the CO_2 evolved is collected, the gypsum is filtered off, and the solution evaporated until the Na_2SO_4 crystallizes out. Grossmann¹ claims the process of obtaining niter cake in a porous, friable form which may be readily ground, by adding to the molten material a carbonate such as Na_2CO_3 , or any substance which evolves gas or vapor, with or without a diluent such as Na_2SO_4 . Barbier² has patented the process of cooling a solution of niter cake of density 1.4 down to about 10° , when crystals of Glauber salt separate, and describes suitable apparatus for the purpose. Grossmann³ treats a solution of CaSO_3 with niter cake and after filtration obtains a solution containing mainly NaOH and Na_2SO_4 ; the Na_2SO_4 is crystallized out and the final liquor used as caustic soda. He obtained, from 100 tons niter cake, 36 tons pure Na_2SO_4 and 15 tons caustic soda; costs of production are discussed. Chatfield⁴ uses a solution of niter cake to absorb ammonia from gas liquor, etc., and crystallizes out ammonium sulfate and sodium sulfate. Hipp⁵ dissolves the niter cake, precipitates the heavy metals by means of an alkaline sulfide, evaporates the solution, mixes with common salt and ignites. White⁶ uses it in the manufacture of soda-alum. Collins⁷ suggests roasting potash feldspar with niter cake and crystallizing out the alum.

It is reported that in Canada niter cake is now being used to make sulfate pulp, on account of the shortage of the sulfur hitherto used for making sulfite pulp.

FOR THE PRODUCTION OF MISCELLANEOUS SUBSTANCES—In several of the above processes, hydrochloric acid is obtained; likewise when niter cake is heated with calcium chloride, a process which yields gypsum as a by-product. According to Hart,⁸ hydrochloric acid made from niter cake always contains some sulfuric acid and often contains nitric acid and iodine. Kerr has patented⁹ the process of producing hydrochloric acid, magnesium sulfate and sodium sulfate by heating to 200° a mixture of about 2 parts niter cake and 1 part magnesium chloride, draining off the hydrochloric acid thereby produced, and separating the sulfates by crystallization. Magnesium sulfate may also be made by stirring hot niter cake into magnesite or dolomite, forming a spongy mass from which the sulfate may be extracted with water and crystallized.¹⁰ Bouchard-Praceig¹¹ and Rollo¹² propose the employment of niter cake as a means of decomposing solutions of bleaching powder, thus obtaining free chlorine and gypsum. Cheeseman¹³ claims the process of using it, after neutralizing, by making it react with barium hydrosulfide to produce blanc fixe

(BaSO_4) and sodium hydrosulfide. Naef¹ suggests neutralizing the free acid, reducing the sulfate by means of fine coal at a red heat, and crystallizing the product. A similar scheme has been patented by the Verein Chem. Fabriken.² Parker³ proposes to neutralize a solution of niter cake with iron, and then to treat with sodium carbonate or hydroxide.

Grossmann⁴ proposes to utilize it in the production of an extra quantity of nitric acid by mixing it with niter and charcoal and heating the mixture under suitable conditions.

Its use has also been suggested for the following purposes: To increase the extraction of copper when roasting copper pyrites by charging it into the lower doors of a multiple hearth furnace; alone, or with salt, in the roasting of ores; to replace sodium carbonate in opening up tungsten ores; as a source of acid for leaching copper, zinc, or other metals, in the preparation of sulfates from scrap metal; for converting chromate into dichromate; for the liberation of phenol from its sodium salt in the process of manufacture of phenol; in laundry work, to replace some of the weak acids now used; in reclaiming rubber from scrap; in the refining of petroleum; in the making and glazing of slag bricks; as a weed killer; for flushing drains; and as a possible means of keeping down flies by sprinkling it on manure heaps.

In conclusion, it may be pointed out that the best mode of using a solution of niter cake for any particular purpose could be ascertained from the appropriate solubility data; this involves the investigation, throughout a range of temperature, of the three-component system $\text{Na}_2\text{SO}_4\text{--H}_2\text{SO}_4\text{--H}_2\text{O}$, and of four-component systems such as $\text{Na}_2\text{SO}_4\text{--H}_2\text{SO}_4\text{--FeSO}_4\text{--H}_2\text{O}$, investigations which would not be difficult to carry out with the needful accuracy,⁵ and would be of scientific interest as well as of technical importance at the present time.⁶

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CHEMICAL TESTS FOR THE DETECTION OF RANCIDITY

By ROBERT H. KERR

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Numerous tests have been proposed for the recognition of rancidity. None of them seem, however, to have found any wide-spread application. This may be ascribed to two causes: first, there is considerable confusion of ideas as to exactly what is meant by the term rancidity; and second, once a fat has become definitely rancid, its condition is so clearly evident that no chemical test is needed to recognize it.

While it is true that the recognition of rancidity by taste and odor is so easy that there is no need for the use of chemical tests in the case of fats which have definitely become rancid, there are yet many cases

¹ British Patent 110,405 (1916).

² British Patent 10,450 (1902).

³ British Patent 12,832 (1915); *C. A.*, **11**, 878; *J. Soc. Chem. Ind.*, **35** (1916), 155; *C. A.*, **10**, 1408.

⁴ British Patent 19,530 (1893).

⁵ U. S. Patent 726,533 (1903).

⁶ U. S. Patent 714,846 (1903).

⁷ *J. Soc. Chem. Ind.*, **34** (1916), 1121.

⁸ *This Journal*, **10** (1918), 238.

⁹ U. S. Patent 1,203,357 (1916); *C. A.*, **11**, 88.

¹⁰ *From Rev. des prod. chim.*, cited in *This Journal*, **10** (1918), 228.

¹¹ French Patent 221,245.

¹² British Patent 6,898 (1904).

¹³ U. S. Patent 714,145 (1902).

¹ *J. Soc. Chem. Ind.*, **34** (1916), 1121.

² German Patent 231,991 (1909); *C. A.*, **5**, 2709.

³ British Patent 24,639 (1903).

⁴ *J. Soc. Chem. Ind.*, **36** (1917), 1035.

⁵ Some data on the above system are presented by Le Chatelier and Bogitch, *Rev. metall.*, **12** (1915), 949, who find that a double salt, $\text{Na}_2\text{SO}_4\text{--FeSO}_4\cdot 2\text{H}_2\text{O}$, separates under certain conditions.

⁶ Work along this line is in progress under the direction of Professor H. W. Foote, of Yale University.

in which a reliable chemical test may prove of value. If the fat has a strong natural odor, or has absorbed an odor by reason of contact with an odoriferous substance, the recognition of the early stages of rancidity may well be interfered with. Mixing of the rancid fat with a fresh fat, particularly if the latter has a strong natural odor, may serve to disguise its condition long enough to permit the marketing of an unfit fat for food. Manufacturers, refiners, dealers, and large users might find it of great advantage in many cases to be able to recognize the onset of rancidity before it became evident to the senses of taste and smell.

Rancidity is a chemical change in the fat due to the action of oxygen. Its development and progress are accelerated by certain accessory factors, notably light, heat, presence of moisture, and contact with certain metals, but oxygen is absolutely essential. Without oxygen there is and can be no rancidity. The reactions involved appear to be complex. The products formed are numerous, and subject to variation, both with the character of the fat and the stage of rancidity. It is not the present purpose to discuss the products formed, but it may be stated that aldehydes, ketones, and acids of less molecular weight than those originally present appear to be constant constituents of rancid fats. Most, if not all, of the chemical tests proposed for the recognition of rancidity depend on the presence of one or all of these classes of bodies, and it is to such bodies that the characteristic odor and taste of rancid fats are due.

Two of the many tests proposed for the detection of rancidity have been studied in the Meat Inspection Laboratory of the Bureau of Animal Industry at Washington, D. C., and both have been found to be of use. These two are the phloroglucin-hydrochloric acid, color reaction of Kreis, and the "oxidizability value" of Issoglio. A modification of the Kreis test has been found to be of greatest value in judging fats suspected of rancidity.

The Kreis test¹ consists in shaking the fat with strong hydrochloric acid and a 1 per cent solution of phloroglucin in ether. If the fat is rancid a red or pink color is developed, the depth of color being proportional to the degree of rancidity. Kreis ascribed the reaction to the presence of aldehydes and ketones in the rancid fats.

Winckel² investigated the Kreis test and condemned it on the following grounds: first, that it is not specific, being given by other aldehydes and ketones than those which occur in rancid fats; second, that the depth of color is not exactly proportional to the degree of rancidity; and third, that the test is far too delicate to be used as a means of distinguishing sound from rancid fats.

The Kreis test has been given a very thorough study in the Washington Meat Inspection Laboratory. The difficulty experienced in dealing with fats in which rancidity is present but the characteristic taste and odor masked by "off" or offensive odors and tastes due to other causes and in distinguishing between such

fats and similar fats which were not rancid, made the need for a chemical test acute. The Kreis test was chosen as the most promising of the chemical tests described in the literature and was given a thorough and careful study. The results of this study confirmed the objections raised by Winckel and also disclosed the fact that some oils, notably crude cottonseed oil, contain bodies which cause them to give the test when in a perfectly sweet condition. Nevertheless, a field of usefulness was found for the test in dealing with samples in which the characteristic odor and taste of rancidity were obscured. Samples of this character can be definitely and accurately classed as rancid or not rancid by the use of the Kreis test. The test has been in regular use since 1909 for this purpose and for confirmation of judgment based on physical evidence, and has been found to be valuable and reliable when used with strict regard to its limitations. As a result of experience and testing against many hundred samples, both of known and unknown character and condition, the following statements regarding the test may be made:

- 1—All rancid fats react to the Kreis test.
- 2—The intensity of the reaction is roughly but not exactly proportional to the degree of rancidity.
- 3—Fresh, sweet fats do not give the reaction except in certain special cases. Such a case is that of crude cottonseed oil which reacts with great intensity. In this case the substance which causes the reaction is removed by refining with caustic soda.
- 4—The Kreis test is too delicate to be used alone as a criterion of rancidity. If all fats which react were to be pronounced rancid many samples which are not rancid in any sense would have to be condemned as rancid.
- 5—The Kreis test is not specific for rancid fats. It is given by aldehydes and ketones, other than those which occur in rancid fats, by most of the essential oils, by crude cottonseed oil and probably by other crude oils.

In making use of the Kreis test for the detection of rancidity, it is necessary to guard against a reaction due to the presence of any reacting substance, other than those due to rancidity. If such a substance is present any conclusion drawn from a positive reaction is worthless. While the necessity of guarding against this source of error limits the use of the test to some extent it does not greatly affect its value, as all of the animal fats and all refined vegetable oils are free from reacting substances. These are exactly the classes of fats most likely to become rancid and most likely to required laboratory examination to determine rancidity.

The extreme sensitiveness of the Kreis reaction is not wholly a drawback. It enables one to predict the appearance of rancidity before it becomes evident to the senses. When a fat becomes rancid it undergoes certain definite changes which follow one another in orderly sequence. The time required to pass through each stage is variable and depends on several factors, but the different stages are always the same. The appearance of the Kreis test marks the beginning of an early stage of incipient rancidity and gives warning of the onset of rancidity some time before the changes have progressed to such a point as to be evident to the senses. Under most conditions the interval of

¹ *Verhandlungen der Naturforschenden Gesellschaft in Basel*, 15 (1903-4), 225.

² *Z. Nahr. und Genussm.*, 9 (1905), 90.

time between the first appearance of the Kreis test and the appearance of sensible rancidity is sufficient to permit the conservation of the product by immediate use. The practical utility of this is evident.

In the use of the reaction as a criterion of rancidity, however, its extreme sensitiveness becomes a drawback. If all fats which give a reaction are to be condemned as rancid, a great many of which are not rancid in any true sense of the word must be condemned. At the same time it has been found that any fat which gives a positive Kreis test but does not have a rancid smell or taste, is in a state of incipient rancidity, and that the characteristic physical signs will soon develop. For these reasons, the use of the Kreis tests is chiefly limited to the confirmation of suspicions of rancidity based on taste and odor and to reaching a definite decision in those cases in which the odor and taste of rancidity are masked by other odors and tastes. It has proved of great value in this connection. In applying the test to practical use it was found desirable to find a means of judging its intensity. After considerable work, a method was devised and tried out. Trial of this method led to several changes and improvements. The method now in use in the Meat Inspection Laboratories of the Bureau of Animal Industry is based on the original method of the writer and has been modified as a result of suggestions made by Mr. C. H. Swanger and Mr. C. T. N. Marsh of the Meat Inspection Laboratories of the Bureau of Animal Industry located at New York, N. Y., and St. Louis, Mo. The method as now used is as follows:

10 cc. of the suspected oil or melted fat are placed in a large test tube (8 × 1), and 10 cc. of strong HCl (sp. gr. 1.19) added. The tube is closed with a rubber stopper and shaken vigorously for approximately 30 sec. Ten cc. of a 0.1 per cent solution of phloroglucin in ether are then added and the tube closed and shaken as before. It is then allowed to stand. If the fat is rancid, a red or pink color will appear in the acid layer. The depth of this color is roughly but not exactly proportional to the degree of rancidity. To determine the intensity of the reaction the original fat is diluted with kerosene or with an oil or fat which does not react and the intensity judged by the degree of dilution at which a reaction ceases to be observed. In judging this point a recognizable red or pink shade is regarded as a reaction; a faint orange or yellow is not. The intensity of the reaction is reported in terms of the highest dilution at which a reaction is obtained. For example, if a fat is found to react when so diluted that there is 1 part of the fat in 20 parts of the mixture but not in higher dilution, it is reported as reacting in dilution 1 to 20.

In the work of the Washington Meat Inspection Laboratory it is the custom to make two dilutions, one containing 1 part of the suspected fat in 10 parts of the mixture and one containing 1 part of fat in 20 parts of the mixture. Fats are thus divided into four classes as follows:

Class 1—Fats giving no reaction.

Class 2—Fats giving a reaction when undiluted, but no reaction in dilution 1 to 10.

Class 3—Fats giving a reaction in dilution 1 to 10 but none in dilution 1 to 20.

Class 4—Fats giving a reaction in dilution 1 to 20.

Class 1 represents fresh sweet fats. Fats of this class are fit for any use and may be expected to withstand

severe exposure before becoming rancid. Class 2 represents fats which have not yet become rancid to taste and smell, but in which those changes which will later manifest themselves as rancidity are already in progress. Class 3 represents a late stage of incipient rancidity. Fats of this class are well advanced on the road toward rancidity and their condition is usually evident to the senses of taste and smell. Class 4 represents fats which have definitely become rancid. One who is familiar with the taste and odor of rancid fats has but little need for chemical tests when dealing with this class.

Kerosene has been found most convenient for use as an indifferent oil for diluting. Some kerosenes have, however, been found which gave red or yellow colors. To avoid error on this account it is recommended that each lot of kerosene be tested and, if necessary, purified. The following method of purification has been found effective:

2000 cc. of kerosene are shaken vigorously in a large separatory funnel with 50 cc. of HCl (sp. gr. 1.19). After separating, the acid is drawn off, a fresh portion of 50 cc. added and shaken again. After separating, the kerosene is shaken with a third portion of the acid. A few drops of the phloroglucin solution used in the test are added before the third shaking. If the separated acid shows a red color it is drawn off and the shaking with successive portions of acid continued until the separated acid ceases to show red. The kerosene is then washed three times in the separatory funnel with 500 cc. of warm water. After the last washing it is allowed to stand some time in a warm place and the last portions of separated water carefully drawn off. It is then transferred to a large beaker and heated to approximately 80 to 90° C., 50 g. of fuller's earth are then added, with stirring, and the oil held at 80 to 90° C. with stirring for 5 min. The fuller's earth is then removed by filtration. Kerosene purified in this way is completely indifferent in the Kreis test and will remain so.

The "oxidizability value" test of Issoglio¹ depends on the presence in rancid fats of volatile organic bodies which are separated by distillation with steam and estimated by titration with a standard solution of potassium permanganate. These substances are produced by oxidation of the fat, are normal constituents of rancid fats, and increase in amount with increasing rancidity.

The method as described by Issoglio is as follows:

From 20 to 25 g. of the sample are mixed with 100 cc. of water and distilled in a current of steam, so that 100 cc. of distillate are collected in 10 min. Ten cc. of the homogeneous distillate are then mixed with 50 cc. of water, 10 cc. of 20 per cent sulfuric acid, and 50 cc. of *N*/100 potassium permanganate solution, the mixture heated to the boiling point and kept boiling for 5 min. in a flask connected with a ground-in condenser. After cooling, the liquid is treated with 50 cc. of *N*/100 oxalic acid and titrated with *N*/100 potassium permanganate solution. If *N* represents the amount of potassium permanganate required for the oxidation and *n* that required in a blank test, and *P* the weight of fat taken, the oxidizability value of the fat may be expressed by the equation

$$\frac{X}{P} = \frac{(N - n)80}{P}$$

Hence the oxidizability value represents the mg. of oxygen required to oxidize the organic compounds separated under constant conditions from the fat.

¹ G. Issoglio, *Ann. chim. applicata*, 1916, 1-18.

With regard to the significance of the results obtained, Issoglio states that the oxidizability value of sound, fresh fats varies from about 3 to 10, while rancid fats show much higher values. Oils and fats which show a value of 15 or more are said to be rancid or to have undergone some other change.

Comparison of results obtained by Issoglio's method with the writer's modification of the Kreis tests is shown by the following table:

SAMPLE No.	Material	Oxidizability Value (Issoglio)	Kreis Test
1099	Lard	14.72	Class 1, no reaction
839	Cottonseed Oil	7.92	Class 1, no reaction
1046	Coconut Oil	8.00	Class 1, no reaction
763	Tallow	8.32	Class 1, no reaction
1295	Lard	3.84	Class 1, no reaction
1047	Soy Bean Oil	13.44	Class 2, reaction less than 1 : 10
1188	Lard	4.16	Class 2, reaction less than 1 : 10
1200	Lard	5.44	Class 2, reaction less than 1 : 10
1359	Lard	10.24	Class 2, reaction less than 1 : 10
1376	Lard	12.16	Class 2, reaction less than 1 : 10
923	Lard	10.56	Class 2, reaction less than 1 : 10
924	Lard	12.80	Class 2, reaction less than 1 : 10
889	Lard	19.52	Class 3, reaction between 1 : 10 and 1 : 20
847	Soy Bean Oil	16.96	Class 3, reaction between 1 : 10 and 1 : 20
329	Lard	17.28	Class 4, reaction more than 1 : 20
1360	Lard	10.88	Class 4, reaction more than 1 : 20
XX1	Lard	7.04	Class 4, reaction more than 1 : 20
1412	Inedible Grease	23.36	Class 4, reaction more than 1 : 20
XX2	Lard	18.84	Class 4, reaction more than 1 : 20
XX3	Lard	21.12	Class 4, reaction more than 1 : 20

It is found that the results conform in the main to the standards set. If fats of Classes 1 and 2 with respect to the Kreis test are regarded as sweet, and fats of Classes 3 and 4 are rancid, the oxidizability values of the sweet fats vary from 3.84 to 14.72, and all values above 10, with one exception, are found in Class 2. The oxidizability values of the rancid fats with two exceptions are found to be above 15, the lowest value being in fact 16.96. The two exceptions which were found to have oxidizability values of 7.04 and 10.88, respectively, were rancid beyond any possible question, being strongly rancid to taste and smell, besides giving the Kreis test in dilution 1 : 20. It would appear fair then to regard an oxidizability value of 15 or more as strong confirmatory evidence of rancidity.

In working with Issoglio's method it was noted that the distillate was clear, showing that the oxidizable organic bodies which came over were all soluble in water. Experiments were made to determine the relation between the total amount of water-soluble and volatile oxidizable organic bodies. After some preliminary experiments the following method of extraction was determined upon:

25 g. of the fat are weighed into a 200 cc. Erlenmeyer flask and 100 cc. of distilled water added. The flask is allowed to stand on the steam bath for 2 hrs. with occasional shaking. At the end of this time the water is separated from the fat by filtering through a wet filter paper. The paper is closely fitted to the funnel and thoroughly wetted. The whole contents of the flask are poured on the wet paper. The water containing the soluble matters extracted from the fat runs through, while the fat is completely retained by the wet paper. The filtrate is caught in a 100 cc. graduated flask. After cooling, the flask is made up to the mark, shaken thoroughly and 10 cc. taken for titration. Oxidation is carried out exactly as specified by Issoglio. The results obtained are, therefore, directly comparable, those by the original method representing volatile organic matters separated by distillation and those by the modified method representing total water-soluble matter.

Following are some of the results obtained by the water extraction method:

SAMPLE No.	Material	Oxidizability Value	Kreis Test
4155	Lard	8.96	Class 1, no reaction
4187	Lard	7.36	Class 1, no reaction
4263	Lard	10.24	Class 1, no reaction
3680	Lard	15.68	Class 4, reaction 1 : 20
4154	Lard	19.84	Class 4, reaction 1 : 20
4327	Lard	16.00	Class 4, reaction 1 : 20
4328	Lard	14.40	Class 4, reaction 1 : 20

The results obtained were seen to be similar to those obtained with like samples by the distillation method. The two methods were then compared directly. For this purpose a lot of fat which was being purposely allowed to become rancid was chosen. This had already been under observation by Issoglio's method for some time. As the results are of interest and as the progress of the sample is typical they are given in full.

Date	Oxidizability Value By Distillation	Oxidizability Value By Extraction	Kreis Test
Sept. 6	7.04	...	Reacts in dilution 1 : 20
Sept. 20	8.32	...	Reacts in dilution 1 : 20 (increased)
Oct. 4	11.20	...	Reacts in dilution 1 : 30
Oct. 18	12.80	...	Reacts in dilution 1 : 30 (increased)
Nov. 1	9.28	15.04	Reacts in dilution 1 : 30 (increased)
Dec. 6	10.88	13.76	Reacts in dilution 1 : 50
Jan. 8	8.96	16.00	Reacts in dilution 1 : 100

It will be noted that the oxidizability value, whether determined by distillation or by extraction with water, does not increase uniformly but fluctuates. This is in sharp contrast to the Kreis test which becomes more intense at an increasing rate. Observations of taste and odor, while they cannot be compared by any standard, leave no room for doubt that the Kreis test shows the true condition of affairs much more clearly than does the oxidizability value. The oxidizability value obtained by extraction with water appears to follow the actual condition of the fat as judged by taste and smell more closely than does that obtained by the distillation method. As shown by the results quoted, the water extraction method gives slightly higher figures. As the extraction method may be carried out more easily and with less close attention than with the distillation method it is regarded as preferable.

The utility of the methods described depends on their application. Both methods must be applied with strict regard to their limitations. The Kreis test shows the presence of certain aldehydes and ketones. We know that such bodies are formed in that type of chemical change that we know as rancidity. When we find such bodies in a fat which is by the circumstances of its origin and handling free from similar bodies of natural origin, or which we know, by test, to have been free from such bodies at a previous time, we may then fairly accept the test as evidence of rancidity. The method of determining the intensity of the reaction by dilution with an indifferent oil enables one to record degrees of rancidity in definite figures, to compare the rancidity of different samples examined at different times, to establish standards of fitness for any purpose, and to determine definitely whether or not any given sample conforms to those standards. The determination of the oxidizability value, either by Issoglio's method of distillation or preferably by the water extraction method, is a measure of the presence of volatile or soluble products of oxidation. It yields less exact and definite information than

is given by the Kreis test, yet has a certain value as a confirmatory test. The products of oxidation on which it depends being water-soluble and volatile, can readily be removed from the fat by washing, or by blowing with steam or air. A rancid fat, freshly washed or blown, would have an oxidizability value little, if any, greater than if fresh and sweet, but would be little less the rancid on that account. A high oxidizability value taken in connection with the usual physical signs of rancidity is to be regarded as confirmatory evidence of rancidity. A low value cannot, however, be held as conclusive evidence of the absence of rancidity. A negative reaction to the Kreis test can be so regarded. Examination of several hundred samples, during a period of over eight years, has failed to disclose a single sample which displayed the physical evidences of rancidity and at the same time failed to give the test.

If adequate precautions are taken to exclude the known source of error and due allowance is made for its supersensitive character, the evidence given by a positive reaction is definite and dependable. The method described above for determining the intensity of the reaction affords a trustworthy and sufficiently accurate means for the measurement of degree of rancidity.

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NOTES ON THE COLOR DESIGNATION OF OIL VARNISHES¹

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In the writing of varnish specifications and in the examination of varnish samples, it is often desirable to designate the color of the material desired, or of the sample examined. Thus, the varnish specifications of some of the Government Departments and of some of the other large varnish consumers state that the material submitted shall not be darker in color than that of a standard sample which is held by the consumer.

The varnish manufacturer, however, usually designates the color of his products by a number, representing the color of a varnish in an arbitrarily established color scale. Such a scale is made from a series of varnishes, whose color is permanent to light; the lightest varnish obtainable, usually a white dammar, forms the one end, and the darkest commercial varnish forms the other end of the scale. Such a scale usually consists of ten standard samples, numbered from No. 1, the lightest, to No. 10, the darkest. Any given varnish is then designated, according to its color, as No. 3, No. 7, etc. In practical work, this designation is sufficiently definite for all purposes; but for manufacturing control work, slight differences in the depth and even in the shade of the color often have some particular significance. Many manufacturers, therefore, are not content to designate by the whole numbers, but subdivide the scale, and described a color, for example, as 4.6, indicating that it is lighter than No.

5, darker than No. 4, and somewhat nearer in color to No. 5 than to No. 4. For the use of an individual manufacturer, this scheme is probably satisfactory, but it is doubtful if the color scales of any two manufacturers coincide at more than one point, if at any.

It is desirable, therefore, to have some simple means of designating the color of a varnish which will obviate the necessity of retaining a standard sample of material of satisfactory color, and which will enable the varnish manufacturers to establish the most important points on their color scales.

The most convenient method for this purpose is the use of an easily prepared solution, whose color is fixed by its composition. In attempts to find a suitable solution a large number of colored salts in a variety of solvents were tried, but the most satisfactory results were obtained by the use of potassium dichromate in concentrated sulfuric acid. By varying the quantity of dichromate, the color of almost any varnish, with the possible exception of the very light-colored turbid dammars, can be reproduced, so that it has been found possible to imitate not only the depth of color but also practically the exact color shades of a great variety of commercial varnishes submitted to this laboratory. No difficulty was found in thus producing a color scale by which the color of a varnish can be defined at least as accurately as by a 10-point scale, such as is used by varnish manufacturers. The dilute dichromate-sulfuric acid solutions are decidedly yellow, like the lighter varnishes, and the more concentrated solutions are a deep rich red as are the darker varnishes. A solution of 0.25 g. of dichromate in 100 cc. of sulfuric acid represents a very light colored varnish; 1.0 g., a medium colored; 2.0 g., a dark colored; and over 4 g., a very dark colored varnish.

The method of making the solutions consists in dissolving a weighed quantity of pure powdered potassium dichromate in a measured quantity of pure, colorless, concentrated sulfuric acid of sp. gr. 1.84. The solution and varnish, whose color is being matched, are placed in separate, thin-walled, clear glass tubes of the same diameter (1 to 2 cm.), to a depth of not less than 2.5 cm., and are compared by looking transversely through the column of the liquids by transmitted light. The solutions corresponding approximately to the color scale of one of the large manufacturers are as follows:

Number in scale	Grams of $K_2Cr_2O_7$ in 100 cc. H_2SO_4
1(a).....	0.10
2.....	0.25
3.....	0.35
4.....	0.50
5.....	1.00
6.....	1.50
7.....	2.00
8.....	4.00
9.....	8.00+

(a) Is a pale white dammar with which no satisfactory comparison can be made.

Upon standing, the darker colored solutions may tend to deposit crystals of chromic anhydride. To prevent this, it is sometimes necessary to warm the solution and make the color comparison while the solution is perfectly clear. Warming the acid to hasten the solution of the dichromate, or to produce a clear solution

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