the addition, which took 30 minutes, the temperature rose from an initial 105 to 140°, when evolution of ethyl chloride ceased. The reaction product was distilled rapidly at *ca.* 130° (0.2 mm.). The colorless hygroscopic distillate was fractionated and the fraction boiling at 148–152° (0.8 mm.), $n^{25}D$ 1.4699, collected, yield 50%.

Anal. Calcd. for $C_6H_{11}Cl_2O_4P$: Cl, 28.47; P, 12.45. Found: Cl, 27.31; P, 12.71.

***p*-Nitrophenyl osazone**, red crystals from alcohol, m.p. 255° dec.

Anal. Calcd. for $C_{18}H_{21}N_6O_7P$: N, 18.11; P, 6.67. Found: N, 17.95; P, 6.61.

O,O-Diethyl 2,2,2-Trichloro-1-acetoxyethylphosphonate.—One-tenth mole of I (R = C_2H_5) was acetylated with acetic anhydride (sodium acetate catalyst) in 48% yield, b.p. 116–117° (0.05 mm.), $n^{25}D$ 1.4653.

Anal. Calcd. for $C_8H_{14}Cl_3O_5P$: Cl, 32.48. Found: Cl, 32.34.

BELTSVILLE, MARYLAND

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, RAVENSHAW COLLEGE, UTKAL UNIVERSITY]

2-β-Naphthylimino-4-thiazolidone and its Derivatives

BY M. K. ROUT AND G. N. MAHAPATRA

RECEIVED AUGUST 16, 1954

An improved method of synthesis of thiazolidones is illustrated by the preparation of 2-β-naphthylimino-4-thiazolidone. The condensation products of the above thiazolidone with aldehydes and their bromine derivatives also are described. The bromine derivatives have been screened for fungicidal action and the arylidene derivatives for use as analytical reagents.

In view of the close relationship between thiazolidones and thiazoles, the presence of a thiazolidine moiety in Penicillin and the reported use of thiazolidone compounds as anesthetics,[1] anticonvulsants[2] and amebacidal agents,[3] it was of interest to explore newer methods of synthesis of thiazolidones and new applications of them.

Several methods are available for synthesis of thiazolidones.[4,5] The present method (illustrated by the preparation of 2-β-naphthylimino-4-thiazolidone) consists of heating arylthiocarbamides with chloroacetic acid in absolute alcohol in the presence of anhydrous sodium acetate and is superior to the method of Desai, Hunter and Koppar,[5] since the procedure adopted here is more rapid and does not involve the isolation of the intermediate substituted formamidinethiolacetic acid which was obtained by Desai and Hunter[5] by a rather prolonged operation. The thiazolidone structure for this compound to the exclusion of a possible thiohydantoin structure has been confirmed by establishing (a) the cyclic nature of the sulfur atom (by heating with mercuric oxide and chloroacetic acid), (b) by testing for the presence of S–CH_2–CO group by Andreasch's test,[6] (c) by boiling with hydrochloric acid and then establishing the structure of the glycolide formed by boiling with hydrochloric acid and then establishing the structure of the glycolide formed by its unambiguous synthesis from chloroacetic acid and β-naphthylthiourethan. When the reaction was carried out in refluxing alcohol, following the method of preparation of the diphenyl analog,[7] a compound fairly soluble in water and acidic in nature was obtained. It was found to be identical with β-naphthylformamidinethiolacetic acid hydrochloride prepared by Desai and Hunter[5] by a different procedure.

The thiazolidone compound thus prepared has been condensed with aldehydes. In view of the fact that closely related compounds like benzylidenerhodanine[8] and 2,5-dimercapto-1,3,4-thiodiazole[9] already have found use as analytical reagents, the thiazolidone compound and its condensation products have been tested for use in this direction. The condensation products with aldehydes are expected to be more effective reagents than the parent thiazolidones in view of the decided superiority of arylidenerhodanine over rhodanine as reagents in inorganic analysis.[10]

On screening the arylidene derivatives for use as analytical reagents, formation of metallic complexes was observed with silver, mercury and copper salts. Conditions of complete precipitation especially *p*H, were then studied with different arylidene derivatives and it was found that the *p*-dimethylaminobenzylidene derivative was more useful than others, effecting complete precipitation of the metal at all *p*H's in the acidic range and was therefore taken up for more detailed investigations. Results indicate that this is a very satisfactory reagent for estimation of silver.

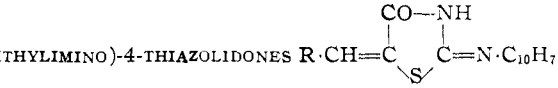
The amount of silver found on ignition in the silver compound on the basis of the proposed structure agrees within 0.2% with the amount of silver added. Details of the analytical tests will be published elsewhere.

Both the thiazolidone compound and its arylidene derivatives also have been brominated in the hope of obtaining very powerful fungicides in view of the established fact that halogens confer fungicidal activity.[11] By undertaking bromination, it was possible also to test the validity of the assumption made by Hunter and co-workers[12] that the keto–enol system present in tetrahydrothiazole derivatives does not take part in the production of the bromine addition compound. Since the assumption was found to be correct in the present case

(1) A. R. Surrey, THIS JOURNAL, **71**, 3354 (1949).
(2) H. D. Troutman and L. M. Long, *ibid.*, **70**, 3436 (1948).
(3) A. R. Surrey and R. A. Cutler, *ibid.*, **76**, 578 (1954).
(4) A. R. Surrey, *ibid.*, **69**, 2911 (1947).
(5) R. D. Desai, F. G. Hunter and L. G. Koppar, *Rec. trav. chim.*, **54**, 118 (1935).
(6) R. Andreasch, *Ber.*, **12**, 1385 (1879).
(7) S. B. Dutt and D. P. Ahuja, *J. Indian Chem. Soc.*, **28**, 12 (1951).
(8) I. M. Kolthoff, THIS JOURNAL, **52**, 2222 (1930).
(9) P. Ray and J. Gupta, *J. Indian Chem. Soc.*, **12**, 308 (1935).
(10) G. Ettisch and J. Tamchyna, *Mikrochem.*, **10**, 92 (1931).
(11) Goldsworthy and Green, *Phytopath*, **29**, 700 (1939).
(12) M. O. Farooq and R. F. Hunter, *J. Indian Chem. Soc.*, **9**, 545 (1932).

TABLE I

5-(ARYLIDENE)-2-(β-NAPHTHYLIMINO)-4-THIAZOLIDONES



R	Yield, %	M.p., °C.	Color	Nitrogen, % Calcd.	Nitrogen, % Found	Sulfur, % Calcd.	Sulfur, % Found
o-Hydroxyphenyl	80	246	Brownish-red	8.09	7.93	9.24	9.13
p-Hydroxyphenyl	70	288	Brown	8.09	7.82	9.24	9.04
o-Nitrophenyl	60	240	Brown	7.47	7.16	8.53	8.31
m-Nitrophenyl	65	301	Yellow	7.47	7.43	8.53	8.63
p-Nitrophenyl	70	325	Orange	7.47	7.32	8.53	8.71
p-Dimethylaminophenyl	75	304	Orange-red	7.50	7.81	8.58	8.23
p-Hydroxy-*m*-methoxyphenyl	70	285	Deep yell.	7.42	7.5	8.51	8.15
Phenylvinyl	80	260	Dirty yell.	7.87	7.81	8.98	8.87
p-Methoxyphenyl	65	331	Golden yell.	7.77	7.73	8.88	8.31
Furyl	70	315	Yellow	8.75	8.27	10.00	10.15

and bromine did not enter the keto–enol system, in order to have brominated thiazolidones (with bromine attached to the nucleus), the arylidene derivatives were treated with bromine. As expected, bromine entered the unsaturated bond, proof for which has been obtained as follows. When the parent aryliminothiazolidone compound after reaction with bromine in chloroform was subsequently treated with sulfurous acid, the original compound was regenerated, thus excluding the possibility of (a) addition of bromine to the phenylimino grouping and (b) attachment of bromine to the aryl nucleus or to the nuclear sulfur atom in the aryliminothiazolidone compound. When, however, the bromine derivative of the arylidenearyliminothiazolidone compound (obtained after treatment with sulfurous acid) was refluxed with alcoholic potassium hydroxide, potassium bromide precipitated, indicating that the bromine was attached to the aliphatic fragment of the molecule. The bromine content also corresponded to the presence of two bromine atoms which therefore must have been added to the unsaturated ethylenic bond.

For assaying fungicidal activity, the method of Montgomery and Moore[13] with slight modifications was used. *Alternania polanduii* Ayyangar was used as the fungus indicator. The thiazolidone compounds completely inhibited spore germination even at a concentration of 50 parts per million. The brominated thiazolidones were, however, more powerful, completely inhibiting spore germination even at a concentration of six to eight parts per million. Details of fungicidal tests will be published elsewhere.

Experimental

2-β-Naphthylimino-4-thiazolidone (I).—β-Naphthylthiourea (6.1 g., 0.03 mole) prepared by reaction of β-naphthylamine hydrochloride with ammonium thiocyanate was heated under reflux with chloroacetic acid (3.0 g., 0.031 mole) in the presence of anhydrous sodium acetate (3.0 g.) and absolute alcohol (25 cc.) on the water-bath for 3 to 4 hours. The reaction mixture was poured into cold water, and the precipitate was washed several times with boiling water to remove sodium acetate, and finally crystallized from alcohol; yield 7 g., m.p. 225°.

Anal. Calcd. for $C_{13}H_{10}N_2OS$: C, 64.46; H, 4.13; S, 13.22; N, 11.57. Found: C, 64.12; H, 4.03; S, 13.1; N, 11.37.

2-β-Naphthylimino-5-benzal-4-thiazolidone (II).—The thiazolidone compound (2.3 g. 0.0096 mole) and benzaldehyde (1 g., 0.0095 mole) were refluxed in glacial acetic acid (20 cc.) in the presence of anhydrous sodium acetate (1.5 g.) for 3 hours. The clear solution on dilution with water gave a deep yellow precipitate. After standing overnight, the precipitate was collected, washed well with water and then recrystallized from alcohol; yield 85%, m.p. 321°.

Anal. Calcd. for $C_{20}H_{14}N_2OS$: C, 72.72; H, 4.24; S, 9.69; N, 8.48. Found: C, 72.6; N, 4.1; S, 9.55; N, 8.41.

Data on other arylidenethiazolidones are recorded in Table I.

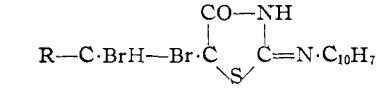
Bromination of II.—A solution of 5-benzal-2-β-naphthylimino-4-thiazolidone (II) (1 g.) in chloroform (30 cc.) was treated with bromine (1 cc.) in 4 cc. of chloroform at 0–3° and the mixture was kept in ice for an hour. As no crystallization occurred, the solution was concentrated under reduced pressure at laboratory temperature when a vermillion-colored bromo addition compound III was formed. On treatment with sulfurous acid and basification with ammonia, this substance gave the dibromo derivative of 5-benzal-2-β-naphthylimino-4-thiazolidone (IV), m.p. 228°, yield 85%.

Anal. Calcd. for $C_{20}H_{14}N_2OSBr_2$: Br, 32.65. Found: Br, 32.35.

The labile bromine content in the unstable perbromide compound was estimated by dissolving the bromo addition compound in chloroform, to which a drop or two of acetic acid had been added, and adding a strong aqueous solution of potassium iodide. The iodine liberated on shaking the mixture was titrated with *N*/20 thiosulfate. The amount of labile bromine found corresponded to the presence of 2 to 3 atoms of labile bromine in the molecule. Table II describes the properties of bromine derivatives of other thiazolidones.

TABLE II

5-BROMO-5-ARYLBROMOMETHYL-2-(β-NAPHTHYLIMINO)-4-THIAZOLIDONES



R	Yield, %	M.p., °C.	Sulfur, % Calcd.	Sulfur, % Found	Bromine, % Calcd.	Bromine, % Found
Phenyl	82	228	6.53	6.31	32.65	32.35
o-Hydroxyphenyl	78	120	6.32	6.11	31.62	31.33
p-Hydroxyphenyl	60	208	6.32	6.43	31.62	31.46
o-Nitrophenyl	74	91	5.98	5.83	29.90	29.71
m-Nitrophenyl	82	161	5.98	6.03	29.90	29.87
p-Nitrophenyl	85	295	5.98	6.14	29.90	29.45
p-Dimethylaminophenyl	75	156	6.0	5.71	30.02	29.91
p-Hydroxy-*m*-methoxyphenyl	70	155	5.97	5.83	29.85	29.88
Dibromostyryl	90	128	4.73	5.01	49.34	49.13
p-Methoxyphenyl	75	103	6.15	6.35	30.47	30.79
Furyl	70	Above 360	6.66	6.45	33.33	33.14

Acknowledgment.—The authors are grateful to Dr. B. Padhi, Department of Botany, Ravenshaw College, for help in carrying out the fungicidal tests and to Board of Scientific & Industrial Research, Orissa, for a research grant.

CUTTACK 3, ORISSA, INDIA

(13) Montgomery and Moore, *J. Pomol and Hort. Sci.*, **16**, 253 (1938).