Synthesis of 3-Aminonocardicinic Acid, the Basic Nucleus of Nocardicins

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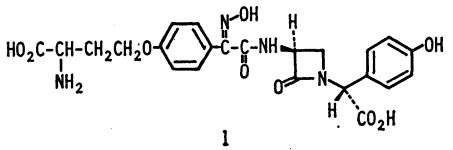
A short and high-yielding synthesis of optically active 3-aminonocardicinic acid (3-ANA) is described. The fourth component condensation reaction of N^2-protected L-2,3-diaminopropanoic acid with *p*-benzyloxybenzaldehyde and butyl isocyanide gave directly the amide derivatives of 3-ANA, as a diastereomeric mixture, which was, after conversion of the amide group into the benzhydryl ester, led in good yield to a single disatereomer with natural chirality *via* epimerization. Deprotection of the 3-ANA derivative gave 3-ANA.

Attension has been given to the synthesis of nocardicins, *e.g.*, **1**, which are unusual monocyclic β-lactam antibiotics isolated from Nocardia species.[1,2] In this paper, we wish to report a short and high-yielding synthesis of optically active 3-aminonocardicinic acid (3-ANA, **2**) which is the key intermediate for the synthesis of nocardicins. It is based on the Ugi reaction using isoncyanides as azetidinone forming reagents.[3] In this reaction, the use of L-2,3-diaminopropanoic acid as a chiral starting material would permit direct formation of the 3-ANA derivatives with the natural chirality at the position 3. On the contrary, one of the most successful approaches to the synthesis of 3-ANA has used D-*p*-hydroxyphenylglycine as a chiral strating material, following asymmetric induction to the position 3 *via* ketene-imine cycloaddition for the azetidinone construction.[2a] The noteworthy feature of our route will be shown by quantitative transformation *via* epimerization of the resulting diastereomeric mixture into a single diastereomer with the natural chirality.



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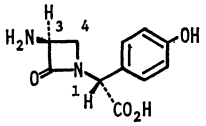

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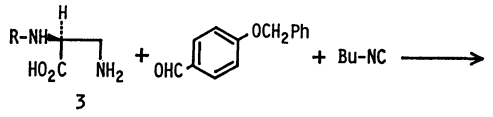
Results and Discussion

The starting materials, N^2-protected L-2,3-diaminopropanoic acids (**3a**—**c**), were prepared according to our previous report[4] or the published method.[5] The amino acids **3a**—**c** were allowed to react with *p*-benzyloxybenzaldehyde and butyl isocyanide in methanol at room temperature. In each case, the product was a diasteromeric mixture, in a ratio of approximately 1 to 1, which could be separated by column chromatography on silica gel. The results are summarized in Table 1. The azetidinones **4a** and **5a** were chosen as precursors of 3-ANA because these compounds were obtained in the best yield and the 2,2,2-trichloroethoxycarbonyl *N*-protecting group possessed the advantage of permitting stepwise deprotection of the resulting protected 3-ANA derivative.



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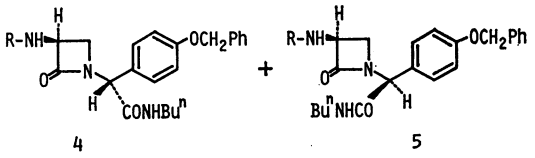


4 5

a, R = CCl_3CH_2OCO
b, R = $C_6H_5CH_2OCO$
c, R = Bu^tOCO

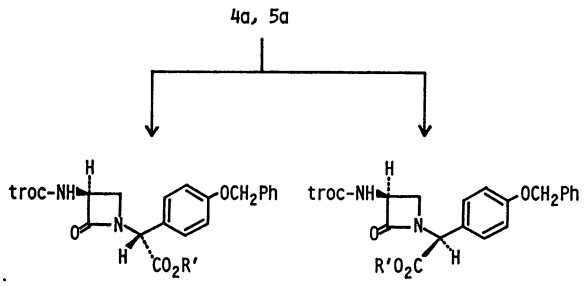
TABLE 1. YIELDS AND PHYSICAL PROAERTIES OF THE UGI REACTION PRODUCTS

Substrate	Products 4 Mp θ_m/°C	4 $[\alpha]_D^{b)}$/°	5 Mp θ_m/°C	5 $[\alpha]_D^{b)}$/°	Yield[a)] %
3a	182—184	−119.0 (*c* 1.0)	100—101	+35.2 (*c* 1.0)	68
3b	151—152	−120.5 (*c* 0.99)	175—176	+33.5 (0.94)	31.3
3c	161—162	−104.8 (*c* 1.02)	Oil	—	59

a) Isolated total yield on the basis of **3**. b) In methanol.

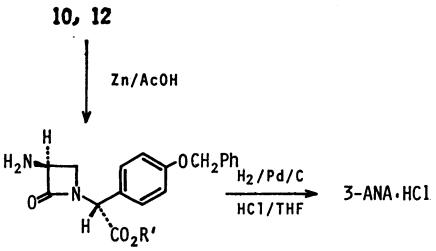
Selective cleavage of the exocyclic amide bond was achieved *via* the imidoyl chloride. The azetidinone **4a** was treated with phosphorus pentachloride in dichloromethane in the presence of pyridine, and successively with methanol. The acidic work-up of the reaction mixture gave a 4 : 1 mixture of the methyl esters **6** and **7** in 66% yield together with recovery (16.3%) of a 2 : 1 mixture of **4a** and **5a**, indicating that epimerization at the exocyclic C–H took place to a considerable extent under the reaction conditions. Similarly, the 1 : 1 mixture of **4a** and **5a** gave a 5 : 3 mixture of **6** and **7** in 68% yield.

Hydrolysis of the methyl ester **6** with aqueous sodium hydroxide or lithium iodide–pyridine was also accom-



6, R'=CH_3 7, R'=CH_3
8, R'=H 9, R'=H
10, R'=CH_2Ph 11, R'=CH_2Ph
12, R'=$CHPh_2$ 13, R'=$CHPh_2$

troc = CCl_3CH_2OCO



14, R'= CH_2Ph
15, R'= $CHPh_2$

panied by epimerization to result in a mixture of the acids **8** and **9**. Thus, the epimerization was extremely facile as reported previously.[2b] Therefore, the methyl esters **6** and **7**, in the form of the 5 : 3 mixture, were converted into the benzyl esters **10** and **11** (62% yield as a 4 : 3 mixture) or the benzhydryl esters **12** and **13** (91% yield as a 4 : 3 mixture) by saponification, followed by treatment with benzyl chloride or diphenyldiazomethane. Treatment of **11** with triethylamine in aqueous methanol resulted in an equilibrium mixture of the diastereomers **10** and **11** to provide more **10**. The benzhydryl ester was found to be more convenient in terms of its easy crystallization. The crude product, in the form of the 4 : 3 mixture of **12** and **13**, was directly crystallized from aqueous methanol containing triethylamine to give a single isomer **12** in 85% overall yield from the methyl esters **6** and **7**.

Table 2. ^{1}H-NMR chemical shifts of 4-protons[a]

Compound	4β-Protons	4α-Protons
4a	3.27	3.93
5a	3.57	3.31
4b	3.25	3.84
5b	3.55	3.40
4c	3.27	3.82
5c	3.53	3.09
6	3.11	3.96
7	3.59	3.45
10	3.09	3.92
11	3.56	3.42
12	3.08	3.92

a) In ppm downfield from internal TMS in $CDCl_3$.

Stereochemistry of the diastereomers was assigned on the basis of the ^{1}H-NMR spectral data. It has been reported that in the NMR spectra of nocardicin series the 4β-protons always appeared in higher field than the 4α-protons.[2a] In agreement with this fact, the 4β-protons of **4a**—**c**, **6**, **10**, and **12** with the natural chirality appeared in higher field by 0.66—0.85 ppm than their 4α-protons, while in the cases of **5a**—**c**, **7**, **11**, and **13** the 4α-protons resonanced in slightly higher field than the 4β-protons (Table 2).

Removal of the 2,2,2-trichloroethoxycarbonyl group of **10** was carried out with zinc in aqueous acetic acid to yield quantitatively the free amine **14**, the ^{1}H-NMR spectrum of which corresponded well with that of the dibenzyl derivative of 3-ANA previously reported.[2b] Catalytic deprotection of **14** with 10% palladium on carbon as catalyst in the presence of hydrogen chloride produced 3-ANA hydrochloride. Similarly, the benzhydryl ester **12** gave 3-ANA hydrochloride in quantitative yield. Total yield from **3a** was 38%.

Experimental

Melting points (capillary) were uncorrected. IR spectra were recorded on a JASCO IRA-1 spectrometer. NMR spectra were determined with tetramethylsilane as an internal standard on a Hitachi R-600 or a JEOL FX-100 spectrometer, chemical shifts being given in ppm unit. Optical rotations were measured with a Perkin-Elmer 241 polarimeter. Elemental analyses were performed in the material analysis center of this institute. Columns of chromatography were packed with Wakogel C-200.

(3S)-1-(α-Butylcarbamoyl-p-benzyloxybenzyl)-3-(2,2,2-trichloroethoxycarbonylamino)-2-azetidinone (4a, 5a). A mixture of **3a** (2.80 g, 0.01 mol), *p*-benzyloxybenzaldehyde (2.55 g, 0.012 mol) and butyl isocyanide (1.25 g, 0.015 mol) in methanol (80 ml) was stirred at room temperature for 3 d. The methanol was removed *in vacuo*, and the residue was crystallized from ethyl acetate–diisopropyl ether to give **4a** (1.15 g). The filtrate was evaporated *in vacuo*, and the residue was chromatography on silica gel with benzene–ethyl acetate to give **4a** (0.86 g, 36% total yield) and **5a** (1.77 g, 32% yield). The individual properties of **4a** and **5a** follow. **4a**: mp 182—184 °C; $[\alpha]_D$ −119.0° (*c* 1.0, MeOH); IR (Nujol) 1765, 1740, and 1663 cm^{-1}; NMR ($CDCl_3$) δ 0.90 (3H, t, J=6, CH_3), 1.41 (4H, m, $(CH_2)_2$), 3.27 (3H, m, NCH_2 and H4β), 3.93 (1H, t, J=5, H4α), 4.70 (2H, s, CH_2CCl_3), 4.83 (1H, m, H3), 5.07 (2H, s, OCH_2Ar), 5.23 (1H, s, methine), 5.48 (1H, m, NH), 5.97 (1H, m, NH), and 6.68—7.53 (9H, m, Ar). Found: C, 46.06; H, 4.55; N, 8.85; Cl, 22.95%. Calcd for $C_{25}H_{28}N_3O_5Cl_3$: C, 46.32; H, 4.75; N, 9.00; Cl, 22.78%.

5a: mp 100—101 °C; $[\alpha]_D$ +35.2° (*c* 1.0, MeOH); IR (nujol) 1743, 1733, and 1658 cm^{-1}; NMR ($CDCl_3$) δ 0.93 (3H, t, J=6, CH_3), 1.47 (4H, m, $(CH_2)_2$), 3.31 (3H, m, NCH_2 and H4α), 3.57 (1H, dd, J=2.7 and 6.6, H4β), 4.46 (1H, m, H3), 4.74 (2H, ABq, J=12, CH_2Cl_3), 5.06 (2H, s, OCH_2Ar), 5.44 (1H, s, methine), 5.68 (1H, broad d, J=7.5, NH), and 6.92—7.36 (10H, m, Ar and NH).

(3S)-3-(Benzyloxycarbonylamino)-1-(α-butylcarbamoyl-p-benzyloxybenzyl)-2-azetidinone (4b, 5b). By the use of the procedure described above, this compound was obtained in 31.3% yield from **3b** as a solid, in the form of a diastereomeric mixture of **4b** and **5b** in the ratio 10 : 9 (determined by NMR spectra). Repeated column chromatography of the mixture

gave pure **4b** and **5b**, the individual properties of which were as follows. **4b**: mp 151—152 °C; $[\alpha]_D$ −120.5° (*c* 0.99, MeOH); IR ($CHCl_3$) 3420, 3350, 1760, 1728, and 1680 cm^{-1}; NMR ($CDCl_3$) δ 0.89 (3H, t, J=6, CH_3), 1.40 (4H, m, $(CH_2)_2$), 3.25 (3H, m, NCH_2 and H4β), 3.84 (1H, t, J=5.4, 4Hα), 4.80 (1H, m, H3), 5.06 (4H, s, OCH_2Ar), 5.18 (1H, s, methine), 5.37 (1H, m, NH), 6.30 (1H, m, NH), and 6.95—7.50 (14H, m, Ar). Found: C, 69.61; H, 6.41; N, 8.12%. Calcd for $C_{30}H_{33}N_3O_5$: C, 69.88; H, 6.45; N, 8.15%. **5b**: mp 175—176 °C; $[\alpha]_D$ +33.5 °C (*c* 0.94, MeOH); IR ($CHCl_3$) 3440, 3360, 1763, 1720, and 1665 cm^{-1}; NMR ($CDCl_3$) δ 0.93 (3H, t, J=6, CH_3), 1.50 (4H, m, $(CH_2)_2$), 3.40 (3H, m, NCH_2 and H4α), 3.55 (1H, dd, J=2.4 and 6.6, H4β), 4.35 (1H, m, H3), 5.05 (2H, s, OCH_2Ar), 5.13 (2H, s, OCH_2Ar), 5.44 (1H, s, methine), 5.55 (1H, m, NH), and 6.86—7.50 (14H, m, Ar). Found: C, 69.64; H, 6.36; N, 8.11%. Calcd for $C_{30}H_{33}N_3O_5$: C, 69.88; H, 6.45; N, 8.15%.

*(3S)-3-(t-Butoxycarbonylamino)-1-(α-butylcarbamoyl-*p*-benzyloxybenzyl)-2-azetidinone (**4c**, **5c**).* By the use of the procedure described above, this compound was prepared from **3c**. The yield of *ca.* a 1 : 1 diastereomeric mixture of **4c** and **5c** was 59%. The individual properties of **4c** and **5c** follow. **4c**: mp 161—162 °C; $[\alpha]_D$ −104.8° (*c* 1.02, MeOH); IR (nujol) 3300, 1765, 1700, and 1665 cm^{-1}; NMR ($CDCl_3$) δ 0.90 (3H, t, J=6, CH_3), 1.41 (9H, s, Bu^t), 1.50 (4H, m, $(CH_2)_2$), 3.27 (3H, m, NCH_2 and H4β), 3.82 (1H, t, J=5.4, H4α), 4.72 (1H, m, H3), 5.06 (2H, s, OCH_2Ar), 5.14 (1H, s, methine), and 6.88—7.50 (9H, m, Ar). Found: C, 67.10; H, 7.34; N, 8.64%. Calcd for $C_{27}H_{35}N_3O_5$: C, 67.34; H, 7.33; N, 8.73%. **5c**: oil; IR (neat) 3320, 1755, 1690, and 1655 cm^{-1}; NMR ($CDCl_3$) δ 0.93 (3H, t, J=6, CH_3), 1.45 (9H, s, Bu^t), 1.20—1.65 (4H, m, $(CH_2)_2$), 3.09 (1H, t, J=5.5, H4α), 3.30 (2H, m, NCH_2), 3.53 (1H, dd, J=2.7 and 5.5, H4β), 4.20 (1H, m, H3), 5.03 (2H, s, OCH_2Ar), 5.44 (1H, s, methine), and 6.86—7.50 (9H, m, Ar).

*(3S)-1-(α-Methoxycarbonyl-*p*-benzyloxybenzyl)-3-(2,2,2-trichloroethoxycarbonylamino)-2-azetidinone (**6**, **7**).* Phosphorus pentachloride (313 mg, 1.5 mmol) was added at −20 °C to a suspension of **4a** (557 mg, 1 mmol) and pyridine (237 mg, 3 mmol) in dichloromethane (6 ml). The mixture was stirred at 0 °C for 5 h, and then cooled to −60 °C. After addition of anhydrous methanol (0.6 ml), the mixture was brought gradually to 0 °C, then stirred at 0 °C for 1.5 h, and poured into ice–water (5 ml). The mixture was vigorously stirred at 0 °C for 1 h. The aqueous layer was extracted with dichloromethane. The combined extracts were dried ($MgSO_4$) and evaporated *in vacuo*. The residue was chromatographed on silica gel with benzene–ethyl acetate to give **6** (273 mg, 53%), **7** (68 mg, 13.2%), and a 2 : 1 mixture of **4a** and **5a** (91 mg, 16.3% recovery). The physical properties of **6** follow. Mp 139—140 °C; $[\alpha]_D$ −141.3° (*c* 0.98, MeOH); IR (Nujol) 3240, 1760, and 1735 cm^{-1}; NMR ($CDCl_3$) δ 3.11 (1H, dd, J=2.4 and 5.6, H4β), 3.75 (3H, s, OCH_3), 3.96 (1H, t, J=5.6, H4α), 4.69 (2H, s, CH_2Cl_3), 4.90 (1H, m, H3), 5.07 (2H, s, CH_2Ar), 5.51 (1H, m, NH), 5.57 (1H, s, methine), and 6.94—7.48 (9H, m, Ar). Found: C, 51.27; H, 4.01; N, 5.39, Cl, 20.88%. Calcd for $C_{22}H_{21}N_2O_6Cl_3$: C, 51.23; H, 4.10; N, 5.43; Cl, 20.62%. The physical properties of **7** follow. Oil; $[\alpha]_D$ +65.0° (*c* 3.31, MeOH); IR (neat) 3300 and 1740 cm^{-1}; NMR ($CDCl_3$) δ 3.45 (1H, t, J=5.6, H4α), 3.59 (1H, dd, J=2.4 and 5.6, H4β), 3.76 (3H, s, OCH_3), 4.73 (2H, s, CH_2Cl_3), 4.80 (1H, m, H3), 5.07 (2H, s, OCH_2Ar), 5.55 (1H, s, methine), 5.85 (1H, m, NH), and 6.88—7.50 (9H, m, Ar).

A similar experiment was repeated with the 1 : 1 mixture of **4a** and **5a** on the 0.01 mol scale, yielding a 5 : 3 mixture of **6** and **7** (3.51 g, 68%).

*Benzyl O-Benzyl-*N*-(2,2,2-trichloroethoxycarbonyl)-3-aminonocardicinate (**10**).* To a solution of the 5 : 3 mixture of **6** and **7** (346 mg, 0.67 mmol) in 80% aqueous acetone (10 ml), 1 M† aqueous KOH was added dropwise at 0 °C over 1 h. After being stirred at 0 °C for 2 h, the solution was evaporated to dryness *in vacuo*. The residue was suspended in DMF (5 ml), and treated with benzyl chloride (102 mg) and a few drops of *N,N,N′,N′*-tetramethylethylenediamine . The mixture was stirred overnight at room temperature, poured into ice–water (20 ml), and then extracted with ethyl acetate. The extracts were washed with brine, dried ($MgSO_4$), and evaporated *in vacuo*. The residue was separated by preparative TLC in benzene–ethyl acetate to give **10** (135 mg, 34%) as needles and **11** (111 mg, 28%) as an oil. The physical properties of **10** follow. Mp 128—129 °C; $[\alpha]_D$ −104.4° (*c* 0.94, MeOH); IR ($CHCl_3$) 1760 and 1740 cm^{-1}; NMR ($CDCl_3$ δ 3.09 (1H, dd, J=2.4 and 5.6, H4β), 3.92 (1H, t, J=5.6, H4α) 4.68 (2H, s, CH_2Cl_3), 4.87 (1H, m, H3), 5.06 (2H, s, OCH_2Ar), 5.18 (2H, s, OCH_2Ar), 5.47 (1H, m, NH), 5.61 (1H, s, methine), 6.94 (2H, d, J=9, Ar), 7.17 (2H, d, J=9, Ar), 7.30 and 7.39 (10H, each s, Ar). Found: C, 57.88; H, 4.29; N, 4.72%. Calcd for $C_{28}H_{25}N_2O_6Cl_3$: C, 56.82; H, 4.26; N, 4.73%. The physical properties of **11** follow. Oil; $[\alpha]_D$ +42.24° (*c* 0.76, MeOH); IR ($CHCl_3$) 1755 and 1740 cm^{-1}; NMR ($CDCl_3$) δ 3.42 (1H, t, J=5.6, H4α), 3.56 (1H, dd, J=2.4 and 5.6, H4β), 4.70 (2H, s, CH_2CCl_3), 4.83 (1H, m, H3), 5.05 (2H, s, OCH_2Ar), 5.19 (2H, s, OCH_2Ar), 5.59 (1H, s, methine), 5.80 (1H, broad d, J=8, NH), 6.93 (2H, d, J=8.8, Ar), 7.13 (2H, d, J=8.8, Ar), 7.29 and 7.38 (10H, each s, Ar).

The oily isomer **11** (95 mg) was dissolved in aqueous methanol. After addition of a few drops of triethylamine, the solution was allowed to stand at room temperature for 3 days, while the epimerization of **11** was effected to result in a new diastereomeric mixture of **10** and **11** in a ratio of 4 : 3. The solution was seeded with crystals of **10**, and left for an additional day to yield pure **10** (51 mg).

*Benzhydryl O-Benzhyl-*N*-(2,2,2-trichloroethoxycarbonyl)-3-aminonocardicinate (**12**).* To a solution of the 5 : 3 diastereomeric mixture of **6** and **7** (516 mg, 1 mmol) in 80% aqueous acetone (10 ml), 0.5 M aqueous NaOH (2.2 ml) was added dropwise at 0 °C over 1 h. The solution was stirred at 0 °C for 2 h, and concentrated to 5 ml *in vacuo*. The remaining solution was acidified with hydrochloric acid, and extracted with ethyl acetate. The ethyl acetate solution was dried ($MgSO_4$), and then treated with a small excess of diphenyldiazomethane until the red colour no longer disappeared. The solution was evaporated *in vacuo*, and the residue was purified through a short column of silica gel to yield *ca.* a 4 : 3 mixture of **12** and **13** (610 mg, 91%) as a pale-yellow oil.

The mixture (610 mg) was dissolved in hot aqueous methanol (4 ml) containing one drop of triethylamine. The solution was seeded with crystals of **12** and allowed to stand at room temperature for 3 h. The crystals were colloected by filtration to yield pure **12** (480 mg). Repeated procedure on the filtrate gave an additional crop of **12** (88 mg, 85% total yield).

The physical properties of **12** follow. Mp 135—136 °C; $[\alpha]_D$ −123.2° (*c* 0.44, MeOH); IR (Nujol) 1760 and 1735 cm^{-1}; NMR ($CDCl_3$) δ 3.08 (1H, dd, J=2.4 and 5.6, H4β), 3.92 (1H, t, J=5.6, H4α), 4.68 (2H, s, CH_2CCl_3), 4.86 (1H, m, H_3), 5.07 (2H, s, OCH_2Ar), 5.41 (1H, broad d, J=8, NH), 5.69 (1H, s, methine), 6.91 (2H, d, J=9, Ar), 7.11 (2H, d, J=9, Ar), and 7.00—7.46 (16H, m, $CHPh_2$ and Ar). Found: C, 60.90; H, 4.13; N, 4.29; Cl, 15.56%. Calcd for $C_{34}H_{29}$-

† 1 M=1 mol dm^{-3}.

$N_2O_6Cl_3$: C, 61.14; H, 4.38; N, 4.19; Cl, 15.92%.

*Benzyl O-Benzyl-3-aminonocardicinate (**14**).* The compound **10** (150 mg, 0.25 mmol) was dissolved in a mixture of 1 M aqueous KH_2PO_4 (0.25 ml), 90% aqueous acetic acid (2 ml) and THF (3 ml). Zinc powder (165 mg) was added and the mixture was vigorously stirred for 1 h and then filtered. The filtrate was concentrated *in vacuo* below 30 °C. The residue was diluted with water (10 ml), neutralized with $NaHCO_3$, and extracted with ethyl acetate. The extracts were washed with brine, dried ($MgSO_4$), and then evaporated *in vacuo*. The residue was purified by passing through a short column of silica gel with benzene–ethyl acetate to yield **14** (101 mg, 96%) as a colourless oil. The physical properties of **14** were as follows and corresponded well with those previously reported.[2b] $[\alpha]_D$ −128.2° (*c* 0.71, MeOH) [lit,[2b] $[\alpha]_D$ −138° (TFE)]; NMR ($CDCl_3$) δ 2.81 (1H, dd, J=2.2 and 5.4, H4β), 3.86 (1H, t, J=5.4, H4α), 4.22 (1H, dd, J=2.2 and 5.4, H3), 5.06 (2H, s, OCH_2Ar), 5.17 (2H, s, OCH_2Ar), 5.58 (1H, s, methine), 6.93 (2H, d, J=8.8, Ar), 7.16 (2H, d, J=8.8, Ar), 7.29 and 7.39 (10H, each s, Ar).

*Benzhydryl O-Benzyl-3-aminonocardicinate (**15**).* By the use of the procedure described above, this compound was obtained from **12** in quantitative yield as an oil, $[\alpha]_D$ −129° (*c* 0.61, THF); NMR ($CDCl_3$) δ 1.67 (2H, broad s, NH_2), 2.80 (1H, dd, J=2 and 5, H4β), 3.85 (1H, t, J=5, H4α), 4.20 (1H, m, H3), 5.07 (2H, s, OCH_2Ar), 5.70 (1H, s, methine), and 6.80—7.60 (20H, m, $CHPh_2$ and Ar).

*3-Aminonocardicinic Acid (3-ANA, **2**).* *From **15***: A mixture of **15** (98 mg, 0.2 mmol) and 10% palladium on carbon (50 mg) as catalyst in anhydrous THF–ethanol (*ca.* 1 : 1, 6 ml) containing hydrogen chloride (0.2 mmol) was placed under a hydrogen atmosphere at atmospheric pressure, and stirred for 6 h at room temperature. The catalyst was removed by filtration and the filtrate was concentrated *in vacuo*. The residue was triturated in ether to give 3-ANA hydrochloride (54 mg, quantitative yield) as a white solid, $[\alpha]_D$ −207° (*c* 0.3, H_2O); NMR (D_2O) δ 3.29 (1H, dd, J=2.2 and 6.5, H4β), 3.93 (1H, t, J=6.5, H4α), 5.57 (1H, s, methine), 6.96 (2H, d, J=8.5, Ar), and 7.30 (2H, d, J=8.5, Ar).

*From **14***: By the use of the procedure described above the compound **14** (167 mg, 0.4 mmol) was deprotected to give 3-ANA hydrochloride (106 mg), which was identical with that obtained from **15** (NMR, TLC, $[\alpha]_D$ value).

References

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