the β-diketones employed in obtaining the previous data have been used again in obtaining the data for Ce(III) given in Table II. So, for convenience of comparison of the points in Fig. 1, the symbols for the points representing the previously reported data are given at the bottom of Table I along with the Table II guide numbers for the β-diketones involved.

In Fig. 2, it is seen that there is essentially a linear relationship between pK_D and log K_{f_1}, the first chelate compound formation constant, for the series of β-diketones containing two aromatic rings with cerium(III). However, upon the addition of a second chelating group to cerium(III), those β-diketones which contain a thienyl group have slightly higher stability constants than would be expected from the positions of the other β-diketones. The same relationship, but of greater magnitude, is noted for the third constants. Since the effect is most pronounced for the third constants, in which case the cerium is probably surrounded by the six oxygen atoms of the three attached β-diketones in an octahedral fashion, it would appear that the close proximity of the bulky sulfur atoms to the central metal ion aids in shielding the coördination centers from interaction with the solvent.

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COMMUNICATIONS TO THE EDITOR

ACHROMYCIN.[1] SYNTHETIC STUDIES. III. SYNTHESIS OF 3-AMINO-D-RIBOSE, A HYDROLYTIC PRODUCT

Sir:

One of the hydrolysis products of Achromycin is a 3-aminopentose, either 3-aminoribose or 3-aminoxylose. This is the first known 3-amino sugar and first known aminopentose to exist in a natural source.[2] The structure has now been proven to be 3-amino-D-ribose by synthesis from L-arabinose via β-methyl 2,3-anhydro-L-ribopyranoside (I).[3]

Treatment of I with ammonium hydroxide at 100° under pressure afforded a 65% yield of β-methyl-3-amino-L-xylopyranoside, m.p. 191–192° dec., $[\alpha]^{34}D$ +61.4° (1% in H_2O). *Anal.* Calcd. for $C_6H_{13}NO_4$: C, 44.2; H, 8.03; N, 8.60. Found: C, 44.2; H, 8.07; N, 8.93. Acetylation with aqueous acetic anhydride formed 98% of β-methyl 3-acetamino-L-xylopyranoside (II), m.p. 194–195°, $[\alpha]^{24}D$ +64.4° (2% in H_2O). *Anal.* Calcd. for $C_8H_{15}NO_5$: C, 46.8; H, 7.36; N, 6.83. Found: C, 46.4; H, 7.53; N, 6.74. Since II failed to consume periodate, the alternate structure, β-methyl-2-amino-L-arabinopyranoside, which could be formed on ring opening of I, was eliminated.[4]

When II was treated with methanesulfonyl chloride in pyridine, an 83% yield of β-methyl-2,5-dimesyl-3-acetamino-L-xylopyranoside (III), m.p. 150°, $[\alpha]^{24}D$ +18.8° (2% in pyridine), was obtained. *Anal.* Calcd. for $C_{10}H_{19}NO_9S_2$: C, 33.2; H, 5.30; N, 3.88. Found: C, 33.7; H, 5.43; N, 4.06. Reaction of III with sodium acetate in boiling 95% alcohol caused elimination of one mesyl group with inversion via an oxazoline.[5] Work-up by acetylation gave a 66% yield of β-methyl 2-acetyl-3-acetamino-4-mesyl-L-lyxopyranoside, m.p. 171–172°, $[\alpha]^{24}D$ −11.0° (1.4% in pyridine). *Anal.* Calcd. for $C_{11}H_{19}NO_8S$: C, 40.6; H, 5.89; N, 4.31. Found: C, 40.9; H, 5.78; N, 4.22. Further treatment with sodium acetate in 95% boiling Methyl Cellosolve eliminated the second mesyl group with inversion to an all *cis*-configuration. Acetylation then afforded 70% of α-methyl-2,4-diacetyl-3-acetamino-D-ribopyranoside, IV, m.p. 116–117°, $[\alpha]^{24}D$ +93.7° (1.6% in $CHCl_3$). *Anal.* Calcd. for $C_{12}H_{19}NO_7$: C, 49.8; H, 6.62; N, 4.85. Found: C, 49.8; H, 6.84; N, 4.73. Direct treatment of III with sodium acetate in 95% Methyl Cellosolve caused elimination of both mesyl groups with inversion. Acetylation afforded 70% yield of IV. Hydrolysis of IV with boiling 1% hydrochloric acid gave 83% of 3-amino-D-ribose hydrochloride, m.p. 160° dec., $[\alpha]_D$ −25.0° (2% in H_2O). *Anal.* Calcd. for $C_5H_{11}NO_4 \cdot HCl$: C, 32.4; H, 6.52; N, 7.55. Found: C, 32.6; H, 6.82; N, 7.79. Comparative I.R. spectra showed this compound to be identical with the 3-aminopentose obtained on hydrolysis of Achromycin.[2]

It is interesting to note that this synthesis proceeds through all four pentose configurations. Derivatives of 3-amino-D-allose also have been

(1) Achromycin is the American Cyanamid Co. trademark for the antibiotic, Puromycin.

(2) C. W. Waller, P. W. Fryth, B. L. Hutchings and J. H. Williams, THIS JOURNAL, **75**, 2025 (1953).

(3) S. Mukherjee and A. R. Todd, *J. Chem. Soc.*, 971 (1947).

(4) It should be noted that a *trans* configuration of amine and hydroxyl is obtained by Walden inversion. Opening of the oxide ring of α-methyl-2,3-anhydro-4,6-benzylidene-D-mannopyranoside with ammonia has been shown by W. H. Myers and G. J. Robertson [THIS JOURNAL, **65**, 8 (1943)] to give α-methyl-3-amino-4,6-benzylidene-D-altropyranoside and α-methyl-2-amino-4,6-benzylidene-D-glucopyranoside.

(5) Although this is the first known example of this reaction in the carbohydrate field, the reaction has been described with *trans*-acetaminocyclohexanol-2-tosylate by G. E. McCasland, R. K. Clark and H. E. Carter in THIS JOURNAL, **71**, 641 (1949).

synthesized by inversion of an altrose-2-mesylate and will be the subject of a future paper.

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2,6-DI-BUTYLPYRIDINE—AN UNUSUAL PYRIDINE BASE

Sir:

2,6-Di-*t*-butylpyridine was synthesized by the reaction of *t*-butyllithium with 2-*t*-butylpyridine.

Excess *t*-butyllithium, prepared from 0.5 mole of *t*-butyl chloride and 1.0 mole of lithium sand in ethyl ether, was added to 0.2 mole of 2-*t*-butylpyridine in 200 ml. of purified 90–100° petroleum ether. The reactants were maintained at −78° for several hours. The temperature was then raised and solvent removed by distillation until the mixture refluxed at 70°. After seven hours, the mixture was hydrolyzed and the base recovered by distillation. The yield was 18.8 g. (0.099 mole) of 2,6-di-*t*-butylpyridine (b.p. 100–101° at 23 mm., $n^{20}D$ 1.5733).

Anal. Calcd. for $C_{13}H_{21}N$: C, 81.6; H, 11.0; N, 7.3. Found: C, 81.4; H, 10.9; N, 7.5.

The picrate could not be prepared. The chloroaurate melted at 184.2–184.5.

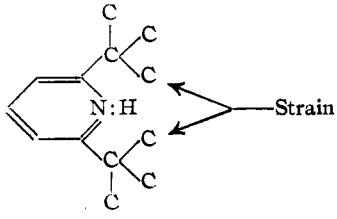
Anal. Calcd. for $C_{13}H_{22}NAuCl_4$: C, 29.4; Au, 37.1. Found: C, 29.7; Au, 36.9.

The base reacts with hydrogen chloride. However, it does not react with methyl iodide or with boron trifluoride. The base thereby permits the quantitative separation of hydrogen chloride from a mixture containing boron trifluoride. For the first time we have a simple method of distinguishing between protonic and Lewis acids.

2,6-Di-*t*-butylpyridine is a relatively weak pyridine base. The pK_a values, measured in 50% aqueous ethanol at 25°, for this and related compounds are

R	Pyridine	2-RC_5H_4N	2,6-$R_2C_5H_3N$
Methyl	4.38	5.05	5.77
Isopropyl	4.38	4.82	5.34
t-Butyl	4.38	4.68	3.58

Thus, 2,6-di-*t*-butylpyridine is weaker than expected by 1.4 pK_a units. We attribute the low pK_a value to steric strain involving the bound proton. The result suggests that the steric requirements of the lone pair on the nitrogen atom must be less than those of the hydrogen atom and its bonding pair.



It follows that the homomorphic molecule, *m*-di-*t*-butylbenzene, should also be strained. This proposal of steric interaction operating between large bulky groups with meta orientation appears capable of accounting for a considerable number of otherwise anomalous data in the literature.

In contrast to other pyridine bases, 2,6-di-*t*-butylpyridine undergoes ready nuclear sulfonation by sulfur trioxide. Identical solutions of sulfur trioxide in liquid sulfur dioxide were prepared. To the solutions (−10°) were added equimolar amounts of pyridine, 2,6-lutidine and 2,6-di-*t*-butylpyridine. After four hours, the solvent was evaporated and the products recovered. Pyridine and 2,6-lutidine formed the sulfur trioxide addition compounds, whereas the 2,6-di-*t*-butylpyridine formed a sulfonic acid, m.p. (dec.) 310°.

Anal. Calcd. for $C_{13}H_{21}NSO_3$: C, 57.6; H, 7.8; N, 5.2. Found: C, 57.5; H, 7.8; N, 5.1.

The S-benzylthiouronium derivative melted at 216.0–216.5°.

Anal. Calcd. for $C_{21}H_{31}N_3S_2O_3$: N, 9.6. Found: N, 9.6.

The product is presumably the 4-sulfonic acid. We are presently attempting to confirm the structure by an independent synthesis. This ready substitution of a pyridine base must result from the blocking of the nitrogen atom. With coördination impossible, the electrophilic reagent readily attacks the heterocyclic nucleus. The result supports the conclusion that the inertness of pyridine rings results primarily from interaction of electrophilic reagent with the lone pair and not from any unusual inertness of the pyridine nucleus.

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RECEIVED JUNE 12, 1953

THE STRUCTURE OF CHAMAZULENE

Sir:

It has been previously reported that the blue essential oil obtained by steam distillation of *Artemisia absorescens* L. contains an azulene.[1,2] This azulene has now been identified as chamazulene by means of its derivatives (trinitrobenzene complex, m.p. 132°, the melting point was not depressed on admixture with an authentic sample; picrate, m.p. 116°) and its infrared spectrum.

The structure of chamazulene, the azulene from camomile oil,[3] has not as yet been established, but from the spectral measurements of Plattner[4] it has been generally assumed to be 1,5-dimethyl-8-isopropylazulene.[5] During the course of this investigation it has been possible to prove its structure as 1,4-dimethyl-7-ethylazulene.

From the acetone cold extract of the above-mentioned plant a crystalline substance was isolated, the analysis of which corresponded to the formula $C_{15}H_{20}O_3$, m.p. 145°, $[\alpha]^{20}D$ +63° ($CHCl_3$) (*c* 4.24) (*Anal.* Calcd.: C, 72.7; H, 8.1. Found: C, 72.8; H, 8.2).

(1) G. Pellini, *Ann. chim. appl.*, **13**, 97 (1923); *Chem. Zentr.*, **94**, IV, 607 (1923).

(2) A. Weizmann, *Bull. Research Council Israel*, **1**, 92 (1952).

(3) L. Ruzicka and A. J. Haagen-Smit, *Helv. Chim. Acta*, **14**, 1104 (1931).

(4) Pl. A. Plattner, *ibid.*, **24**, 283E (1941).

(5) L. H. Chopard-dit-Jean and E. Heilbronner, *ibid.*, **35**, 2187 (1952).