

Spirans XXI. Synthesis of Silaazaspiro[4.5]decanes and Silaazaspiro[5.5]undecanes.

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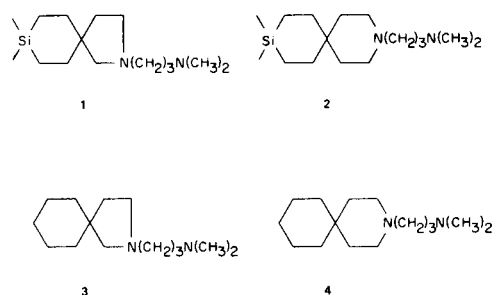
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Received June 15, 1973

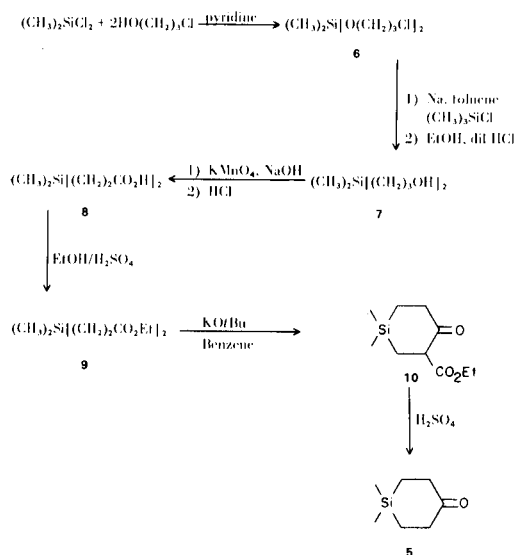
N-(2-Dimethylaminopropyl)-8,8-dimethyl-8-sila-2-azaspiro[4.5]decane (**1**) and *N*-(3-dimethylaminopropyl)-9,9-dimethyl-9-sila-3-azaspiro[5.5]undecane (**2**) have been synthesized from 4,4-dimethyl-4-silacyclohexanone (**5**). Biological evaluation of **1** and **2** indicated cytotoxic action against human cancer cells grown in tissue culture.

Previous work has shown (2,3) that silicon analogs of medicinal agents exhibit biological activity. In our continued effort (4) in structure-activity relationship for the antineoplastic effect of azaspirans, silicon analogs **1** and **2** of azaspirans **3** and **4** have been synthesized.

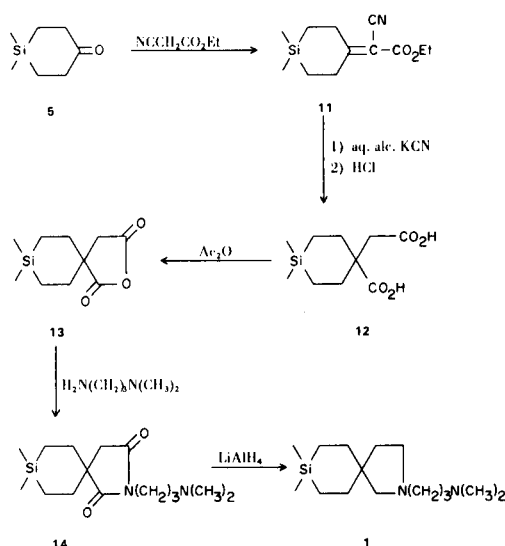
The key intermediate in our synthesis was 4,4-dimethyl-4-silacyclohexanone (**5**). An improved preparation of **5** prepared by a modification of the procedure of Benkeser and Bennett (5) is shown in Scheme I with improvement of yield.



SCHEME I



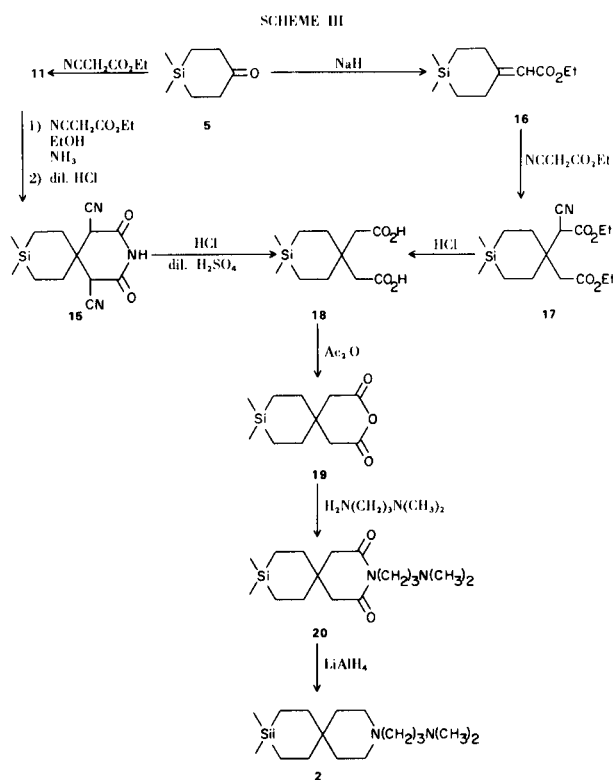
SCHEME II



Ketone **5** was treated with ethyl cyanoacetate using a modified Cope (7) procedure and gave the condensed product **11**. Addition of potassium cyanide across the

double bond, followed by hydrolysis with concentrated hydrochloric acid gave acid **12**. Acid **12** was converted to anhydride **13** and on treatment with 3-dimethylaminopropylamine formed cyclized silaazaspiroimide **14**. Reduction of **14** with lithium aluminum hydride afforded **1**.

The preparation of silaazaspiran **2** is outlined in Scheme III.



In this route, the reaction of ketone **5** with ethyl cyanoacetate gave **11** as before. Ester **11** underwent Michael addition with ethyl cyanoacetate in the presence of ammonia and simultaneous cyclization produced the ammonium salt of dicyanoimide (**15**). However, attempted hydrolysis of **15** with concentrated hydrochloric acid for a prolonged time was unsuccessful. Two attempts to hydrolyze the same imide with either 40% or 50% sulfuric acid were also unsuccessful. In an alternate path, ketone **5** was subjected to a modified Wittig reaction (8) to provide **16** which on addition of ethyl cyanoacetate gave cyano-ester **17** (9). This type of Michael addition in which ethyl cyanoacetate adds an α,β to the carbonyl has not been generally well developed. However, it has proved to be invaluable in our work, and of wide applicability on which we will report more in the future employing other systems.

Hydrolysis of **17** with concentrated hydrochloric acid proved difficult and was overcome by repeated recycling of the unhydrolyzed imide with vigorous stirring to give the desired diacid **18**. This acid when treated with acetic anhydride afforded **19** and following the reaction with 3-dimethylaminopropylamine produced silaazaspiroimide **20**. A lithium aluminum hydride reduction of **20** provided the silaazaspiran **2**.

Although the pmr absorption of the *gem*-dimethyl group of diacid **12** was centered at *ca.* zero ppm, the two methyl groups were magnetically nonequivalent and were separated by 1.6 Hz. A similar nonequivalence was noted in anhydride **13**, the methyl groups being separated by 4.5 Hz. The *gem*-dimethyl groups of **14** were also not equivalent (5.5 Hz). No separation was observed for amine **1** indicating that the anisotropy of the carbonyl group is necessary for this nonequivalence. None of the compounds in Scheme III showed any nonequivalence of methyl groups attached to silicon in their pmr spectra.

Compounds **1** and **2** as their dihydrochloride salts were screened for toxicity in rats and gave acute LD₅₀ range of 100-125 mg./kg. When tested against human cancer cells grown in tissue culture, amine **1** inhibited complete cancer cell growth at a concentration of 1×10^{-5} g./ml. while **2** inhibited growth at 1×10^{-6} g./ml.

The dimethiodide of **1** when tested in dogs under numbutal anesthesia, lowered the blood pressure 40% at a dosage of 10 mg./kg. iv.

EXPERIMENTAL

All melting points were determined on a Thomas-Hoover melting point apparatus and are uncorrected. Elemental analyses were performed by Schwarzkopf Microanalytical Laboratory, Woodside, New York. Infrared spectra were taken on a Perkin-Elmer Model 137 using polystyrene as a calibration. The pmr spectra were obtained on a Varian A-60 spectrometer using tetramethylsilane as an internal standard (added subsequently to the solutions). Chemical shifts are expressed in parts per million (δ). Anhydrous sodium sulfate was used as a drying agent. Dimethyldi(3-chloropropoxy)silane (**6**).

This compound was synthesized utilizing the general procedure of Speier (10). Dimethyldichlorosilane, 258.2 g. (2.0 moles) and 632.9 g. (8.0 moles) of pyridine were separately cooled at 0° and then mixed. The mixture was stirred at ice bath temperature and 378.2 g. (4.0 moles) of 3-chloro-1-propanol was added at such a rate that the temperature did not rise. The mixture was allowed to come to room temperature and filtered free of pyridine hydrochloride. The excess pyridine was removed and the product was distilled at $140-142^\circ$ (25 mm) to yield 422 g. (86%) of **6** [lit. (10) 141° (25 mm)]; ir (neat): 8.05, 9.10, and 13.4μ ; pmr (deuteriochloroform): δ 0.1 (s, 6), 2.0 (pentet, 4, $J = 6$ Hz), 3.74 (t, 4, $J = 6$ Hz), and 3.91 (t, $J = 5$ Hz).

Dimethyldi(3-hydroxypropyl)silane (**7**).

The procedure by Speier (10) was employed. To a sodium sand 81.4 g. (3.5 moles) in toluene, a sufficient portion of

trimethylchlorosilane from a total of 195.6 g. (1.8 moles) was added to lower the boiling point of mixture to 101°. The remainder of trimethylchlorosilane was mixed with 199.7 g. (0.814 mole) of **6** and was added to the reaction mixture at such a rate to keep the reaction mixture boiling. The deep blue reaction mixture was heated for one-half hour after addition and allowed to cool to room temperature. It was treated in turn with absolute alcohol, 20% hydrochloric acid, and diluted with water. The hydrolyzed product was warmed for 30 minutes, and allowed to cool to room temperature, the toluene layer separated and dried. After removal of solvent and a considerable amount of forerun, the desired diol **7** was collected at 174-178° (24 mm), 66.8 g. (47%) [lit. (10) 176° (24 mm)]; ir (neat): 2.96, 7.98, and 11.9 μ ; pmr (deuteriochloroform): δ 0.0 (s, 6), 0.29-0.74 (m, 4), 1.26-1.86 (m, 4), 3.56 (t, 4, J = 7 Hz), and 4.15 (broad s, 2).

Dimethyldi(2-carboxyethyl)silane (**8**).

This compound was prepared as outlined by Benkeser and Bennett (5) with modification. The product isolation was facilitated by removal of the last few steps with improvement in yield. A solution of 124.1 g. (0.786 mole) of potassium permanganate in 2357 ml. of water was prepared and cooled to 10°. A solution of 11.67 g. (0.291 mole) of sodium hydroxide in 200 ml. of water was mixed with 51.9 g. (0.294 mole) of **7** and cooled to 0°. This was added rapidly to the permanganate solution, the mixture was stirred at ice-bath temperature for 6 hours and for 16 additional hours while it was allowed to come to room temperature. The mixture was filtered through a Buchner funnel and the colorless filtrate was concentrated to one-tenth its volume. The concentrated solution was cooled and 100 ml. of concentrated hydrochloric acid was added in portions with stirring. After cooling for 1 hour, the diacid was filtered, washed twice with cold water, and pressed. The acid was kept in an oven for 24 hours at 105°. The liquid thus obtained solidified on cooling to room temperature to give 38 g. (63.2%) of **8**. Recrystallization from benzene-petroleum ether gave material of m.p. 97-98° [lit. (5) 97-98°]; ir (Nujol): 5.85, 8.0, and 11.9 μ ; pmr (DMSO- d_6): δ 0.0 (s, 6), 0.55-0.93 (m, 4), 1.96-2.46 (m, 4), and 12 (s, 2).

Dimethyldi(2-carboethoxyethyl)silane (**9**).

Diacid **8**, (251 g., 1.22 moles) was esterified with alcohol and concentrated sulfuric acid by the method of Ingold (11). The product was distilled at 82-84° (0.05 mm) to yield 260.4 g. (85.1%) of **9**; ir (neat): 5.73, 8.0, and 11.9 μ ; pmr (deuteriochloroform): δ 0.0 (s, 6), 0.66-1.05 (m, 4), 1.21 (t, 6, J = 7 Hz), 2.08-2.50 (m, 4), and 4.11 (q, 4, J = 7 Hz).

Anal. Calcd. for C₁₂H₂₄O₄Si: C, 55.34; H, 9.28; Si, 10.78. Found: C, 55.19; H, 9.63; Si, 10.40.

2-Carboethoxy-4,4-dimethyl-4-silacyclohexanone (**10**).

To a mixture of 136.9 g. (1.22 moles) potassium *t*-butoxide in 1 l. of dry benzene at reflux was added 256 g. (0.98 mole) of **9** dissolved in 300 ml. of dry benzene with stirring. During the addition period, a viscous semi-solid was formed which on continuous stirring was dissolved in benzene. After the addition was complete, the reaction mixture was refluxed for 2 hours, the solution cooled to room temperature and neutralized with 20% hydrochloric acid. The benzene layer was separated, washed with 10% sodium bicarbonate solution, water, a saturated salt solution, and dried. After removal of benzene, the residue was distilled at 67-69° (0.3 mm) giving 159.3 g. (75.8%) of β -ketoester **10** which gave a deep bluish green color with ferric chloride solution; ir (neat): 5.70, 5.81, 7.96, 6.06 and 11.87 μ .

Anal. Calcd. for C₁₀H₁₈O₃Si: C, 55.99; H, 8.46; Si, 13.10. Found: C, 56.16; H, 8.53; Si, 13.18.

4,4-Dimethyl-4-silacyclohexanone (**5**).

A mixture of 159 g. (0.741 mole) of **10** and 704 ml. of 25% sulfuric acid was refluxed for 12 hours with stirring. The mixture was cooled to room temperature, poured into 300 ml. of water and extracted thrice with ether. The ether extracts were washed successively with 10% potassium bicarbonate solution, water, a saturated salt solution, and dried. After removal of ether, the liquid was distilled at 73-74° (11 mm) to yield 83.8 g. (79.5%) of **5** [lit. (5) 73-74° (11 mm)]; ir (neat): 5.87, 8.0, 11.9 μ ; pmr (deuteriochloroform): δ 0.0 (s, 6), 0.6-0.95 (m, 4), and 2.15-2.51 (m, 4).

Ethyl α -Cyano- α -(4,4-dimethyl-4-silacyclohexylidene)acetate (**11**).

Silaketone **5**, 14.3 g. (0.1 mole) was converted into its cyanoalkylidene ester with ethyl cyanoacetate by the procedure of Cope (7). The product was distilled at 108-110° (0.45 mm) giving 20.1 g. (84.7%) of a pale yellow liquid **11**; ir (neat): 4.45, 5.75, 6.23, 7.97, and 11.8 μ ; pmr (deuteriochloroform): δ 0.0 (s, 6), 0.64-1.02 (m, 4), 1.23 (t, 3, J = 7 Hz), 2.57-3.14 (m, 4), and 4.19 (q, 2, J = 7 Hz).

Anal. Calcd. for C₁₂H₁₉NO₂Si: C, 60.71; H, 8.06; N, 5.90; Si, 11.83. Found: C, 60.96; H, 8.22; N, 6.13; Si, 11.63.

4,4-Dimethyl-4-silacyclohexane-1-carboxy-1-acetic Acid (**12**).

To a solution of 13 g. (0.0532 mole) of **11** in 70 ml. of alcohol was added a solution of 5.25 g. of potassium cyanide dissolved in 28 ml. of water and the mixture was allowed to stand for 2.5 days at room temperature. All the solvents were removed and the dried salt was refluxed with 85 ml. of concentrated hydrochloric acid for 14 hours. The mixture was diluted with water, cooled, and filtered. The crude acid was dissolving in boiling saturated potassium bicarbonate solution and filtered while hot. The filtrate on cooling was acidified with concentrated hydrochloric acid with stirring and the precipitated white diacid filtered, washed with cold water, pressed, and dried giving 9.2 g. (75%) of **12**, m.p. 161-162°. Recrystallization from benzene-petroleum ether gave material of m.p. 162-163°; ir (Nujol): 5.84, 7.97, and 11.8 μ ; pmr (DMSO- d_6): (two separate singlets at 0.0 ppm separated by 1.6 Hz, 6 H), δ 0.36-0.78 (m, 4), 1.58-2.18 (m, 4), 2.45 (s, 2), and 12 (s, 2).

Anal. Calcd. for C₁₀H₁₈O₄Si: C, 52.14; H, 7.87; Si, 12.19. Found: C, 52.31; H, 8.03; Si, 12.12.

4,4-Dimethyl-4-silacyclohexane-1-carboxy-1-acetic Acid Anhydride (**13**).

A mixture of 9.2 g. (0.0399 mole) of diacid **12** was refluxed with 45 ml. of acetic anhydride for 2.5 hours and the clear solution was allowed to cool to room temperature. The excess acetic anhydride was removed under diminished pressure and the residue was recrystallized from isooctane. The white crystalline material **13**, 8.1 g. (95.6%) melted at 88.5-89.5°; ir (Nujol): 5.36, 5.59, 8.0, and 11.8 μ ; pmr (deuteriochloroform): δ 0.0 (s, 3), 0.07 (s, 3), 0.19-1.15 (m, 4), 1.75-2.16 (m, 4), and 2.76 (s, 2).

Anal. Calcd. for C₁₀H₁₆O₃Si: C, 56.56; H, 7.59; Si, 13.23. Found: C, 56.63; H, 7.71; Si, 13.11.

N-(2-Dimethylaminopropyl)-8,8-dimethyl-8-sila-2-azaspiro[4.5]-decan-1,3-dione (**14**).

To 7.6 g. (0.0357 mole) of powdered anhydride **13**, 3.65 g. of 3-dimethylaminopropylamine was added dropwise with shaking.

The reaction was exothermic and heat was applied to obtain a clear melt. The mixture was heated at 190° for 1 hour and allowed to cool to room temperature. Distillation at 118-128° (0.08 mm) yielded 9.8 g. (92.5%) of **14** which melted at 87-88°; (Nujol): 3.59, 5.62, 5.86, 8.01, and 11.9 μ ; pmr (deuteriochloroform): δ 0.0 (s, 3), 0.09 (s, 3), 0.33-0.83 (m, 4), 1.50-2.93 (m, 6), 2.14 (s, 6), 2.23 (t, 2, J = 7 Hz), 2.49 (s, 2), and 3.50 (t, 2, J = 7 Hz).

Anal. Calcd. for C₁₅H₂₈N₂O₂Si: C, 60.76; H, 9.52; N, 9.45; Si, 9.47. Found: C, 61.10; H, 9.39; N, 9.47; Si, 9.22.

The hydrochloride derivative was prepared by dissolving imide **14** in ethyl acetate and adding a saturated solution of alcoholic hydrogen chloride gas. Anhydrous ether was added to this acidic solution until it became cloudy and was cooled. The precipitated hydrochloride was filtered and dried, m.p. 206-207°. Recrystallization from ethyl acetate raised the melting point to 207-208°.

Anal. Calcd. for C₁₅H₂₉ClN₂O₂Si: Cl, 10.64. Found: Cl, 10.72.

The methiodide was made by adding excess methyl iodide to a solution of imide **14** in ethyl acetate with shaking. The mixture was cooled, and the separated crystalline material was filtered, and dried, m.p. 230-231°. The recrystallized methiodide from ethyl acetate melted at 231-232°.

Anal. Calcd. for C₁₆H₃₁IN₂O₂Si: I, 28.94. Found: I, 29.05. N-(2-Dimethylaminopropyl)-8,8-dimethyl-8-sila-2-azaspiro[4.5]-decane (**1**).

To a solution of 2.5 g. lithium aluminum hydride in 200 ml. of anhydrous ether, a solution of 9.2 g. (0.031 mole) of **14** dissolved in 200 ml. of anhydrous ether was added over a period of 15 minutes and the mixture stirred for 3 hours. The reaction mixture was decomposed with 10 ml. of water, stirred for an additional hour, filtered and the filtrate dried. The ether was removed and the residual oil was distilled at 106-108° (0.55 mm) to yield 8.1 g. (97.3%) of amine **1**: pmr (deuteriochloroform): δ 0.0 (s, 6), 0.36-0.75 (m, 4), 1.40-1.90 (m, 8), 2.22 (s, 6), 2.28-2.71 (overlapping t, 6), and 2.34 (s, 2).

Anal. Calcd. for C₁₅H₃₂N₂Si: C, 67.09; H, 12.01; N, 10.43; Si, 10.46. Found: C, 67.26; H, 12.33; N, 10.19; Si, 10.71.

Amine **1** was dissolved in absolute alcohol and was made acidic by adding a saturated solution of alcoholic hydrogen chloride gas. Anhydrous ether was added to the solution until it became turbid and the solution was cooled. The precipitated dihydrochloride was filtered and dried, m.p. 311-311.5°. The recrystallized salt from ethanol melted at 311.5-312°.

Anal. Calcd. for C₁₅H₃₄Cl₂N₂Si: Cl, 20.76. Found: Cl, 21.04.

Excess methyl iodide was added to a solution of amine **1** in absolute alcohol and the mixture was cooled for 1 hour. The dimethiodide formed was filtered and dried, m.p. 287-288.5°. It melted at 288-288.5° on recrystallization from alcohol-ethyl acetate.

Anal. Calcd. for C₁₇H₃₈I₂N₂Si: I, 45.94. Found: I, 46.05. 1,5-Dicyano-9,9-dimethyl-9-sila-3-azaspiro[5.5]undecan-2,4-dione (**15**).

A mixture of 25 g. (0.103 mole) of **11** and 11.7 g. (0.103 mole) of ethyl cyanoacetate was placed in a 500 ml. thick-wall flask and cooled to 0°. To this solution was added 110 ml. of absolute alcohol previously saturated with anhydrous ammonia at 0°. The flask was stoppered, sealed with a tape, and stored for 2 days at 0.5°. The separated ammonium salt of the dicyanoimide was filtered, pressed, and washed with anhydrous ether

and dried. The dried salt was dissolved in 1 l. of water with boiling and the solution was filtered while hot. The filtrate was made acidic by adding concentrated hydrochloric acid with stirring and allowed to cool. The precipitated dicyanoimide was filtered, washed with cold water, and dried giving 13.2 g. (46.5%) of **15**. A portion after recrystallization from ethyl acetate melted at 271-273°; ir (Nujol) 3.07, 4.43, 5.80, 7.97, and 11.85 μ ; pmr (DMSO-d₆): δ 0.0 (s, 6), 0.42-0.96 (m, 4), 1.59-1.99 (m, 4), 4.60 (s, 1), and 4.81 (s, 2).

Anal. Calcd. for C₁₃H₁₇N₃O₂Si: C, 56.69; H, 6.22; N, 15.26; Si, 10.20. Found: C, 56.98; H, 6.39; N, 15.04; Si, 10.10.

Attempted Hydrolysis of 1,5-Dicyano-9,9-dimethyl-9-sila-3-azaspiro[5.5]undecan-2,4-dione (**15**).

Attempts to hydrolyze the dicyanoimide **15** either with concentrated hydrochloric acid or with aqueous sulfuric acid of varied strengths failed to provide the corresponding diacid **18**. The hydrolysis of **15** was carried out with concentrated hydrochloric acid up to 96 hours without success. When the same imide was refluxed with 40% sulfuric acid from 12 to 24 hours, the material was unchanged. Imide **15** when refluxed with 50% sulfuric acid gave largely decomposition and intractable gum.

Ethyl α -(4,4-Dimethyl-4-silacyclohexylidene)acetate (**16**).

The procedure described in organic syntheses (8) was followed using 42.7 g. (0.3 mole) of **5**. The fraction collected at 49-65° (0.03 mm) was redistilled giving 38.7 g. (60.7%) of **16b**.p. 52-60° (0.03 mm); ir (neat): 5.82, 6.07, 8.01, and 11.87 μ ; pmr (deuteriochloroform) δ 0.0 (s, 6), 0.56-0.93 (m, 4), 1.19 (t, 3, J = 7 Hz), 2.33 (broad t, 2), 2.68-3.13 (m, 2), 4.09 (q, 2, J = 7 Hz), and 5.60 (broad s, 1).

Anal. Calcd. for C₁₁H₂₀O₂Si: C, 62.21; H, 9.49; Si, 13.22. Found: C, 62.00; H, 9.35; Si, 13.06.

Diethyl 4,4-Dimethyl-4-silacyclohexane-1-(α -cyano)acetate-1-acetate (**17**).

To a solution of sodium ethoxy [4.45 g. (0.1936 mole) sodium in 200 ml. of absolute alcohol] was added 21.9 g. (0.1936 mole) of ethyl cyanoacetate slowly and the mixture allowed to cool. To this solution, 37.4 g. (0.176 mole) of **16** was added and the mixture was refluxed for 2 hours on a steam bath. It was allowed to come to room temperature and neutralized with dilute hydrochloric acid. The resulting solution was diluted with cold water and extracted with small portions of ether. The ether extracts were washed with 10% sodium bicarbonate solution, water, a saturated salt solution, and dried. Removal of ether and distillation gave a forerun of unreacted materials. A fraction collected at 132-136° (0.225 mm) was redistilled to yield 16.4 g. (28.6%) of the desired product at 120-124° (0.05 mm); ir (neat): 4.43, 5.75, 8.0, and 11.8 μ ; pmr (deuteriochloroform): δ 0.0 (s, 6), 0.61 (broad t, 4), 1.23 (t, 3, J = 7 Hz), 1.26 (t, 3, J = 7 Hz), 1.86 (broad t, 4), 2.54 (s, 2), 4.12 (q, 2, J = 7 Hz), 4.20 (s, 1), and 4.22 (q, 2, J = 7 Hz).

Anal. Calcd. for C₁₆H₂₇NO₄Si: C, 59.04; H, 8.36; N, 4.30; Si, 8.63. Found: C, 58.91; H, 8.45; N, 4.63; Si, 8.80.

4,4-Dimethyl-4-silacyclohexane-1,1-diacetic Acid (**18**).

A solution of 16 g. (0.0491 mole) of cyanodiester **17** and 100 ml. of concentrated hydrochloric acid was refluxed for 12 hours, the mixture diluted with water, and cooled. The mixture was filtered and the solid residue (9 g.) was dissolved in saturated potassium bicarbonate solution on boiling and filtered while hot. The filtrate was acidified with concentrated hydrochloric acid,

and on cooling and filtering gave 1.7 g. of crystalline diacid **18** m.p. 198-202°. The residue from bicarbonate solution was washed with water, dried (7.3 g.), and was again refluxed with 80 ml. of concentrated hydrochloric acid for 12 hours with stirring and treating in the same manner, yielded 2.2 g. of diacid, m.p. 198-202°. The unreacted fraction (4.9 g.) on hydrolysis with concentrated hydrochloric acid with vigorous stirring gave 1.2 g. of diacid, m.p. 198-202°. The fraction that remained (3.3 g.) was rehydrolyzed in a similar manner to yield 1.4 g. of diacid, m.p. 198-202° with 1.5 g. of residue. A total of 6.5 g. of diacid (54.1%) was obtained. A portion on recrystallization from ethyl acetate raised the melting point to 209-212° and second recrystallization from ethyl acetate gave material which melted at 211-212°; ir (Nujol): 5.84, 7.98, and 11.8 μ ; pmr (DMSO-d₆): δ 0.0 (s, 6), 0.3-0.75 (m, 4), 1.43-1.90 (m, 4), 2.36 (s, 4), and 12 (s, 2).

Anal. Calcd. for C₁₁H₂₀O₄Si: C, 54.06; H, 8.25; Si, 11.50. Found: C, 54.34; H, 8.39; Si, 11.64.

4,4-Dimethyl-4-silacyclohexane-1,1-diacetic Acid Anhydride (**19**).

A mixture of 5 g. (0.0491 mole) of diacid **18** was refluxed with 25 ml. of acetic anhydride for 1 hour and cooled to room temperature. The excess acetic anhydride was removed under vacuum and the crude product was distilled at 65-67° (0.05 mm) to yield 4.4 g. (95.2%) of **19**, m.p. 102-104°. Recrystallization from ethyl acetate-petroleum ether raised the melting point to 104-105°.

Anal. Calcd. for C₁₁H₁₈O₃Si: C, 58.37; H, 8.01; Si, 12.41. Found: C, 58.65; H, 8.16; Si, 12.19.

N-(3-Dimethylamino propyl)-9,9-dimethyl-9-sila-3-azaspiro[5.5]-undecan-2,4-dione (**20**).

To a powdered 4 g. (0.0176 mole) of anhydride **19**, 2 g. of 3-dimethylaminopropylamine was added dropwise and the mixture was warmed to obtain a clear melt. The melt was heated to 180° for 1 hour and was cooled to room temperature. The product was distilled at 139-145° (0.05 mm) to yield 3.7 g. (67.6%) of imide (**20**); ir (carbon tetrachloride): 5.75, 5.92, 8.0 and 11.8 μ .

Anal. Calcd. for C₁₆H₃₀N₂O₂Si: C, 61.89; H, 9.74; N, 9.02; Si, 9.04. Found: C, 61.59; H, 9.42; N, 9.04; Si, 9.05.

N-(3-Dimethylamino propyl)-9,9-dimethyl-9-sila-3-azaspiro[5.5]-undecane (**2**).

To a solution of 1 g. of lithium aluminum hydride in 50 ml. of anhydrous ether, a solution of 3 g. (0.01 mole) of imide **20** dissolved in 50 ml. of anhydrous ether was added and the mixture was stirred for 2 hours at room temperature. The reaction mixture was decomposed by the slow addition of 4 ml. of water and was stirred for an additional hour, filtered and the filtrate was dried. The ether was removed and the residue was distilled at 102-106°

(0.1 mm) to yield 2.41 g. (88%) of a pale yellow oil; pmr (deuteriochloroform): δ 0.0 (s, 6), 0.26-0.72 (m, 4), 1.14-1.92 (m, 10), 2.22 (s, 6), and 2.26-2.59 (m, 8).

Anal. Calcd. for C₁₆H₃₄N₂Si: C, 68.01; H, 12.13; N, 9.92; Si, 9.94. Found: C, 67.94; H, 12.20; N, 9.88; Si, 10.14.

Amine **2** was dissolved in absolute methanol and a saturated solution of alcoholic hydrogen chloride gas was added. The precipitate dihydrochloride was dissolved by adding methanol on warming and the clear solution was allowed to cool. The precipitated product was filtered and dried, m.p. 308-310°. This on recrystallization from alcohol-ether gave a white crystalline solid which melted at 311-313°.

Anal. Calcd. for C₁₆H₃₆Cl₂N₂Si: C, 54.06; H, 10.21; Cl, 19.95; N, 7.88; Si, 7.90. Found: C, 54.19; H, 10.20; Cl, 20.03; N, 7.80; Si, 7.68.

Acknowledgment.

We are grateful to the Geschickter Fund for Medical Research for providing the biological data and support.

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