The specific gravities and solidifying points are taken exactly as described previously.

H. Interpretation of Results—After the tests show the point to be within the determinative areas the method of interpolation is as follows: If the plotted point occurs in the lower set of curves a line is drawn through the point normal to the curves between which it lies. The distance from curve to curve is measured accurately along this line and the fractional distance of the point is interpolated into per cent phenol. If the point occurs in the upper set of curves, the line is drawn through the point parallel to the nearest of the dotted converging lines, the linear distance measured and the percentage interpolated as before.

If mixtures are made, the calculations are somewhat complicated and the following formula may be used:

$$\begin{aligned} \text{Let } A &= \text{per cent phenol found in mixture} \\ B &= \text{Grams "to 197"} \text{ fraction taken} \\ C &= \text{Grams pure phenol taken} \\ X &= \text{per cent phenol in "to 197"} \text{ fraction} \\ X &= \frac{A(B + C) - 100 C}{B} \end{aligned}$$

The per cent phenol in the "to 197" fraction multiplied by the weight of the fraction gives the weight of total phenol in the oil or crude acid taken.

A specimen test on acid with the recorded data may be shown as follows:

TAKEN: Crude Acid, 300 g.	
Distilled 170–190°	60.65 g.
190–202°	178.05 g.
190–202° redistilled	
to 197°	78.05 g.
Total under 197°	138.7 g. = 46.2 per cent
Sp. gr. at 25/25° C.	1.0602
Solidifying point	20.4°
These constants are indeterminate.	
MIXTURE { to 197° fraction	25 g.
{ Pure phenol	25 g.
Sp. gr. at 45/45° C.	1.0576
Solidifying point	31.7° C.
Phenol in fraction mixture (from curve)	84.75 per cent
PHENOL IN ORIGINAL ACIDS (calculated)	32.2 per cent

The method requires about two days to complete a test but several can be run simultaneously. The keynote of success in this work is extremely careful and accurate attention to the details of manipulation. This test has been in use in our laboratories since the early part of 1916, and has given very satisfactory results.

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A NOTE ON SILICON-COATED METAL

By W. E. VAWTER

Received February 10, 1917

The resistance of silicon to the corrosive action of acids and alkalis is taken advantage of in chemical industry by using apparatus constructed of iron which contains a large percentage of silicon. However, the high silicon castings have small tensile or compressive strength and breakage is high. It was therefore thought that, if iron could be satisfactorily coated with silicon, a great saving could be effected. Coating iron by dipping into molten silicon is unsatisfactory, since the melting points of the metals are similar and iron is soluble in fused silicon.

The object of a study made by the author was to investigate a process for coating a metal, preferably iron, with silicon, so that the non-resisting metal would be amply protected from any corrosive chemical, and at the same time stand up under severe handling, without injury to the object or the protective coating. Samples of iron were heated to temperatures of 400 to 600° C. in an atmosphere of silicon hydride,¹ in order to ascertain whether the gas would decompose and form a coating of silicon upon the surface of the iron.

EXPERIMENTAL

1—Iron wire was heated to 550° C. in a current of dry silicon hydride for one hour. Small patches of silicon formed over the surface of the wire, but when the sample was placed in a normal solution of sodium chloride, corrosion immediately started where no silicon was present, totally undermining the silicon coating after two weeks' immersion.

2—A repetition of Experiment 1. In this experiment the silicon did not appear to be undermined; the coating of silicon remained after two weeks' immersion, although corrosion had taken place rapidly at all other places.

3—This sample was heated to 500° C. for two hours. A thin film of silicon was deposited on the wire and the wire became badly pitted where there was no coating of silicon. The silicon coat was intact after two weeks' immersion.

4—This sample was heated for 3½ hrs. at 550° C. Very little silicon adhered to the wire, and that which deposited was in scales and could easily be removed.

5—This sample was first pickled in acid and then heated in a current of silicon hydride at 550° C. for 2 hrs. The resulting coating was smooth and uniform in color, and the treated iron remained in salt solution four days before any corrosion was noticed; this was at the end where the wire had been cut and had no silicon protection.

6—The sample was first heated to 700° C. and then allowed to cool to 550° C. before exposing to the gas. While an excellent coat was obtained, which stood up well in the salt solution, no advantage in preheating could be observed.

7—This sample, after running two hours at 550° C., was further heated for 5 minutes at 700° C. Ten days' immersion in salt solution completely removed the coat. It was expected that the silicon would attach itself more firmly to the iron by the heat treatment, but the after-heating probably broke the coat at some place and allowed corrosion to set in.

8—An exact duplicate of Experiment 5 with similar results.

9—A piece of wire, which had been pickled, washed, dried and exposed to the air for several hours, until

¹ The silicon hydride used in these experiments was prepared by treating an alloy of magnesium and silicon with a dilute solution of hydrochloric acid. The evolved gas consisted of about 5 per cent of silicon hydride and 95 per cent of hydrogen. The alloy was prepared by intimately mixing one part of powdered silicon with two parts of powdered magnesium and heating the mixture for two hours at 600° C. in an atmosphere of hydrogen. This alloy has the composition approximately represented by the formula SiMg₂.

a film of oxide had formed, was treated as in Experiment 5, but no silicon adhered to the wire.

10—A sample was heated at 550° C. for 10 min. and the temperature was then changed to 700° C. for the same period. This alternation was prolonged 1½ hrs. Little silicon deposited upon the wire and that which did had a tendency to scale off.

11—A sample treated by the method used in Experiment 5 was replaced in the tube and heated to 700° C., but the coat scaled.

12—This sample was heated 5 hours at 750° C. Silicon deposited upon the wire, but a slight bending would break the coat and it could be peeled off with the fingers. The wire did not heat uniformly and that portion which was maintained at a lower temperature did not give this fracture effect. The iron under the scale was unchanged, which would indicate that the silicon merely forms a shell over the iron.

Other metals, copper, nickel and aluminum, were also subjected to treatment, but no coating of any description was obtained.

It is interesting to observe, that silicon will coat iron when applied by this method, under proper conditions; but no practical use can be looked for along this line. What was desired was an adherent, homogeneous deposit of silicon on iron; but the above experiments showed that only a thin and fragile shell formed over the iron.

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THE COMPOSITION OF MENHADEN OIL FATTY ACIDS¹

By E. TWITCHELL

The object of this analysis was as much to test the use of my melting-point method of determining fatty acid mixtures as to investigate the true composition of the fatty acids found in menhaden oil.

In a previous paper² I described a method of determining the composition of mixtures of solid fatty acids, which consisted in adding a certain proportion of the mixture to be analyzed to a solvent consisting of a pure fatty acid of the kind to be determined, then finding the melting point and noting how much the original melting point of the solvent had been depressed. This depression was caused by all the acids in the mixture except the one sought, which, being identical with the solvent, would have no effect on it. Assuming that the other acids, singly or in mixture, produced a lowering of the melting point of the solvent proportional to their total concentration and independent of the kind of acid, it was a simple calculation to find the amount of these other acids and, by difference, that of the one sought.

The assumption that the lowering of the melting point of the solvent acid is proportional to the percentage of foreign acids is very nearly true in most cases up to 20 per cent, though, if the solvent is an acid of unusually low melting point as compared with the dissolved acid, as for instance, behenic dissolved

in myristic acid, the melting-point curve beyond 10 per cent of the dissolved acid is no longer a straight line and the depression caused by 20 per cent of this acid is abnormally great. In such cases only 10 per cent of the acid of higher melting point was used in the mixture.

The assumption that all acids produce the same lowering of melting point is for this purpose near enough to the truth where the more common fats and oils are concerned, the fatty acids of which do not differ greatly in molecular weight. I have generally taken 4° as the lowering of melting point caused by adding 20 parts of one fatty acid to 80 parts of another considered as the solvent. However, where the acids are to some extent known it will be more accurate to take values determined for each fatty acid. A number of these values I shall give below.

This as an analytical method is limited to fatty acids solid at ordinary temperatures, but can be extended by applying it to the solid fatty acids obtained from liquid acids either by the hydrogenation process or by fusion with caustic potash. The hydrogenation process, by the addition of hydrogen, converts unsaturated fatty acids into saturated ones having the same number of carbon atoms; oleic, linolic, linolenic and clupanodonic acids are all converted into stearic acid. Fusion with caustic potash produces a decomposition of members of the oleic series by which the principal product is a saturated fatty acid having two less atoms of carbon; oleic acid is converted into palmitic acid, erucic into arachidic, etc. Linolic acid, with two double linkages, is converted into myristic acid and it may be assumed that all acids of the linolic series on fusion with caustic potash yield a saturated acid with four less carbon atoms. As to the action of caustic potash on the still more unsaturated acids, so far as I know, no experiments have been made, though it has been assumed that acids with three double linkages (linolenic acid) would yield a saturated acid of six less carbon atoms and those having four double linkages (clupanodonic acid) would yield a saturated acid having eight less carbon atoms.

It is easily seen what an aid this power of converting liquid acids into solid acids according to definite laws can be toward arriving at the composition of a fatty acid mixture; and in my previous paper I made use of the hydrogenation process. In that paper I gave results of my analysis of menhaden oil fatty acids as follows:

	Per cent
Palmitic acid.....	22.7
Other solid, saturated acids.....	11.8
Unsaturated acids with 16 carbon atoms.....	None
Unsaturated acids with 18 carbon atoms.....	26.7
Unsaturated acids with 22 carbon atoms.....	20.2
Other unsaturated acids.....	18.6
	100.0

The vacancies in this analysis were due to my not having the pure standard acids to correspond with all of the fatty acids in the mixture. I had at that time only palmitic, stearic and behenic acids. I have since prepared myristic and arachidic acids, making the series of normal saturated fatty acids with even num-

¹ Read at the 211th regular meeting of the Cincinnati Section, American Chemical Society, March 28, 1917.

² THIS JOURNAL, 6 (1914), 564.