Reaction of 2'-Hydroxy[1,1';3',1'']terphenyl-5'-carbaldehyde with 2-Naphthylamine and 1,3-Diketones

N. G. Kozlov¹, V. A. Tarasevich², D. A. Vasilevskii², and L. I. Basalaeva¹

¹ Institute of Physical Organic Chemistry, National Academy of Sciences of Belarus, ul. Surganova 13, Minsk, 220072 Belarus e-mail: loc@ifoch.bas-net.bv

Received November 11, 2004

Abstract—The condensation of 2'-hydroxy[1,1';3',1"]terphenyl-5'-carbaldehyde with 2-naphthylamine and 1,3-cyclohexanedione or dimedone gave 7,8,9,10,11,12-hexahydrobenzo[a]acridin-11-ones, while analogous three-component condensation with 1,3-indandione afforded azaindeno[1,2-b]phenanthren-12-one. In addition, hexahydro-2H-xanthene-1,8-diones and arylmethylenebisdiketones were isolated as by-products.

DOI: 10.1134/S1070428006010167

We previously studied three-component condensations of 2-naphthylamine with 1,3-diketones and mono- or disubstituted benzaldehydes [1–3]. In the present work we involved in analogous condensation for the first time a trisubstituted benzaldehyde, 2'-hydroxy-[1,1';3',1"]terphenyl-5'-carbaldehyde (I). Derivatives of I are known as polymer stabilizers, dyes, medicines, and insecticides [4–6]. We examined reactions of aldehyde I with 2-naphthylamine (II) and a series of 1,3-diketones: 1,3-cyclohexanedione (IIIa), 5,5-dimethyl-1,3-cyclohexanedione (IIIb, dimedone), and 1,3-indandione (IV). The reactions of I with amine II and diones IIIa and IIIb were performed by heating equimolar amounts of the reactants in ethanol.

We found that the reaction direction is determined by the order of mixing of the reactants. When amine II was initially mixed with diketone IIIa or IIIb, the only product was the corresponding enamine Va or Vb which (after isolation) failed to react with aldehyde I. Mixing of amine II with aldehyde I, followed by addition of diketone IIIa or IIIb, selectively afforded benzo[a]acridin-11-one VIa or VIb. The condensation is likely to involve initial formation of amino ketone A which undergoes rearrangement into intermediate B according to the scheme proposed in [7]; dehydration of B is accompanied by intramolecular ring closure to give final products VIa and VIb (Scheme 1). Analogous compounds were obtained by condensation of preliminarily isolated Schiff base VII with diketones

IIIa and IIIb under the same conditions, i.e., on heating in a boiling polar solvent.

Intermediate formation of arylmethylenebisdiketones **C** whose dehydration leads to xanthene-1,8-diones **VIIIa** and **VIIIb** is believed to be proved, for compounds **VIIIa** and **VIIIb** were isolated from the reaction mixture as concomitant products. Reaction of **VIIIa** and **VIIIb** with amine **II** gives benzoacridinones **VIIIa** and **VIIIb** were also obtained by heating aldehyde **I** with 2 equiv of diketone **IIIa** or **IIIb** in boiling 1-butanol.

The reaction of aldehyde I with 2-naphthylamine (II) and 1,3-indandione (IV) was performed by heating equimolar amounts of the reactants in boiling 1-butanol. Our experimental and published [8] data suggest that the final product, 13-(2'-hydroxy[1,1';3',1"]terphenyl-5'-yl)-7-azaindeno[1,2-b]phenanthren-12-one (IX), is formed through intermediate amino ketone D which undergoes dehydration to intermediate E and oxidation of the latter. The use of 1-butanol as solvent allowed us to avoid isolation and dehydrogenation of intermediate product E, which were necessary when reactions of amine II with indandione IV and substituted benzaldehydes were carried out in ethanol [9]. We also found that the condensation of amine II with aldehyde I and diketone IV gives 2-(2'-hydroxy-[1,1';3',1"]terphenyl-5'-ylmethylidene)indan-1,3-dione (X). Therefore, we presumed that compound IX may be synthesized by reaction of indandione X with amine

² Institute of New Materials Chemistry, National Academy of Sciences of Belarus, ul. Skoriny 36, Minsk, Belarus

Scheme 1.

R = H(a), Me(b).

II. In fact, we synthesized dione **X** by reaction of **IV** with aldehyde **I**, and the condensation of **X** with amine **II** under analogous conditions led to formation of fused polycyclic product **IX** (Scheme 2).

The structure of compounds Va, Vb, VIa, VIb, VII, VIIIa, VIIIb, IX, and X was confirmed by the analytical data and ¹H NMR and IR spectra. The IR spectra of Va, Vb, VIa, and VIb contained bands

Scheme 2.

typical of NH stretching vibrations at 3266-3258 and 1650-1630 cm⁻¹. In the spectra of VIa and VIb, stretching vibrations of the ketone carbonyl group conjugated with the enamine fragment appeared at 1609-1610 cm⁻¹. Compound VII characteristically showed in the IR spectrum an absorption band at 1676 cm⁻¹ due to N=CH stretching vibrations. The C-O-C fragments in molecules VIIIa and VIIIb give rise to absorption at 1211 and 1249 cm⁻¹, respectively. Stretching vibrations of aliphatic C-H bonds in ketones Va, Vb, VIa, VIb, VIIIa, and VIIIb were observed at 2959-2933 cm⁻¹, and bands at 3229-3024 cm⁻¹ were assigned to stretching vibrations of aromatic C-H bonds. The IR spectrum of X contained a strong absorption band at 1567 cm⁻¹ due to stretching vibrations of the carbonyl groups conjugated with the benzene ring. A medium-intensity band at 1561 cm⁻¹ in the spectrum of IX belongs to the carbonyl group conjugated with both benzene and naphthalene rings. Compounds VI-X also showed in the IR spectra a medium-intensity band in the region 3537–3311 cm⁻¹, which corresponds to stretching vibrations of the hydroxy group.

The ¹H NMR spectra of ketones **V–X** were fully consistent with the assumed structures. The chemical shifts of protons on the C¹, C¹², and nitrogen atoms allowed us to distinguish between the acridinone structure of **VIa** and **VIb** and phenanthridinone derivatives

which were postulated in [10] as condensation products of 1.3-diketones with Schiff bases of the naphthalene series. The 1-H proton in VIa and VIb resonates at δ 8.05–8.10 ppm, while the corresponding signal of phenanthridine derivatives appears in a weaker field, at $\delta \sim 8.80$ ppm [11]. The position of the 1-H signal in the ¹H NMR spectra of **VIa** and **VIb** is determined by shielding by the bulky aryl substituent. Likewise, downfield shift of the 12-H signal (δ 5.85 ppm for VIa and 5.80 ppm for VIb) relative to its usual position in the spectra of dihydropyridine derivatives results from anisotropic effect of the neighboring substituent containing three aromatic rings. The NH proton in VIa and VIb has a chemical shift δ of 9.35–9.30 ppm (s), which is typical of acridine derivatives [11]. In the spectrum of terphenylindandione X, the CH= signal appears as the second downfield singlet (δ 8.50 ppm, next to the signal from hydroxy proton) due to conjugation of the exocyclic double bond with two carbonyl groups (cf. [12]).

EXPERIMENTAL

The IR spectra were recorded on a Nicolet Protege-460 Fourier spectrometer. The 1 H NMR spectra were measured on Tesla BS-567A (100 MHz) and Bruker AC-500 (500 MHz) instruments from 2–5 wt % solutions in DMSO- d_6 ; the chemical shifts were referenced to TMS as internal standard.

110 KOZLOV et al.

2'-Hydroxy[1,1';3',1"]terphenyl-5'-carbaldehyde (I) was synthesized from [1,1';3',1"]terphenyl-2'-carbaldehyde and hexamethylenetetraamine in the presence of trifluoroacetic acid, following the procedure reported in [13], mp 168–169°C.

3-(2-Naphthylamino)-2-cyclohexenone (Va). Diketone **IIIa**, 1.12 g (0.01 mol), was added to a solution of 1.43 g (0.01 mol) of 2-naphthylamine (**II**) in 30 ml of ethanol, and the mixture was heated for 3 h under reflux. The solvent was distilled off, and the crystalline residue was recrystallized from ethanol–benzene (1:3). Yield 1.25 g (53%). Yellow crystals, mp 176°C. IR spectrum, v, cm⁻¹: 3430, 3250, 3210, 2925, 1620, 1597, 1499, 1464, 1364, 1305, 1247, 1186, 1136, 811, 754, 473. ¹H NMR spectrum, δ, ppm: 1.85–1.90 m (2H, CH₂), 2.20–2.30 m (2H, CH₂), 2.38–2.42 m (2H, CH₂), 5.70 s (1H, CH), 7.20–7.70 m (7H, H_{arom}), 8.80 s (1H, NH). Found, %: C 81.03; H 6.35; N 5.92. $C_{16}H_{15}NO$. Calculated, %: C 81.01; H 6.33; N 5.90.

5,5-Dimethyl-3-(2-naphthylamino)-2-cyclohexenone (Vb) was synthesized in a similar way using dimedone (**IIIb**). Yield 1.59 g (60%). Yellow crystals, mp 185°C. IR spectrum, *v*, cm⁻¹: 3448, 3260, 3229, 3024, 2954, 2926, 1640, 1581, 1534, 1504, 1464, 1365, 1308, 1276, 1246, 1149, 1120, 868, 819, 774, 761, 605, 551, 468. ¹H NMR spectrum, δ, ppm: 1.10 s (6H, CH₃), 2.10 s (2H, CH₂), 2.40 s (2H, CH₂), 5.49 s (1H, CH), 7.30–7.90 m (7H, H_{arom}), 8.90 s (1H, NH). Found, %: C 81.53; H 7.14; N 5.26. C₁₈H₁₉NO. Calculated, %: C 81.51; H 7.17; N 5.28.

12-(2'-Hydroxy[1,1';3',1'']terphenyl-5'-yl)-7,8,9,10,11,12-hexahydrobenzo[a]acridin-11-one (VIa). Aldehyde I, 2.74 g (0.01 mol), was added to a solution of 1.43 g (0.01 mol) of amine II in 50 ml of ethanol, the mixture was heated for 15 min under reflux, 1.12 g (0.01 mol) of 1,3-cyclohexanedione (IIIa) was added, and the mixture was heated for 5 h under reflux. After cooling, the precipitate was filtered off, washed with hot methanol, and recrystallized from benzene. Yield 3.73 g (89%), colorless crystals, mp 320°C. IR spectrum, v, cm⁻¹: 3537, 3264, 3193, 2933, 1650, 1609, 1582, 1518, 1492, 1465, 1420, 1395, 1317, 1279, 1235, 1190, 1135, 1116, 1029, 958, 819, 773, 759, 703, 638, 598. ¹H NMR spectrum, δ, ppm: 1.85–2.05 m (2H, CH₂), 2.20–2.35 m (2H, CH₂), 2.60–2.70 m (2H, CH₂), 5.85 s (1H, CH), 7.08 s (2H, H_{arom}), 7.20-7.45 m (13H, H_{arom}, 1H, OH), 7.65 d (1H, H_{arom}), 7.74 d (1H, H_{arom}), 8.05 d (1H, H_{arom}), 9.35 s (1H, NH). Found, %: C 85.17; H 5.51; N 2.86. C₃₅H₂₇NO₂. Calculated, %: C 85.20; H 5.48; N 2.84.

12-(2'-Hydroxy[1,1';3',1'']terphenyl-5'-yl)-9,9-dimethyl-7,8,9,10,11,12-hexahydrobenzo[*a***]acridin-11-one (VIb)** was synthesized in a similar way using dimedone (**IIIb**). Yield 3.55 g (80%), colorless crystals, mp 279–280°C. IR spectrum, v, cm⁻¹: 3534, 3266, 3197, 2943, 1648, 1610, 1582, 1519, 1494, 1467, 1422, 1393, 1339, 1318, 1280, 1236, 1182, 1149, 1118, 1075, 1030, 1013, 958, 904, 880, 820, 770, 760, 748, 703, 698, 632, 597, 586. ¹H NMR spectrum, δ, ppm: 1.08 s (3H, CH₃), 1.10 s (3H, CH₃), 2.10–2.13 m (2H, CH₂), 2.15–2.20 m (2H, CH₂), 5.80 s (1H, CH), 7.10 s (2H, H_{arom}), 7.20–7.49 m (13H, H_{arom}, 1H, OH), 7.70 d (1H, H_{arom}), 7.78 d (1H, H_{arom}), 8.10 d (1H, H_{arom}), 9.30 s (1H, NH). Found, %: C 85.18; H 5.96; N 2.71. C₃₇H₃₁NO₂. Calculated, %: C 85.22; H 5.95; N 2.69.

5'-(2-Naphthyliminomethyl)[1,1';3',1'']terphenyl-2'-ol (VII). A solution of 2.74 g (0.01 mol) of aldehyde **I** in 10 ml of 1-butanol was added to a solution of 1.43 g (0.01 mol) of amine **II** in 20 ml of ethanol, and the mixture was heated for 15 min under reflux. The mixture was cooled, and the precipitate was filtered off and recrystallized from ethanol. Yield 2.95 g (85%). Yellow crystals, mp 138–139°C. IR spectrum, v, cm⁻¹: 3311, 3056, 2916, 2847, 1676, 1583, 1462, 1427, 1321, 1228, 1163, 1116, 1026, 892, 784, 748, 699, 578, 504. ¹H NMR spectrum, δ, ppm: 7.20–7.50 m (10H, H_{arom}), 7.59–7.90 m (9H, H_{arom} , 1H, OH), 8.50 s (1H, CH). Found, %: C 87.20; H 5.23; N 3.52. $C_{29}H_{21}NO$. Calculated, %: C 87.22; H 5.26; N 3.51.

9-(2'-Hydroxy[1,1';3',1'']terphenyl-5'-yl)- 2,3,4,5,6,7,8,9-octahydro-1*H***-xanthene-1,8-dione (VIIIa).** A solution of 2.74 g of aldehyde **I** and 2.24 g (0.02 mol) of 1,3-cyclohexanedione (**IIIa**) in 50 ml of ethanol was heated for 6 h under reflux. The precipitate was filtered off, washed with diethyl ether, dried, and recrystallized from methanol. Yield 1.95 g (42%), colorless crystals, mp 201°C. IR spectrum, v, cm⁻¹: 3520, 3180, 2957, 2863, 1595, 1463, 1428, 1372, 1300, 1211, 1160, 775, 700, 673. ¹H NMR spectrum, δ, ppm: 1.90–2.05 m (2H, CH₂), 2.10–2.24 m (2H, CH₂), 2.30–2.40 m (2H, CH₂), 4.65 s (1H, CH), 7.00 s (2H, H_{arom}), 7.20–7.70 m (10H, H_{arom}, 1H, OH). Found, %: C 80.50; H 5.65. C₃₁H₂₆O₄. Calculated, %: C 80.52; H 5.63.

9-(2'-Hydroxy[1,1';3',1'']terphenyl-5'-yl)-3,3,6,6-tetramethyl-2,3,4,5,6,7,8,9-octahydro-1*H*-xanthene-1,8-dione (VIIIb) was synthesized as described for compounds VIIIa using dimedone (IIIb). Yield 1.89 g (45%), colorless crystals, mp 211–212°C. IR spectrum, v, cm⁻¹: 3525, 3034, 2959, 2927, 2887, 2869, 1591,

1467, 1426, 1373, 1306, 1249, 1218, 1165, 880, 777, 702, 679. 1 H NMR spectrum, δ , ppm: 1.00 s (3H, CH₃), 1.10 s (3H, CH₃), 2.20–2.30 m (2H, CH₂), 2.40–2.50 m (2H, CH₂), 4.57 s (1H, CH), 6.90 s (2H, H_{arom}), 7.15–7.70 m (10H, H_{arom}, 1H, OH). Found, %: C 81.04; H 6.53. C₃₅H₃₄O₄. Calculated, %: C 81.08; H 6.56.

13-(2'-Hydroxy[1,1';3',1"]terphenyl-5'-yl)-7-azaindeno[1,2-b]phenanthren-12-one (IX). A solution of 1.43 g (0.01 mol) of amine II in 10 ml of 1-butanol and a solution of 1.46 g (0.01 mol) of 1,3-indandione (IV) in 10 ml of 1-butanol were added to a solution of 2.74 g (0.01 mol) of aldehyde I in 20 ml of 1-butanol, and the mixture was heated for 4 h under reflux. The mixture was cooled, and the precipitate was filtered off and washed with three portions of hot acetone. Yield 3.36 g (64%). Yellow crystalline substance, mp 315°C. IR spectrum, v, cm⁻¹: 3383, 3076, 2917, 1679, 1561, 1468, 1417, 1320, 1221, 1195, 1184, 1151, 1091, 991, 735, 699. 1 H NMR spectrum, δ , ppm: 7.40–7.70 m (15H, H_{arom}), 7.75-7.95 m (4H, H_{arom}), 8.20 d (1H, H_{arom}), 8.50 s (2H, H_{arom}), 9.48 br.s (1H, OH). Found, %: C 86.84; H 4.40; N 2.63. C₃₈H₂₃NO₂. Calculated, %: C 86.86; H 4.38; N 2.66.

2-(2'-Hydroxy[1,1';3',1'']terphenyl-5'-ylmethylidene)indan-1,3-dione (**X**). A solution of 2.74 g (0.01 mol) of aldehyde **I** and 1.46 g (0.01 mol) of 1,3-indandione (**IV**) in 30 ml of 1-butanol was heated for 30 min under reflux. The precipitate was filtered off, washed with diethyl ether, and recrystallized from acetone. Yield 2.80 g (70%). Yellow crystals, mp 246°C. IR spectrum, v, cm⁻¹: 3460, 2923, 1681, 1567, 1468, 1418, 1326, 1282, 1219, 1193, 1153, 1086, 995, 960, 926, 880, 779, 733, 704, 691, 601, 526. ¹H NMR spectrum, δ , ppm: 7.35–7.45 m (3H, H_{arom}), 7.47–7.50 m (6H, H_{arom}), 7.60–7.68 m (2H, H_{arom}), 7.80–7.96 m

(5H, H_{arom}), 8.50 s (1H, CH), 9.25 br.s (1H, OH). Found, %: C 83.60; H 4.49. $C_{28}H_{18}O_3$. Calculated, %: C 83.58; H 4.48.

REFERENCES

- 1. Kozlov, N.G., Basalaeva, L.I., and Dikusar, E.A., *Khim. Prirodn. Soedin.*, 2004, vol. 40, p. 79.
- 2. Kozlov, N.G., Basalaeva, L.I., and Tychinskaya, L.Yu., *Russ. J. Org. Chem.*, 2002, vol. 38, p. 1166.
- 3. Kozlov, N.G., Basalaeva, L.I., and Skakovskaya, Yu.E., *Russ. J. Gen. Chem.*, 2002, vol. 72, p. 1238.
- 4. Barnekow, A., Biosci. Rep., 1983, vol. 3, p. 153.
- Jacobs, S., Kull, F.C., Earp, H.S., Svoboda, M.E., Yan Wyk, J.J., and Cuatrecasas, P., *J. Biol. Chem.*, 1983, vol. 258, p. 958.
- Westermark, B., Wasteson, A., and Heldin, C.-H., Nature, 1982, vol. 295, p. 419.
- 7. Cortes, E., Martinez, R., Avila, J.G., and Toscano, R.A., *J. Heterocycl. Chem.*, 1988, vol. 25, p. 895.
- 8. Kozlov, N.G. and Gusak, K.N., *Russ. J. Org. Chem.*, 1999, vol. 35, p. 402.
- 9. Kozlov, N.S. and Gusak, K.N., *Dokl. Akad. Nauk SSSR*, 1990, vol. 314, p. 1419.
- 10. Kozlov, N.S., *5,6-Benzokhinoliny* (5,6-Benzoquinolines), Minsk: Nauka i Tekhnika, 1970.
- 11. Kozlov, N.G., Gusak, K.N., Tereshko, A.B., Firgang, S.I., and Shashkov, A.S., *Russ. J. Org. Chem.*, 2004, vol. 40, p. 1181.
- 12. Dyer, J.R., Applications of Absorption Spectroscopy of Organic Compounds, Englewood Cliffs: Prentice-Hall, 1965. Translated under the title Prilozheniya absorbtsionnoi spektroskopii organicheskikh soedinenii, Moscow: Khimiya, 1970, p. 100.
- 13. Shiraishi, T., Kameyama, K., Imai, N., Domoto, T., Katsumi, I., and Watanabe, K., *Chem. Pharm. Bull.*, 1988, vol. 36, p. 974.