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THE DETECTION OF ACETONE IN CHLOROFORM.*

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INTRODUCTION.

The U. S. P. X in its monograph on chloroform does not include a test for acetone. It has been suggested that such a test should be included since, as much chloroform is produced from acetone, acetone may be found as an impurity in chloroform; as a result the investigation has been carried out.

Middleton and Hymas (1) employed Nessler's reagent to detect acetone in ether and found it to be satisfactory for small quantities. We have applied it to acetone in chloroform and found it to be equally satisfactory for small quantities of acetone in chloroform. (Since this article was written the British Pharmacopœia, 1932, has appeared, containing a limit test for aldehyde in chloroform with Nessler's reagent.)

Gros (2) found that acetone in dilute aqueous solutions reacts with Nessler's reagent in the cold to give a yellowish precipitate, which on analysis showed the following to be present: mercury, 61.73%; iodine, 27.14%; chlorine, 3.42%, and acetone, 3.94%. We have obtained a canary-yellow precipitate by adding Nessler's reagent to an aqueous solution of acetone and chloroform. The dried precipitate had the following composition: mercury, 72.16%; iodine, 14.85%; chlorine, 3.06%. This precipitate is soluble in an excess of acetone. A dilute aqueous solution of trichlorotertiary butyl alcohol (Chloretone), upon reaction with Nessler's reagent, produced a precipitate similar to that with acetone in chloroform. Both precipitates melted at 235° C. with decomposition, and the two, when mixed intimately, melted at the same temperature.

Kolthoff (3) has used both salicyl aldehyde and vanillin in the presence of solid potassium hydroxide as reagents for acetone. He found that salicyl aldehyde can be applied to ketones other than acetone, while vanillin was specific for acetone.

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On investigation, we found that these tests can be applied to acetone in chloroform to detect about 1 part in 20,000.

The Dutch Pharmacopœia uses the vanillin test for acetone in ether.

Van Slyke's (4) mercuric sulphate test for acetone was applied and proved to be unsatisfactory.

Pittarelli (5) in his experiments found that rubber under the influence of steam or boiling water yields a volatile substance which responds to all tests most characteristic of acetone. This was kept in mind throughout our work. Particular care was taken that the chloroform did not come in contact with any rubber. The reagent furfural used showed a light red or pink color in a blank test, as a result it was redistilled, special care being taken that no rubber stoppers were used. A blank test using the redistilled furfural showed a very slight pink color. Chloroform which had no acetone present but had been in contact with rubber showed a positive test with furfural and with sodium nitroprusside and showed a slight turbidity which might be mistaken for that produced by acetone with Nessler's reagent.

EXPERIMENTAL.

REAGENTS.—*Sodium Nitroprusside:* Dissolve 10 Gm. of reagent sodium nitroprusside in 100 cc. of distilled water.

Mercuric Sulphate: Dissolve 73 Gm. of red mercuric oxide in 1000 cc. of 4 normal sulphuric acid.

Potassium Dichromate: Dissolve 25 Gm. of reagent potassium dichromate in 500 cc. of distilled water.

Barium Hydroxide: A saturated solution.

Ammonium sulphide solution, yellow, Mallinckrodt.

Salicyl aldehyde.

Vanillin, U. S. P.

Mercuric Chloride: Saturated solution.

Nessler's Reagent U. S. P.: Dissolve 10 Gm. of potassium iodide in 10 cc. of distilled water, and add gradually a saturated aqueous solution of mercuric chloride, with constant agitation, until a slight red precipitate remains undissolved. To this mixture add 30 Gm. of potassium hydroxide and after solution has taken place, add 1 cc. additional of the solution of mercuric chloride. Dilute this solution with distilled water to a volume of 200 cc. Allow the precipitate to subside and draw off the clear liquid.

SAMPLES.—*Sample A.* U. S. P. Chloroform.

Sample B. Purified Chloroform. One hundred cc. of chloroform were washed thoroughly with three successive 100-cc. portions of a 10 per cent solution of sodium bisulphite and four 100-cc. portions of distilled water, then dried with anhydrous sodium sulphate and distilled. This procedure was repeated three times.

Sample C. U. S. P. Chloroform for Anesthesia.

Sample D. C. P. Chloroform.

Sample E. Reagent Chloroform.

Sample 1A. U. S. P. chloroform containing one per cent of pure acetone.

Sample 2A. U. S. P. chloroform containing 0.5 per cent of pure acetone.

Sample 3A. U. S. P. chloroform containing 0.1 per cent of pure acetone.

Sample 4A. U. S. P. chloroform containing 0.01 per cent of pure acetone.

Sample 5A. U. S. P. chloroform containing 0.001 per cent of pure acetone.

Sample 6A. U. S. P. chloroform containing 0.0005 per cent of pure acetone.

Sample 7A. U. S. P. chloroform containing 5 per cent of pure acetone.

Sample 1B. Purified chloroform containing one per cent of pure acetone.

Sample 2B. Purified chloroform containing 0.5 per cent of pure acetone.

Sample 3B. Purified chloroform containing 0.1 per cent of pure acetone.

Sample 4B. Purified chloroform containing 0.01 per cent of pure acetone.
Sample 5B. Purified chloroform containing 0.001 per cent of pure acetone.
Sample 6B. Purified chloroform containing 0.0005 per cent of pure acetone.
Sample 7B. Purified chloroform containing 5 per cent of pure acetone.
Sample F. Pure acetone.
Sample G. Cyclohexanone.
Sample GG. Chloroform containing 1 per cent of cyclohexanone.
Sample H. Methyl ethyl ketone.
Sample HH. Chloroform containing one per cent methyl ethyl ketone.
Sample I. Acetophenone.
Sample II. Chloroform containing one per cent acetophenone.
Sample J. Methyl acetophenone.
Sample JJ. Chloroform containing one per cent of methyl acetophenone.

Test I. Sodium Nitroprusside.—To 5 drops of sodium nitroprusside were added 5 cc. of the chloroform sample and the mixture then made alkaline with ten per cent sodium hydroxide. (The nitroprusside solution must be added to the sample before it is made alkaline.) Acetone shows a red or ruby red color.

Test II. Mercuric Sulphate.—Ten cc. of concentrated sulphuric acid and 35 cc. of mercuric sulphate were mixed. To 5 cc. of this mixture were added 5 cc. of chloroform and 1 cc. of potassium dichromate solution and the mixture then gently boiled for three minutes. Acetone gives a yellow precipitate.

Test III. Mercuric Chloride and Ammonium Sulphide.—Ten cc. of chloroform were thoroughly mixed with 10 cc. of distilled water. Five cc. of the water extract were then mixed with 5 drops of mercuric chloride solution. The mixture was then added to 10 cc. of barium hydroxide and filtered. To the filtrate was added one cc. of ammonium sulphide. The presence of acetone is shown by the formation of a black precipitate.

Test IV. Salicyl Aldehyde.—Ten cc. of chloroform sample were thoroughly mixed with 15 cc. of distilled water. Ten cc. of the water extract were heated to 70° C. on a water-bath with one Gm. of solid potassium hydroxide and 10 drops of salicyl aldehyde, allowing the potassium hydroxide to rest on the bottom of the tube. A red ring on the surface of the potassium hydroxide indicates acetone.

Test V. Vanillin.—Ten cc. of chloroform sample were well shaken in a glass-stoppered cylinder with 10 cc. of distilled water, the water layer was separated and to it were added 5 mg. of vanillin and one Gm. of solid potassium hydroxide, then warmed for 15 minutes on a water-bath at 60–70° C. without shaking. The presence of acetone is indicated by an orange or red layer above the potassium hydroxide.

Test VI. Furfural.—Two cc. of chloroform were well shaken with 12 cc. of distilled water. To 6 cc. of the water extract were added 3 cc. of ten per cent solution of sodium hydroxide and 1 cc. of a 10 per cent furfural solution. After standing 10 minutes 1 cc. of this solution was treated with 3 cc. of concentrated hydrochloric acid. A red color indicates acetone.

The furfural used was redistilled two times, care being taken that it did not come in contact with rubber.

Test VII. Nessler's Reagent.—Three cc. of chloroform were shaken with 12 cc. of distilled water in a glass-stoppered cylinder. To 5 cc. of the water extract were added 5 cc. of Nessler's reagent and the mixture shaken. Acetone is indicated by the immediate formation of a white or canary-yellow precipitate.

The results of all of these tests have been assembled in Table I. In this table the appearances of the reactions are indicated by the following legends under the respective tests.

Y	= yellow	C. y.	= canary-yellow precipitate
G	= green	W	= white precipitate
N	= negative	Y. p.	= yellow precipitate
V. l. p.	= very light pink	T	= turbid
R	= red	L. p.	= light pink
L. r.	= light red	O	= orange
B. p.	= brown precipitate	L. o.	= light orange
Bl	= black precipitate		

TABLE I.—RESULTS OF TESTS.

Sample.	Test I.	Test II.	Test III.	Test IV.	Test V.	Test VI.	Test VII.
A	Y	G	N	N	N	V. l. p.	N*
B	Y	G	N	N	N	V. l p.	N
C	Y	G	N	N	N	V. l. p.	N*
D	Y	G	G	N	N	V. l p.	N*
E	Y	G	G	N	N	V. l. p.	N*
1A	R	Y	Bl	R	R	R	W
2A	R	Y	Bl	R	R	R	C. y.
3A	Y	Y	Bl	R	R	R	C. y.
4A	Y	N	N	R	L. r.	L. r.	C. y.
5A	Y	N	N	L. r.	L. r.	L. r.	C. y.
6A	Y	N	N	N	N	L. p.	T
7A	R	Y	Bl	R	R	R	W
1B	R	Y	Bl	R	R	R	C. y.
2B	R	Y	Bl	R	R	R	C. y.
3B	Y	N	N	R	O	R	C. y.
4B	Y	N	N	L. r.	L. o.	L. r.	C. y.
5B	Y	N	N	L. r.	L. r.	L. p.	T
6B	Y	N	N	N	N	L. p.	T
7B	R	Y	Bl	R.	R	R	C. y.
F	R	Y	Bl	R.	R	R	N
G	R	Y	Bl	R	N	R	W
GG	Y	B. p.	Bl	R	N	R	C. y.
H	R	Y	Bl	R	N	L. r.	Y. p.
HH	R	B. p.	N	L. r.	N	Y	Y. p.
I	R	B. p.	Bl	R	N	Y	Y. p.
II	L. r.	B. p.	N	R	N	Y	Y. p.
J	L. r.	B. p.	Bl	R	N	Y	C. y.
JJ	L. r.	B. p.	N	L. r.	N	Y	C. y.

* A slight yellowish turbidity appeared after about three minutes, and after standing for one hour or more became dark red.

SUMMARY AND CONCLUSION.

The sensitiveness of a test for acetone may be expressed in terms of the smallest concentration of acetone required to give a just distinctly perceptible reaction.

The sensitiveness of the nitroprusside, mercuric sulphate and mercuric chloride tests is very limited, the colors produced are not very sharp or definite, as a result they could not be used to detect such small quantities of acetone as might be present in chloroform.

The salicyl aldehyde and vanillin tests are sensitive enough to detect one part of acetone in 20,000. The salicyl aldehyde will give a color with other ketones, while the vanillin is specific for acetone.

In our experiments we found that the furfural test is not quite as sensitive as the salicyl aldehyde and vanillin tests but a great deal easier to perform. The purest of reagents must be used to obtain the best results.

The Nessler test is by far the most sensitive for small quantities of acetone, although if acetone is present in more than ten per cent it cannot be detected. A definite canary-yellow precipitate is obtained when the ratio of acetone to chloroform is 1:50,000, while a definite turbidity is still obtained at a concentration of 1:200,000. In performing this test care must be taken to use ammonia-free water. For small quantities such as may be found in U. S. P. chloroform as an impurity, we prefer this test due to its simplicity.

It will be noted that other ketones give, in the presence of chloroform, a reaction with Nessler's reagent that is similar to the acetone reaction. The colors, however, as a rule are paler, shading toward white. The reaction is therefore not qualitatively positive for acetone, but for ketones in general.

Acetone alone, in water solutions, of less than 5 per cent concentration, will form a permanent white or pale yellow precipitate with Nessler's reagent. Higher aliphatic and aromatic ketones give the reaction in higher concentratons as well.

Aldehydes alone, and in the presence of chloroform, yield by this test an orange precipitate immediately becoming dark red and finally black. Chloroform alone, in aqueous solution, yields after ten minutes, a red turbidity that eventually becomes a red and finally a black precipitate. This action of chloroform alone is due doubtless to alkaline hydrolysis of the chloroform to potassium formate, which subsequently reduces the mercury salt to metallic mercury.

It is believed that the test with Nessler's reagent, with the immediate production of a turbidity or precipitate, is the most satisfactory means of detecting the presence of aldehydes and ketones in chloroform.

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PHYTOCHEMICAL TERMINOLOGY.[*,1]

BY EDWARD KREMERS AND COLABORERS.

Terpene.[2,3]

The object of this brief essay is not to define the word terpene, neither to outline a classification of the hydrocarbons known as terpenes. All that is intended is to show the reader who is not a specialist in the field how the word has

* Section on Historical Pharmacy, A. PH. A., Toronto meeting, 1932. See also 21 (1932), 252.

1 For introductory remarks, see THIS JOURNAL, 21 (1932), 252.

2 Copies of a first draft of this paper were submitted to a number of persons whose criticism was invited. Without going into details, the reader may be interested in two comments quite opposite in tendency. The first of these is by Dr. Francis D. Dodge. His comments are herewith quoted:

"In regard to the article on 'Terpenes,' the older classifications, based on incomplete knowledge have of course only historical interest. Even Wallach's classification seems to me of doubtful value. For example, Limonene and Dipentene appear at present to be identical in structure.

"The properties given under Limonene could apply only to one compound, not to a group.

"One might set up some such classification as single ring, double ring, triple ring, etc., but I fail to see any advantage in it.