The methoxybenzocoumarins were also prepared according to the same procedure, except that they were precipitated from their ethanol solution by means of water, and were recrystallized from ethanol or benzene.

3′,4′-Trimethylenecoumarino(7′,8′-4,3)brasan-5,10-quinone (XIII). To a solution of 1.5 g. of 2′-hydroxy-3,4-trimethylene-7,8-benzocoumarin in 100 ml. of dry pyridine, 1.4 g. of 2,3-dichloro-1,4-naphthoquinone was added, and the mixture was refluxed for 30 minutes. After cooling, the brown precipitate was collected, washed first with ethanol then with water, dried, and recrystallized from nitrobenzene, giving brown-red sublimable needles (70–75% yield) which did not melt below 360°, and gave a deep violet halochromy in sulfuric acid.

Anal. Calc'd for $C_{26}H_{14}O_5$: C, 76.8; H, 3.5. Found: C, 76.5; H, 3.2.

3′,4′ - Tetramethylenecoumarino(7′,8′ - 4,3)brasan - 5,10 quinone, similarly prepared from 2′-hydroxy-3,4-tetramethylene-7,8-benzocoumarin, crystallized from nitrobenzene in brown-red sublimable needles, m.p. above 360°, giving a deep violet halochromy in sulfuric acid.

Anal. Calc'd for $C_{27}H_{16}O_5$: C, 77.1; H, 3.8. Found: C, 76.8; H, 3.6.

3′,4′-Trimethylenecoumarino(7′,8′-3,4)brasan-5,10-quinone crystallized from nitrobenzene in dark brown needles, which sublimed to brown-red microcrystals, m.p. above 360°. The coloration in sulfuric acid was likewise a deep violet.

Anal. Calc'd for $C_{26}H_{14}O_5$: C, 76.8; H, 3.5. Found: C, 76.6; H, 3.2.

3′,4′-Trimethylenecoumarino(7′,8′-1,2)brasan-5,10-quinone (XIV). This compound crystallized from nitrobenzene in brown needles, m.p. above 360°; its brown-violet halochromy in sulfuric acid was markedly different from that of the above quinones.

Anal. Calc'd for $C_{26}H_{14}O_5$: C, 76.8; H, 3.5. Found: C, 76.7; H, 3.3.

Ethyl α-Δ²-cyclopentenylacetoacetate (XII). This compound, prepared in 40% yield from the hydrogen chloride adduct with cyclopentadiene, and the sodio derivative of ethyl acetoacetate in toluene medium, was a pale yellow liquid, b.p. 125–126°/13 mm., n_D^{24} 1.4653.

Anal. Calc'd for $C_{11}H_{16}O_3$: C, 67.3; H, 8.2. Found: C, 67.0; H, 8.5.

A cooled solution of 1.5 g. of 1,5-dihydroxynaphthalene and 2 g. of this keto ester in 100 ml. of acetic acid was saturated with hydrogen chloride, and left to stand for 24 hours at room temperature. On dilution with water, 1,5-dihydroxynaphthalene was recovered unchanged. The use of sulfuric acid as condensing agent was also unsuccessful. Ethyl 1-keto-1,2,3,4-tetrahydronaphthalene-2-carboxylate likewise failed to react.

1,3-Dimethoxynaphthalene. This compound (6 g.), prepared from 8 g. of 1,3-dihydroxynaphthalene, 60 ml. of 10% aqueous potassium hydroxide, and 15 g. of dimethyl sulfate, was a pale yellow, viscous oil, b.p. 172–173°/12 mm.

Anal. Calc'd for $C_{12}H_{12}O_2$: C, 76.6; H, 6.4. Found: C, 76.7; H, 6.4.

The *picrate* crystallized from ethanol in brown-red needles, m.p. 141°.

Anal. Calc'd for $C_{18}H_{15}N_3O_9$: C, 51.8; H, 3.6. Found: C, 51.8; H, 3.3.

2,4-Dimethoxy-1-naphthaldehyde. A mixture of 5.5 g. of 1,3-dimethoxynaphthalene, 2.8 g. of dimethylformamide, 5.1 g. of phosphorus oxychloride, and 5 ml. of dry toluene was heated for 3 hours on a boiling water-bath. A saturated aqueous solution of sodium hydroxide was added, and the mixture was refluxed for 30 minutes. The reaction product was taken up in toluene, and the toluene solution was washed with hydrochloric acid, then with water, dried over sodium sulfate, the solvent removed, and the residue vacuum-fractionated. Yield, 2.8 g. of an aldehyde, b.p. 215–235°/13 mm., crystallizing from ethanol in shiny, colorless needles, m.p. 165°, giving a yellow coloration in sulfuric acid.

Anal. Calc'd for $C_{13}H_{12}O_3$: C, 72.2; H, 5.6. Found: C, 71.9; H, 5.2.

The corresponding thiosemicarbazone crystallized from ethanol in pale yellow needles, m.p. 220° (decomp. above 206°).

1-Phenyl-2-(2,4-dimethoxy-1-naphthyl)acrylonitrile (XV). A solution of equimolar amounts of the foregoing aldehyde and benzyl cyanide in warm ethanol was shaken with a few drops of 20% aqueous sodium hydroxide. After addition of water, the precipitate formed was recrystallized from ethanol, giving pale yellow needles, m.p. 151°.

Anal. Calc'd for $C_{21}H_{17}NO_2$: C, 80.0; H, 5.4. Found: C, 80.1; H, 5.6.

7-Hydroxy-3-phenyl-5,6-benzocoumarin (XVI). A mixture of one part of the foregoing nitrile and five parts of redistilled pyridine hydrochloride was refluxed for 10 minutes. Water was added, and the precipitate which formed was recrystallized from benzene, giving pale yellow needles, m.p. 289°, soluble in aqueous sodium hydroxide to give green solutions.

Anal. Calc'd for $C_{19}H_{12}O_3$: C, 79.2; H, 4.2. Found: C, 793.; H, 4.1.

DEPARTMENT OF ORGANIC CHEMISTRY
RADIUM INSTITUTE
UNIVERSITY OF PARIS
PARIS Vᵉ, FRANCE

D-Bis-(p-dimethylaminoisopropylphenyl)-carbodiimide

W. GRUBER AND I. C. GUNSALUS

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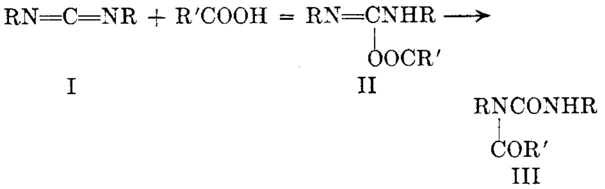
In general, carbodiimides react with carboxylic acids in two ways:[1]

(1) attachment of a proton followed by the attack of the acid anion to form acylurea III:



$$\underset{\text{I}}{RN{=}C{=}NR} + R'COOH = \underset{\text{II}}{\underset{\displaystyle OOCR'}{RN{=}\underset{|}{C}NHR}} \longrightarrow \underset{\text{III}}{\underset{\displaystyle COR'}{R\underset{|}{N}CONHR}}$$

(2) formation of the urea IV and the acid anhydride:

$$I + 2R'COOH = \underset{\text{IV}}{RNHCONHR} + (R'CO)_2O$$

The product depends not only on the structure of both reactants but also on the solvent and the temperature. From a study of a large number of carbodiimides, bis - (*p* - dimethylaminophenyl)carbodiimide (V) and bis-(*p*-tolyl)carbodiimide (VI) have been found to react almost exclusively according to (1) and are therefore suggested as the most suitable reagents for the characterization of carboxylic acids.[2]

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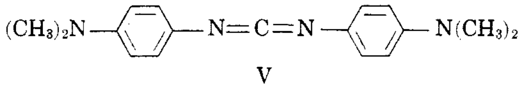
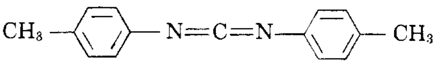
[1] H. G. Khorana, *Chem. Revs.*, **53**, 145 (1953).

[2] F. Zetzsche and A. Fredrich, *Ber.*, **73**, 1114 (1940).



V

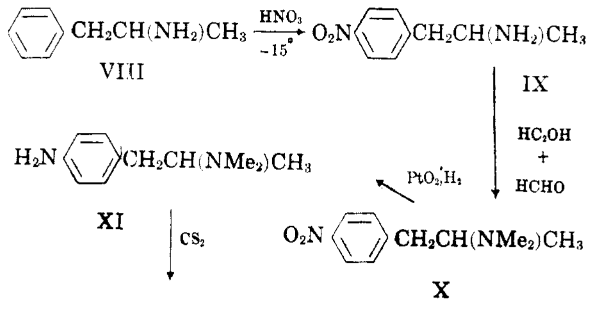


VI

In a previous investigation,[3] the "basic" carbodiimide V was used for the characterization of lipoic acid and some of its derivatives. To study further the reactions of carbodiimides with carboxylic acids, we prepared the optically active compound (XIII) which is, to our knowledge, the first synthesis of an asymmetric diarylcarbodiimide.

Several optically active carbodiimides, *e.g.*, bis-L-menthylcarbodiimide, have been prepared, but their study has shown them to react predominantly according to (2). Analysis of the structures of these substances and of V and VI suggested to us a basic structure for an optically active carbodiimide which is to combine with an organic acid according to (1), namely, a substituted diphenylcarbodiimide, the asymmetric center being located in the side-chain. That this basic structure, represented by XIII, still reacted according to scheme (2) demonstrates the need for more thorough studies of carbodiimides.

In preparing a substituted diphenylcarbodiimide, we started with D-1-phenyl-2-propylamine, commercially available as dexedrine (VIII), since neither 1-(4-nitrophenyl)-1-(N,N-diethylamino)ethane nor 1-(4-aminophenyl)-1-(N,N-diethylamino)ethane (VII) could be resolved. The nuclear nitration was carried out according to[4]; the mixture of nitrobases was fractionated *in vacuo* through a short column and the *p*-isomer was further purified by recrystallization of the hydrochlorides from ethanol:



XII $S{=}C{=}[NHC_6H_4CH_2CH(NMe_2)CH_3]_2 \xrightarrow{HgO}$

$C{=}[NC_6H_4CH_2CH(NMe_2)CH_3]_2$
XIII

XIV $O{=}C{=}[NHC_6H_4CH_2CH(NMe_2)CH_3]_2$

The carbodiimide (XIII) is an oil, sensitive to moisture by which it is transformed to the urea (XIV); it can be distilled under a pressure of 0.010 mm. in small portions without racemization. Infrared analysis shows a strong band at 2132 cm.$^{-1}$ indicative of the N=C=N grouping. Compound XIII reacts with anhydrous oxalic acid in dry dioxane to form the disubstituted urea (XIV) and a mixture of carbon monoxide and carbon dioxide. With an excess of organic acids in different solvents exclusive formation of the urea (XIV) occurs. Thus, D-bis-(*p*-dimethylaminoisopropylphenyl)carbodiimide falls into that class of carbodiimides which react according to scheme (2) and therefore it is not useful in making derivatives of organic acids.

EXPERIMENTAL

Melting points were taken on the Kofler apparatus and are therefore corrected; analyses by Clark's Microanalytical Lab., Urbana, Ill.

1-(4-Nitrophenyl)-1-(N,N-diethylamino)ethane. 1-(4-Nitrophenyl)-1-bromoethane[5] (16.2 g.) and diethylamine (15 ml.) were heated in a sealed tube in a steam cone for 3 hours. The reaction mixture was taken up in 1 *N* hydrochloric acid and extracted with ether; the aqueous layer was made strongly alkaline and the amine was extracted into ether. The base was purified by distillation *in vacuo:* b.p. (0.4 mm.) 107–109°, yield 11.1 g. or 84%; *picrate* (from methanol): m.p. 152–154°.

Anal. Calc'd for $C_{18}H_{21}N_5O_9$: N, 15.52. Found: N, 15.46.

1-(4-Aminophenyl)-1-(N,N-diethylamino)ethane. Reduction was achieved by refluxing the nitro compound (5.0 g.) with granular tin (5 g.) and 5 *N* hydrochloric acid (400 ml.) for 2 hours. The solution was made strongly alkaline; the amine was collected in ether and purified by distillation *in vacuo.* B.p. (0.4 mm.) 89–91°, yield, 4.1 g. (95%).

Anal. Calc'd for $C_{12}H_{20}N_2$: N, 14.57. Found: N, 14.28.

1-(4-Nitrophenyl)-2-aminopropane (IX). Dexedrine (60.0 g., $[\alpha]^{20}_{D}$ +34.2°) was nitrated as described.[4] The mixture of nitrobases was fractionated (0.2 mm.) through a Vigreux column (7.5″). Fraction A: 90–95°, 19.2 g.; fraction B: 95–98°, 5.0 g.; fraction C: 98–105°, 53.0 g. Each of these fractions was converted into its hydrochloride by dissolving the substance in absolute ethanol, saturating the solution with dry hydrogen chloride at 0°, and precipitating the salt by addition of absolute ether. By repeated recrystallization from absolute ethanol a total amount of 48.8 g. (51%) of the *p*-isomer hydrochloride was obtained: m.p. 197–199°, $[\alpha]^{20}_{D}$ +22.0° (*c*, 1.218, water). Further recrystallization did not change the rotation.

Anal. Calc'd for $C_9H_{13}ClN_2O_2$: Cl, 16.36. Found: Cl, 16.25.

The free base was prepared by extracting an alkaline solution of the foregoing hydrochloride with ether and was purified by vacuum-distillation: b.p. (0.5 mm.) 113–114°, $[\alpha]^{20}_{D}$ +31.4° (*c*, 4.700, methanol), yield 39.0 g. Permanganate oxidation of a sample yielded *p*-nitrobenzoic acid. The hydrochloride and picrate are unsuitable for the isolation of the *o*-isomer from the mother liquor of the *para* compound.

1-(4-Nitrophenyl)-2-(N,N-dimethylamino)propane (X). A mixture of 38.0 g. of IX, 100 ml. of formic acid, and 90 ml. of 35% formaldehyde solution was gently refluxed overnight and then was evaporated to dryness under reduced pressure. The residue was taken up in water, made alkaline, and extracted with ether. The dimethylamino compound was

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[3] I. C. Gunsalus, Lois S. Barton, and W. Gruber, *J. Am. Chem. Soc.*, **78**, 1763 (1956).

[4] T. M. Patrick, Jr., E. T. McBee, and H. B. Hass, *J. Am. Chem. Soc.*, **68**, 1153 (1946).

[5] H. B. Hass and M. L. Bender, *J. Am. Chem. Soc.*, **71**, 3482 (1949).

finally distilled *in vacuo:* b.p. (0.5 mm.) 117–119°, yield 39.0 g. (89%). This base was also converted into its *hydrochloride* which was recrystallized from absolute ethanol-ether until its optical rotation was constant: m.p. 224–226°, $[\alpha]^{20}_{D}$ +7.8° (*c*, 2.536, water).

Anal. Calc'd for $C_{11}H_{17}ClN_2O_2$: C, 53.89; H, 7.00; Cl, 14.49. Found: C, 54.09; H, 7.15; Cl, 14.40.

The base was set free from a sample of this hydrochloride: $[\alpha]^{20}_{D}$ 0.0° (*c*, 6.510, methanol), *picrate* (from methanol), m.p. 131–133°, $[\alpha]^{20}_{D}$ +43.5° (*c*, 0.987, acetone).

Anal. Calc'd for $C_{17}H_{19}N_5O_9$: C, 46.68; H, 4.38; N, 16.01. Found: C, 46.77; H, 4.55; N, 16.17.

1-(4-Aminophenyl)-2-(N,N-dimethylamino)propane (XI). The nitro compound X (35.0 g.) was reduced catalytically with Adams' catalyst (1.4 g.) in methanol (1000 ml.): b.p. (0.3 mm.) 104–106° yield 27.0 g. (94%). Recrystallization of this amine was repeated until a constant optical rotation was reached (ether-hexane): m.p. 78–80°, $[\alpha]^{20}_{D}$ −13.8° (*c*, 1.210, methanol).

Anal. Calc'd for $C_{11}H_{18}N_2$: N, 15.72. Found: N, 15.62.

4,4'-Di-[2-(N,N-dimethylamino)-propyl-1]-thiocarbanilide (XII). A mixture of 25.0 g. of the amine (XI), carbon disulfide (80 ml.), and benzene (250 ml.) was refluxed for 24 hours and the yellow precipitate was collected on a Büchner funnel (filtrate A). A small portion of this xanthate was further purified for analysis by extracting it with cold acetone: m.p. 103–106°, insoluble in organic solvents, very soluble in water, yellow color reaction with Cu ions, unstable.

Anal. Cal'cd for $C_{23}H_{36}S_2N_4$: S, 14.82. Found: S, 14.49.

The suspension of the xanthate in benzene (500 ml.) was refluxed until the generation of H_2S ceased (3 days). Filtrate A was combined with the yellow benzene solution and then was evaporated to dryness under diminished pressure. After several recrystallizations (ether-hexane) the optical rotation was constant: m.p. 116–118°, $[\alpha]^{20}_{D}$ −16.4° (*c*, 0.750, methanol); yield, 18.0 g. (64%).

Anal. Calc'd for $C_{23}H_{34}N_4S$: N, 14.06; S, 8.02. Found: N, 13.93; S, 8.24.

Carbodiimide XIII. A mixture of XII (8.0 g.), yellow mercuric oxide (50 g.), and benzene was vigorously stirred and the azeotrope, benzene-water, was distilled off; fresh solvent was added from time to time. After 3 hours the mixture of mercuric sulfide and oxide was filtered and the filtrate was evaporated under reduced pressure. A considerable amount of urea (XIV) was present and was eliminated by repeated addition of hexane to an etheral solution of the mixture. The mother liquor was distilled in small portions, yielding 2.3 g. (31%) of a colorless oil: $[\alpha]^{20}_{D}$ −6.2° (*c*, 1.499, methanol).

Anal. Calc'd for $C_{23}H_{32}N_4$: C, 75.78; H, 8.85; N, 15.37. Found: C, 75.65; H, 8.80; N, 15.13.

Dipicrate (from methanol-acetone): m.p. 128–130°.

Anal. Calc'd for $C_{35}H_{38}N_{10}O_{14}$: N, 17.03. Found: N, 16.85.

The urea (XIV) was recrystallized from benzene-hexane until the optical rotation was constant: m.p. 181–183° (dimorphous, spontaneous transformation from plates to needles at 150–151°), $[\alpha]^{20}_{D}$ −6.7° (*c*, 1.128, methanol).

Anal. Calc'd for $C_{23}H_{34}N_4O$: C, 72.38; H, 8.96; N, 14.65. Found: C, 72.61; H, 8.80; N, 14.46.

A mixture of 191 mg. of XIII, 500 mg. of anhydrous oxalic acid, and 5 ml. of absolute dioxane was slowly warmed up to 80°. Evolution of gas bubbles, which apparently were a mixture of carbon monoxide and dioxide, took place. Carbon dioxide was shown to be present by precipitation of $BaCO_3$ from a solution of barium hydroxide. Addition of water to the reacted mixture gave a precipitate shown to be the urea XIV.

To a solution of 382 mg. of XIII in 5 ml. of acetone a solution of 194 mg. of glacial acetic acid in 5 ml. of ether was added. The precipitate formed (acetate of XIII) was redissolved by adding more acetone. After standing at room temperature for 3 days, the organic solvent was evaporated *in vacuo* at 30°, the residue was taken up in dilute sodium bicarbonate solution and benzene. In the benzene layer only the urea XIV was found. Similar results were obtained with caprylic, lipoic, and cinnamic acids in a variety of solvents.

Acknowledgment. We are greatly indebted to Dr. G. E. Ullyot, Smith, Kline & French Labs., Philadelphia, for a generous gift of dexedrine.

DEPARTMENT OF CHEMISTRY AND CHEMICAL ENGINEERING
UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

Synthesis of Dicyclohexylammonium-1-1'-C^{14} Nitrite

ALFRED L. GLASS

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One type of commercial vapor phase corrosion inhibitor is known to be essentially dicyclohexylammonium nitrite. This substance was selected to be synthesized with a radioactive C^{14} atom, in order that the radioactive tracer technique might be applied to obtain certain basic information concerning the application of vapor phase inhibitors to military packaging.

The high pressure catalytic hydrogenation of aniline, as described below, was used to prepare the radioactive corrosion inhibitor. This process was used, since it resulted in the highest percent yield of finished product, required the minimum of personal handling and exposure to radioactivity, and the initial material was readily available as aniline-1-C^{14}.

SYNTHESIS OF DICYCLOHEXYLAMINE-1-1'-C^{14} (Reference 1)

The hydrogenation of aniline-1-C^{14} was performed in a high-pressure autoclave. The catalyst used in this synthesis was prepared by taking 100 g. of nitric acid-washed kieselguhr and mixing it with 100 g. of nickel nitrate [$Ni(NO_3)_2 \cdot 6H_2O$] in 150 ml. of water. This mixture then was ground in a ball-mill until a creamy consistency was obtained. The paste was carefully heated to 70–80° with stirring, and a solution of 60 g. of ammonium bicarbonate ($NH_4HCO_3 \cdot 5H_2O$) in 400 ml. of water was added gradually with continued stirring. The resulting mixture was filtered and washed twice with 75-ml. portions of distilled water. The moist cake was broken up and dried at 100–110°. A 3-g. portion of this dried, impregnated kieselguhr was reduced in a stream of hydrogen at 425–475° for about 70 minutes. The active catalyst thus prepared was immediately used in the hydrogenation.

Freshly distilled aniline (4 g.) (b.p. 184–185°), 51.0 mg. of aniline-1-C^{14} hydrochloride (200 μc of activity), 50 ml. of dioxane, and the active catalyst were placed into the bomb and the whole was assembled. Hydrogen was added to a pressure of 2000 p.s.i. The temperature was raised to 250°, which caused an increase in pressure to 2300 p.s.i. The pressure was maintained at 2300 p.s.i. by the addition of hydrogen periodically, and the whole was heated at 250° for three hours, with stirring. The bomb then was cooled, disassembled, and the reaction mixture was removed with the aid of diethyl ether. The reaction mixture was filtered to re-

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(1) U. S. Patent 2,092,525, September 7, 1937, H. Adkins and H. Cramer.