hydride in 300 ml. of absolute ether during one hour. After refluxing overnight, the reaction mixture was cooled and hydrolyzed with water and 10% sulfuric acid. Alumina was precipitated with lithium carbonate as described previously, and the picrate of N-methyl-3,4,5-trimethoxybenzylamine crystallized from the filtrate after addition of a hot alcoholic solution of 10 g. of picric acid; yield, 15.0 g. (95%); m.p. 181–182°, after recrystallization from ethanol.

Anal. Calc'd for $C_{17}H_{20}N_4O_{10}$: C, 45.9; H, 4.5. Found: C, 46.0; H, 4.6.

The *hydrochloride* of N-methyl-3,4,5-trimethoxybenzylamine, obtained in 89% yield by decomposition of the picrate with HCl, melted at 178–179° (reported[7] m.p. 178°).

γ-(3,4,5-Trimethoxyphenyl)propylamine. Following the route of Slotta and Heller,[8] 3,4,5-trimethoxybenzaldehyde was condensed with malonic acid in the presence of pyridine and piperidine to obtain 3,4,5-trimethoxycinnamic acid, m.p. 124–125°, (reported[8] m.p. 124°) in 76% yield. Reduction with 2% sodium amalgam resulted in a 75% yield of β-(3,4,5-trimethoxyphenyl)propionic acid, m.p. 100–101°, after recrystallization from benzene-ligroin (reported[8] m.p. 98°). Conversion to the amide by refluxing a chloroform solution of the acid with purified thionyl chloride, removal of solvent under reduced pressure, and treatment of the residue with excess ammonium hydroxide gave a product melting at 108–109°, unchanged after several recrystallizations from benzene-ligroin. Slotta and Heller report a melting point of 171° for this compound.[8] Analysis of a specimen of the substance melting at 108–109° verified the structure assigned.

Anal. Calc'd for $C_{12}H_{17}NO_4$: C, 60.3; H, 7.1; N, 5.9. Found: C, 60.1; H, 7.3; N, 5.9. Reduction of 8.4 g. of β-(3,4,5-trimethoxyphenyl)propionamide with a solution of 3 g. of lithium aluminum hydride in 250 ml. of absolute ether was carried out by the Soxhlet addition method. Treatment of the reaction mixture as previously described gave 12.7 g. (80%) of the picrate of γ-(3,4,5-trimethoxyphenyl)propylamine, m.p. 216–217°, after recrystallization from ethanol-acetic acid.

Anal. Calc'd for $C_{18}H_{22}N_4O_{10}$: C, 47.6; H, 4.9. Found: C, 47.8; H, 5.0.

Decomposition of the picrate with boiling dilute hydrochloric acid, removal of picric acid, and evaporation gave 5.8 g. (89%) of *γ-(3,4,5-trimethoxyphenyl)propylamine hydrochloride*, m.p. 180–181°, after recrystallization from methanol-ethyl acetate.

Anal. Calc'd for $C_{12}H_{20}ClNO_3$: Cl, 13.6; N, 5.4. Found: Cl, 13.4; N, 5.4.

γ-(3,4-Dimethoxyphenyl)propylamine. β-(3,4-Dimethoxyphenyl)propionamide,[12] m.p. 121–122°, (10.5 g.) was added by the Soxhlet extraction method to a solution of 3.8 g. of lithium aluminum hydride in 250 ml. of absolute ether. Treatment of the reaction mixture as described above resulted in a yield of 18.1 g. (85%) of γ-(3,4-dimethoxyphenyl)-propylamine picrate, m.p. 145–146°, after recrystallization from ethanol.

Anal. Calc'd for $C_{17}H_{20}N_4O_9$: C, 48.1; H, 4.7. Found: C, 47.9; H, 4.6.

The *hydrochloride* of γ-(3,4-dimethoxyphenyl)propylamine was obtained in 83% yield by decomposition of the picrate with HCl; m.p. 166–167°, after recrystallization from methanol-ethyl acetate-ether.

Anal. Calc'd for $C_{11}H_{18}ClNO_2$: Cl, 15.3; N, 6.1. Found: Cl, 15.1; N, 6.0.

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[12] Pictet and Finkelstein, *Ber.*, **42**, 1979 (1909).

The Peroxide Induced Reaction of Amines with Carbonyl Sulfide

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Carbonyl sulfide and a strongly basic aliphatic amine react in the cold easily to form the amine thiocarbamate salt, which on heating gives a 1,3-disubstituted symmetrical urea. Apparently the urea formation arises from the reaction of the isocyanate and amine which are formed, in addition to H_2S, by the thermal decomposition of the alkylammonium thiocarbamate.[3,4]

Weakly basic aromatic amines with carbonyl sulfide, at elevated temperatures or under the influence of ultraviolet irradiation, gave exceedingly poor yields of 1,3-diarylureas.[3] Aromatic amines are similarly sluggish in their reactions with carbon disulfide and it was found convenient to speed up the reaction in this case by the addition of dilute aqueous hydrogen peroxide.[5]

This study has extended the effect of peroxides to the reaction of amines with carbonyl sulfide and the results are listed in Table I.

Some findings are worthy of mention. As expected, by analogy to the reaction of amines with carbon disulfide, elemental sulfur was produced. In the case of the 1,3-dialkylureas the products had to be purified by recrystallization until they were sulfur free. With the 1,3-diarylureas the sulfur could be conveniently removed by boiling the mixture in an alkaline solution of sodium sulfide, in which the urea was stable and the sulfur soluble. The sulfur produced corresponded approximately to the molar quantity of urea formed. In experiments where aniline was omitted only a trace amount of sulfur was produced by the action of hydrogen peroxide on carbonyl sulfide, but adding bases increased sulfur formation.

If the hydrogen peroxide was doubled or halved with respect to the aniline concentration the yield of 1,3-diphenylurea was lowered by some 10%, with no appreciable difference in the amount of elemental sulfur isolated. When the hydrogen peroxide concentration was lowered even further, the yields then began to drop sharply.

Where the amines used had a vicinal hydroxy or amino group, there formed the corresponding cyclic products.

When aniline and carbonyl sulfide in methanol are treated either with zinc peroxide, di-*tert*-butyl

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[3] Hagelloch, *Ber.*, **83**, 258 (1950).

[4] Freund and Asbrand, *Ann.*, **285**, 173 (1895).

[5] Hünig, Lehmann, and Grimmer, *Ann.*, **579**, 77 (1953).

TABLE I

PEROXIDE INFLUENCED REACTION OF AMINES WITH CARBONYL SULFIDE[a]

Amine Used	Peroxide Used	Solvent Used	Time (hours)	Temp., °C.	Product	Yield, %
Aniline	H_2O_2	H_2O	24	25	1,3-Diphenylurea	70
	CH[b]	CH_3OH	72	5		80[c]
	DPB[d]	CH_3OH	24	25		0
p-Methoxyaniline	H_2O_2	H_2O	72	25	1,3-Di-*p*-methoxyphenylurea	88
p-Chloroaniline	H_2O_2	H_2O	72	25	1,3-Di-*p*-chlorophenylurea	14
p-Nitroaniline	H_2O_2	H_2O	72	25	No product	0
	H_2O_2	CH_3OH	120	25		0
	CH[b]	CH_3OH	120	25		0
Benzylamine	CH[b]	CH_3OH	96	5	1,3-Dibenzylurea	89
	H_2O_2	H_2O	24	25		75
n-Hexylamine	H_2O_2	H_2O	48	25[f]	1,3-Di-*n*-hexylurea	66
n-Decylamine	H_2O_2	H_2O/CH_3OH	48	5	1,3-Di-*n*-decylurea	76
2-Aminoethanol	CH[b]	CH_3OH	96	25	2-Oxazolidinone	23
Ethylenediamine	H_2O_2	H_2O	120	25	2-Imidazolidinone	6
1,2-Propanediamine	H_2O_2	H_2O	120	25	4-Methyl-2-imidazolidinone	94
p-Aminophenol	H_2O_2	CH_3OH	24	5	1,3-Di-*p*-hydroxyphenylurea	32
2,4,6-Trichloroaniline	H_2O_2	CH_3OH	96	25	No product	0
o-Phenylenediamine[e]	H_2O_2	CH_3OH	96	25	2-Benzimidazolol	82
2-Aminodiphenyl	H_2O_2	CH_3OH	96	25	No product	0
1-Naphthylamine	CH[b]	CH_3OH	96	25	1,3-Di-1-naphthylurea	42
2-Naphthylamine	H_2O_2	H_2O	96	25	1,3-Di-2-naphthylurea	17
	CH[b]	CH_3OH	96	25		92
o-Aminophenol	CH[b]	CH_3OH	96	25	2-Benzoxazolol	89

[a] All these reactions were run essentially as described for the formation of 1,3-diphenylurea for the aromatic amines and 1,3-dibenzylurea for the aliphatic amines. The products were identified by comparison with separately synthesized authentic specimens. [b] Cumene hydroperoxide. [c] Yield in this case based on the addition of a sodium methoxide in a molar equivalent quantity to the amine. Without the sodium methoxide, the yield after 96 hours was only 46%. [d] Dibenzoyl peroxide. [e] Reference 1 reports a 29% yield of benzimidazolone-2 by heating *o*-phenylenediamine with carbonyl sulfide at 225° for 11 hours. [f] When this reaction was run at 5° the yield of 1,3-di-*n*-hexylurea was only 43%.

peroxide, or oxygen at 150° a 27–30% yield, based on the aniline used, of methyl phenylcarbamate was isolated. Magnesium peroxide failed to induce reaction. If the urethan arises from methanolysis of 1,3-diphenylurea, then the yields are good. However, this same reaction in benzene, using di-*tert*-butyl peroxide, afforded only a 33% yield of 1,3-diphenylurea.

EXPERIMENTAL

1,3-Diphenylurea. A suspension of 9.3 g. of aniline in 150 ml. of water containing 10 ml. of 30% hydrogen peroxide was prepared in a 2-l. heavy walled suction flask. The flask was evacuated and carbonyl sulfide then was introduced until a reading of 5 lbs. was retained on the cylinder gauge; a snug fitting rubber stopper was sufficient to hold this pressure. The inlet tube was clamped and the reaction mixture permitted to stand for 24 hours at room temperature. The solid material which deposited was collected and dried; yield 9.0 g.; m.p. 231–232°.

To remove the accompanying sulfur, the product was suspended for two minutes in a boiling solution prepared from 7 g. of sodium sulfide and 7 g. of sodium hydroxide in 50 ml. of H_2O. After cooling and filtering, the product was washed with 100 ml. of cold water; yield 7.5 g. (70%); m.p. 235–236° alone and when mixed with an authentic analytical sample. After concentration and oxidation of the original filtrate, there was obtained another 0.1 g. of sulfur in the form of sulfate.

1,3-Dibenzylurea. A solution of 10.7 g. of benzylamine in 150 ml. of methanol, containing 15.2 g. of cumene hydroperoxide in a 2-l. flask was charged with 5 lb. of carbonyl sulfide as described above and maintained at 5° for 96 hours. Upon collecting and recrystallizing from benzene there was obtained 10.7 g. (89%) of 1,3-dibenzylurea; m.p. 170–171° alone and mixed with an authentic specimen.

Methyl phenylcarbamate. A 1-l. Magne Dash Autoclave was charged with 9.3 g. of aniline, 15 g. of zinc peroxide, 150 ml. of methanol, and 25 lbs. of carbonyl sulfide. The mixture was stirred and heated to 150° for five hours. The reaction mixture was cooled and filtered, the filtrate evaporated to an oily residue, and the residue taken up in benzene. The benzene layer was first extracted twice with dilute aqueous hydrochloric acid, then treated with Norit and filtered, and finally evaporated to dryness; yield 5.1 g. (33%); m.p. 49–50°. Recrystallization from Skelly B provided white needles, m.p. 50–51° alone and when mixed with the authentic material.

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The Direct Conversion of Steroidal Δ^5-3β-Alcohols to Δ^5- and Δ^4-3-Ketones

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The conversion of a Δ^5-3β-alcohol (I) to the corresponding Δ^4-3-ketone (V) is an extremely important reaction in steroid chemistry and represents