mixture of bicyclo[4.2.0]oct-2-ene[12] (40%, isolated by gas chromatography on silicone oil at 100°) and two acetates. Reduction with lithium aluminum hydride in ether gave *exo*-bicyclo[3.2.1]octan-8-ol (*exo*-**4**, 20%) and *endo*-**3** (40%), isolated by gas chromatography (TCEP, 90°).

Solvolysis of 3-Cycloocten-1-ol.—A solution of 80 mg of 3-cycloocten-1-ol in 1 ml of 90% formic acid was heated on a steam cone for 2.5 hr. The cooled mixture was diluted with 10 ml of water and extracted with ether. The ether extracts were washed with water and concentrated, then refluxed with 20% sodium hydroxide in methanol–water for 3 hr. The mixture was extracted with ether and the ether layers were washed with water and dried over magnesium sulfate. Removal of the solvent under nitrogen at atmospheric pressure yielded a mixture of 3-cycloocten-1-ol (50%) and *trans*-2-vinylcyclohexanol (50%), isolated by gas chromatography (silicone oil, 135°).

In another run conducted on a larger scale under the same conditions (starting with 500 mg of 3-cycloocten-1-ol), a mixture containing 75% of 3-cycloocten-1-ol, 3% of *endo*-bicyclo[4.2.0]-octan-7-ol, and 22% of *trans*-2-vinylcyclohexanol was obtained. The components were isolated from a TCEP column at 140°.

Solvolysis of *endo*-Bicyclo[4.2.0]octan-7-ol.—*endo*-Bicyclo-[4.2.0]octan-7-ol (160 mg) in 2 ml of 90% formic acid was heated on a steam cone for 2.5 hr. The cooled mixture was diluted with 4 ml of water and extracted with ether. The ether extracts were washed with water, 5% sodium carbonate solution, water, and saturated sodium chloride solution. After drying (magnesium sulfate), the solvent was removed and the residue was saponified with 2 ml of 15% sodium hydroxide in methanol–water at room temperature for 24 hr. The mixture was diluted with 4 ml of water and extracted with ether. The ether extracts were washed with water and saturated sodium chloride solution, and dried over magnesium sulfate. Removal of the solvent yielded 100 mg of a mixture containing *trans*-2-vinylcyclohexanol (46%), *endo*-**1** (8%), 3-cycloocten-1-ol (37%), and two unidentified alcohols (4 and 5%), isolated from a TCEP column at 140°. The unidentified alcohols are believed to be derived from *trans*-2-vinylcyclohexanol by migration of the double bond. Both had retention times similar to that of *trans*-2-vinylcyclohexanol; the infrared spectrum of each showed the presence of a double bond.

Solvolysis of *exo*-Bicyclo[4.2.0]octan-7-ol.—*exo*-Bicyclo[4.2.0]-octan-7-ol (80 mg) was solvolyzed in 1 ml of 90% formic acid according to the procedure described for the *endo* isomer. The product (70 mg) was homogeneous on gas chromatography (TECP at 140°), and was identified as *trans*-2-vinylcyclohexanol.

Thermal Stability of *endo*-Bicyclo[3.2.1]oct-8-yl Acetate.—A solution of 0.5 g of *endo*-bicyclo[3.2.1]oct-8-yl acetate in 5 ml of 0.5 *M* sodium acetate in glacial acetic acid was heated in a sealed tube at 150° for 3 days. The product, isolated as described for the solvolysis of *endo*-**2** brosylate, was found to be the unchanged acetate. The product was homogeneous on gas chromatography (TCEP) and the infrared spectrum of the collected sample was superimposable on the spectrum of an authentic sample of the acetate.

Registry No.—*exo*-**1** tosylate, 7604-67-3; *endo*-**1** tosylate, 7604-68-4; *exo*-**2** brosylate, 7604-69-5; *endo*-**2** brosylate, 7604-70-8; *exo*-**3** brosylate, 7604-71-9; *endo*-**3** brosylate, 7604-72-0; *exo*-**1** brosylate, 7604-73-1; *exo*-bicyclo[4.2.0]oct-7-yl brosylate, 7604-74-2; *exo*-bicyclo-[4.2.0]oct-7-yl tosylate, 7604-75-3; *endo*-bicyclo[4.2.0]-oct-7-yl tosylate, 7604-76-4; 3-cycloocten-1-ol, 4114-99-2; *endo*-bicyclo[4.2.0]octan-7-ol, 7604-78-6; *exo*-bicyclo[4.2.0]octan-7-ol, 7604-79-7.

The 2,3-Diphenyl-1,4-dioxane Isomers

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2,3-Bis(4-bromophenyl)-1,4-dioxane (**4a**) and its 4-chloro counterpart (**4b**) have been converted to 2,3-diphenyl-1,4-dioxane (**1**), mp 42–45°, and to 2,3-bis(4-carboxyphenyl)-1,4-dioxane (**6**). The partial resolution of the latter constitutes unequivocal proof of the *trans* configuration of the lower melting 2,3-diphenyl-1,4-dioxane isomer. The isomer which melts at 136° is therefore *cis*.

A number of recent reports[4] have been concerned with the conformation of the 2,3-dichloro- and the 2,3-diphenyl-1,4-dioxane isomers as deduced from nmr spectra. In all of these reports the configurations assigned to these pairs of isomers as a result of previous work in these laboratories[5] have been assumed to be correct. The configurational assignments for the dichlorodioxanes were based on unequivocal evidence[5a] and they have since been confirmed by X-ray crystallographic studies.[4b] The configurational assignments for the 2,3-diphenyldioxanes were less unequivocally established, but they were nevertheless well based on conventional organic chemical argument.[5b] Another recent report,[6] however, has contended that the assignment of a *cis* configuration to the higher melting 2,3-dichloro-1,4-dioxane[5a] is wrong, and that the assignments for the 2,3-diphenyl-1,4-dioxanes[5b] are correctly those originally proposed.[7]

The arguments presented for these reassignments of configuration[6] are specious at best. A rational analysis of the A_2B_2 nmr spectrum of the higher melting dichlorodioxane isomer[4d,e] has added additional evidence for its *cis* nature, if such be needed, and the claim that the two isomers are both *trans* (noninterconverting axial,axial and equatorial,equatorial conformers) has since been disavowed.[8] There has been no disavowal of the reversal of the configurational assignments for the diphenyldioxane isomers,[6] however. The question of the correctness of our earlier assignments[5b] for these isomers needs to be laid to rest.

We report here unequivocal evidence that the lower melting diphenyldioxane isomer (46°, **1**) has a *trans* configuration, whence by inference the higher melting isomer (136°, **2**) must have a *cis* configuration. A very recent analysis of the A_2B_2 nmr spectrum of **2** serves to confirm the *cis* nature of the latter isomer.[4f]

The evidence that **1** has a *trans* configuration is summarized in Chart I.

(1) Deceased Dec 8, 1962.

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(4) (a) E. Caspi, T. A. Wittstruck, and D. M. Piatak, *J. Org. Chem.* **27**, 3183 (1962); (b) C. Altona and C. Romers, *Acta Cryst.*, **16**, 1225 (1963); *Rec. Trav. Chim.*, **82**, 1080 (1963); (c) M. C. Planje, L. H. Toneman, and G. Dalinga, *ibid.*, **84**, 232 (1965); (d) R. F. Fraser and C. Reyes-Zamora, *Can. J. Chem.*, **43**, 3445 (1965); (e) D. Jung, *Chem. Ber.*, **99**, 566 (1966); (f) C. Altona and E. Havinga, *Tetrahedron*, **22**, 2275 (1966).

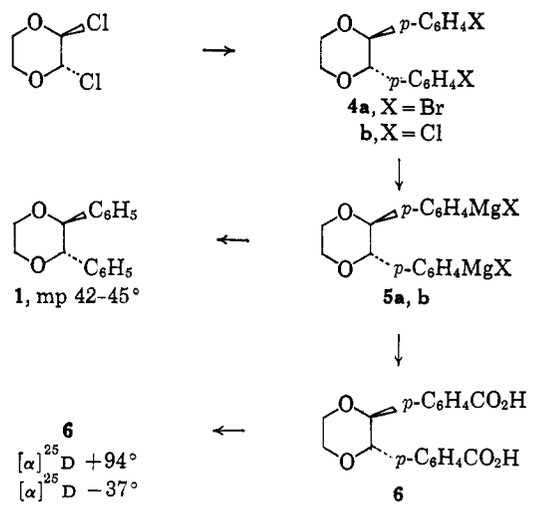
(5) (a) R. K. Summerbell and H. E. Lunk, *J. Am. Chem. Soc.*, **79**, 4802 (1957); (b) R. K. Summerbell and D. R. Berger, *ibid.*, **81**, 633 (1959).

(6) C-Y. Chen and R. J. W. LeFevre, *J. Chem. Soc.*, 558 (1965).

(7) W. Stumpf, *Z. Electrochem.*, **57**, 690 (1953).

(8) C-Y. Chen and R. J. W. LeFevre, *J. Chem. Soc.*, B 544 (1966).

CHART I



The synthesis steps of Chart I were straightforward except that considerable polymeric material accompanied the formation of **4a** and **4b**. Ultraviolet and infrared spectra and combustion analysis of these insoluble polymers suggest that they are *p*-halo-*p*-polyphenyls, most likely a mixture of quadri- and quinquephenyls. Polymers whose absorption spectra and combustion analyses are closely similar are formed upon treatment of ethereal solutions of *p*-chlorophenylmagnesium bromide with a small amount of anhydrous cobaltous chloride, a catalyst prone to promote radical coupling reactions with Grignard reagents.[9] These interesting side-reaction products will be discussed in a separate report.

The structures of **4a** and **4b** were confirmed by their cleavage upon bromination in refluxing carbon tetrachloride[5b] to give 4,4′-dibromobenzil (mp 227–229°[10]) and 4,4′-dichlorobenzil (mp 199–200°[11]), respectively. The *trans* configurations of **1** and **4a**, **4b**, **5a**, and **5b** follow from the partial resolution of **6**. The *cis* isomer of **6** exists either as an unresolvable *meso* boat conformer or (more likely) a rapidly interconverting equatorial,-axial ⇄ axial,equatorial racemic pair of chair conformers.[4f]

Experimental Section[12]

2,3-Bis(4-bromophenyl)-1,4-dioxane (4a).—A solution of 31.4 g (0.200 mole) of *trans*-2,3-dichloro-1,4-dioxane[5a] in 100 ml of anhydrous ether was added to a solution of 4-bromophenylmagnesium bromide, prepared from 12.2 g (0.50 g-atom) of magnesium and 118 g (0.50 mole) of *p*-dibromobenzene in 250 ml of ether, at a rate sufficient to maintain gently reflux. Solid, milky green material began to appear shortly after the addition was begun and this accumulated during the course of the addition and a 2-hr reflux. The mixture was then poured into 300 ml of cold, saturated ammonium chloride. The ether solution, together with the suspended green solid, was washed several times with water then filtered through diatomaceous filter aid. The ether-insoluble material amounted to 53 g.

Distillation of the solvent from the dried ether solution left 32 g of ether-soluble material from which, with some difficulty, 10.5 g (13%) of **4a** could be recovered by crystallization from acetone at −80°, mp 169–170°. In a second experiment, a chromatographic procedure on alumina, using heptane–benzene mixtures as eluent, furnished 8.5 g (11%) of **4a**, mp 168–170°.

Anal. Calcd for $C_{16}H_{14}Br_2O_2$: C, 48.27; H, 3.56. Found: C, 48.4; H, 3.7.

When 1.0 g of bromine in 15 ml of carbon tetrachloride was added to a solution of 0.40 g (1.0 mmole) of **4a** in 25 ml of the same solvent at reflux temperature,[5b] hydrogen bromide was evolved. Distillation of the solvent and crystallization of the residue from benzene furnished 0.30 g (81%) of 4,4′-dibromobenzil, mp 227–229°.[10]

2,3-Bis(4-chlorophenyl)-1,4-dioxane (4b).—A solution of 45.2 g (0.288 mole) of *trans*-2,3-dichloro-1,4-dioxane in 500 ml of ether was added to a solution of 4-chlorophenylmagnesium bromide prepared from 19.5 g (0.80 g-atom) of magnesium and 153 g (0.80 mole) of 4-chlorobromobenzene in 500 ml of ether. A copious precipitate of green solid accumulated shortly after addition was complete. Following a 2-hr reflux, the mixture was hydrolyzed with cold, dilute hydrochloric acid. The solid material was separated by filtration, then extracted with ether; the ether-insoluble polymer weighed 41 g.

The washed ether solution from the reaction combined with the ether extracts of the solid furnished 36 g (42%) of **4b** upon distillation of the solvent. One recrystallization from dioxane–water furnished a 40% yield of **4b**, mp 149.5–150.0°.[13]

Anal. Calcd for $C_{16}H_{14}Cl_2O_2$: C, 62.15; H, 4.56. Found: C, 62.3; H, 4.6.

When 2.0 g of bromine in 30 ml of carbon tetrachloride was added to 1.55 g (5.0 mmoles) of **4b** in 50 ml of the same solvent at reflux,[5b] hydrogen bromide was evolved. Evaporation of the solvent and crystallization of the residue from benzene gave 0.95 g (68%) of 4,4′-dichlorobenzil, mp 199–200°.[11]

2,3-Bis(4-carboxyphenyl)-1,4-dioxane (6).—A solution of 3.98 g (10.0 mmoles) of **4a** and 12.3 g (0.100 mole) of 1-bromopropane in 50 ml of anhydrous tetrahydrofuran was added to 3.16 g (0.130 g-atom) of magnesium over 1 hr. The mixture was then refluxed under dry nitrogen for 6 hr at which time it was cooled and poured onto a slurry of 150 g of pulverized Dry Ice and anhydrous ether. The mixture was acidified with 20 ml of concentrated hydrochloric acid and 100 g of ice and the ether layer was washed several times with water.

Extraction of the ether solution with several portions of 4 *M* ammonium hydroxide, followed by acidification of these extracts, furnished 3.60 g of crude **6** which was recrystallized with difficulty from ethanol, mixed ethanol–ethyl acetate, or ethanol–acetic acid as a white powder, mp 305–306° (3.02 g, 93%).

Anal. Calcd for $C_{18}H_{16}O_6$: C, 65.94; H, 4.90; neut equiv, 164. Found: C, 65.7, 66.3; H, 5.0, 5.2; neut equiv, 169.

In a similar preparation which employed 5.00 g (16.2 mmoles) of **4b** and 17.2 g (0.140 mole) of 1-bromopropane with 5.00 g (0.202 g-atom) of magnesium, 4.75 g (90%) of **6**, mp 305–308°, was obtained.

Resolution of *trans*-2,3-Bis(4-carboxyphenyl)-1,4-dioxane (6).—A solution of 2.00 g (6.1 mmoles) of racemic **6** and 6.00 g (15.2 mmoles) of anhydrous brucine in 500 ml of ethyl alcohol was allowed to stand uncovered overnight in a 1-l. erlenmeyer flask. The salt which was deposited weighed 0.59 g (8.7%). Treatment of this salt with 20% sodium hydroxide, filtration of the insoluble brucine, and acidification with concentrated hydrochloric acid furnished 0.16 g (8.0%) of (+)-**6**: mp 302–306° (no depression), neut equiv 166, and $[\alpha]^{25}D$ +94° (α +1.17°; *c* 0.155, 25.0 ml of ethyl alcohol; *l* = 2 dm).

A second crop of crystals deposited on continued slow evaporation weighed 3.2 g (47%). The (+)-**6** recovered as above amounted to 0.90 g (45%) and exhibited $[\alpha]^{25}D$ +50° (α 0.80°, *c* 0.200, 25 ml of ethyl alcohol; *l* = 2 dm).

A third crop of brucine salt weighing 1.5 g (22%) gave 0.40 g (20%) of (−)-**6** having $[\alpha]^{25}D$ −37° (α 0.48°; *c* 0.160, 25.0 ml of ethyl alcohol; *l* = 2 dm).

***trans*-2,3-Diphenyl-1,4-dioxane (1).**—A solution of 0.600 g (1.51 mmoles) of **4a** and 1.80 g (14.6 mmoles of 1-bromopropane in 20 ml of anhydrous tetrahydrofuran was added over 20 min to 0.49 g (20 mg-atoms) of magnesium. Refluxing under a slow stream of dry nitrogen was continued for 5 hr when the cooled reaction mixture was hydrolyzed with 30 ml of 5% hydrochloric acid. The crude product, as isolated from the washed and dried

(9) M. S. Kharasch and O. Reinmuth, "Grignard Reactions of Nonmetallic Substances," Prentice-Hall, Inc., New York, N. Y., 1954, p 122.

(10) H. Biltz, *Ber.*, **41**, 1761 (1908).

(11) P. J. Montague, *Rec. Trav. Chim.*, **21**, 19 (1902).

(12) Combustion analyses were by H. Beck, Microanalytical Laboratory, Department of Chemistry, Northwestern University, Evanston, Ill.

(13) R. K. Summerbell and L. N. Bauer, *J. Am. Chem. Soc.*, **57**, 2364 (1936).

tetrahydrofuran solution after distillation of the solvent, weighed 0.320 g. Crystallization from pentane, in which the material is quite soluble, furnished a few crystals of **1**, mp 42–45°, no depression when mixed with the product, mp 44–46°, from the reaction of phenylmagnesium bromide with *trans*-2,3-dichloro-1,4-dioxane.[5b] The infrared spectra of the uncrystallized material and the latter[5b] were identical.

In an alternate preparation, 10.0 g (0.0324 mole) of **4b**, 41.0 g (0.334 mole) of 1-bromopropane, and 12.2 g (0.50 g-atom) of magnesium were processed in an analogous way. Crude **1**, weighing 7.6 g (97%), was subjected to a chromatographic procedure on alumina using pentane–ether as an eluent.[5b] The middle fractions (4.3 g total) crystallized after removal of the solvent. These all melted between 40 and 44° (no depression) and had infrared spectra identical with the 2,3-diphenyl-1,4-dioxane (mp 46°), prepared as described.[5b] While the three fractions immediately preceding and immediately following (1.2 g total) would not crystallize, their infrared spectra were indistinguishable from crystalline **1**.

Registry No.— **1**, 4336-11-2; *cis*-**1**, 4336-10-1; **4a**, 7593-64-8; **4b**, 7593-65-9; **6**, 7593-66-0; (+)-**6**, 7650-75-1; (−)-**6**, 7593-67-1.

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Iminodioxolanes from Fluoro Ketones and Alkyl Isocyanides

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Contribution No. 1263 from the Central Research Department, E. I. du Pont de Nemours and Company, Experimental Station, Wilmington, Delaware

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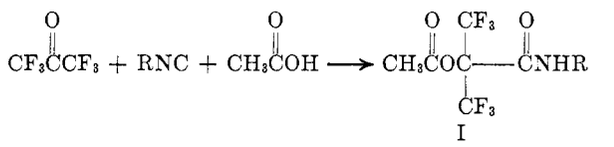
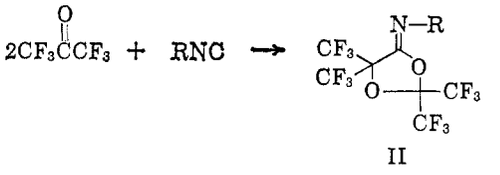
Iminodioxolanes are obtained from the reaction of fluoro ketones, such as hexafluoroacetone, with alkyl isocyanides.

Many diverse products can be prepared from the reaction of a carbonyl compound with an alkyl isocyanide in the presence of a third component (HX).[1] An example is the Passerini reaction, in which α-acyloxycarboxylic acid amides are formed from ketones, isocyanides, and carboxylic acids.[2] However, there appears to be no report of a stable reaction product formed from a ketone and an isocyanide alone.[2a]

We have found that fluoro ketones, such as hexafluoroacetone, undergo the Passerini reaction with extreme ease to give high yields of α-acyloxycarboxylic acid amides (I). If no carboxylic acid is present, however, an immediate and exothermic reaction still occurs, even at very low temperatures, and a 2:1 adduct of the ketone and isocyanide is formed. This adduct, which is a 4-iminodioxolane (II), is the only product formed regardless of the molar ratio of the reactants or the order of addition.



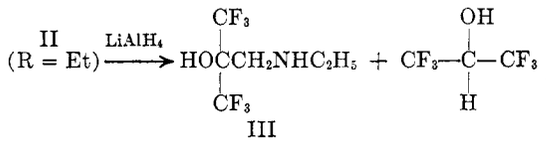
I



II

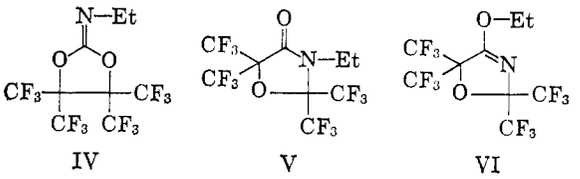
The iminodioxolane (II, R = Et) prepared from hexafluoroacetone and ethyl isocyanide is exceptionally resistant to both acidic and basic hydrolysis. It is unaffected by refluxing concentrated hydrochloric acid or aqueous 10% sodium hydroxide solution. In addition, it has high thermal stability, as it can be distilled at atmospheric pressure and heated at 300° in a sealed tube without decomposition. Products formed from hexafluoroacetone and other isocyanides, such as methyl, cyclohexyl, and *t*-butyl isocyanides, appear to have similar hydrolytic and thermal stability.

The structures of these adducts were established as iminodioxolanes (II) by elemental analysis and spectral data. The adducts show two kinds of fluorine in equivalent amounts in their F^{19} nmr spectra; the H^1 nmr spectra are consistent with an alkyl group attached to nitrogen; the infrared spectra show absorption between 5.64 and 5.68 mμ for the imino group. Because of their surprising hydrolytic stability, however, a more rigorous structure proof for these products was obtained by a reductive degradation of the hexafluoroacetone–ethyl isocyanide adduct. Reduction of II (R = Et) with lithium aluminum hydride gave the amine (III) and hexafluoroisopropyl alcohol. The



III

reduction product (III) shows that in II the carbon of the isocyanide unit is attached to the carbon of a ketone unit, and therefore rules out the iminocarbonate structure (IV) for the adduct. Other possible isomeric rearrangement structures (V and VI) were eliminated from consideration by an independent synthesis of these compounds.[3]



IV V VI

(1) I. Ngi, *Angew. Chem.*, **74**, 9 (1962).

(2) M. Passerini, *Gazz. Chim. Ital.*, **61**, 964 (1931), and preceeding communications.

(2a) NOTE ADDED IN PROOF.—N. P. Gambaryan, E. M. Rokhlin, Yu. V. Zeifman, C. A. Simonyan, and I. L. Knunyants [*Dokl. Akad. Nauk. SSSR*, **166**, 864 (1966)] have recently described the reaction of hexafluoroacetone and nitropentafluoroacetone with cyclohexyl isocyanide to give dioxolanes.

(3) W. J. Middleton and C. G. Krespan, *J. Org. Chem.*, **32**, 951 (1967).