methane.—Pyridone **6**, 10 mg (0.08 mmol), was treated with diazomethane (8 mmol) in the manner described above. Thin layer chromatography with the above-mentioned systems indicated that two products were present: **3** and **5**.

The nmr spectrum of 6-hydroxy-1-methyl-2-pyridone (**6**) in deuteriochloroform is as follows: τ 3.26 (d of t, 1, J_{34} = 10.0 Hz, J_{45} = 3.5 Hz, H-4), 3.76 (d of t, 1, J_{34} = 10.0 Hz, J_{35} = 2.0 Hz, H-3), 6.55 (d of d, 2, J_{45} = 3.5 Hz, J_{35} = 2.0 Hz, H-5), 6.70 (s, 3, CH_3–N).

Registry No.—**1**, 14346-45-3; **5**, 19350-90-4; **6**, 6231-17-0; diazomethane, 334-88-3.

3-Benzylidene-2,5-diketopiperazine

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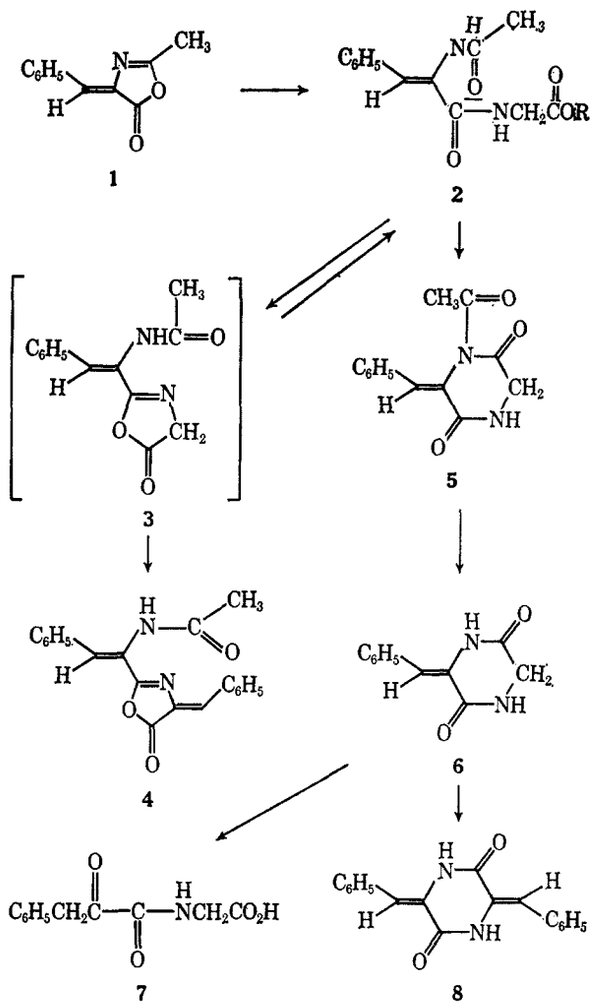
Although 3,6-dibenzylidene-2,5-diketopiperazine (**8**) has been known since 1921,[1] 44 years prior to its isolation as a natural product,[2] the monobenzylidene derivative **6** has not previously been described. As both this compound and the process by which it is produced have a variety of potential synthetic uses,[3] we wish to report our observation of its synthesis.

Fruton and Bergman,[4] in their extensive investigations of dehydropeptides, reported that the azlactone, 2-methyl-4-benzal-5-oxazalone (**1**), condensed with glycine to afford acetyldehydrophenylalanylglycine (**2**, R = H) which upon treatment with benzaldehyde, acetic ahydride, and sodium acetate produced the unsaturated azlactone peptide derivative **4**. In an attempt to obtain the assumed intermediate saturated peptide azlactone (**3**) of the above reaction, we carried out the process with the omission of benzaldehyde. The expected intermediate **3** was not produced; instead N-acetylmonobenzylidinediketopiperazene (**5**) was formed in high yield. In the acetic anhydride–sodium acetate medium, the mixed anhydride–azlactone equilibrium (**2** → **3**, R = Ac) appears rapid and reversible. In the presence of benzaldehyde, the azlactone condensation proceeds to give **4** irreversibly, while in the absence of benzaldehyde a slower intramolecular acylation of the amide nitrogen occurs to give **5**. Trace amounts of **5** can be found in the preparation of **4**. Treatment of acetyldiketopiperazine **5** with a variety of nucleophiles affords monobenzylidene diketopiperazine **6** in high yield. The structure was confirmed by hydrolysis to phenylpyruvoylglycine **7** and condensation with benzaldehyde to afford the dibenzylidene derivative **8** (Scheme I).[1]

SCHEME I



Experimental Section

Acetyldehydrophenylalanylglycine (2, R = H).—Dipeptide **2** was prepared according to the procedure of Fruton and Bergman.[4] From 6.0 g (0.032 mol) of 2-methyl-4-benzal-5-oxazolone (**1**),[5] 7.0 g (83%) of acetyldehydrophenylalanylglycine (**2**, R = H) was obtained which melted at 189–192° (lit.[4] mp 194–195°): $\nu_{max}^{CHCl_3/N(Et)_3}$ (cm^{-1}) 1670 (strong), 1630 (strong); $\tau^{CF_3CO_2H}$ (ppm) 2.51 (6 H, multiplet), 5.58 (2 H, multiplet), 7.62 (2.5 H, singlet), 7.88 (0.5 H, singlet).

The two N-methyl peaks may be due to either *cis–trans* isomerization about the double bond or restricted rotation about one of the amide bonds.

N-Acetyl-6-benzylidene-2,5-diketopiperazine (5).—A solution of 6.0 g (0.023 mol) of acetyldehydrophenylalanylglycine in 15 ml of acetic anhydride was warmed on a steam bath for 9 hr. The acetic anhydride was then removed by distillation leaving a brown solid which melted at 160–170°. After washing well with benzene, 3.82 g (68%) of a pale yellow solid was obtained which melted at 194–198°. Finally recrystallization from chloroform gave a colorless solid which melted at 200–202°: $\nu_{max}^{CHCl_3}$ (cm^{-1}) 3380 (weak), 3020 (weak), 1700 (strong), 1630 (weak), 1420 (medium), 1360 (strong), 1225 (broad, medium); $\tau^{CF_3COH_2}$ (ppm) 2.51 (1 H, singlet), 2.57 (6 H, broad singlet), 5.25 (2 H, singlet), 7.25 (3 H, s). *Anal.* Calcd for $C_{13}H_{12}N_2O_3$: C, 63.93; H, 4.95; N, 11.4. Found: C, 63.93; H, 4.92; N, 11.42.

3-Benzylidene-2,5-diketopiperazine (6).—A solution of 0.10 g (0.00041 mol) of N-acetyl-6-benzylidene-2,5-diketopiperazine (**5**) and 1.0 g (0.01 mol) of aniline in 1 ml of chloroform was allowed to remain overnight at room temperature. The next day the slurry was filtered to give 0.82 g (99%) of crude product which melted at 274–278°. Recrystallization from acetic acid and

(1) T. Sasaki, *Chem. Ber.*, **54B**, 163 (1921).
(2) R. Brown, C. Kelley, and S. E. Wiberley, *J. Org. Chem.*, **30**, 277 (1965).
(3) See, for example, C. Shin, Y. Chigira, M. Masaki, and M. Ohta, *Tetrahedron Lett.*, 4601 (1967).
(4) J. Fruton and M. Bergman, *J. Biol. Chem.*, **166**, 449 (1946); D. G. Doherty, J. E. Tietzman, and M. Bergman, *ibid.*, **147**, 617 (1943).
(5) R. Herbst and D. Shemin, "Organic Syntheses," Coll. Vol. II, John Wiley & Sons, Inc., New York, N. Y., p 1.

water gave an analytical sample which melted at 281–282°: ν_{max}^{KBr} (cm^{-1}) 3200 (w), 1680 (s), 1625 (m), 1440 (w), 775 (w); $\tau^{CF_3CO_2H}$ (ppm) 2.98 (5 H, s), 3.05 (1 H, s), 5.92 (2 H, s). *Anal.* Calcd for $C_{11}H_{10}N_2O_2$: C, 65.34; H, 4.99; N, 13.86. Found: C, 65.18; H, 4.97; N, 13.87.

Hydrolysis of 3-Benzylidene-2,5-diketopiperazine (6).—A slurry of 0.30 g (0.0015 mol) of 3-benzylidene-2,5-diketopiperazine (**5**) in 4 ml of 0.5 *N* hydrochloric acid and 2 ml of glacial acetic acid was refluxed for 2 hr. On cooling in a refrigerator overnight, 0.10 g of a precipitate which was identified as starting material formed. After filtration crystals appeared in the filtrate on standing at room temperature and after cooling another filtration gave 0.20 g (60%) of a colorless solid which melted at 164–166° (lit. mp 166–167°). This material was the same by a mixture melting point test as phenylpyruvylglycine (**7**) prepared by hydrolysis of acetyldehydrophenylalanylglycine (**2**, R = H).[4]

Registry No.—2 (R = H), 19459-01-9; **5**, 19459-02-0; **6**, 19459-03-1.

A Simple Technique for Performing Reactions with Organotin Hydrides

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The most useful reactions of organotin hydrides include additions to unsaturated systems and reductions of functional groups such as halides.[1] Preparation of the organotin hydride usually involves reduction of an organotin halide or oxide with a reducing agent such as lithium aluminum hydride. The hydride is then isolated and used immediately or stored until needed in an air-tight container.

It has been recently reported that organotin hydrides can be prepared by the reaction of the appropriate oxides with polymethylsiloxane, eq 1.[2] The reactants

$$(R_3Sn)_2O + [CH_3SiHO]_n \longrightarrow\longrightarrow 2R_3SnH + [CH_3SiO_{1.5}]_n \quad (1)$$

are simply mixed without solvent and the hydride separated from the cross-linked silicone polymer by distillation. Since the polymer is nonvolatile it appeared to us that a substance which would react with the hydride could be added to the mixture without the necessity for isolating the hydride. Furthermore, silanes do not react readily with unsaturated and reducible functions. This suggested further that the desired reaction of the organotin hydride could be effected by simply mixing the polysiloxane, organotin oxide and substrate, as illustrated in eq 2 for an organic

$$2RX + (R'_3Sn)_2O + [CH_2SiHO]_n \longrightarrow 2RH + 2R'_3SnX + [CH_3SiO_{1.5}]_n \quad (2)$$

halide. A preliminary experiment with *n*-heptyl bromide yielded 70% of *n*-heptane indicating that the method was promising and as effective as the conventional method.[3] Further experiments were then carried out to determine whether yields were generally good with simple halides and whether other reducible functions were reduced in competition with the halides.

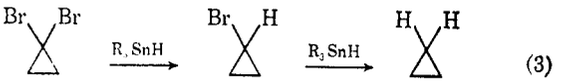
TABLE I

REDUCTION OF GEMINAL DIBROMOCYCLOPROPANES WITH TRI-*n*-BUTYLTIN HYDRIDE GENERATED *in Situ*

Halide	Conditions	% yield of monobromide[a]
1,1-Dibromo-*trans*-2,3-dimethylcyclopropane[b]	0°, 1.5 hr	85
1,1-Dibromo-2,2,3,3-tetramethylcyclopropane[c]	Room temperature, 1.5 hr	73 (78)
7,7-Dibromobicyclo[4.1.0]heptane[d]	50°, 3 hr	79 (82)

[a] Figures in parentheses are from ref 4. [b] P. S. Skell and A. Y. Gardner, *J. Amer. Chem. Soc.*, **78**, 3409 (1956). [c] P. S. Skell and A. Y. Gardner, *ibid.*, **78**, 5430 (1956). [d] W. von E. Doering and A. K. Hoffman, *ibid.*, **76**, 6162 (1954).

One of the more important applications of organotin hydrides in organic synthesis is in the stepwise reduction of geminal polyhalides.[3] This feature has been exploited in the reduction of the adducts of dibromocarbene to simple olefins[4] and to allenes,[5] eq 3.[6] Results of



(3)

the reduction of three dibromocyclopropanes to the corresponding monobromo derivatives are given in Table I, and can be seen to be comparable with those obtained by the conventional procedure.

A survey of the reduction of several aromatic and aliphatic chlorides and bromides was made with the results shown in Table II. Some of the reactions were carried out thermally. Others were initiated photochemically in Pyrex vessels and were found to provide improved yields at lower temperatures. The reactions carried out at 100° or higher were usually accompanied by the formation of a grayish precipitate which was not observed in the photochemical reductions.

It appears that reductions of aromatic bromides by this method are very slow in the presence of a ketone, aldehyde or amino group. Aliphatic carbonyl compounds with α halogens have been shown to be reduced in good yield.[3] Decomposition of organotin hydrides catalyzed by amines is a well-documented process.[1a] When the reduction of *p*-bromo-N,N-dimethylaniline was carried out thermally, the amount of decomposition appeared to be quite large, as reflected in the low yield of reduction product. Although the yield of product was larger in the case of the photochemically induced reduction, the reaction was quite slow.

It is interesting to note that *m*-chlorotoluene was not reduced at all even after irradiation for 5 days, while aliphatic chlorides were reduced in good yield under these conditions. In contrast to this, *o*-bromotoluene

(1) For recent reviews, see (a) H. G. Kuivila in "Advances in Organometallic Chemistry," Vol. I, F. G. A. Stone and R. West, Ed., Academic Press, New York, N. Y., 1964, p 47; (b) W. P. Neumann, *Angew. Chem.*, **76**, 849 (1964); (c) W. P. Neumann, "Die Organishe Chemie Des Zinns," Enke Verlag, Stuttgart, West Germany, 1967; (d) H. G. Kuivila, *Accounts Chem. Res.*, **1**, 299 (1968).

(2) K. Hayashi, J. Iyoda, and I. Shiihara, *J. Organometal. Chem.*, **10**, 81 (1967).

(3) H. G. Kuivila and L. W. Menapace, *J. Org. Chem.*, **28**, 2165 (1963).

(4) D. Seyferth, H. Yamazaki, and D. L. Alleston, *ibid.*, **28**, 703 (1963).

(5) W. Rahman and H. G. Kuivila, *ibid.*, **31**, 772 (1966).

(6) Other methods which are available for this reduction involve strongly basic conditions to which functional groups such as esters and nitriles are sensitive; see D. Seyferth and D. Prokai, *ibid.*, **31**, 1702 (1966); A. J. Frey and R. H. Moore, *ibid.*, **33**, 1283 (1968).