, thoroughly shaken and placed in a dark closet for one hour. The liberated iodine is then titrated with *N*/100 thiosulphate. For extremely accurate work it is necessary to run a blank on the solvent due to the fact that a small amount of iodine is liberated by the same.

Calculations

$$\frac{\text{Cc. of } N/100 \text{ Thio.} \times 0.0560}{10} = \text{Cc. of Peroxide Oxygen, 1 cc. of Ether}$$

This analytical method is interesting in that it bears a definite relation to the qualitative test for peroxides given in the U. S. Pharmacopœia. The results of over nine hundred ethers analyzed for peroxides by the above test and simultaneously by the U. S. P. peroxide tests have shown that with peroxide values 0.0000 – 0.0022 cc. of peroxide oxygen/cc. of ether, the U. S. P. test is negative. With peroxide values 0.0022 – 0.0028 cc. of peroxide oxygen/cc. of ether, the U. S. P. test is doubtful (that is, in this range the U. S. P. test may be positive or negative). With peroxide values above 0.0028 cc. of peroxide oxygen/cc. of ether the U. S. P. peroxide test was always positive. The analyses on which the above statements

* Scientific Section, A. Ph. A., Rapid City meeting, 1929.

¹ The authors wish to make recognition of the pioneer work carried out in the development of these analytical methods by Dr. L. K. Riggs and Mr. H. D. Goulden.

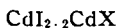
have been based were made by several investigators and the peroxide values varied over a wide range from 0.0000 to 0.0394 cc. of peroxide oxygen/cc. of ether.

In making U. S. P. peroxide tests it was noticed that in ethers whose peroxide content was above 0.0050 cc. of peroxide oxygen/cc. of ether, a white precipitate was observed in the aqueous cadmium potassium iodide portion. We isolated some of this material and on analysis found that it contained 42.16% cadmium and 28.84% iodine. On the basis of our analyses the stoichiometrical ratio of cadmium to iodine is 3 Cd to 2 I.

The formula for cadmium potassium iodide may be written as:



In a similar manner the formula for the unknown precipitate may be written:



where X represents an unknown group whose molecular weight is approximately 100. As cadmium is dibasic it was thought that this might be the acetate ion. Experiments failed to confirm the same.

Time has not permitted the authors to investigate this further. We believe, however, the complete determination of this unknown would be of interest to ether chemistry. The fact that it forms only with ethers which have formed considerable peroxide is evidence that it is directly connected with peroxidation of ether. This precipitate offers an easy method for isolating one impurity produced in the deterioration of ether.

NOTE: The above cadmium compound is not explosive.

DETERMINATION OF MOLECULAR (DISSOLVED) OXYGEN IN ETHER.

This analytical procedure is based on a combination of the above test and the Winkler method for determining dissolved oxygen. It has been demonstrated in our work that both the dissolved and active oxygen react with the precipitated manganous hydroxide and on acidification in the presence of iodide an amount of iodine equivalent to both is liberated. Accordingly we determine total oxygen and by subtracting the peroxide oxygen as determined by the previous method, the value for dissolved oxygen is obtained. A 50-cc. sample of ether is used for each analysis. Experience has shown that this is satisfactory for ethers of peroxide value up to 0.0150 cc. of peroxide oxygen/cc. of ether. On ethers of peroxide value higher than the above, it is necessary to take a proportionately smaller sample.

Method—Manganous Sulphate Solution — 48 Gm./100 cc.
Sodium Hydroxide Solution — 40 Gm./100 cc.

A 400-cc. glass-stoppered bottle of known content is thoroughly flushed out with nitrogen; 1-1 oxygen free alcohol-water as described in the above method is allowed to run into the bottle. At the same time fifty cubic centimeters of the ether to be tested is added by means of a pipette previously swept out with nitrogen. During the addition of all the substances up to the point of acidification a stream of nitrogen is played around the orifice of the bottle. Solvent is added until the height of the liquid is just slightly above the neck of the bottle; 2 cc. of the manganous sulphate solution is then added, followed by 2 cc. of the sodium

hydroxide solution. The bottle is then stoppered taking precaution to allow no gas bubble to remain between the stopper and the liquid. The bottle is thoroughly shaken and then allowed to stand several minutes to allow the precipitate to settle out. It is advisable to shake the bottle several times to insure complete reaction of the oxygen with the manganous hydroxide. After settling out of the precipitate, one Gm. of cadmium potassium iodide is added, followed by 10 cc. of concentrated hydrochloric acid. The addition of reagents displaces some of the liquid in the bottles. Due account of this is taken wherever necessary in the calculations. The bottle is then stoppered and shaken until all of the precipitate has dissolved; 10 cc. more of hydrochloric acid is then added, the bottle stoppered, shaken again and then the contents poured into a beaker and titrated with *N*/100 thiosulphate in a manner similar to the titration for peroxide oxygen. In the calculations due account is taken of the ether displaced by the addition of the manganous sulphate and sodium hydroxide and of the iodine displaced by the second 10 cc. of hydrochloric acid. Twenty cc. of acid cannot be added at once due to the fact that it tends to stir up and eject some of the hydroxide precipitate the amount of which cannot be calculated. By liberating the iodine with the first 10 cc., the second 10 cc. displaces a known amount of that iodine which can be taken into account.

Due to the fact that it is not always possible to remove all of the oxygen from the 1-1 alcohol-water solvent, it is necessary to run a blank on the same.

CALCULATIONS.

A model example of the calculations is as follows:

(A) *Blank Determination on Solvent.*

Thiosulphate factor for oxygen	0.0556
Volume of bottle for analyses	414 cc.
Volume to be used for calculating	400 cc.

NOTE: Fourteen cc. deducted equal to the 2 cc. of manganous sulphate, 2 cc. of sodium hydroxide and the second 10-cc. portion of acid. The first 10-cc. portion of acid displaces nothing but solvent as both the dissolved and peroxide oxygen are in the form of the precipitated manganic acid.

Thiosulphate required for titration — 5 cc.

$$\frac{0.0556 \times 5}{400} = 0.00069 \text{ cc. of O}_2\text{/cc. of solvent}$$

(B) *Ether Analysis*—50 cc. sample of ether.

Volume of bottle for analyses	398 cc.
Thiosulphate required for titration	15 cc.

$$\frac{50 \times 100}{398} = 12.6\% \text{ ether in solution}$$

An amount equivalent to 14 cc. is displaced by reagents.

$$\begin{aligned} 14 \times 12.6\% &= 1.76 \text{ cc. of ether lost by addition of reagents.} \\ 14 - 1.76 &= 12.24 \text{ cc. of solvent lost by addition of reagents.} \\ 50 - 1.76 &= 48.24 \text{ cc. — true volume of ether.} \\ 348 - 12.24 &= 335.76 \text{ cc. true volume of ether.} \\ 0.0556 \times 15 &= 0.8340 \text{ cc. total oxygen.} \\ 335.76 \times 0.00069 &= 0.2327 \text{ cc. oxygen due to solvent.} \end{aligned}$$

$$\frac{0.8340 - 0.2327}{48.24} = 0.0124 \text{ cc. of dissolved and peroxide oxygen/cc. ether}$$

Peroxide Oxygen by first method in this paper = 0.0030 cc./cc. ether

Dissolved Oxygen = 0.0094 cc./cc. ether

CONCLUSIONS.

1. Quantitative methods have been developed for determining active (peroxide) and molecular (dissolved) oxygen in ether.
2. A relation between this quantitative peroxide test and the U. S. P. qualitative test for peroxides has been determined.
3. The nature of the precipitate formed in the U. S. P. test for peroxides on ethers having developed peroxides is discussed.

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A FURTHER STUDY OF THE INCOMPATIBILITY BETWEEN SODIUM SALICYLATE AND SODIUM BICARBONATE.*

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INTRODUCTION.

In a previous communication to THIS JOURNAL one of the authors¹ in a study of the incompatibility between sodium salicylate and sodium bicarbonate in aqueous solution, showed this particular darkening phenomenon to be peculiar to the sodium salt of ortho hydroxy benzoic acid in the presence of alkali bicarbonates. Since the publication of this work, the investigation of certain English workers² along this line has come to our attention. It was claimed by these investigators that the discoloration was due to an impurity in the sodium salicylate.

To determine whether or not this change was inherent to salicylic acid or due to some impurity present and to study the influence of concentration upon the rate of discoloration are the purposes of this investigation.

EXPERIMENTAL.

Influence of Impurity.—A sample of salicylic acid obtained from oil of wintergreen and recrystallized was secured. This product was again recrystallized from hot water. A sample of this acid was converted into sodium salicylate and 60 cc. of a solution prepared containing 2 Gm. each of sodium salicylate and chemically pure sodium bicarbonate.

This solution was stored in flint glass, in a partially filled flask in diffused daylight.

Within three days, slight signs of discoloring were visible, within seven days the solution was dark brown and finally became black as did those samples previously described by one of the authors.

* Section on Practical Pharmacy and Dispensing, A. PH. A., Rapid City meeting, 1929.

¹ J. C. Krantz Jr., JOUR. A. PH. A., 17 (1928), 1204.

² Anon., Chem. & Drug., 104 (1926), 506; through A. PH. A. YEAR BOOK, 15 (1926), 74.