

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE LOUISIANA STATE UNIVERSITY]

## A NEW METHOD FOR THE PREPARATION OF PHENOLSULFONEPHTHALEIN AND BROMOSULFONEPHTHALEIN

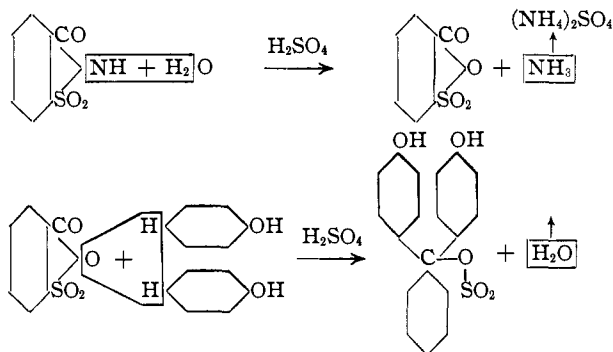
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### Introduction

The method used today for the preparation of phenolsulfonephthalein remains in principle the same as that originally employed by Sohon. An observation made by one of us in this Laboratory that saccharin, heated with phenol and sulfuric acid, gave fair quantities of phenol red led to the present study. This reaction *probably* proceeds according to the following equations



### Experimental

Preliminary work indicated the importance of a study of the effect of temperature, which seemed quite a critical factor. High temperatures up to 180° yielded a dye in good quantity, but it was very dark in color, quite readily assumed a tarry condition and was precipitated with difficulty from solution. Lower temperatures gave far superior products but lower percentage yields.

The effect of temperature was studied by heating ten grams of saccharin with phenol and sulfuric acid for seventeen hours at temperatures ranging from 116 to 135°. The results of five such runs are tabulated in Table I.

TABLE I  
EXPERIMENTAL RESULTS

Temp., °C.	Molar ratios, phenol	Saccharin to sulfuric acid	Yield, % of theoretical	Quality of product
116	1:4.9	1:3.9	1.0	Excellent
120	1:4.9	1:3.9	1.0	Excellent
125	1:4.9	1:3.9	1.5	Excellent
130	1:4.9	1:3.9	4.6	Fair
135	1:4.9	1:3.9	10.9	Poor

It appears that increase in temperature increases the yield progressively but with accompanying deterioration of the product. The maximum temperature yielding a good product was found to be 125°.

The dye obtained by heating from 130° upwards to 150° was increasingly worse. When isolated it was very dark and inclined to be tarry, rather than the bright red, dry product sought. Examination of some of those samples obtained at temperatures above 135° gave us reason to believe that considerable sulfonation had occurred. They exhibited the typical phenol red color changes but were not tested for their *PH* range.

The next factor studied was the effect of time upon yield. The optimum temperature which gave a dye of good quality, as previously determined, was 125°, for which reason this was chosen as the constant temperature for the following four runs.

The quantities of the reagents were the same as those used in the study of temperature effect, that is, 10 g. of saccharin in the molar ratio of 1:4.9 of phenol, and 1:3.9 of sulfuric acid. The results for four different intervals of time expressed in per cent. of theoretical yield are tabulated below.

TABLE II  
VARIATION OF YIELD WITH TIME

Time in hours	17	35	48	86
Theoretical yield, %	1.5	12.9	24.8	27.0

These results indicate that the best yields may be expected when the experiment reaction mixture is heated for at least forty-eight hours.

Variations of the proportions of saccharin to phenol was next tried. In the five tests, the mixtures were heated for eighty-six hours at a constant temperature of 125°. The molar ratio of saccharin to sulfuric acid was 1:3.9 in each case. The five runs are tabulated below.

TABLE III  
VARIATION OF YIELD WITH VARIOUS PROPORTIONS OF SACCHARIN

Molar ratio of saccharin to phenol	1:2	1:4	1:4.9	1:5.3	1:9.7
Theoretical yield, %	1.7	10.0	27.0	22.5	20.0

These yields point to a desirable molar ratio of about 1:5.

The next study considered the proper proportions of saccharin to sulfuric acid. The molar ratio of saccharin to phenol previously employed, 1:4.9, was used and the heating was conducted for eighty-six hours at 125°. The variation in the molar ratio of saccharin to acid is tabulated below.

TABLE IV  
RESULTS WITH VARIOUS PROPORTIONS OF SULFURIC ACID

Molar ratio of saccharin to sulfuric acid	1:2.5	1:3.9	1:6.4
Theoretical yield, %	10.4	24.8	2.0

The molar ratio of 1:3.9 seemed to be the most desirable.

A study of Tables I, II, III and IV led to the belief that the following are the optimum conditions: time, 48 hours; temperature, 120°; molar ratios, saccharin 1, phenol 5, sulfuric acid, 4.

Certain metal sulfates were next tested as to their catalytic power of accelerating the reaction. To each of a number of test-tubes was added 1 g. of the metal salt along with the proportions of reagents just given. These tubes were again heated at 120° for forty-eight hours. A check tube containing no added metal sulfate was included for comparison of color development. This was the means of judging the efficiency as a catalyst of the added salt. The findings are tabulated below.

TABLE V  
RESULTS WITH METALLIC SULFATES

Metal sulfate, 1 g.	Intensity of color development as com- pared to check tube containing no metal salt	Metal sulfate, 1 g.	Intensity of color development as com- pared to check tube containing no metal salt
Copper	Slight decrease	Cerium	Decrease
Zinc	Slight decrease	Cobalt	Decrease
Mercuric	No difference	Ferric	Marked decrease
Aluminum	Decrease	Manganese	Marked decrease
Chromium	Decrease	Nickel	Marked decrease
Bismuth	Decrease	Silver	No color at all
Thorium	Decrease		

Observations on color intensity were first made on the melt in tubes immediately after heating. These melts were then dissolved, neutralized and diluted, and comparisons of color made with the check tube. In no case was any catalytic action observed.

Experiments were conducted on the effect of various other substances ordinarily used as condensing agents, as possible substitutes for the sulfuric acid. There is always a danger of sulfonation when sulfuric acid is used, which makes necessary a lower temperature with consequent lowering of yield.

The first experiment consisted of heating the optimum proportions of saccharin and phenol with the condensing agents, with the inclusion of one blank. The substances tested were: anhydrous aluminum chloride, anhydrous zinc chloride, anhydrous ferric chloride and phosphoric acid (85%). In all cases the development of color was slight after the tubes were heated for seventeen hours at 120° except with the check tube containing sulfuric acid, in which the deep red color developed as usual. The superiority of sulfuric acid as condensing agent was obvious.

The second experiment consisted of heating saccharin, phenol and sulfuric acid together in tubes with the addition of the four condensing agents used in the last test. Comparison with the fifth check tube again showed no improvement due to the extra condensing agent.

A method based upon the foregoing studies which gives the best yield of the highest quality product is given in detail below.

### Procedure

A small balloon flask is charged with 10 g. of saccharin, 25 g. of phenol and 21 g. (12 cc.) of ordinary concentrated sulfuric acid. The contents are warmed until all of the solid is dissolved, then heated in an electric oven at 120° for forty-eight hours. An extra day of heating will increase the yield somewhat. The deep red, tarry looking reaction product is treated while still hot with warm water until solution is nearly complete. Sodium carbonate (a 30% solution is convenient) is added to neutrality, the change of color is the best guide, and the contents are subjected to steam distillation until all traces of phenol are removed. The solution is made faintly acid with hydrochloric acid and allowed to stand. The precipitated dye is filtered off with suction, washed with a minimum of ice water and dried. The dye should be of a bright red color and but slightly soluble in water.

A few comments on the method outlined above may be added. Sodium carbonate solution is used in the neutralization of the sulfuric acid present because it will not bind any considerable quantity of phenol, the latter seeming to prevent the dye from precipitating finally as a fine red powder.

Repeated solution of crude products in sodium carbonate and reprecipitation by addition of hydrochloric acid almost to the neutral point rendered the final product a much brighter red and much easier to precipitate.

The preparation of tetrabromophenolsulfonephthalein offered no difficulty. The method used is given here in brief.

Five grams of phenol red was dissolved in 100 cc. of absolute alcohol and the cooled solution was treated with the calculated quantity of bromine. It was found desirable to use a calibrated 10cc. buret to deliver the bromine, basing the weight upon the accurately determined density at room temperature. Mechanical stirring during the slow addition of the bromine and for a short time after the addition was complete was sufficient to complete reaction.

The brom phenol blue was recovered by diluting, dissolving the dye in sodium carbonate solution and finally precipitating it with hydrochloric acid.

### Conclusions

A simple method for making phenol red has been given. The product is obtained from cheap materials and after the simplest of manipulative operations.

The preparation of brom phenol blue from phenol red is described and offers no new procedure.

The products obtained checked perfectly with the *PH* ranges given in the literature for those substances. They were both further tested by the absorption spectrometric method and were pronounced very pure.

The application of the above method of preparation was found practicable in the condensation of many other phenols yielding useful sulfonephthaleins and work is now in progress on a simple method of preparation for each of those used in colorimetric hydrogen ion estimation.