nism, but further work is necessary for complete proof. If this mechanism is correct, the "chloramine T" reaction furnishes a way of studying the anomalous chlorine–peroxide reaction in a concentration region hitherto inaccessible.

SCHENECTADY, NEW YORK RECEIVED FEBRUARY 15, 1936

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE WASHINGTON SQUARE COLLEGE OF NEW YORK UNIVERSITY]

Thiazolinephenols.[1,2] Their Synthesis and Structure Proof

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Theoretical Part

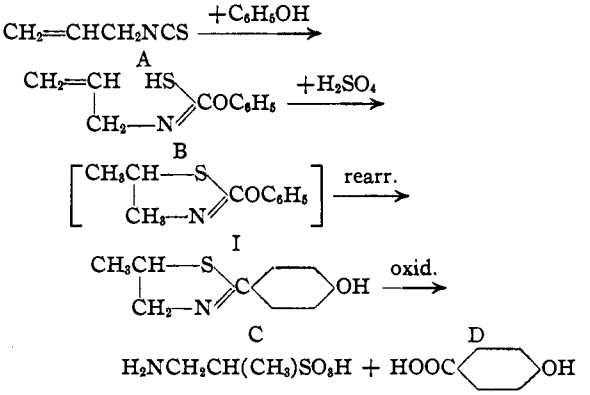
In the course of systematic investigations of the condensations of phenols with unsaturated compounds containing nitrogen (unsaturated amines, ureas, cyanides, isocyanides, isocyanates, thiocyanates and isothiocyanates)[3] the condensation system "phenols–allyl mustard oil" is of particular interest, because instead of straight addition of the phenol to the ethylenic linkage, the formation of thiazolinephenols took place, as set forth in this communication.

Since thiazolinephenols do not appear to be reported in the literature, investigation of the reaction mechanism as well as structure proof of the condensation products was necessary. By analogy of the reported rearrangement of allyl thiourea, aryl thioureas, allylthiocarbaminyl semicarbazide and thiosemicarbazide[4] to the corresponding thiazolines under the influence of cationoid reagents, the formation of thiazolinephenol from allyl mustard oil, phenol and concentrated sulfuric acid, can then be explained best by a similar reaction mechanism.

The observed and normal formation of the allylphenyl thiourethan (A)[5] from allyl isothiocyanate and phenol must be taken in account first, followed by cyclization under the influence of the acidic condensing agent to the 5-methyl-2-phenoxythiazoline (B). The required subsequent rearrangement of this non-isolated intermediary ether to the final 5-methyl-2-(4′-hydroxy)-phenylthiazoline (I), in presence of sulfuric acid, can be regarded as being analogous to the rearrangement of secondary alkyl phenyl ethers already known.[6]

To prove the structure more fully, the above thiazolinephenol was oxidized, employing the method of Andreasch, Prager and others[4a,b,7] and β-methyltaurin (C), together with *p*-hydroxybenzoic acid (D), were isolated.

Graphically, the reaction mechanism as well as the structure proof may then be presented as follows.



To illustrate that the above scheme represents a fairly general reaction, not only phenol (I, Ia, Ib) itself was condensed with mustard oil, but also its alkylated homologs (*m*-cresol II, IIa, IIb) and related dihydroxy compounds (guaiacol III, IIIa, IIIb and resorcinol IV, IVa, IVb), all yielding the corresponding thiazolinephenols, as enumerated in the table given.

Experimental Part

Condensation Method.—To a mixture consisting of 0.5 mol of allyl mustard oil and one mol of phenol, cooled to 0–5°, one mol of concd. sulfuric acid, kept at the same temperature, was slowly added under constant stirring or agitation. The same low temperature was maintained not only throughout the entire addition of the condensing agent, but also for the next twenty-four hours, after which

(1) Presented at the Kansas City meeting of the American Chemical Society, April, 1936.

(2) From Part I of the thesis presented by William F. Hart to the Faculty of the Graduate School of New York University in candidacy for the degree of Doctor of Philosophy.

(3) Niederl and co-workers, THIS JOURNAL, **53**, 277 (1931); **55**, 2571 (1933); **56**, 2412 (1934).

(4) (a) S. Gabriel, *Ber.*, **22**, 2984 (1889); (b) B. Prager, *ibid.*, **22**, 2991 (1889); (c) J. Gadamer, *Arch. Pharm.*, **234**, 20 (1896); (d) H. Will, *Ann.*, **52**, 11 (1844); (e) Busch and Lotz, *J. prakt. Chem.*, [2] **90**, 270 (1914).

(5) Schneider and Wrede, *Ber.*, **47**, 2042 (1914).

(6) Niederl and co-workers, THIS JOURNAL, **53**, 1928 (1931); **54**, 1063 (1932); **55**, 284 (1933); Sprung and Wallis, *ibid.*, **56**, 1715 (1934); Sowa, Hinton and Nieuwland, *ibid.*, **55**, 3402 (1933); **54**, 2019 (1932); R. A. Smith, *ibid.*, **56**, 717 (1934).

(7) Andreasch, *Monatsh.*, **4**, 134 (1883); Young and Crookes, *J. Chem. Soc.*, **89**, 71 (1896).

TABLE I

	Compound	Formula	M. p., °C.	Analyses, % Calcd. C	Calcd. H	Calcd. N	Found C	Found H	Found N
I	5-Methyl-2-(4′-hydroxy)-phenylthiazoline	$C_{10}H_{11}OSN$	166–168	62.12	5.74	7.25	62.22	6.02	7.22
	(a) Hydrochloride	$C_{10}H_{12}OSNCl$	187	52.37	5.27	6.11	52.25	5.98	6.09
	(b) Picrate	$C_{16}H_{14}O_8SN_4$	178			13.27			13.20
II	5-Methyl-2-(2′-methyl-4′-hydroxy)-phenylthiazoline	$C_{11}H_{13}OSN$	131	63.71	6.32	6.76	63.90	6.45	6.75
	(a) Hydrochloride	$C_{11}H_{14}OSNCl$	175			5.74			5.80
	(b) Picrate	$C_{17}H_{16}O_8SN_4$	154			12.84			12.90
III	5-Methyl-2-(4′-hydroxy-3′-methoxy)-phenylthiazoline	$C_{11}H_{13}O_2SN$	142	59.14	5.87	6.27	59.33	5.98	6.35
	(a) Hydrochloride	$C_{11}H_{14}O_2SNCl$	187			5.43			5.55
	(b) Picrate	$C_{17}H_{16}O_9SN_4$	159–160			12.39			12.51
IV	5-Methyl-2-(2′,4′-dihydroxy)phenylthiazoline	$C_{10}H_{11}O_2SN$	184	57.37	5.30	6.64	57.48	5.45	6.67
	(a) Hydrochloride	$C_{10}H_{12}O_2SNCl$	251	48.85	4.92	5.72	48.81	5.10	5.73
	(b) Picrate	$C_{16}H_{14}O_9SN_4$	190			12.78			12.85

the reaction mixture was left standing for three days at room temperature to bring the reaction to completion. The condensation product was then treated with small amounts of water to extract the sulfuric acid as well as any acid-soluble material. This aqueous extract was neutralized with sodium carbonate and extracted with ethyl acetate. The ethyl acetate solution was dried with anhydrous calcium chloride and filtered. The solvent, as well as most of the unreacted phenol, mustard oil and some allylamine, were distilled off successively by gradually heating the condensation product to 110° (10 mm.). The remaining residue then was once more dissolved in ethyl acetate and this solution extracted with dilute hydrochloric acid (10%). The acidic aqueous extract obtained was neutralized with sodium carbonate or sodium hydroxide and the separating oil allowed to crystallize or once more taken up in ethyl acetate. Again the solvent was removed by vacuum distillation and the residue dissolved in a minimum of 95% ethyl alcohol. On prolonged standing of this concentrated alcoholic solution at about 0°, the respective thiazolinephenols began to crystallize. Recrystallizations were effected by using ethyl alcohol or benzene, together with norite for the removal of highly colored impurities.

The hydrochlorides were prepared by evaporating to dryness filtered solutions of the thiazolinephenols in dilute hydrochloric acid (10%). Further purification was accomplished by precipitating the thiazolinephenol hydrochlorides from either alcoholic or aqueous solutions by the slow addition of acetone until decided turbidity was observed. The corresponding picrates were obtained by the slow addition of the filtered aqueous solutions of the hydrochlorides to an equal volume of a filtered concentrated aqueous solution of picric acid. They were recrystallized from 95% ethyl alcohol.

Oxidation Method.—To 1.050 g. of the thiazolinephenol hydrochloride, dissolved in 10 cc. of dilute hydrochloric acid, 0.66 g. of potassium chlorate was added, the system warmed gently, allowed to stand overnight and then evaporated to dryness on a steam-bath. The entire residue was taken up in a minimum quantity of 95% ethyl alcohol, and on addition of 5 volumes of ether the β-methyl taurin separated. It was recrystallized from an ether–alcohol mixture and identified by quantitative analysis. The residue obtained after the removal of the ether and alcohol from the above extract by distillation, was dissolved in hot water, neutralized with sodium carbonate and evaporated to dryness on a steam-bath. This residue was extracted repeatedly with ether and then decomposed with dilute hydrochloric acid. The mixture was again evaporated to dryness and then extracted with 95% ethyl alcohol. The process of evaporation and extraction was repeated until the residue was free from inorganic matter. This residue was then exhaustively treated with chloroform to ascertain the presence of any salicylic acid and to remove further impurities. The final residue then proved to be *p*-hydroxybenzoic acid, identified by its qualitative reactions, melting point and mixed melting point with a standard sample.

Summary

1. The studies of the condensation of phenols with a variety of unsaturated compounds have been extended to include allyl mustard oil.

2. The condensation products obtained appear to be thiazolinephenols. The formation of these heterocyclic phenols appears not to involve an addition of the phenol to the ethylenic linkage, as in numerous other systems, but rather a series of chemical transformations involving several rearrangements.

3. The physiological and pharmacological properties of these relatively non-toxic thiazolinephenols are under investigation.

NEW YORK, N. Y. RECEIVED JANUARY 29, 1936