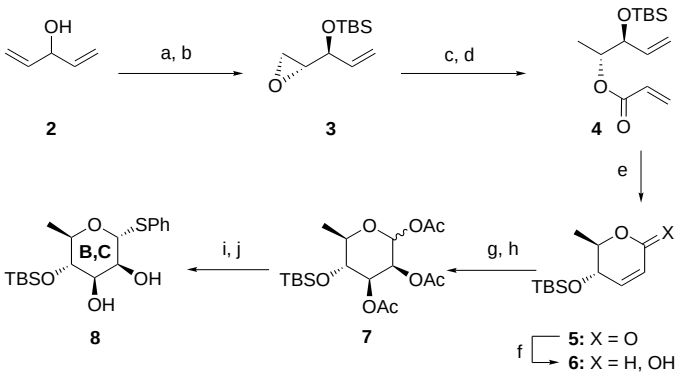
[12] For unclear reasons, condensation fails to go to completion, even upon use of a large excess of Grignard reagent, at increased dilution or temperature, or by reverse addition.
[13] P. S. Bailey, J. E. Keller, *J. Org. Chem.* **1968**, *33*, 2680 – 2684.
[14] E. F. J. de Vries, J. Brussee, A. van der Gen, *J. Org. Chem.* **1994**, *59*, 7133 – 7137.
[15] D. Kahne, S. Walker, Y. Cheng, D. V. Engen, *J. Am. Chem. Soc.* **1989**, *111*, 6881 – 6882.
[16] R. G. Dushin, S. J. Danishefsky, *J. Am. Chem. Soc.* **1992**, *114*, 3471 – 3475.
[17] B. A. Garcia, J. L. Poole, D. Y. Gin, *J. Am. Chem. Soc.* **1997**, *119*, 7597 – 7598.
[18] R. R. Schmidt, J. Michel, *Angew. Chem.* **1980**, *92*, 763 – 764; *Angew. Chem. Int. Ed. Engl.* **1980**, *19*, 731 – 732.
[19] A. W. Johnson, R. M. Smith, R. D. Guthrie, *J. Chem. Soc. Perkin Trans. 1* **1972**, 2153 – 2159.
[20] All new compounds exhibited satisfactory spectral and exact mass data.

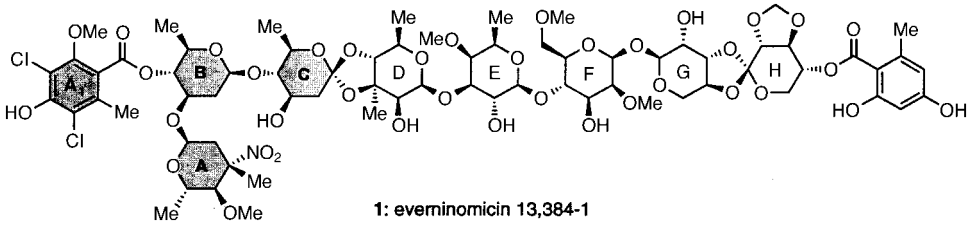


Scheme 1. Synthesis of **8**. a) L-(+)-diisopropyl tartrate (0.09 equiv), $Ti(OiPr)_4$ (0.072 equiv), *t*BuOOH (2.0 equiv), CH_2Cl_2, $-15\,^\circ C$, 9 d; b) TBSCl (1.2 equiv), imidazole (1.5 equiv), CH_2Cl_2, $0 \rightarrow 25\,^\circ C$, 85% over two steps; c) $LiEt_3BH$ (1.0 M in THF, 1.1 equiv), CH_2Cl_2, $-40\,^\circ C$, 1 h, 91%; d) $CH_2{=}CHC(O)Cl$ (1.1 equiv), Et_3N (1.2 equiv), CH_2Cl_2, $0 \rightarrow 25\,^\circ C$, 1 h, 90%; e) $(PCy_3)_2Ru(=CHPh)Cl_2$ (0.15 equiv), CH_2Cl_2, $40\,^\circ C$, 72 h, 90%; f) DIBAL (2.2 equiv), CH_2Cl_2, $-78\,^\circ C$, 1 h, 98%; g) OsO_4 (0.03 equiv), NMO (1.5 equiv), acetone/H_2O (20/1), $25\,^\circ C$, 24 h, 97%; h) Ac_2O (4.0 equiv), Et_3N (6.0 equiv), 4-DMAP (0.1 equiv), CH_2Cl_2, $0 \rightarrow 25\,^\circ C$, 2 h, 98%; i) PhSH (1.3 equiv), Me_3SiOTf (0.03 equiv), CH_2Cl_2, $0 \rightarrow 25\,^\circ C$, 3 h, 69%; j) K_2CO_3 (0.2 equiv), MeOH, $25\,^\circ C$, 3 h, 100%. Cy = cyclohexyl, DIBAL = diisobutylaluminum hydride, 4-DMAP = 4-dimethylaminopyridine, NMO = 4-methylmorpholine *N*-oxide, TBS = *tert*-butyldimethylsilyl, Tf = trifluoromethylsulfonyl.

Stereocontrolled Synthesis of the Everninomicin $A_1B(A)C$ Ring Framework**

K. C. Nicolaou,* Rosa M. Rodríguez, Helen J. Mitchell, and Floris L. van Delft

Everninomicin[1] (13,384-1, **1**), a highly effective antibiotic against drug-resistant bacterial strains, is a member of the orthosomycin family of compounds. Its novel and challenging structure encompasses, among other structural elements, the nitrosugar **A** and the fully substituted aromatic ring $\mathbf{A_1}$, and has stimulated a number of synthetic studies.[2] Notable among these are the formation of $\mathbf{A_1B(A)}$ and $\mathbf{A_1BC}$ systems by Scharf et al.[2h, k–m] and approaches to 2-deoxy-β-glycosides by Sinay et al.[2i–j] In the preceding contribution[3] we described a stereoselective synthesis of evernitrose (ring **A**) in its activated form (**26**, see Scheme 5). Here we report efficient constructions of rings **B**, **C**, and $\mathbf{A_1}$ as well as their assembly to the $\mathbf{A_1B(A)C}$ ring system (**28**, see Scheme 5) of everninomicin (**1**). The reported chemistry features a number of interesting strategies including a) an approach based on ring-closing olefin metathesis[4] to the common precursor **8** for carbohydrate systems **B** and **C** (see Scheme 1), b) control of the stereochemistry of the 2-deoxy-β-anomeric by a 1,2-migration and a sulfur-directed glycosidation,[5] and c) use of an acyl fluoride to effect formation of the sterically demanding ester bond between rings $\mathbf{A_1}$ and **B**.



An asymmetric synthesis of the common precursor to rings **B** and **C** is shown in Scheme 1. Sharpless epoxidation of prochiral divinylmethanol (**2**)[6] followed by silylation (TBSCl, imidazole, 85% over two steps)[7] furnished epoxide **3**. Regioselective ring opening of **3** with $LiEt_3BH$ ("super hydride") followed by esterification with acryloyl chloride under basic conditions (Et_3N) provided diolefin **4** (90%). Ring-closing metathesis induced by $(PCy_3)_2Ru(=CHPh)Cl_2$ as catalyst afforded lactone **5** (90%).[8] Contrary to expectations, dihydroxylation of **5** under a variety of conditions led to the wrong diastereomer, with the oxygen atoms *cis* to the bulky TBS group. Fortunately, reduction of lactone **5** with DIBAL, followed by OsO_4-catalyzed dihydroxylation of the resulting

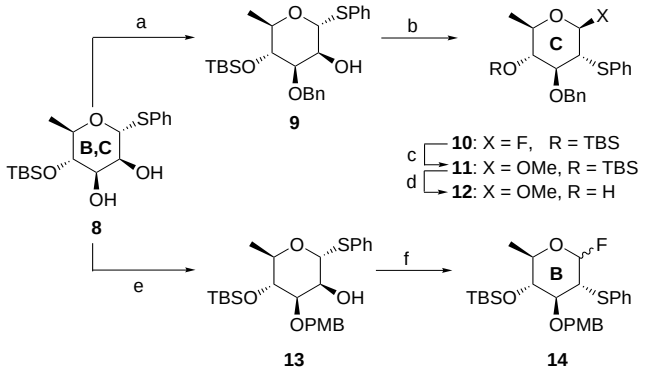
[*] Prof. Dr. K. C. Nicolaou, Dr. R. M. Rodríguez, H. J. Mitchell, Dr. F. L. van Delft
Department of Chemistry and
The Skaggs Institute for Chemical Biology
The Scripps Research Institute
10550 North Torrey Pines Road, La Jolla, CA 92037 (USA)
Fax: (+1) 619-784-2469
and
Department of Chemistry and Biochemistry
University of California, San Diego
9500 Gilman Drive, La Jolla, CA 92093

[**] This work was financially supported by the National Institutes of Health (USA) and the Skaggs Institute for Chemical Biology. We also thank the M. E. C., Spain (R.M.R., Fullbright), and the Netherlands Organization for Scientific Research (NWO; (F.L.v.D.) for fellowships.

  1433-7851/98/3713-1874 $ 17.50+.50/0

lactol **6** (mixture of anomers), led to the exclusive and quantitative formation of the desired 2,3-diol, which was peracetylated to afford triacetate **7** (98%, mixture of anomers). Exposure of **7** to PhSH and TMSOTf followed by deacetylation gave dihydroxy-α-thioglycoside **8** as the sole product (69% over two steps).

Scheme 2 summarizes the selective conversion of thioglycoside **8** into both glycosyl acceptor **12** and glycosyl donor **14**; the 1,2-migration technique previously developed in our

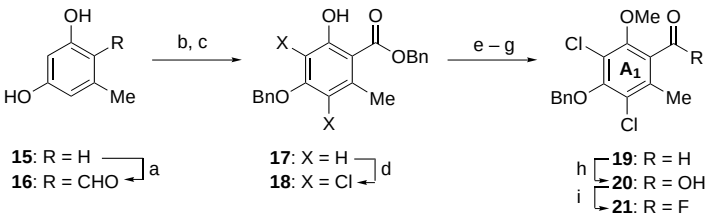


Scheme 2. Synthesis of the **B** and **C** rings. a) 1. nBu$_2$SnO (1.3 equiv), PhH, 80 °C, 12 h; 2. BnBr (1.5 equiv), nBu$_4$NI (1.0 equiv), 80 °C, 2 h, 80%; b) DAST (1.3 equiv), CH_2Cl_2, 0 °C; c) MeOH (2.0 equiv), $SnCl_2$ (1.8 equiv), 4-Å molecular sieves, Et_2O, −15 °C, 100% over two steps, $\alpha:\beta \approx 1:10$; d) nBu$_4$NF (1.5 equiv), THF, 25 °C, 2 h, 95%; e) 1. nBu$_2$SnO (1.3 equiv), PhH, 80 °C, 12 h; 2. PMBCl (1.5 equiv), nBu$_4$NI (1.0 equiv), 80 °C, 2 h, 92%; f) DAST (1.3 equiv), CH_2Cl_2, 0 °C, 100%. Bn = benzyl, DAST = Et_2NSF_3, PMB = *p*-methoxybenzyl.

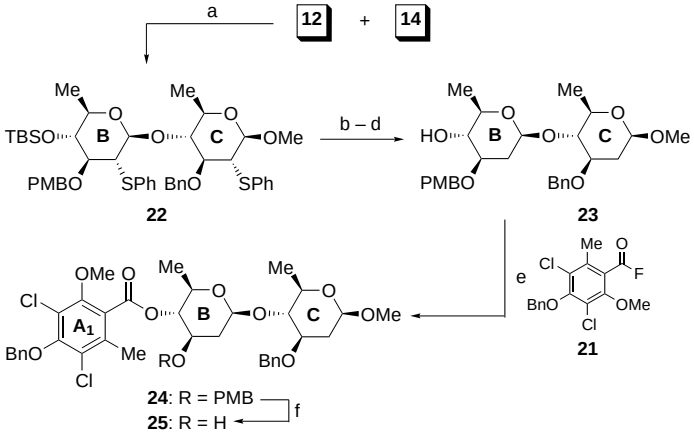
laboratories was employed.[5] Thus, regioselective protection of position 3 of **8** was effected with nBu$_2$SnO/BnBr for ring **C** (→**9**, 80%) and with nBu$_2$SnO/PMBCl for ring **B** (→**13**, 92%). Thioglycosides **9** and **13** underwent smooth 1,2-migration on exposure to DAST to furnish glycosyl fluorides **10** (mixture of β and α anomers, ca. 17:1) and **14** (mixture of β and α anomers, ca. 14:1), respectively, in quantitative yields. As expected, glycosidation of **10** with MeOH and $SnCl_2$ in Et_2O was directed by the PhS group at C2 to give predominantly the β anomer **11** (91%, ca. 10:1). Desilylation of **11** gave compound **12** (95%).

The anticipated difficulties[2h, k–m] in forming the ester bond between rings $\mathbf{A_1}$ and **B** led us to evaluate the use of fluoride **21** (Scheme 3). Its synthesis began with Gatterman formylation of resorcinol **15** (→**16**, 92%). Oxidation of aldehyde **16** to the carboxylic acid ($NaClO_2$, 80%) followed by exposure to benzyl alcohol under Mitsunobu conditions led to the phenol derivative **17** (100% based on 75% conversion). Chlorination of **17** (Cl_2, buffered conditions,[2e] 70%) followed by methylation of the phenolic group (CH_2N_2,[2e] 100%), DIBAL reduction (90%), and PDC oxidation gave the aldehyde **19** (90%). Further oxidation of **19** with $NaClO_2$ and treatment with $[(Me_2N)_2CF]PF_6$[9] then led to the targeted acyl fluoride **21** (97%), which cleanly withstood chromatographic purification.

The assembly of the $\mathbf{A_1BC}$ ring system **25** from its monocyclic building blocks **12**, **14**, and **21** is shown in Scheme 4. Thus, β-glycosidic coupling,[5] directed by the PhS



Scheme 3. Synthesis of dichloroisoeverninic acyl fluoride (**21**). a) 1. $Zn(CN)_2$ (1.5 equiv), $AlCl_3$ (2.4 equiv), HCl (g), 0 °C, 3 h; 2. H_2O, 0 → 100 °C, 30 min, 92%; b) $NaClO_2$ (2.4 equiv), NaH_2PO_4 (2.5 equiv), DMSO, 0 °C, 12 h, 80%; c) BnOH (2.0 equiv), DIAD (2.0 equiv), Ph_3P (2.0 equiv), THF, 0 °C, 4 h, 100% based on 75% conversion; d) Cl_2 (1.0 M in AcOH, 3.0 equiv), NaOAc (2.25 equiv), AcOH, −50 → 0 °C, 70%; e) CH_2N_2 (excess), Et_2O, dark, 0 °C, 12 h, 100%; f) DIBAL (1.2 equiv), CH_2Cl_2, −78 °C, 1 h, 90%; g) PDC (3.0 equiv), 3-Å molecular sieves, CH_2Cl_2, 25 °C, 3 h, 90%; h) $NaClO_2$ (3.0 equiv), NaH_2PO_4 (3.0 equiv), 2-methyl-2-butene (2.0 M in THF, 4.0 equiv), *t*BuOH, H_2O, 25 °C, 3 h, 95%; i) $[(Me_2N)_2CF]PF_6$ (1.5 equiv), *i*Pr_2NEt (2.0 equiv), CH_2Cl_2, 0 → 25 °C, 12 h, 97%. DIAD = diisopropylazodicarboxylate, PDC = pyridinium dichromate.



Scheme 4. Assembly of the $\mathbf{A_1BC}$ ring system **25**. a) **12** (1.0 equiv), **14** (1.5 equiv), $SnCl_2$ (1.0 equiv), Et_2O, 4-Å molecular sieves, −15 °C, 12 h, 78%; b) Raney Ni (excess), MeOH, 65 °C, 2 h; c) BnBr (2.0 equiv), NaH (2.2 equiv), nBu$_4$NI (0.2 equiv), DMF, 0 °C, 1 h; d) nBu$_4$NF (1.3 equiv), THF, 25 °C, 2 h, 78% over three steps; e) 1. **23** (1.0 equiv), 4-Å molecular sieves, THF, 2 h; 2. nBuLi (1.6 M in hexanes, 2.0 equiv), 25 °C, 1 h; 3. **21** (3.0 equiv), THF, 24 h, 80%; f) DDQ (2.0 equiv), CH_2Cl_2/H_2O (15/2), 25 °C, 2 h, 80%. DDQ = 2,3-dichloro-5,6-dicyano-1,4-benzoquinone.

group at C2, of **12** with **14** was promoted by $SnCl_2$ in Et_2O to afford disaccharide **22** in 78% yield. Desulfurization of **22** with Raney Ni, followed by rebenzylation of the partially deprotected hydroxyl group at C3 of ring **C** and desilylation, furnished disaccharide **23** (78% over three steps). Activation of **23** with nBuLi facilitated its coupling with fluoride **21** (→**24**, 80%). Finally, selective removal of the PMB group from **24** was achieved with DDQ to furnish **25** (80%).

The coupling of tricyclic system **25** with glycosyl fluoride **26**[3] in the presence of $BF_3 \cdot Et_2O$ proceeded stereoselectively to afford the desired α-glycoside **27** (95%, Scheme 5), from which the benzyl groups were selectively removed by hydrogenolysis to afford the targeted $\mathbf{A_1B(A)C}$ ring segment **28** of everninomicin (**1**) in 95% yield.

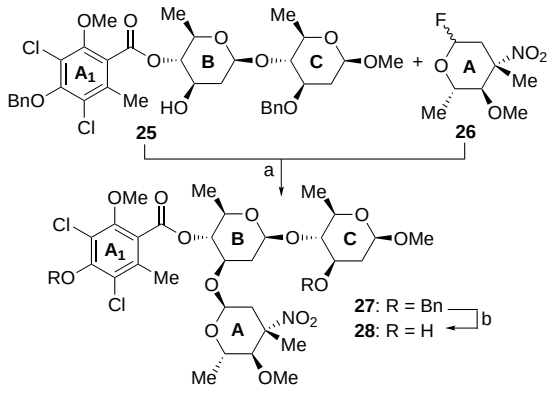
The described chemistry demonstrates a number of novel synthetic strategies for the asymmetric synthesis of carbohydrate units corresponding to everninomicin and for their

Table 1. Selected physical properties of compounds **22**, **25**, and **28**.

22: $R_f = 0.42$ (silica gel, 30% Et_2O in hexanes); $[\alpha]_D^{22} = -45.3$ ($c = 0.97$ in $CHCl_3$); IR (thin film): $\tilde{\nu}_{max} = 2930, 2855, 1514, 1472, 1438, 1248, 1102, 1024, 871, 837\ cm^{-1}$; ^1H NMR (500 MHz, $CDCl_3$): $\delta = 7.51-7.22$ (m, 17H, ArH), 6.79 (d, $J = 8.5$ Hz, 2H, ArH), 4.92 and 4.72 (AB, $J = 10.0$ Hz, 2H, CH_2Ar), 4.85 and 4.67 (AB, $J = 10.0$ Hz, 2H, CH_2Ar), 4.68 (d, $J = 9.0$ Hz, 1H, H1′), 4.07 (d, $J = 8.5$ Hz, 1H, H1), 3.77 (s, 3H, p-CH_3OAr), 3.56 (dd, $J = 9.5$, 9.0 Hz, 1H, H4), 3.44 (s, 3H, OCH_3), 3.29 (m, 4H, H3, H3′, H4′, H5 or H5′), 3.10 (dd, $J = 10.5$, 8.5 Hz, 1H, H2), 3.05 (dd, $J = 9.5$, 6.0 Hz, 1H, H5′ or H5), 3.00 (dd, $J = 11.0$, 9.0 Hz, 1H, H2′), 1.45 (d, $J = 6.5$ Hz, 3H, H6 or H6′), 1.12 (d, $J = 6.0$ Hz, 3H, H6′ or H6), 0.92 (s, 9H, tBuSi), 0.06 (s, 3H, CH_3Si), 0.05 (s, 3H, CH_3Si); ^{13}C NMR (125 MHz, $CDCl_3$): $\delta = 138.8, 136.8, 134.5, 133.0, 130.6, 129.1, 128.5, 127.9, 127.4, 127.1, 126.2, 113.5, 103.9, 102.9, 82.9, 81.7, 80.8, 76.8, 75.7, 75.1, 72.5, 71.1, 57.6, 56.9, 55.6, 55.2, 26.0, 18.7, 18.3, 18.0, -3.4, -3.9$; HR-MS (FAB) calcd for $C_{46}H_{60}O_8S_2SiCs$ [$M + Cs^+$]: 965.2553, found: 965.2521.

25: $R_f = 0.29$ (silica gel, 60% Et_2O in hexanes); $[\alpha]_D^{22} = -6.43$ ($c = 0.53$ in $CHCl_3$); IR (thin film): $\tilde{\nu}_{max} = 3500, 2925, 1736, 1651, 1558, 1456, 1392, 1258, 1095, 1068, 1034\ cm^{-1}$; ^1H NMR (500 MHz, $CDCl_3$): $\delta = 7.60$ (bd, $J =$ 8.0 Hz, 2H, ArH), 7.44–7.32 (m, 8H, ArH), 5.03 (s, 2H, **A**$_1$-CH_2Ar), 4.82 (dd, $J = 9.0$, 8.5 Hz, 1H, H4′), 4.80 (bd, $J = 9.0$ Hz, 1H, H1′), 4.71 and 4.67 (AB, J = 11.5 Hz, 2H, CH_2Ar), 4.34 (dd, $J = 10.0$, 2.0 Hz, 1H, H1), 3.88 (s, 3H, **A**$_1$-OCH_3), 3.79 (bddd, $J = 9.5$, 9.0, 4.0 Hz, 1H, H3′), 3.59 (ddd, $J =$ 11.5, 8.5, 5.5 Hz, H3), 3.48 (s, 3H, OCH_3), 3.38 (m, 2H, H5 and H5′), 3.29 (dd, $J = 9.5$, 8.5 Hz, 1H, H4), 2.68 (d, $J = 4.0$ Hz, 1H, OH), 2.36 (s, 3H, **A**$_1$-CH_3), 2.36 (m, 1H, $H2'_{eq}$), 2.3 (ddd, $J = 12.5$, 5.5, 2.0 Hz, 1H, $H2_{eq}$), 1.74 (ddd, $J = 12.5$, 9.5, 9.0 Hz, 1H, $H2'_{ax}$), 1.59 (ddd, $J = 12.5$, 11.5, 10.0 Hz, 1H, $H2_{ax}$), 1.34 (d, $J = 5.5$ Hz, 1H, H6′), 1.30 (d, $J = 6.0$ Hz, 1H, H6); ^{13}C NMR (125 MHz, $CDCl_3$): $\delta = 166.4, 153.0, 151.9, 138.6, 135.9, 133.2, 128.6, 128.5, 127.5, 127.4, 127.0, 125.5, 121.4, 100.5, 100.4, 83.2, 79.9, 77.6, 74.9, 71.8, 70.9, 69.7, 62.4, 56.5, 39.4, 37.0, 30.3, 18.2, 17.7, 17.4$; HRMS (FAB) calcd for $C_{36}H_{42}O_{10}Cl_2Na$ [$M + Na^+$]: 727.2053, found: 727.2029.

28: $R_f = 0.3$ (silica gel, 50% Et_2O in hexanes); $[\alpha]_D^{22} = -45.2$ ($c = 0.54$ in $CHCl_3$); IR (thin film): $\tilde{\nu}_{max} = 3456, 2926, 2854, 1725, 1544, 1449, 1389, 1299, 1250, 1127, 1037\ cm^{-1}$; ^1H NMR (500 MHz, $CDCl_3$): $\delta = 6.98$ (s, 1H, **A**$_1$-OH), 4.98 (dd, $J = 4.5$, 1.5 Hz, 1H, H1″), 4.94 (dd, $J = 9.0$, 9.0 Hz, 1H, H4′), 4.53 (dd, $J = 9.5$, 1.5 Hz, 1H, H1′), 4.40 (dd, $J = 9.5$, 1.5 Hz, 1H, H1), 4.21 (ddd, $J = 11.5$, 9.5, 5.5 Hz, 1H, H3′), 3.92 (dq, $J = 9.0$, 6.5 Hz, 1H, H5′), 3.88 (s, 3H, **A**$_1$-OCH_3), 3.65 (d, $J = 9.0$ Hz, 1H, H4″), 3.62 (dq, $J = 9.0$, 6.5 Hz, 1H, H5″), 3.63 (m, 1H, H3), 3.49 (s, 3H, 1-OCH_3), 3.39 (m, 1H, H5″), 3.35 (s, 3H, 4″-OCH_3), 2.99 (dd, $J = 9.0$, 8.5 Hz, 1H, H4), 2.47 (dd, $J = 14.0$, 5.0 Hz, 1H, $H2''_{ax}$), 2.38 (s, 3H, **A**$_1$-CH_3), 2.37–2.28 (m, 2H, $H2_{eq}$ and $H2'_{eq}$), 2.03 (dd, $J = 14.0$, 2.0 Hz, 1H, $H2''_{eq}$), 1.76–1.58 (m, 2H, $H2_{ax}$ and $H2'_{ax}$), 1.67 (s, 3H, 3″-CH_3), 1.44 (d, $J = 6.5$ Hz, 3H, H6 or H6′), 1.29 (d, $J =$ 6.0 Hz, 3H, H6 or H6′), 0.86 (d, $J = 6.0$ Hz, 3H, H6″); ^{13}C NMR (125 MHz, $CDCl_3$): $\delta = 165.5, 153.5, 150.2, 134.7, 125.5, 121.6, 117.6, 100.7, 92.5, 89.9, 89.0, 84.3, 82.8, 75.5, 72.0, 70.2, 69.5, 66.4, 62.1, 60.8, 56.7, 40.0, 38.1, 36.0, 34.3, 29.7, 19.5, 18.1, 17.8, 17.7$; HRMS (FAB) calcd for $C_{30}H_{43}Cl_2NO_{14}Na$ [$M + Na^+$]: 734.1958, found: 734.1938.



Scheme 5. Construction of the **A**$_1$**B**(**A**)**C** ring system. a) **26** (1.8 equiv), $BF_3 \cdot Et_2O$ (1.3 equiv), CH_2Cl_2, 4-Å molecular sieves, $-30 \rightarrow 25\,^\circ C$, 36 h, 95%; b) H_2, Pd/C, tBuOMe, 25 °C, 2 h, 95%.

stereocontrolled assembly into a polycyclic framework corresponding to the **A**$_1$**B**(**A**)**C** region of the target molecule **1**. The total synthesis of **1** and designed analogues for chemical biology studies should be forthcoming.

Received: February 4, 1998 [Z11436IE]
German version: *Angew. Chem.* **1998**, *110*, 1975–1977

Keywords: everninomicin · carbohydrates · glycosidations · glycosides · metathesis

[1] a) D. E. Wright, *Tetrahedron* **1979**, *35*, 1207–1237; b) A. K. Ganguly, B. Pramanik, T. C. Chan, O. Sarre, Y.-T. Liu, J. Morton, V. M. Girijavallabhan, *Heterocycles* **1989**, *28*, 83–88; c) A. K. Ganguly in *Topics in Antibiotic Chemistry*, *Vol. 2*, (Ed.: P. G. Sammes), Wiley, New York, **1978**, pp. 61–96; d) A. K. Ganguly, V. M. Girijavallabhan, O. Sarre, (Schering-Plough), WO-A 87/02366, **1987** [*Chem. Abstr.* **1987**, *107*, 97061]; e) P. Mahesh, V. P. Gullo, H. Roberta, D. Loebenberg, J. B. Morton, G. H. Miller, H. Y. Kwon, (Schering-Plough), EP-B 0 538 011 A1, **1992** [*Chem. Abstr.* **1993**, *119*, 10331].

[2] a) J. Brimacombe, L. W. Doner, *J. Chem. Soc. Perkin Trans. 1* **1974**, 63–65; b) J. Yoshimura, M. Matzuzama, M. Funabashi, *Bull. Chem. Soc. Jpn.* **1978**, *51*, 2064–2067; c) J. Brimacombe, A. S. Mengech, *J. Chem. Soc. Perkin Trans. 1* **1980**, 2055–2059; d) I. Lundt, J. Thiem, A. Prahst, *J. Org. Chem.* **1984**, *49*, 3063–3069; e) J. Dorhagen, H.-D. Scharf, *Tetrahedron* **1985**, *41*, 173–175; f) J. Thiem, A. Prahst, I. Lundt, *Liebigs Ann. Chem*. **1986**, 1044–1056; g) S. Hatateyama, K. Sakurai, S. Tanano, *Tetrahedron Lett*. **1986**, *27*, 4485–4488; h) P. Jütten, J. Dorhagen, H.-D. Scharf, *Tetrahedron* **1987**, *43*, 4133–4140; i) M. Truntel, P. Tavecchia, A. Veyrieres, P. Sinay, C*arbohydr. Res.* **1989**, *191*, 29–52; j) P. Tavecchia, M. Truntel, A. Veyrieres, P. Sinay, *Tetrahedron Lett*. **1989**, *30*, 2533–2536; k) P. Jütten, H.-D. Scharf, *Carbohydr. Res.* **1991**, *212*, 93–108; l) P. Jütten, H.-D. Scharf, G. Raabe, *J. Org. Chem.* **1991**, *56*, 7144–7149; m) C. Zagar, H.-D. Scharf, *Carbohydr. Res.* **1993**, *248*, 107–118.

[3] K. C. Nicolaou, H. J. Mitchell, F. L. van Delft, F. Rübsam, R. M. Rodríguez, *Angew. Chem.* **1998**, *110*, 1972–1974; *Angew. Chem. Int. Ed*. **1998**, *37*, 1871–1874.

[4] Recent review: M. Schuster, S. Blechert, *Angew. Chem.* **1997**, 109, 2124–2145; *Angew. Chem. Int. Ed. Engl.* **1997**, *36*, 2036–2056.

[5] a) K. C. Nicolaou, T. Ladduwahetty, J. L. Randall, A. Chucholowski, *J. Am. Chem. Soc.* **1986**, *108*, 2466–2467; b) K. C. Nicolaou, C. W. Hummel, N. J. Bockovich, C.-H. Wong, *J. Chem. Soc. Chem. Commun.* **1991**, 870–872.

[6] D. B. Smith, Z. Wang, S. L. Schreiber, *Tetrahedron* **1990**, *46*, 4793–4808.

[7] A higher yield was obtained by modification of the workup (high dilution with hexane, washing with H_2O) of the reported silylation procedure: J. Jin, S. M. Weinreb, *J. Am. Chem. Soc.* **1997**, *119*, 5773–5775.

[8] For a recent example of a synthesis of lactams based on olefin metathesis, see F. P. J. T. Rutjes, *Tetrahedron Lett*. **1997**, *38*, 677–680.

[9] L. A. Carpino, A. El-Faham, *J. Am. Chem. Soc.* **1995**, *117*, 5401–5402.

  1433-7851/98/3713-1876 $ 17.50+.50/0