

chloric acid. After about five minutes the crystals of crude citrinin are centrifuged off, dissolved in 30 cc. of dioxane at room temperature, and the solution is centrifuged. A small amount of insoluble material is discarded, and to the clear supernatant fluid one volume of distilled water is added. Citrinin crystallizes out immediately in long microscopic needles or plates. If the citrinin concentration is low, it is necessary to add more water in order to effect crystallization. The citrinin is centrifuged off and dried in vacuum at room temperature (yield, 1.5 g.). The melting point is at 163 to 166°. We were able to confirm fully the action of citrinin on *Streptococcus aureus* as reported by Raistrick and associates.

*P. citrinum* (P25 and ad95) was very kindly sent by Dr. H. Raistrick and forwarded to us through the courtesy of Dr. C. Thom of U. S. Department of Agriculture.

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### Acidic and Basic Catalysis in Urethan Formation

BY D. S. TARBELL, R. C. MALLATT AND J. W. WILSON

Urethans, because of their favorable characteristics, are frequently used to identify alcohols and phenols. They are usually prepared by heating an alcohol or phenol in the absence of a catalyst.<sup>1</sup> However, scattered statements indicate that this formation of urethans, particularly from phenols, is catalyzed not only by bases<sup>2</sup> but by aluminum chloride<sup>3</sup> and hydrogen chloride.<sup>4</sup> A general survey of the effect of acidic and basic catalysts on urethan formation has therefore been undertaken, but, as this work has been interrupted, the present brief report is now submitted.

Experiments in which equivalent amounts of *o*-cresol and phenyl isocyanate were heated without solvent but with catalyst at 100° and the urethan which had formed after varying times isolated, showed that the following substances have a catalytic effect: sodium carbonate, sodium acetate, pyridine, acetic acid, trichloroacetic acid, zinc chloride and hydrogen chloride. Without a catalyst a yield of less than 50% was obtained after nine hours of heating. The addition of 2% of either zinc chloride or pyridine gave a 100% yield in less than fifteen minutes.

Similar experiments with other phenols varying greatly in acid character, from *p*-nitrophenol to *p*-triphenylmethylphenol, gave in fifteen minutes without a catalyst zero, with the same catalysts, practically 100% yields of urethan. On the other hand, 2,4-dinitrophenol, 2,6-di-

nitro-4-chlorophenol and picric acid did not form urethans under any conditions tried.

More exact experiments using purified *o*-cresol and  $\alpha$ -naphthyl isocyanate were made as follows: solutions of 9.2 mmol. of each reagent and a small amount of a catalyst in 3.00 cc. of purified ligroin (b. p. 60–65°) in stoppered test-tubes, were heated in the vapors of refluxing methanol (65°) and after a definite time cooled in ice and filtered. The resultant crystals were washed twice with 2-cc. portions of cold ligroin in which they are practically insoluble, dried and weighed.

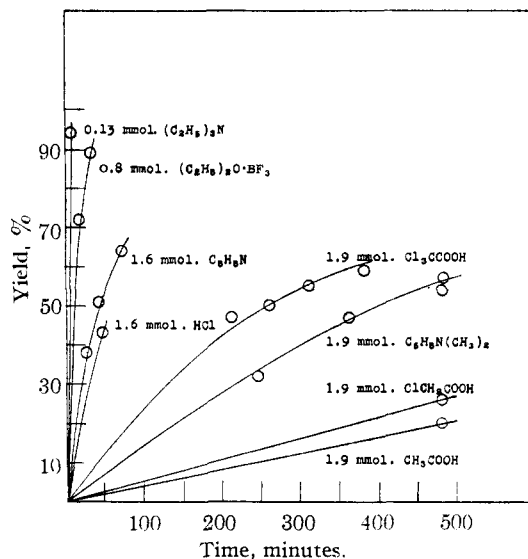


Fig. 1.

The results are shown as curves in Fig. 1, and from them it can be seen that triethylamine is by far the most effective catalyst tried. It is probably significant that it is a much stronger base than the less effective catalysts pyridine and dimethylaniline.<sup>5</sup> Boron fluoride etherate is the most active acid tested, and the catalytic activity of the other acids tested is roughly in the order of their acid strengths in water. When no catalyst was used, only an 11% yield was obtained after nine days, a result which could not be shown on the graph.

An 80% yield of the urethan (m. p. 141–142.5°)<sup>6</sup> was obtained by mixing the above quantities of *o*-cresol and  $\alpha$ -naphthyl isocyanate in 30 cc. of ligroin with two drops of triethylamine, and letting the mixture stand for two and one-half hours at room temperature. From this it appears that an excellent and rapid procedure for preparing urethans from phenols in general would be to use the above quantities of materials, reflux the solution a few minutes and cool slowly to allow crystallization.

**Phenylurethans of Tertiary Alcohols.**—These compounds were prepared by heating a mixture of 2 or 3 g. of the *t*-alcohol with an equivalent quantity of phenyl isocyanate and 0.1 g. of anhydrous sodium acetate for four to five hours on a steam-bath. In each case the reaction product was contaminated with some diphenylurea and unreacted phenyl isocyanate. If the oily product failed to crystal-

(1) Shriner and Fuson, "Identification of Pure Organic Compounds," 2nd Edition, John Wiley and Sons, Inc., New York, N. Y., 1940, p. 136.

(2) Dieckmann, Hoppe and Stein, *Ber.*, **37**, 4627 (1904); Michael and Cobb, *Ann.*, **363**, 64 (1908); Vallee, *Ann. chim. phys.*, (7) **15**, 331 (1908); Claisen, *Ann.*, **418**, 82 (1919); French and Wirtel, *This Journal*, **48**, 1736 (1926).

(3) Leuckart, *Ber.*, **18**, 873 (1885); Farinholt, Harden and Twiss, *This Journal*, **55**, 3383 (1933).

(4) Tarbell and Kincaid, *ibid.*, **62**, 728 (1940).

(5) Hall, *ibid.*, **52**, 5115 (1930).

(6) French and Wirtel, ref. 2, give 141–142°.

lize, it was purified by distillation in vacuum. In this manner the phenylurethans in Table I were obtained.

TABLE I

	M. p., °C. (uncor.)	Formula	Analyses, %			
			Calcd.		Found	
			C	H	C	H
Phenylurethan of Dimethylbutylcarbinol	62-63	C <sub>14</sub> H <sub>21</sub> NO <sub>2</sub>	71.5	8.9	71.8	8.9
Diphenylmethylcarbinol	124-125	C <sub>21</sub> H <sub>19</sub> NO <sub>2</sub>	79.5	6.0	79.7	5.7
Triethylcarbinol	61-61.5	C <sub>14</sub> H <sub>21</sub> NO <sub>2</sub>	71.5	8.9	70.9	8.8
Methylethylbenzylcarbinol	83.5-84	C <sub>18</sub> H <sub>21</sub> NO <sub>2</sub>	76.3	7.5	75.9	7.3
Diethylbenzylcarbinol	96-96.5	C <sub>19</sub> H <sub>23</sub> NO <sub>2</sub>	76.7	7.8	76.7	7.4

<sup>a</sup> Analyses by R. W. King.

Discussion of the mechanism of the catalysis will be deferred, but it seems to be a case of general acid-base catalysis. The tests for determining general acid-base catalysis which are employed in aqueous systems cannot be used readily here, since the isocyanates must be kept in inert solvents.

It is hoped to study this catalysis effect in greater detail and to include the reactions of alcohols and isocyanates.

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### Optical Properties of 2-Sulfanilamidopyrimidine (Sulfadiazine)

BY ALBERT S. WILKERSON

Thanks to the courtesy of Mr. Leonard Dhein of the American Cyanamid Company, Bound Brook, New Jersey, we have been able to determine the optical and related properties of a sample of sulfadiazine (m. p. 254°)<sup>1</sup> with the following results: monoclinic, colorless, transparent to translucent; luster vitreous. Cleavage pinacoidal at right angles, perfect.  $H = 1-2$ . Solubility 0.0123 g./100 cc.,<sup>1</sup> H<sub>2</sub>O at 37°. Optically biaxial positive;  $\alpha = 1.680$ ,  $\beta = 1.695$ ,  $\gamma = 1.788$ ; all  $\pm 0.002$ ,  $2V = 45-46^\circ$ ,  $Y//b$ ,  $Z \wedge c = 20^\circ(?)$ , elongation// $b$ .

(1) R. O. Roblin, *et al.*, THIS JOURNAL, **62**, 2002 (1940), found 255-256° with decomposition; they found the solubility to be 0.0123 g./100 cc.

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## NEW COMPOUNDS

### Certain Naphthylidene Sulfanilamide Derivatives

The procedures employed for the preparation of the following compounds were modifications of methods used in

the preparation of the aniline derivatives of the sulfonated  $\alpha$ - and  $\beta$ -naphthoquinones.<sup>1,2</sup> To conform with *Chemical Abstracts* the nomenclature of these compounds was suggested by Dr. Austin M. Patterson.

**N<sup>4</sup>-(3-Hydroxy-4-oxo-1(4)-naphthylidene)-sulfanilamide.**—A solution of 8.6 g. of sulfanilamide (Eastman Kodak Co.) in 200 cc. of water at 60-65° was added with stirring to a solution of 13.0 g. of 1,2-naphthoquinone-4-sodium sulfonate (Eastman purified by the method of Folin<sup>3</sup>) in 300 cc. of water at 45-50°. The reaction mixture after standing for fifteen minutes at room temperature was kept in the ice box overnight. The reddish orange precipitate was filtered off, washed with water and dried in a vacuum desiccator over sulfuric acid; yield, 9.9 g. (60%). The compound melted at 271-273° (uncor.). It is insoluble in cold water, very difficultly soluble in hot water, very soluble in alkali, formic acid, slightly soluble in hydrochloric acid, alcohol, dioxane and acetone.

*Anal.* Calcd. for C<sub>16</sub>H<sub>12</sub>O<sub>4</sub>SN<sub>2</sub>: N, 8.53. Found: N, 8.41.

**N<sup>4</sup>-(3-Hydroxy-4-oxo-7-sulfo-1(4)-naphthylidene)-sulfanilamide, Sodium Salt.**—To a solution containing 2.7 g. of 1,2-naphthoquinone-4,6-sodium disulfonate<sup>1</sup> in 75 cc. of water, 1.7 g. of sulfanilamide was added. The mixture was stirred mechanically until all the solid went into solution. This required fifteen minutes. Then 1.5 cc. of superoxol was added and stirring continued for an additional ten minutes. The deep red-brown solution was clarified with a small amount of Merck activated charcoal to remove the brown impurity. Upon addition of 10 g. of powdered sodium chloride the solution became a thick paste in a few minutes. After cooling in the ice box for two hours, the dark red needles were filtered off and dried in a vacuum desiccator over sulfuric acid. The weight of the crude material (contaminated with sodium chloride) was 4.6 g. It was recrystallized by solution in 50 cc. of water at 60° and subsequent chilling. The crystalline compound was filtered off, washed with ice-cold water, ice-cold 95% alcohol, ether and dried in a vacuum desiccator over sulfuric acid; yield, 2.2 g. (41%).

*Anal.* Calcd. for C<sub>16</sub>H<sub>11</sub>O<sub>7</sub>S<sub>2</sub>N<sub>2</sub>Na: N, 6.50. Found: N, 6.51.

**N<sup>4</sup>-[4-Oxo-3-(*p*-sulfamylanilino)-2-sulfo-1(4)-naphthylidene]-sulfanilamide.**—A solution of 1.7 g. of sulfanilamide in 100 cc. of water at 80° was added with stirring to a solution of 1.6 g. of 1,4-naphthoquinone-2-potassium sulfonate<sup>4</sup> in 50 cc. of water at 55°. As soon as the temperature of the mixture reached 50°, a small amount of yellow orange crystals (not identified) separated. These were filtered off by suction and discarded. To the filtrate at 30° was added 1 cc. of concentrated hydrochloric acid and the reaction mixture cooled in the ice box for three hours. The bright red needles that separated were filtered off, washed with cold water and dried in a vacuum desiccator over sulfuric acid; yield, 1.4 g. (50%). The material was recrystallized from 40 cc. of boiling water. It is fairly soluble in hot water. Dried in a vacuum desic-

(1) M. Böniger, *Ber.*, **27**, 23, 3050 (1894).

(2) P. Seidel, *ibid.*, **25**, 423 (1892).

(3) O. Folin, *J. Biol. Chem.*, **51**, 377 (1922).

(4) L. F. Fieser and M. Fieser, THIS JOURNAL, **57**, 491 (1935).