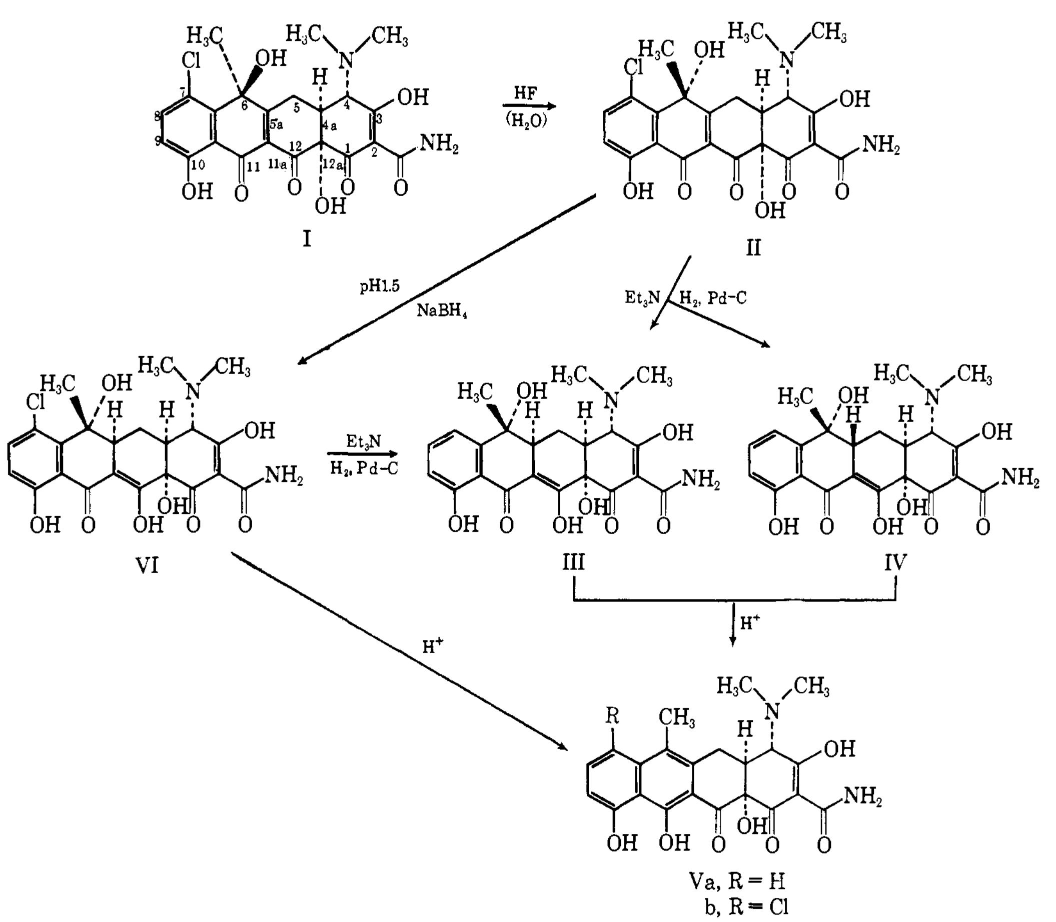

ϵ 4.08), 388 mμ (log ϵ 4.12); $\nu_{max}^{(D_3C)_2SO}$ 59 Hz (C-methyl) (tetracycline C-6 methyl is at 93 Hz). *Anal.* Calcd for $C_{22}H_{24}N_2O_8$: mol wt, 444.1531. Found: 444.1535 (mass spectroscopy)] was formed in 30% yield, separated from its 5a epimer by liquid–liquid partition chromatography on neutral (acid-washed) diatomaceous earth, and converted to anhydrotetracycline (Va) in 30% yield with great difficulty. Only by heating in methanesulfonic acid for 3.5 hr at 50° was reaction complete. The stereochemical assignments are based on the fact that 5a-epitetracycline (H and OH *cis*) is converted to Va more difficultly than is tetracycline[1] (H and OH *trans*).

5a-Epi-6-epitetracycline (IV), formed in 5% yield [[α]^{25}D −130 ± 6° (*c* 0.5, 0.1 *N* MeOH–HCl), $\lambda_{max}^{0.1\,N\,HCl}$ 267, 352 mμ (log ϵ 4.21, 4.06); $\lambda_{max}^{0.1\,N\,NaOH}$ 245, 262, 385 mμ (log ϵ 4.13, 4.13, 4.17); $\nu_{max}^{(D_3C)_2SO}$ 64 Hz (C–CH_3). *Anal.* Calcd for $C_{22}H_{24}N_2O_8$: mol wt, 444.1531. Found: mol wt, 444.1531 (mass spectroscopy)], was converted to Va in 30% yield merely by heating in concentrated hydrochloric acid for 5 min at 60°.

Miller[11] has shown that I gives 7-chloro-5a-epitetracycline upon reduction with sodium borohydride at pH 1.5. When II is subjected to these conditions, a single product was isolated by partition chromatography which was identified as 7-chloro-6-epitetracycline (VI), in contrast to the finding of Miller [$\lambda_{max}^{0.1\,N\,HCl}$ 263, 360 mμ (log ϵ 4.16, 3.52); $\lambda_{max}^{0.1\,N\,NaOH}$ 245, 395 mμ (log ϵ 4.15, 3.80). *Anal.* Calcd for $C_{22}H_{23}N_2O_8Cl$: mol wt, 478. Found: mol wt, 478 (mass spectroscopy)] and which was converted to anhydrochlorotetracycline (Vb) as well as to III.

Although I and 5a-epitetracycline are biologically inactive,[1] II has *in vitro* activity against *Staphylococcus aureus* 209P of 1.5 times that of tetracycline and an *in vivo* activity orally in mice against *Staphylococcus aureus* strain Smith of 0.5 times that of tetracycline. In addition III and IV have *in vitro* activities of 60 and 40% that of tetracycline.

We shall report the results of further investigations into the chemistry of these interesting compounds as well as more detailed correlations of biological activity in a full paper.

Acknowledgment. The authors are grateful to Mr. L. Brancone and staff for the elemental analyses, Mr. W. Fulmor and staff for the spectral measurements (the nmr spectra were obtained on a Varian Associates A-60 spectrometer), Dr. J. Karliner for the mass spectra, the above groups for assistance in interpretation of the spectra, Dr. J. Hlavka for helpful suggestions, Mr. G. Redin for the *in vivo* testing, and Mr. A. Dornbush for the *in vitro* testing.

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Received September 29, 1967

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[11] Dr. P. A. Miller (Chemotherapy Research Section, Lederle Laboratories), private communication. The authors are indebted to Dr. Miller for permission to publish his results here.

Formation of Aliphatic Semidiones under Conditions of the Acyloin Condensation[1]

Sir:

Numerous dibasic acid esters yield cyclic semidiones when treated with sodium–potassium alloy in dimeth-

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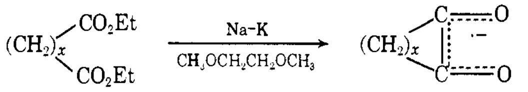
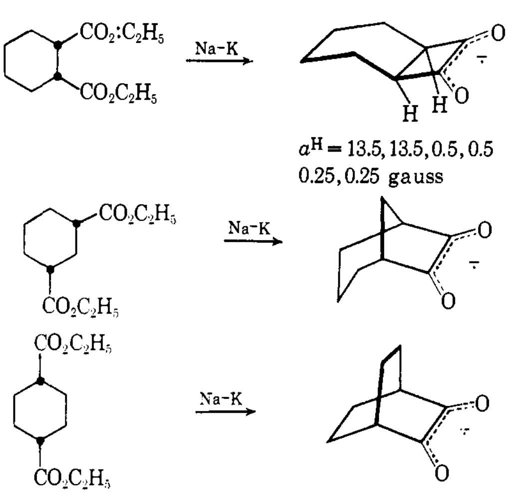
[1] Applications of Electron Spin Resonance Spectroscopy to Problems of Structure and Conformation. XIII. This work was supported by a grant from the National Science Foundation (GP-6402X).

Figure 1. First derivative esr spectra of semidiones obtained by treatment of **1**–**4** with sodium–potassium alloy: (A) semidione **1a**; (B) semidione **2a**; (C) semidione **3a**; (D) semidione **4a**. Spectra were recorded at 25° by a Varian Associates E-3 spectrometer.

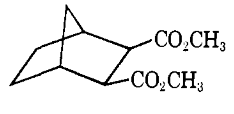
oxyethane solution at 25°.[2] The expected monocyclic semidiones are formed from the methyl esters of succinic, glutaric, adipic, and pimelic acids.[3] *cis*-



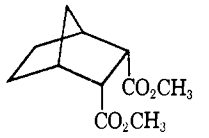
Cyclohexane-1,2-dicarboxylic acid (ethyl ester) yields the expected semidione. However the *trans* ester fails to yield a paramagnetic product. The expected semidiones are also formed from the *cis*-cyclohexane-1,3 and -1,4-dicarboxylic acid esters.[4]



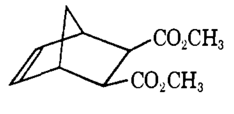
$a^H = 13.5, 13.5, 0.5, 0.5$
$0.25, 0.25$ gauss



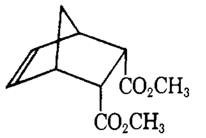
1



2



3



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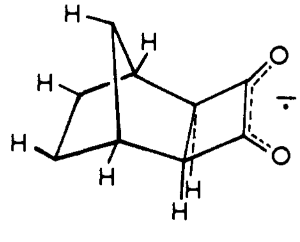
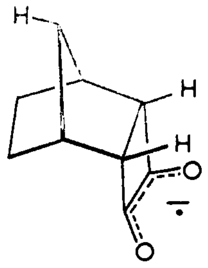
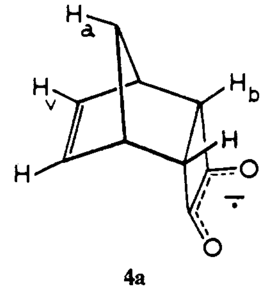


1a
a^H = 11.1 (2), 0.4 (5) gauss



2a
a^H = 10.5 (2), 2.4 gauss



4a
a^H = 10.2 (2), 2.7, 0.4 (2) gauss

The utility of this technique is emphasized in the spectra obtained from diesters **1**–**4** (Figure 1). Semidiones **1a** and **2a** show hyperfine splitting by the hydrogen atoms shown.[5] In **4a** an additional long-range interaction occurs with the double bond. In the semidione derived from **3** hyperfine splitting by six hydrogen atoms is observed. In addition to the cyclobutane hydrogen atoms (a^H = 10.4 gauss) hyperfine splitting of a^H = 0.5 (2) and 0.3 (2) is observed. Probably the other two bridgehead hydrogen atoms and the two vinyl hydrogen atoms are involved. The large 2.5-gauss interaction of the *anti* hydrogen atoms in **2a** and **4a** is of interest.[6] In this regard the hyperfine splitting reported for **5** is surprising.[7]

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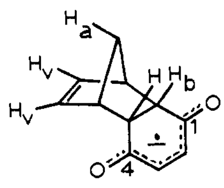
(2) Standard conditions employed 60 mg of alloy/ml of a 0.2 *M* solution of the ester.

(3) The spectra were similar to those reported previously in dimethyl sulfoxide solution: G. A. Russell and E. T. Strom, *J. Am. Chem. Soc.*, **86**, 744 (1964).

(4) The spectrum for bicyclo[3.2.1]octane-6,7-semidione is given by G. A. Russell, G. Holland, K.-Y. Chang, and L. H. Zalkow, *Tetrahedron Letters*, 1955 (1967); for bicyclo[2.2.2]octane-2,3-semidione, see G. A. Russell and K.-Y. Chang, *J. Am. Chem. Soc.*, **87**, 4381 (1965).

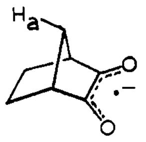
(5) In **1a** two of the 0.4 gauss splittings are removed by substitution of deuterium at the *exo,exo*-5,6 positions.

(6) G. A. Russell, P. R. Whittle, and J. McDonnell, *J. Am. Chem. Soc.*, **89**, 5515 (1967).

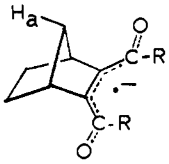


5

The splitting by H_b of 5.7 gauss indicates that $\rho_{C\text{-}1} = \rho_{C\text{-}4}$ in **5** is about $0.5\rho_{C-\pi}$ in **4a** (H_b = 10.2 gauss). On this basis one might predict for **5** that $H_v = 0.5$ (0.4) and $H_a = 0.5$ (2.7) gauss. The actual value of H_v of 0.2 gauss in **5** is in excellent agreement with this prediction. However, the experimental value of $a_a{}^H$ = 0.2 gauss in **5** is surprisingly low.[8] This may indicate the importance of coplanarity of the four bonds and the p_z orbital in the hyperfine splitting of H_a in **4a** and in **5**. It is also of considerable interest that in **1a**–**4a** but not in **5** the coefficients for the carbonyl carbon atom in the highest occupied molecular orbital have the same sign. In **5** the Hückel molecular orbital coefficients for C-1 and C-4 are of opposite sign and $(c_1 + c_4)^2$ will be zero.[9] In a similar manner we predict that the value of $a_a{}^H$ in **6** (a^H = 6.5 gauss[4]) will be much greater than in **7**.



6



7

Acknowledgment. Dr. G. Underwood detected the acyclic semidiones from ethyl acetate and ethyl isobutyrate in the presence or sodium–potassium alloy. These experiments led directly to the present work.

(7) S. F. Nelsen and B. M. Trost, *Tetrahedron Letters*, 5737 (1966).

(8) The assignment of this splitting to the *anti*-hydrogen appears very questionable to us.

(9) For a discussion of the point that $a^H = Q(c_1 + c_4)^2$ and not $a^H = Q(c_1{}^2 + c_4{}^2)$ see D. H. Whiffen, *Mol. Phys.*, 6, 224 (1963).

(10) National Aeronautics and Space Administration Predoctoral Fellow, 1965–1967.

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Received October 12, 1967

Germylation of Ferrocene under Friedel-Crafts Conditions. The Question of the Existence of Germonium Ions[1]

Sir:

In contrast to its carbon analog, the siliconium ion, $(C_6H_5)_3Si^+$, is not stabilized by π-orbital overlap,[2] although silicon of the SiH_3 group has been shown to withdraw electrons into its 3d orbitals from the benzene ring.[3] While the extent of delocalization in the case of silicon would be expected to exceed that to be found in the analogous case of germanium,[4] the latter, due to greater ease of ionization of the germanium–halogen bond, might be expected to form a cation more readily than silicon.[5,6] Nevertheless, several reported attempts to detect the existence of the germonium ion, $(C_6H_5)_3Ge^+$, have not been successful.[5,7,8] An investigation of dimethyldichlorogermane in water has indicated that hydrolysis may proceed *via* $(CH_3)_2Ge^{2+}$.[9]

Recently, we reported the first successful use of halosilanes in reactions analogous to Friedel–Crafts alkylation.[10] Ferrocene was silylated by chloro- and aminosilanes in the presence of anhydrous aluminum chloride, serving as evidence that siliconium ion, probably stabilized as a ferrocene π complex, can be generated under these conditions. We now report that germonium ion, presumably also in the form of a nonclassical intermediate in which $\geqslant Ge^+$ is π-bonded to the cyclopentadienyl ring of ferrocene, is capable of forming *via* the aluminum chloride catalyzed reaction of that compound with bis(N,N-dimethylamino)-dichlorogermane. Germanium derivatives of ferrocene have been isolated in a combined yield of >50%.

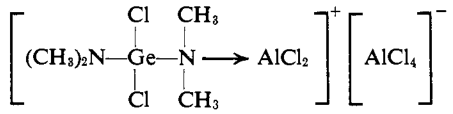
$$4FcH + [(CH_3)_2N]_2GeCl_2 \xrightarrow[(H_2O)]{2AlCl_3} \underset{50\%}{(Fc_2GeO)_3} + \underset{<1\%}{(Fc_3Ge)_2O}$$

(Fc = ferrocenyl)

Silylated ferrocenes totaling only 9% were obtained from a reaction performed identically with bis(N,N-dimethylamino)dichlorosilane as reactant.

$$4FcH + [(CH_3)_2N]_2SiCl_2 \xrightarrow[(H_2O)]{2AlCl_3} \underset{4\%}{Fc_2Si(OH)_2} + \underset{5\%}{Fc_3SiOH}$$

The greater reactivity of germanium is attributed to a combination of factors: (1) a more effective ferrocene π complexing of germanium due to its greater size and positive character;[6] (2) the (predicted) weaker bond strength of Ge–N;[11] (3) the (predicted) greater basicity of nitrogen attached to germanium[11] resulting in a more effective coordination of aluminum chloride to nitrogen. Concerning the last factor, a catalytic, dimolar aluminum chloride complex of a donor species, *e.g.*



$$\left[(CH_3)_2N\text{—}\underset{Cl}{\overset{Cl}{Ge}}\text{—}\underset{CH_3}{\overset{CH_3}{N}} \longrightarrow AlCl_2\right]^+ \left[AlCl_4\right]^-$$

may be applicable to germanium as well as silicon,[10] but this has not yet been established. Regarding the first two factors, it is envisioned that nucleophilic attack of ferrocene on germanium *via* the ring π system occurs, in a concerted displacement of a negative ionic species, with the "pull" exerted by the catalyst.[12]

(1) Presented at the 3rd International Symposium on Organometallic Chemistry, Munich, Aug 28–Sept 1, 1967, Abstracts, p 174.

(2) H. Gilman and G. E. Dunn, *Chem. Rev.*, 52, 77 (1953); J. Y. Corey and R. West, *J. Am. Chem. Soc.*, 85, 4034 (1963).

(3) L. Goodman, A. H. Konstam, and L. H. Sommer, *ibid.*, 87, 1012 (1965).

(4) W. K. Musker and G. B. Savitsky, *J. Phys. Chem.*, 71, 431 (1967).

(5) O. H. Johnson and E. A. Schmall, *J. Am. Chem. Soc.*, 80, 2931 (1958).

(6) It is noteworthy, however, that a large body of evidence has been accumulated based on which germanium has been assigned an electronegativity value *higher* than that for silicon, which is contrary to prediction based on customary interpretation of the periodic table: A. L. Allred and E. G. Rochow, *J. Inorg. Nucl. Chem.*, 5, 269 (1958).

(7) A. B. Thomas and E. G. Rochow, *J. Am. Chem. Soc.*, 79, 1843 (1957).

(8) M. E. Peach and T. C. Waddington, *J. Chem. Soc.*, 1238 (1961).

(9) E. G. Rochow and A. L. Allred, *J. Am. Chem. Soc.*, 77, 4489 (1955).

(10) G. P. Sollott and W. R. Peterson, Jr., *ibid.*, 89, 5054 (1967).

(11) K. Jones and M. F. Lappert, *J. Chem. Soc.*, 1944 (1965).