

pressure; gas absorption was complete in 2.5 hr. The catalyst was removed by filtration and the solvent evaporated on the steam bath. The residue had  $n_D^{25} 1.4790$  and  $[\alpha]_D^{25} +15.2^\circ$ . The dibenzylidene derivative had the m.p. 124–125°.

(+)*cis*-8-Methylhydrindane (X). The ketone (IX) (3.5 g.) was refluxed for two hr. at 135° with 4.0 g. of potassium hydroxide, 80 ml. of diethyleneglycol, and 7.0 g. of 85% hydrazine hydrate. The water was distilled off and then the temperature was raised to 200° for 4 hr. The mixture was cooled, taken up in water, extracted with pentane, and the pentane layer washed with concentrated sulfuric acid until the acid no longer became colored. The pentane solution was washed with water, dried over magnesium sulfate, and the pentane removed, leaving two grams of an oil whose infrared spectrum showed no carbonyl band and was identical with that given in ref. 7. The oil crystallized on cooling, m.p. 5°,  $[\alpha]_D^{25} +3^\circ$  (6% in chloroform).

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DEPARTMENT OF CHEMISTRY  
COLUMBIA UNIVERSITY  
NEW YORK 27, N. Y.

### A New Synthesis of *cis*-1,2-Cyclohexanediol

FREDERICK V. BRUTCHER, JR.,<sup>1</sup> AND GEORGE EVANS III

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*cis*-1,2-Cyclohexanediol (I) has found considerable use as a model compound for synthetic and mechanistic studies. In discussing methods of preparing I, Criegee and Stanger<sup>2</sup> have recommended a four-step method starting with cyclohexene. As pointed out by Winstein, Hess, and Buckles,<sup>3</sup> however, its success is dependent on the reaction conditions of the replacement reaction.

We have developed a much simpler two-step synthesis of I from cyclohexene which requires about a day's time and which is amenable to large scale work. The method employed is that developed<sup>4</sup> for *cis*-hydroxylation in the synthetic steroid series. It involves the interaction of an olefin with iodine, silver acetate, and wet acetic acid to give, by way of a neighboring group replacement reaction,<sup>3</sup> *cis*-hydroxy acetate in one operation. Subsequent hydrolysis yields the free diol.

Using this technique, we have obtained after one recrystallization quite pure I in 66% yield. Considerable variation of the reaction conditions did not improve the yield. The use of iodine mono-

chloride in place of iodine decreased the yield of I to 32%.

### EXPERIMENTAL<sup>5</sup>

*cis*-1,2-Cyclohexanediol (I). To a slurry of 16 g. (0.096 mole) of silver acetate in 150 ml. of glacial acetic acid in a three-neck flask equipped with a condenser, thermometer, and stirrer was added 3.42 g. (0.0416 mole) of freshly distilled cyclohexene, b.p. 83–85°. Accompanied by vigorous stirring, 11.7 g. (0.046 mole) of powdered iodine was added over a 30-min. period at room temperature. Finally, 0.67 g. (0.042 mole) of water was added and the reaction mixture was heated with vigorous stirring for 3 hr. at 90–95°. After the reaction mixture was cooled, filtered, and the silver iodide precipitate washed well with hot benzene and ethyl acetate, the combined filtrates were evaporated at the water pump to give a yellow viscous oil which was taken up in methanol and filtered. The filtrate was neutralized with a few ml. of alcoholic potassium hydroxide, treated with 3.5 g. of potassium hydroxide in 20 ml. of methanol and hydrolyzed by refluxing for 1.5 hr. (darkening occurred). After evaporation of the methanol at the water pump, the residue was taken up in 500 ml. of warm diethyl ether and filtered. The filtrate was evaporated yielding 3.92 g. (81%) of crude glycol. Recrystallization from carbon tetrachloride yielded 3.2 g. (66%) of white *cis*-1,2-cyclohexanediol, m.p. 97–98°, lit.<sup>2</sup> m.p. 96–98°.

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UNIVERSITY OF PENNSYLVANIA  
PHILADELPHIA 4, PA.

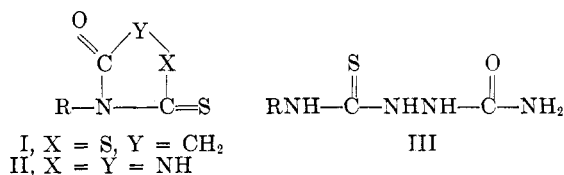
(5) All melting points are uncorrected.

### Some 4-Substituted Thiourazoles<sup>1</sup>

C. K. BRADSHER, FRANCES C. BROWN, AND SIDNEY T. WEBSTER<sup>2</sup>

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It was shown that 3-substituted rhodanines (I) possess pronounced antimicrobial activity.<sup>3–5</sup> The present work deals with the synthesis of some related 4-substituted thiourazoles (II). The thioura-



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TABLE I  
 1-SUBSTITUTED-2-THIOBIUREAS AND 4-SUBSTITUTED THIURAZOLES

R	Yield, <sup>a</sup> %	M.P., <sup>b</sup> °C.	Formula	C		H		N	
				Calcd.	Obsd.	Calcd.	Obsd.	Calcd.	Obsd.
Thiobiureas (III)									
CH <sub>3</sub>	97	210–211	(Lit. <sup>c</sup> 212°)						
C <sub>2</sub> H <sub>5</sub>	94	200.5	C <sub>4</sub> H <sub>10</sub> N <sub>4</sub> OS	29.62	29.65	6.21	6.30	34.55	34.46
C <sub>3</sub> H <sub>7</sub>	84	201–201.5	C <sub>6</sub> H <sub>12</sub> N <sub>4</sub> OS	34.07	34.13	6.88	6.83	31.79	31.80
C <sub>4</sub> H <sub>9</sub>	92	204	C <sub>8</sub> H <sub>14</sub> N <sub>4</sub> OS	37.87	37.66	7.42	7.36	29.45	29.32
C <sub>5</sub> H <sub>11</sub>	96	206	C <sub>7</sub> H <sub>16</sub> N <sub>4</sub> OS	41.15	41.02	7.90	7.89	27.43	27.29
C <sub>6</sub> H <sub>13</sub>	87	205.5–206	C <sub>8</sub> H <sub>18</sub> N <sub>4</sub> OS	44.01	43.88	8.31	8.49	25.67	25.74
C <sub>7</sub> H <sub>15</sub>	74	206	C <sub>9</sub> H <sub>20</sub> N <sub>4</sub> OS	46.52	46.97	8.68	8.68	24.12	24.28
(CH <sub>3</sub> ) <sub>2</sub> CH	95	194.5–195	C <sub>6</sub> H <sub>12</sub> N <sub>4</sub> OS	34.07	34.31	6.88	6.62	31.79	31.80
C <sub>6</sub> H <sub>5</sub> (CH <sub>2</sub> ) <sub>2</sub>	68	215–215.5	C <sub>10</sub> H <sub>14</sub> N <sub>4</sub> OS	50.40	50.61	5.92	5.98	23.51	23.54
C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub>	100	193–194	C <sub>9</sub> H <sub>12</sub> N <sub>4</sub> OS	48.19	48.12	5.40	5.47	24.98	25.15
C <sub>6</sub> H <sub>5</sub>	98	196.5–197.5	(Lit. 198°, Ref. 6)						
Thiourazoles (II)									
CH <sub>3</sub>	67	210–212	(Lit. <sup>d</sup> 212°)						
C <sub>2</sub> H <sub>5</sub>	69	184–184.5 <sup>e</sup>	C <sub>4</sub> H <sub>7</sub> N <sub>3</sub> OS	33.09	32.96	4.86	4.90	28.94	28.83
C <sub>3</sub> H <sub>7</sub>	75 (56)	175–176 <sup>f</sup>	C <sub>5</sub> H <sub>9</sub> N <sub>3</sub> OS	37.72	37.57	5.70	5.71	26.39	26.35
C <sub>4</sub> H <sub>9</sub>	74	154.5–155.5 <sup>g</sup>	C <sub>6</sub> H <sub>11</sub> N <sub>3</sub> OS	41.60	41.75	6.40	6.35	24.26	24.30
C <sub>5</sub> H <sub>11</sub>	77	151–151.5 <sup>h</sup>	C <sub>7</sub> H <sub>13</sub> N <sub>3</sub> OS	44.90	45.02	7.00	7.03	22.44	22.46
C <sub>6</sub> H <sub>13</sub>	91	146.5–147.5 <sup>i</sup>	C <sub>8</sub> H <sub>15</sub> N <sub>3</sub> OS	47.73	47.83	7.51	7.50	20.88	20.88
C <sub>7</sub> H <sub>15</sub>	88	145.5–146.5 <sup>i</sup>	C <sub>9</sub> H <sub>17</sub> N <sub>3</sub> OS	50.20	50.23	7.96	7.64	19.52	19.83
(CH <sub>3</sub> ) <sub>2</sub> CH	51 (36)	174–175 <sup>f</sup>	C <sub>5</sub> H <sub>9</sub> N <sub>3</sub> OS	37.72	37.89	5.70	5.43	26.39	26.63
C <sub>6</sub> H <sub>5</sub> (CH <sub>2</sub> ) <sub>2</sub>	93	171.5–172.5 <sup>j</sup>	C <sub>10</sub> H <sub>11</sub> N <sub>3</sub> OS	54.28	54.42	5.01	5.02	18.99	18.97
C <sub>6</sub> H <sub>5</sub> CH <sub>2</sub>	83	216.5–217.5 <sup>k</sup>	C <sub>9</sub> H <sub>9</sub> N <sub>3</sub> OS	52.16	52.30	4.38	4.24	20.29	20.36
C <sub>6</sub> H <sub>5</sub>	83 (35)	193.5–195.5	(Lit. 196°, Ref. 6)						

<sup>a</sup> All yields are for products melting within 3° of the analytical sample. In a few cases yields have been based upon starting material actually consumed. In such cases the smaller number in brackets is the per cent of the starting material converted. <sup>b</sup> All melting points are for pure samples. <sup>c</sup> S. Janniah and P. Guha, *J. Indian Inst. Sci.*, **16A**, 25 (1933). <sup>d</sup> L. Loewe and M. Türgen, *Rev. fac. sci. univ. Istanbul*, **14A**, 227 (1949). <sup>e</sup> Previous sintering at 150–160°. <sup>f</sup> Sintering above 155°. <sup>g</sup> Sintering at 147–151°. <sup>h</sup> Previous sintering at 139–146°. <sup>i</sup> Sintering above 139°. <sup>j</sup> Sintering above 162°. <sup>k</sup> Sintering above 195°.

zoles were obtained by cyclizing 1-substituted-2-thiobiureas<sup>6</sup> (III) which had been obtained by the action of isothiocyanates on semicarbazide. Eleven 4-substituted thiurazoles were prepared and tested for activity against *A. niger*, *B. subtilis*, and *E. coli*. The intermediate thiobiureas were likewise tested. It is interesting that although none of the compounds showed useful activity toward the microorganisms used, several of the 1-substituted thiobiureas significantly *accelerated* the rate of growth of *A. niger* at 250 p.p.m.

#### EXPERIMENTAL<sup>7</sup>

**Isothiocyanates.** The alkyl and aralkyl isothiocyanates were prepared by the action of ethyl chlorocarbonate on the appropriate *N*-alkyl dithiocarbamate essentially as described earlier.<sup>8</sup>

**1-Substituted-2-thiobiureas (III).** To a solution containing 11.2 g. of semicarbazide hydrochloride and 5.4 g. of anhy-

drous sodium carbonate in about 30 ml. of hot water, 0.1006 mole of the alkyl (aryl) isothiocyanate was added in 50 ml. of ethanol. The solution was boiled gently on a hot plate for 2–4 min. and the solution was then cooled in an ice bath for about an hour. The product was collected and dried in a vacuum oven at 80°. The analytical sample was prepared by recrystallization from ethanol.

**4-Substituted thiurazoles (II).** Eight grams of the 1-substituted-2-thiobiurea was dissolved in 30–40 ml. of 2*N* sodium hydroxide by shaking, and the resulting mixture heated on the steam bath for thirty to fifty minutes (evolution of ammonia). The alkaline solution was acidified with hydrochloric acid and the resulting precipitate collected. The crude product was purified by shaking it in 20 ml. of 10% ammonium hydroxide solution which dissolved the 4-alkylthiurazole, but not the 1-alkyl-2-thiobiurea present. The unchanged starting material was recovered by filtration, and the desired thiurazole (II) was obtained by acidification of the filtrate with hydrochloric acid. The product usually separated as colorless needles which were collected and dried *in vacuo* at 100°. The analytical sample was prepared by recrystallization from hot water.

**Antimicrobial testing.** The testing methods were the same as those described earlier.<sup>5,9</sup>

DEPARTMENT OF CHEMISTRY  
DUKE UNIVERSITY  
DURHAM, N. C.

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(9) We are indebted to Mrs. Dorcas Clarke for carrying out these tests.