The distillation residue consisted of a brown, viscous semisolid.

(b). α-Chloro-*p*-xylene (29 g., 0.2 mole) was added dropwise during 1 hr. to a mixture of *p*-xylene (10.6 g., 0.1 mole), carbon disulfide (100 ml.), and aluminum chloride (1.3 g., 0.01 mole) at room temperature. After completion of the addition, the reaction mixture was stirred for 2 hr. and worked up in the usual manner. Fractionation of the organic material yielded 1.3 g. of *p*-xylene, b.p. 55–57° (47 mm.), 5 g. of II, b.p. 127° (1.3 mm.), n_D^{20} 1.5654, and 5 g. of a yellow, viscous oil, b.p. 167–168° (0.5 mm.) which slowly crystallized on standing, m.p. 118–119° (from ethanol). The infrared spectrum was different from that of the solid, m.p. 111.5–112° from the *p*-xylene–ferric chloride reaction. The distillation residue (14.4 g.) was a brown, sticky semisolid.

Di(p-xylyl)methane and α-chloro-p-xylene. To a carbon disulfide (20 ml.) solution of III (0.9 g., 4 mmoles) was added 50 mg. of aluminum chloride and then 0.5 g. (4 mmoles) of α-chloro-*p*-xylene dropwise at room temperature. The reaction was allowed to continue at room temperature for 1 hr. After addition of water, the organic layer, containing suspended yellow solid, was separated and the solvent removed by evaporation. The yellow residue was extracted with hot methanol leaving 0.2 g. of highly insoluble (ether, carbon disulfide, chloroform), pale yellow solid which did not melt at 320°. From the methanol extract was recovered 0.25 g. of crude III, m.p. 54–56°.

Ferric chloride and o-xylene. The reaction, carried out at 20–30° for 5 hr., yielded 2.2 g. (3%) of 4-chloro-*o*-xylene, 2 g. of brown, high-boiling oil, and 24 g. of coal-like solid which did not contain chlorine. The 4-chloro-*o*-xylene, b.p. 192.5°, n_D^{20} 1.5226 (lit.[15] b.p. 191.5°) was characterized[16] by its infrared spectrum and oxidative derivative, 4-chloro-2-methylbenzoic acid, m.p. 169.5–170°; lit.[17] m.p. 171°.

Ferric chloride and m-xylene. Following the occurrence of an energetic reaction at 17°, the temperature was held at 26° for 1 hr. After the work-up, distillation of the product yielded 16 g. (23%) of 4-chloro-*m*-xylene, b.p. 186–187° (745 mm.), n_D^{20} 1.5226; lit.[18,19] b.p. 186.5° (767 mm.), n_D^{25} 1.5230. The infrared spectrum showed typical absorption bands for 1,2,4-substitution. Oxidation[16] with chromic anhydride in acetic acid gave 4-chloro-3-methylbenzoic acid, m.p. 208–209°; lit.[18] m.p. 209–210°.

A colorless liquid, wt. 8 g. (7.6%), b.p. 122–123° (1.1 mm.), b.p. 292° (746 mm., test tube), n_D^{20} 1.5651, d^{20} 0.9686, was also obtained. Upon cooling in the refrigerator overnight, it solidified to colorless crystals, m.p. 35–38°. The melting point was increased to 39–40° after two crystallizations from methanol.

Anal. Calcd. for $C_{16}H_{18}$: C, 91.37; H, 8.63, mol. wt., 210. Found: C, 91.33; H, 8.42; mol. wt., 205.

The mixture melting point with authentic 2,2′,4,4′-tetramethylbiphenyl showed no depression, and the infrared spectra of the two samples were identical.

Treatment with 2:1 sulfuric acid–nitric acid yielded a tetranitro derivative, pale yellow crystals, m.p. 139–140° from chloroform.

Anal. Calcd. for $C_{16}H_{14}N_4O_8$: N, 14.35. Found: N, 14.42, 14.47.

The residue from fractional distillation was a black, amorphous solid (no chlorine), wt. 16 g.

2,2′,4,4′-Tetramethylbiphenyl. 4-Iodo-*m*-xylene was prepared as previously described.[20] After three distillations the product was obtained as a pale yellow liquid, b.p. 104° (10 mm.), b.p. 232° (745 mm.), $n_D^{16.5}$ 1.5990; lit.[21,22] b.p. 111° (14 mm.), b.p. 230° (742 mm.), $n_D^{16.3}$ 1.6008.

The method[21] of Ullmann and co-workers, involving specially treated[23] copper, was used for the conversion of 4-iodo-*m*-xylene to 2,2′,4,4′-tetramethylbiphenyl, m.p. 40–41° from methanol; lit.[21] m.p. 41°, b.p. 288° (722 mm.).

Acknowledgment. We gratefully acknowledge support of this work by the National Science Foundation.

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[15] A. Krüger, *Ber.*, **18**, 1755 (1885).

[16] Performed by F. J. Donat.

[17] F. Kunckell, *Ber.*, **41**, 2648 (1908).

[18] O. Jacobsen, *Ber.*, **18**, 1760 (1885).

[19] H. S. King and M. K. Merriam, *Proc. Nova Scotian Inst. Sci.*, **18**, 276 (1933–1934), *Chem. Abstr.*, **29**, 6214 (1935).

[20] R. L. Datta and N. R. Chatterjee, *J. Am. Chem. Soc.*, **39**, 435 (1917).

[21] F. Ullmann and G. M. Meyer, *Ann.*, **332**, 40 (1904).

[22] K. von Auwers and A. Frühling, *Ann.*, **422**, 160 (1921).

[23] E. C. Kleiderer and R. Adams, *J. Am. Chem. Soc.*, **55**, 4219 (1933).

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF KENTUCKY]

Reactions of Some Organic Compounds with Cupric Bromide

ARTHUR W. FORT

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The reactions of isophorone, 3,4,5-trimethylanisole, 5,5-dimethylcyclohexane-1,3-dione and β-naphthol with cupric bromide in methanol or methanol-water are described.

The chlorination of acetone by cupric chloride has been described by Kochi,[1] who mentioned also the reactions of diethyl ketone and acetophenone with cupric chloride. That reactions of cupric halides with other active-hydrogen compounds might be unusual and have synthetic application seemed to be an attractive possibility, and experiments have been carried out using isophorone (I), 3,4,5-trimethylanisole (II), β-naphthol (III), and 5,5-dimethylcyclohexane-1,3-dione (IV) as active-hydrogen compounds.

Preliminary experiments with I in methanol showed that cupric bromide was a more active oxidizing agent than cupric chloride, and further work was limited to use of cupric bromide. All reactions reported below were carried out either in methanol or methanol-water.

Isophorone (I) reacted fairly slowly with cupric

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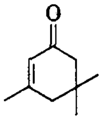
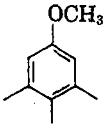
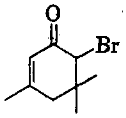
[1] J. K. Kochi, *J. Am. Chem. Soc.*, **77**, 5274 (1955).

bromide in methanol at room temperature, and I was still present in the reaction mixture after a period of three days, as shown by isolation of its 2,4-dinitrophenylhydrazone derivative. After removal of unchanged I by oxidation with permanganate, distillation gave a 38% yield of 3,4,5-trimethylanisole (II), identified by its physical properties, by the melting point of its bromo derivative, and by comparison of its infrared spectrum with that of an authentic sample.

The reaction of isophorone with cupric bromide probably leads to 6-bromoisophorone (VI) as first-formed product, along with hydrogen bromide and cuprous bromide.[1] VI would be unstable in the presence of hydrogen bromide and, in methanol, would be expected to give II by analogy with the corresponding reaction of 6-tosyloxyisophorone.[2] Small amounts of other products were also obtained, but of these, only 2-bromo-3,4,5-trimethylanisole (V) was identified completely.


I


II


VI

The isolation of V from the above reaction suggested that cupric bromide is an efficient brominating agent in spite of the incompleteness of its reaction with I. Such was found to be the case by the conversion of II into its monobromo derivative (V) in good yield by reaction with cupric bromide in boiling methanol.

β-Naphthol (III) reacted readily with cupric bromide in methanol-water. Potassium bromide served to keep cuprous bromide in solution, and the organic products were easily collected by filtration. III was converted partly into highly colored, gummy material, and 1-bromo-2-naphthol was obtained in only 50% yield.

The reaction of 5,5-dimethylcyclohexane-1,3-dione (IV) with cupric bromide in methanol-water–potassium bromide proceeded readily, giving 2-bromo-5,5-dimethylcyclohexane-1,3-dione in good yield.

The products obtained in the reactions of II, III, and IV with cupric bromide are the same as those obtained by bromination with molecular bromine.

EXPERIMENTAL

All melting points reported are corrected. Microanalyses are by Drs. Weiler and Strauss, Oxford, England.

Cupric bromide with isophorone (I). I[2] (27.6 g., 0.200 mole) was added with cooling to a stirred solution of 98 g. (0.44 mole) of cupric bromide in 250 ml. of dry methanol and the mixture was allowed to stand at room temperature for 3 days. Methanol (150 ml.) was removed by distillation, ether (100 ml.) and hexane (100 ml.) were added, the mixture was made alkaline by addition of sodium hydroxide pellets, then filtered, and the filter cake was washed with 800 ml. of hexane-ether. The combined filtrates were washed with water, solvent was removed by distillation, and the residue was treated with potassium permanganate in acetone-water to oxidize unchanged I. The oxidation mixture was filtered, acetone was removed by distillation, and the aqueous mixture was extracted with hexane. The hexane solution was washed with dilute sodium carbonate solution, then with water, and dried. Hexane was removed by evaporation and the residue was distilled under reduced pressure to give 11.5 g. (38%) of 3,4,5-trimethylanisole (II), b.p. 98.5–100° (10 mm.), m.p. 20–26.5°, infrared spectrum like that of authentic II[2]; 2.0 g., b.p. 92–115° (4 mm.), which was not identified; and 6.5 g. of viscous pot residue from which 1.8 g. (6%) of an unidentified aromatic compound, $C_{20}H_{26}O_2$, was obtained by crystallization from hexane, m.p. 115–116° after recrystallization from acetone.

Anal. Calcd. for $C_{20}H_{26}O_2$: C, 80.49; H, 8.78; mol. wt., 298. Found: C, 80.17; H, 8.66; mol. wt., 246.

A *dibromo derivative* of the compound m.p. 115–116° was obtained with bromine in warm acetic acid, m.p. 175°.

Anal. Calcd. for $C_{20}H_{24}O_2Br_2$: C, 52.65; H, 5.30. Found: C, 52.53; H, 5.50.

In another experiment steam distillation was used to separate organic products from cuprous bromide. In this experiment none of the product, m.p. 115–116°, was obtained, but a small amount of 2-bromo-3,4,5-trimethylanisole (V) was isolated from the pot residue of fractional distillation, m.p. 79.5–80.5° after two recrystallizations from hexane, m.p. not depressed by admixture with authentic V.[2]

The crude 3,4,5-trimethylanisole (II), above, was purified by fractional crystallization. Fractions melting above 22° were combined and further purified by adsorption on activated alumina and elution with hexane. Distillation gave 6.7 g., b.p. 102–102.5° (11 mm.), m.p. 26–28° (lit.[3] m.p. 28–29°), n_D^{24} 1.5221. Lower melting fractions were combined and also purified by chromatography on alumina. Distillation gave 2.7 g., b.p. 103–104° (13 mm.). This material was completely melted by 22°, but its infrared spectrum was almost identical with that of authentic II. The lowest melting fraction was treated like those above. Distillation gave 0.2 g., b.p. 94° (7 mm.), infrared spectrum like that of authentic II except for a strong peak at 8.98 μ and weak peaks at 10.90, 11.23, and 13.0 μ, all of which are found in the spectrum of 2,3,5-trimethylanisole.[2]

Cupric bromide with 3,4,5-trimethylanisole (II). A solution of 7.50 g. (0.050 mole) of II and 22.3 g. (0.100 mole) of cupric bromide in 50 ml. of methanol was boiled under reflux for 20 hr. Methanol (25 ml.) was removed by distillation and the residue was steam distilled until 7.5 l. of distillate was collected. Filtration of the distillate gave 10.3 g. of pale yellow crystalline product. Two recrystallizations from methanol gave 9.02 g. (79%) of 2-bromo-3,4,5-trimethylanisole, m.p. 79.5–80.5°.

Cupric bromide with β-naphthol (III). A solution of 28.8 g. (0.200 mole) of III in 100 ml. of methanol was mixed with a solution of 90 g. (0.40 mole) of cupric bromide and 60 g. (0.50 mole) of potassium bromide in 200 ml. of 50% methanol-water. The reaction mixture was allowed to stand for 15 hr. with occasional swirling, then boiled for 15 min., diluted with 200 ml. of saturated potassium bromide solution, and cooled. The highly colored crude product was collected by filtration and sublimed at atmospheric pressure to give 22.3 g. (50%) of 1-bromo-2-naphthol, m.p. 83° (lit.[4] m.p. 83°). The acetate was recrystallized from methanol, m.p. 56–57° (lit.[4] m.p. 55–56°).

Cupric bromide with 5,5-dimethylcyclohexane-1,3-dione (IV). A solution of 28.0 g. (0.200 mole) of IV in 200 ml. of methanol was mixed with a solution of 94 g. (0.42 mole)

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(2) A. W. Fort, *J. Org. Chem.*, **26**, 332 (1961).

(3) K. v. Auwers, *Ann.*, **422**, 160 (1921).

(4) S. E. Hazlet, *J. Am. Chem. Soc.*, **62**, 2156 (1940).

of cupric bromide and 60 g. (0.50 mole) of potassium bromide in 200 ml. of water and the mixture was allowed to stand at room temperature for 65 hr. The crystalline product was collected by filtration, washed with concd. potassium bromide solution, and recrystallized from methanol-water to give 37.1 g. (85%) of 2-bromo-5,5-dimethylcyclohexane-1,3-dione (VII), m.p. 177–178°. The melting point was not depressed by admixture with VII prepared by the procedure of Vorländer.[5]

Acknowledgment. Financial support of this work from the Faculty Research Fund of the University of Kentucky is gratefully acknowledged.

LEXINGTON, KY.

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[5] D. Vorländer and M. Kohlmann, *Ann.*, **322**, 239 (1902).

[CONTRIBUTION FROM THE ROHM AND HAAS CO.]

Reactions of *N*-Alkylazomethines and Enamines with Isocyanates and Isothiocyanates

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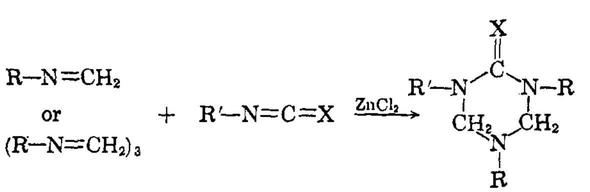
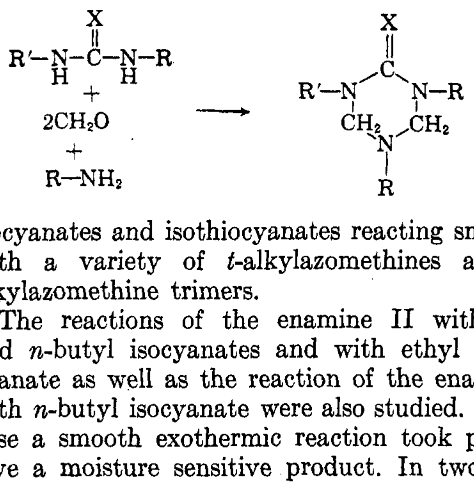
Isocyanates and isothiocyanates react with azomethines to yield triazones and thiotriazones and with enamines to produce substituted ureas.

The electrophilic character of isocyanates and isothiocyanates, as indicated by their ready reaction with a variety of electron rich species, is well known.[1] Enamines have been shown by Stork, *et al.*[2] to react by nucleophilic attack of their β-vinyl carbon atom upon some electrophilic substrate, the facile alkylation of the enamine II with methyl iodide being an excellent example of this situation. The nucleophilic nature of imines is also well known. These facts, coupled with our knowledge of the zinc chloride catalyzed reaction of ketene with *N-t*-alkylazomethines[3] have lead us to study the reactions of *N*-alkylazomethines and enamines with isocyanates and isothiocyanates.

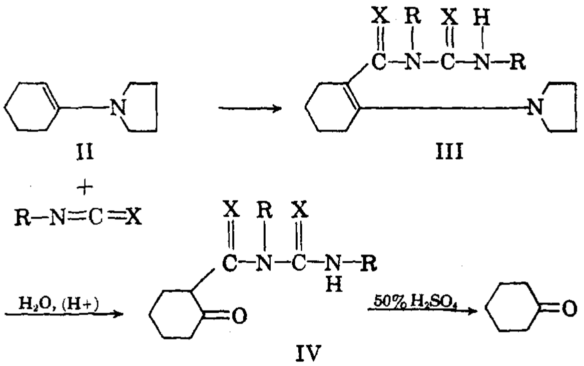
Isocyanates and isothiocyanates react smoothly with a variety of *N*-alkylazomethines to produce triazones or thiotriazones of the general structure, I. The physical properties and analytical data for the compounds are listed in Table I. The structure of two representatives of the series, If and Ii, was confirmed by independent synthesis from the corresponding urea or thiourea, formaldehyde, and the appropriate primary amine. The reaction is seen to be quite general with phenyl isocyanate (see Ig) and cyanic acid (see Ia) as well as alkyl isocyanates and isothiocyanates reacting smoothly with a variety of *t*-alkylazomethines and *N*-alkylazomethine trimers.

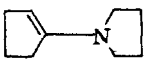


I



The reactions of the enamine II with ethyl and *n*-butyl isocyanates and with ethyl isothiocyanate as well as the reaction of the enamine V with *n*-butyl isocyanate were also studied. In each case a smooth exothermic reaction took place to give a moisture sensitive product. In two cases, (III, $R = —C_2H_5$, $X = O$; $R = —C_2H_5$, $X = S$), the products were solids and could be isolated and characterized. Analysis and neutral equivalent were in agreement with the proposed structures. All products of the type III were very readily hy-





V

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[1] R. G. Arnold, J. A. Nelson, and J. J. Verbanc, *Chem. Revs.*, **57**, 47 (1957).

[2] G. Stork, R. Terrell, and J. Szmuszkovitz, *J. Am. Chem. Soc.*, **76**, 2029 (1954).

[3] D. H. Clemens and W. D. Emmons, *J. Org. Chem.*, **26**, 949 (1961).