in **4a** *vs.* 227 in **6a**. In the bis derivative **7** there were two peaks at 221 and 235 cps.

Registry No.—2, 16797-56-1; **4a**, 16797-57-2; **4b**, 16797-59-4; **6a**, 16797-60-7; **6b**, 16797-61-8; **7**, 16797-62-9.

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Derivatives of Morphine. VI.[1] The Structure of Dihydrodesoxycodeine E, the Product of Electrolytic Reduction of 14-Bromocodeinone

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Through electrolytic reduction of 14-bromocodeinone (I) in 25% sulfuric acid, Speyer and Sarre[4] prepared a phenolic dihydrodesoxycodeine (II), $C_{18}H_{23}NO_2 \cdot 0.5C_2H_5OH$, mp 139–140° dec. Their results were subsequently confirmed by Small and Cohen,[5] who proposed the name "dihydrodesoxycodeine E" to distinguish the substance from the several other known dihydrodesoxycodeines. Since II is reduced catalytically (Pd), with uptake of 1 mol of hydrogen, to the well-known tetrahydrodesoxycodeine (III), it must be one of the four possible analogs of III with a double bond in ring C (Scheme I). Of these, the Δ^5 and Δ^6 isomers are known compounds,[6] the dihydrodesoxycodeines C and B, respectively. Both are different from II, which must thus have its double bond in Δ^7 (IIb) or $\Delta^{8(14)}$ (IIa). No evidence on this point appears in the published literature, but the two possibilities should be readily distinguishable by nmr spectroscopy.

Colorless, well-crystallized preparations of II, obtained from a strongly discolored authentic sample[7] still remaining from the work of Small and Cohen[5] by recrystallization from a variety of solvents or by vacuum sublimation, and a new sample isolated by alumina chromatography from a crude product prepared recently by the method of Speyer and Sarre,[4] all showed a triplet (1 H) centered around $\delta \sim 5.7$ in their nmr spectra. This triplet is very similar to that occurring at δ 5.5[8,9] in the spectrum of neopine (IV) as the X part of a deceptively simple ABX system,[8] and definitely caused by the proton at C-8. As expected, similar signals appear in the spectra of other $\Delta^{8(14)}$ compounds, such as isoneopine (V, triplet, δ 5.5),[9] desoxycodeine D ("desoxyneopine")[10] (VI, triplet, δ 5.5),[11] and neopine methyl ether[12] (VII, quartet, δ 5.45).[11]

The material available at present thus unquestionably has formula IIa rather than IIb. However, even our best samples, though homogeneous on gas chromatography, gave low, very unsharp melting points instead of mp 139–140° given in the literature. Unequivocal proof was thus needed that the substance is chemically identical with the one prepared long ago.[4,5] This proof was furnished by the complete agreement of the melting points of the methiodide and methyl ether methiodide, prepared from one of our samples, with literature values.[4] The nmr spectrum of II methiodide again showed a triplet (1 H) in the olefinic region, this time centered at δ 6.25, and analogous to signals in the spectra of the methiodides of VI[10] and VII[12] (triplets at δ 6.3 and 6.1, respectively).

These findings prove conclusively that II is indeed the $\Delta^{8(14)}$ isomer IIa. The discrepancy between the melting points found by us for II, and those recorded in the literature, appears to be based on polymorphism rather than variable solvation, since it persists after sublimation.

II is thus formed from I by removal of the carbonyl oxygen, reductive opening of the oxygen bridge, and hydrogenolysis of the bromine with allylic shift of the double bond. The last one of these changes is formally identical with that taking place during the *catalytic* (Pd on C in chloroform) reduction[13] of I to neopinone (VIII). The conversion of I to II might conceivably consist of an analogous process, accompanied by the removal of the carbonyl oxygen and opening of the ether bridge. The two processes may or may not be totally concerted; however, no information on the actual mechanism of the electrolytic process is available.

Experimental Section

Nmr spectra were taken on a Varian A-60 instrument in $CDCl_3$ with TMS as internal standard.

Dihydrodesoxycodeine E (IIa).—Both the original, brown sample and the colorless, well-crystallized (rhombic leaflets) preparations obtained from it by vacuum sublimation or recrystallization from ethanol, benzene, or ether, showed very unsharp melting points from about 90° to about 110–115° if taken on a Kofler hot stage. In capillaries, partial melting took place from $\sim$100° up, the last crystals disappearing only at $\sim$140°. Vapor phase chromatograms of the purified samples showed only one peak, retention time 3.55 min (3% OV-17 on Gas Chrom Q mesh 80; column 6 ft × 3 mm, 235°; inlet pressure 26 psi).[14] The old sample showed the same peak accompanied by very small peaks at 4.5 and 8.8 min.

The methiodide (mp 198–199° after recrystallization from ethanol and benzene, lit.[4] mp 199°) and methyl ether methiodide (mp 238–243°, lit.[4] mp 245°) were prepared by the method of Speyer and Sarre.[4] The sample of VI methiodide, left from the work of Small and Mallonee,[10] was labeled "mp 203–204°;" the melting point is given as "204–206° (evacuation tube)" in ref 10. However, the melting point was now found to be $\sim$230° (hot stage); Rapoport and Bonner[15] found 233–234°.

Isolation of II.—The crude mixture of bases resulting from reduction[16] of I by the method of Speyer and Sarre[4] was chro-

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[1] Paper V: U. Eisner and U. Weiss, *J. Org. Chem.*, **33**, 1264 (1968).

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[4] E. Speyer and K. Sarre, *Ber.*, **57**, 1404 (1924).

[5] L. F. Small and F. L. Cohen, *J. Amer. Chem. Soc.*, **53**, 2227 (1931).

[6] *Cf.* K. W. Bentley, "The Chemistry of the Morphine Alkaloids," Clarendon Press, Oxford, 1954, p 155, and literature quoted there.

[7] This sample and those of several reference compounds were made available from the collection of the late Dr. L. F. Small through the courtesy of Drs. E. L. May and L. S. Sargent.

[8] T. Rüll, *Bull. Soc. Chim. Fr.*, 586 (1963).

[9] S. Okuda, S. Yamaguchi, Y. Kawazoe, and K. Tsuda, *Chem. Pharm. Bull.* (Tokyo), **12**, 104 (1964); T. J. Batterham, K. H. Bell, and U. Weiss, *Aust. J. Chem.*, **18**, 1799 (1965).

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[11] Unpublished observations.

[12] L. F. Small, *ibid.*, **20**, 953 (1955).

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[14] The authors are indebted to Mrs. P. F. Highet for the gas chromatograms.

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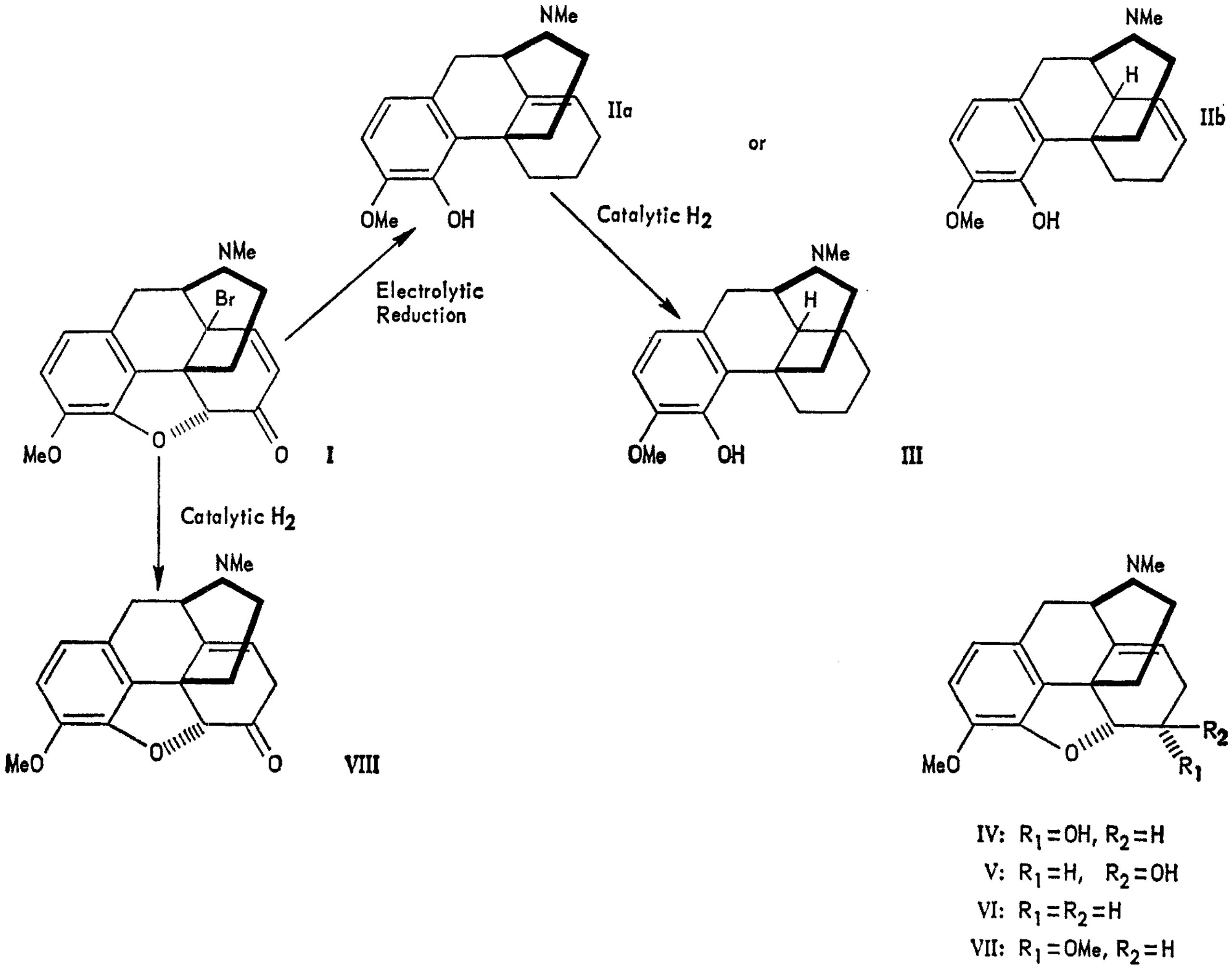
[16] The authors are much indebted to Mlle. G. Chalier, Grenoble, France, for performing this electrolytic reduction.

SCHEME I



matographed on alumina. Elution with benzene-methylene chloride (1:1) yielded first unchanged I, 19%, followed by II, 31%. Subsequent elution with chloroform and chloroform-methanol 6:1 gave additional, more polar fractions, which were not identified; they were nonketonic (no ν (CO) between 1700 and 1721 cm^{-1}). The melting point and nmr spectrum of the sample of II obtained in this way agreed completely with those of the old samples.

Registry No.—I, 5140-31-8; IIa, 16808-39-2.

Laboratory Application of a Chemical Reactor Column. The Synthesis of Perdeuteriotropilidene

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Perdeuteriotropilidene, which was required in larger quantities in our program of investigations of mechanisms of oxidation reaction, was prepared in low isotopic purity (total deuterium content 90.8%, C_7D_8 55.9%) by Doering and Gaspar[1] by base-catalyzed hydrogen exchange between tropilidene and a deuterated solvent under drastic conditions. For our purposes a considerably higher deuterium content was desirable. As repeated equilibration turned out to be impractical (only about 50% tropilidene could be recovered after treating 5.0 g of tropilidene with 5.0 g of potassium dissolved in 75 g of triethylcarbinol under exchange conditions), a direct synthetic approach was sought.

Of the several methods of tropilidene syntheses available in the literature either the photochemically[2,3] or metal-catalyzed[4] reaction of benzene with diazomethane seemed most promising. The disadvantage of the photochemical method is the formation of toluene as a by-product. This drawback is removed in the catalytic process[4-7] which was explored in considerable detail by Müller and Fricke,[4] who were able to obtain yields up to 85% based on diazomethane. In their modification diazomethane was used in a benzene solution and a large excess of benzene over diazomethane (40:1) was required.

For the synthesis of perdeuteriotropilidene from ben-

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