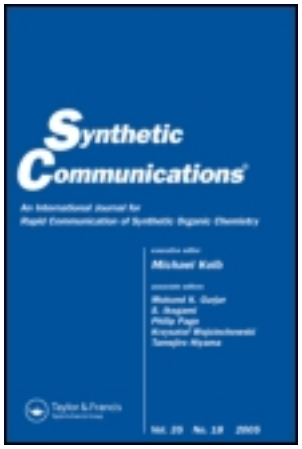

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CONVENIENT SYNTHESIS OF 11-ARYL-1,12-DIHYDRO-11*H*-NAPHTHOPYRANO[2,3-d]PYRIMIDIN-12-ONES

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Various imidates* 3 *were successfully synthesized from naphthopyrans and ethyl orthoesters in moderate yields. These intermediates undergo rapid condensation with several primary amines to give the corresponding 11-aryl-1,12-dihydro-11H-naphthopyrano[2,3-d] pyrimidin-12-ones 4.

Keywords: Imidates; naphthopyranopyrimidinones; naphthopyrans; pyranopyrimidinones

INTRODUCTION

Considerable interest has been shown in several pyran ring systems, especially for pyranopyrimidines, on account of their different types of interesting biological activities. It has been reported that various pyranopyrimidines exhibit antimicrobial,[1] antibacterial,[2] antigenotoxic,[3] and antifungal activities.[4–6] Also, pyranopyrimidines derivatives can have antiplatelet, antithrombotic,[7] analgesic, anti-inflammatory, and antiphlogistic activity.[8–9] Moreover, the biological activities of fused pyrimidines have led to intensive research on their synthesis.[10–20] We report here the synthesis of new pyranopyrimidinones derivatives **4** using 2-amino-4-aryl-4*H*-naphtho[2,1-*b*]pyran-3-ethoxycarbonyl **2** as a starting material.

RESULTS AND DISCUSSION

In continuation of our previous work,[3,10–12] it seemed interesting to use naphthopyrans for the synthesis of new naphthopyranopyrimidinones. In the present study, we began first by synthesizing 2-amino-4-aryl-4*H*-naphtho[2,1-*b*]pyran-3-ethoxycarbonyl **2** by reacting α-cyanocinnamonitriles **1** with 2-naphthol under reflux of ethanol (Scheme 1).

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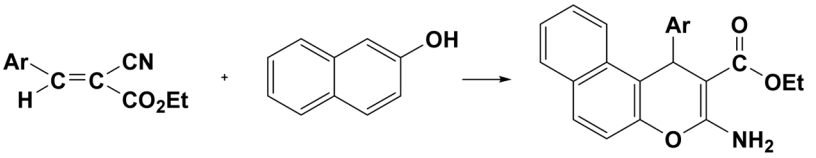


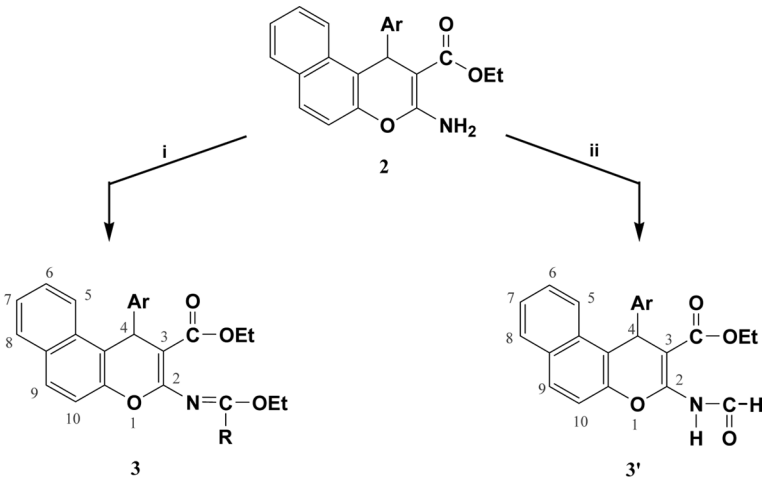
1 2

2a: Ar=Ph
2b: Ar= p-CH_3Ph
2c: Ar= o-OCH_3Ph
2d: Ar=o-ClPh

Scheme 1. Reagents and conditions: EtOH/pyperidine, reflux, 5 h.

These compounds were obtained in good yields and will be opposed to several orthoesters (ethyl orthoacetate or ethyl orthopropionate) to give the corresponding 2-[(ethoxyalkylidene)amino]-4-aryl-3-ethoxycarbonyl-4*H*-naphtho[2,1-b]pyrans **3**. While with ethyl orthoformiate, we noticed that the product did not match to imidate **3**. Indeed, different spectroscopic techniques have shown that compounds **3′** were identified as 4-aryl-3-ethoxycarbonyl-2-formylamino-4*H*-naphtho[2,1-b]pyrans (Scheme 2).

Starting from the key intermediate imidates **3** with an excess of the suitable primary amine, under reflux of toluene, we obtained the pyranopyrimidinones **4** (Scheme 3), whose structure was confirmed by ^{1}H NMR data by the disappearance of signals related to the two ethoxy groups and the presence of signals introduced by amine.

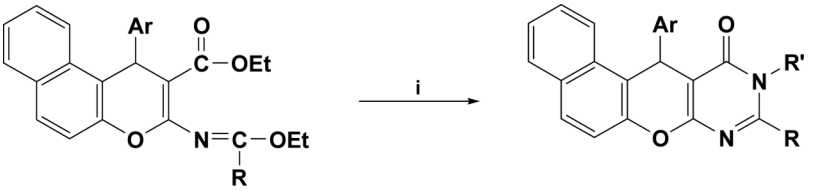


2 3 3'

3a: Ar= Ph R:Me **3e**: Ar= Ph R:Et
3b: Ar= p-CH_3Ph R:Me **3f**: Ar= p-CH_3Ph R:Et
3c: Ar= o-OCH_3Ph R:Me **3g**: Ar= o-OCH_3Ph R:Et
3d: Ar= o-ClPh R:Me **3h**: Ar= o-ClPh R:Et

3'a: Ar=Ph
3'b: Ar=o-ClPh

Scheme 2. Reagents and conditions: CH_3COOH, reflux, 24 h: (i) $MeC(OEt)_3$ or $EtC(OEt)_3$; (ii) $CH(OEt)_3$.



3 4

4a:	Ar= o-ClPh	R:Me	R': Ph	**4f:**	Ar= Ph	R:Me	R': furan-2-yl
4b:	Ar= o-ClPh	R:Me	R': CH_2Ph	**4g:**	Ar=p-CH_3Ph	R:Et	R': Ph
4c:	Ar= o-OCH_3Ph	R:Me	R': Ph	**4h:**	Ar=p-CH_3Ph	R:Et	R': CH_2Ph
4d:	Ar= o-OCH_3Ph	R:Me	R': CH_2Ph	**4i:**	Ar= o-OCH_3Ph	R:Et	R': Ph
4e:	Ar= o-OCH_3Ph	R:Me	R': C_6H_{11}	**4j:**	Ar= o-OCH_3Ph	R:Et	R': CH_2Ph

Scheme 3. Reagents and conditions: (i) R′-NH_2 in toluene, reflux, 48 h.

Structures of the target compounds (**1**–**4**) were confirmed by infrared (IR), ^{1}H NMR, and ^{13}C NMR spectral data. In addition, all the new pyranopyrimidinone derivatives have been determined with high-resolution mass spectra (HRMS) and microanalyzed satisfactorily for C, H, and N.

In conclusion, we have synthesized and analyzed a series of 2-[(ethoxyalkylidene)amino]-4-aryl-3-ethoxycarbonyl-4*H*-naphtho[2,1-b]pyrans **3** that are variously substituted at the 2- and 4-phenyl moieties, by reacting 2-amino-4-aryl-4*H*-naphtho [2,1-*b*]pyran-3-ethoxycarbonyl **2** with several orthoesters. Subsequently, these imidates **3** were opposed to primary amines to give new naphthopyranopyrimidinone **4** derivatives.

EXPERIMENTAL

All melting points were determined on a Kofler-type microscope and are uncorrected. IR spectra were recorded on a Perkin-Elmer Fourier transform FT–IR spectrophotometer (4000–400 cm^{-1}) using KBr pellets. ^{1}H NMR and ^{13}C NMR spectra were recorded at room temperature (rt) in $CDCl_3$ or dimethylsulfoxide (DMSO-d_6) at 300, 400, or 500 MHz and at 75, 100, or 125 MHz, respectively, using solvent peaks [$CDCl_3$: 7.27 (D), 77.2 (C) ppm and DMSO-d_6 2.50 (D) and 39.7 (C) ppm] as internal reference. The assignment of chemical shifts is based on standard NMR experiments (^{1}H, ^{13}C) using tetramethylsilane (TMS) as the internal standard. Mass spectra (MS) were recorded on a gas chromatography (GC) MS spectrometer with an atmospheric pressure electrospray (API-ES) ionization source. Elemental analyses (C, H, and N) were performed at the Instituto de Química Orgánica (Consejo Superior de Investigaciones Científicas, Spain). All solvents were dried by standard methods.

General Procedure for 2-Amino-4-aryl-3-ethoxycarbonyl-4*H*-naphtho[2,1-b]pyrans 2a–d

A mixture of α-cyanocinnamonitriles **1a–e** (0.01 mmol) and 2-naphthol (0.01 mmol) in ethanol (20 ml) was refluxed for 5 h with the presence of 0.2 equivalent

of piperidine. The solid product that formed was filtered, washed with cold ethanol, dried, and recrystallized with a suitable solvent to give compounds **2a–e** in good yields.

Selected Data

2-Amino-3-ethoxycarbonyl-4-phenyl-4*H*-naphtho[2,1-b]pyran (2a). Yield 82%, mp 168–170 °C; ^{1}H NMR (DMSO-d_6; 300 MHz) δ: 1.23 (t, $J = 7.0$ Hz, 3H), 4.08 (q, $J = 7.0$ Hz, 2H), 5.51 (s, 1H), 7.00–8.02 (m, 11H, Ar-H), 7.67 (br, 2H, NH_2, cancelled by D_2O); ^{13}C NMR (DMSO-d_6; 75 MHz) δ: 14.91, 37.02, 59.39, 78.27, 117.20, 119.32, 123.64, 125.27, 126.42, 127.55, (double intensity): 128.21, (double intensity): 128.59, 129.04, 129.42, 130.78, 131.25, 147.24, 147.38, 160.98, 168.65; IR (KBr) ν_{CO}: 1685, ν_{NH_2}: 3300–3438 cm^{-1}.

2-Amino-3-ethoxycarbonyl-4-(p-methylphenyl)-4*H*-naphtho[2,1-b]pyran (2b). Yield 72%, mp 194–196 °C; ^{1}H NMR (DMSO-d_6; 300 MHz) δ: 1.24 (t, $J = 7.0$ Hz, 3H), 2.10 (s, 3H), 4.09 (q, $J = 7.0$ Hz, 2H), 5.49 (s, 1H), 6.93–8.01 (m, 10H, Ar-H), 7.68 (br, 2H, NH_2, cancelled by D_2O); ^{13}C NMR (DMSO-d_6; 75 MHz) δ: 14.92, 20.94, 36.64, 59.38, 78.39, 117.18, 119.48, 123.67, 125.20, 127.46, (double intensity): 128.09, (double intensity): 129.00, 129.13, 129.30, 130.82, 131.26, 135.39, 144.47, 147.20, 160.95, 168.73; IR (KBr) ν_{CO}: 1687, ν_{NH_2}: 3320–3440 cm^{-1}.

2-Amino-3-ethoxycarbonyl-4-(o-methoxylphenyl)-4*H*-naphtho[2,1-b]-pyran (2c). Yield 60%, mp 188–190 °C; ^{1}H NMR (DMSO-d_6; 300 MHz) δ: 1.14 (t, $J = 6.9$ Hz, 3H), 3.80 (s, 3H), 4.01 (q, $J = 6.9$ Hz, 2H), 5.82 (s, 1H), 6.72–8.25 (m, 10H, Ar-H), 7.68 (br, 2H, NH_2, cancelled by D_2O); ^{13}C NMR (DMSO-d_6; 75 MHz) δ: 14.77, 31.34, 55.83, 59.18, 77.50, 111.63, 117.16, 119.59, 120.84, 123.77, 125.07, 127.32, 127.79, 128.91, 128.95, 130.55, 131.04, 131.38, 135.50, 147.36, 156.15, 161.48, 169.09; IR (KBr) ν_{CO}: 1690, ν_{NH_2}: 3339–3425 cm^{-1}.

2-Amino-4-(o-chlorophenyl)-3-ethoxycarbonyl-4*H*-naphtho[2,1-b]pyran (2d). Yield 65%, mp 170–172 °C; ^{1}H NMR (DMSO-d_6; 300 MHz) δ: 1.15 (t, $J = 7.0$ Hz, 3H), 4.05 (q, $J = 7.0$ Hz, 2H), 5.82 (s, 1H), 7.00–8.20 (m, 10H, Ar-H), 7.79 (br, 2H, NH_2, cancelled by D_2O); ^{13}C NMR (DMSO-d_6; 75 MHz) δ: 14.97, 34.62, 59.34, 77.22, 117.32, 118.58, 123.51, 125.33, 127.58, 127.92, 128.29, 129.18, 129.78, 129.99, 131.10, 131.13, 131.71, 131.97, 144.59, 147.38, 161.23, 168.78; IR (KBr) ν_{CO}: 1692, ν_{NH_2}: 3341–3430 cm^{-1}.

General Procedure for 2-[(Ethoxyalkylidene) Amino]-4-aryl-3-ethoxycarbonyl-4*H*-naphtho[2,1-b]pyrans 3a–h

A solution of **2a–e** (0.01 mmol) was treated with ethyl orthoester (0.06 mmol) and acetic acid (0.5 ml). The mixture was heated, and the ethanol formed was continuously distilled at atmospheric pressure. Then we added a second portion of acetic acid, and the main mixture was heated under reflux for 24 h. The solid product formed was collected by filtration and recrystallized with a suitable solvent to give compounds **3a–h** and **3′a, b**.

Selected Data

2-[(Ethoxyethylidene)amino]-3-ethoxycarbonyl-4-phenyl-4*H*-naphtho-[2,1-b]pyran (3a). Yield 81%, mp 120–122 °C; ^{1}H NMR ($CDCl_3$; 300 MHz) δ: 1.17 (t, $J = 7.1$ Hz, 3H), 1.25 (t, $J = 7.2$ Hz, 3H), 1.95 (s, 3H), 4.18 (q, $J = 7.1$ Hz, 2H), 4.25 (q, $J = 7.2$ Hz, 2H), 5.70 (s, 1H), 6.92–8.17 (m, 11H, Ar-H); ^{13}C NMR ($CDCl_3$; 75 MHz) δ: 14.46, 14.59, 17.93, 37.60, 60.36, 63.49, 94.28, 117.41, 118.29, 123.89, 125.05, 126.41, 127.20, 127.23, 127.73, 128.46, 128.83, 129.13, 131.36, 131.47, 131.77, 146.25, 148.48, 159.37, 166.91, 167.59; IR (KBr) ν_{CO}: 1670 cm^{-1}.

2-[(Ethoxyethylidene)amino]-3-ethoxycarbonyl-4-(p-methylphenyl)-4*H*-naphtho[2,1-b]pyran (3b). Yield 90%, mp 118–120 °C; ^{1}H NMR ($CDCl_3$; 300 MHz) δ: 1.32 (t, $J = 6.9$ Hz, 3H), 1.40 (t, $J = 7.0$ Hz, 3H), 1.98 (s, 3H), 2.24 (s, 3H), 4.18 (q, $J = 6.9$ Hz, 2H), 4.38 (q, $J = 7.0$ Hz, 2H), 5.80 (s, 1H), 7.03–8.08 (m, 10H, Ar-H); ^{13}C NMR ($CDCl_3$; 75 MHz) δ: 14.19, 14.23, 17.33, 20.19, 37.49, 58.91, 62.03, 92.86, 115.94, 116.90, 122.38, 123.55, 125.75, (double intensity): 127.10, 127.36, 127.56, (double intensity): 127.87, 129.81, 130.23, 134.64, 141.85, 146.84, 157.82, 165.48, 166.19; IR (KBr) ν_{CO}: 1680 cm^{-1}.

2-[(Ethoxyethylidene)amino]-3-ethoxycarbonyl-4-(o-methoxylphenyl)-4*H*-naphtho[2,1-b]pyran (3c). Yield 84%, mp 144–146 °C; ^{1}H NMR ($CDCl_3$; 300 MHz) δ: 1.30 (t, $J = 7.2$ Hz, 3H), 1.41 (t, $J = 7.1$ Hz, 3H), 2.04 (s, 3H), 3.87 (s, 3H), 4.14 (q, $J = 7.2$ Hz, 2H), 4.38 (q, $J = 7.1$ Hz, 2H), 6.79 (s, 1H), 6.79–8.31 (m, 10H, Ar-H); ^{13}C NMR ($CDCl_3$; 75 MHz) δ: 14.19, 14.33, 17.61, 33.85, 55.42, 59.88, 63.14, 92.98, 111.13, 117.06, 118.20, 120.73, 123.94, 124.49, 126.64, 127.73, (double intensity): 128.35, 131.04, 131.20, 131.49, 134.11, 148.31, 156.33, 159.57, 166.76, 167.47; IR (KBr) ν_{CO}: 1665 cm^{-1}.

2-[(Ethoxyethylidene)amino]-4-(o-chlorophenyl)-3-ethoxycarbonyl-4*H*-naphtho[2,1-b]pyran (3d). Yield 40%, mp 120–122 °C; ^{1}H NMR ($CDCl_3$; 300 MHz) δ: 1.27 (t, $J = 7.0$ Hz, 3H), 1.40 (t, $J = 7.0$ Hz, 3H), 2.02 (s, 3H), 4.18 (q, $J = 7.0$ Hz, 2H), 4.20 (q, $J = 7.0$ Hz, 2H), 6.20 (s, 1H), 6.97–8.36 (m, 10H, Ar-H); ^{13}C NMR ($CDCl_3$; 75 MHz) δ: 14.26, 14.44, 17.80, 36.31, 60.04, 63.22, 93.36, 117.18, 117.97, 123.91, 124.83, 127.05, 127.14, 127.27, 127.39, 128.49, 129.05, 129.58, 131.29, 131.66, 132.24, 143.64, 148.25, 159.38, 166.40, 167.38; IR (KBr) ν_{CO}: 1670 cm^{-1}.

2-[(Ethoxypropylidene)amino]-3-ethoxycarbonyl-4-phenyl-4*H*-naphtho-[2,1-b]pyran (3e). Yield 89%, mp 176–178 °C; ^{1}H NMR ($CDCl_3$; 300 MHz) δ: 1.13 (t, $J = 7.2$ Hz, 3H), 1.30 (t, $J = 7.2$ Hz, 3H), 1.41 (t, $J = 7.2$ Hz, 3H), 2.32 (q, $J = 7.2$ Hz, 2H), 4.18 (q, $J = 7.2$ Hz, 2H), 4.38 (q, $J = 7.2$ Hz, 2H), 5.83 (s, 1H), 7.08–8.08 (m, 11H, Ar-H); ^{13}C NMR ($CDCl_3$; 75 MHz) δ: 09.32, 12.99, 13.17, 23.98, 37.87, 58.89, 61.98, 92.49, 115.92, 116.86, 122.38, 123.58, 125.20, 125.78, (double intensity): 127.14, (double intensity): 127.22, 127.36, 127.65, 129.82, 130.22, 144.66, 146.92, 157.73, 165.52, 169.19; IR (KBr) ν_{CO}: 1690 cm^{-1}.

2-[(Ethoxypropylidene)amino]-3-ethoxycarbonyl-4-(p-methylphenyl)-4*H*-naphtho[2,1-b]pyran (3f). Yield 30%, mp 110–112 °C; ^{1}H NMR ($CDCl_3$;

75 MHz) δ: 1.11 (t, $J = 7.2$ Hz, 3H), 1.27 (t, $J = 7.2$ Hz, 3H), 1.39 (t, $J = 7.2$ Hz, 3H), 2.23 (s, 3H), 2.30 (q, $J = 7.2$ Hz, 2H), 4.14 (q, $J = 7.2$ Hz, 2H), 4.34 (q, $J = 7.2$ Hz, 2H), 5.75 (s, 1H), 7.00–8.05 (m, 10H, Ar-H); IR (KBr) ν_{CO}: 1683 cm^{-1}.

2-[(Ethoxypropylidene)amino]-3-ethoxycarbonyl-4-(o-methoxylphenyl)-4*H*-naphtho [2,1-b]pyran (3g). Yield 83%, mp 162–164 °C; ^{1}H NMR ($CDCl_3$; 300 MHz) δ: 1.03 (t, $J = 7.2$ Hz, 3H), 1.11 (t, $J = 7.2$ Hz, 3H), 1.27 (t, $J = 7.2$ Hz, 3H), 2.28 (q, $J = 7.2$ Hz, 2H), 3.75 (s, 3H), 4.00 (q, $J = 7.2$ Hz, 2H), 4.23 (q, $J = 7.2$ Hz, 2H), 5.99 (s, 1H), 6.66–7.61 (m, 10H, Ar-H); ^{13}C NMR ($CDCl_3$; 75 MHz) δ: 10.83, 14.46, 14.65, 25.38, 34.09, 55.80, 60.08, 63.32, 93.24, 111.48, 117.37, 118.76, 121.06, 124.30, 124.78, 126.93, 127.99, (double intensity): 128.63, 131.32, 131.55, 131.88, 134.61, 148.69, 156.69, 159.60, 167.10, 170.60; IR (KBr) ν_{CO}: 1676 cm^{-1}.

2-[(Ethoxypropylidene)amino]-4-(o-chlorophenyl)-3-ethoxycarbonyl-4-*H*-naphtho[2,1-b]pyran (3h). Yield 80%, mp 178–180 °C; ^{1}H NMR ($CDCl_3$; 300 MHz) δ: 1.03 (t, $J = 7.2$ Hz, 3H), 1.14 (t, $J = 7.2$ Hz, 3H), 1.29 (t, $J = 7.2$ Hz, 3H), 2.22 (q, $J = 7.2$ Hz, 2H), 4.06 (q, $J = 7.2$ Hz, 2H), 4.23 (q, $J = 7.2$ Hz, 2H), 6.07 (s, 1H), 6.85–7.59 (m, 10H, Ar-H); ^{13}C NMR ($CDCl_3$; 75 MHz) δ: 10.75, 14.44, 14.64, 25.56, 36.63, 60.32, 63.47, 93.51, 117.52, 118.45, 124.27, 124.36, 125.16, 127.38, 127.57, 127.72, 128.03, 128.82, 129.37, 131.53, 131.67, 132.46, 144.04, 148.61, 159.52, 166.79, 169.80; IR (KBr) ν_{CO}: 1680 cm^{-1}.

3-Ethoxycarbonyl-4-phenyl-2-formylamino-4*H*-naphtho[2,1-b]pyran (3′a). Yield 31%, mp 203–207 °C; ^{1}H NMR ($CDCl_3$; 500 MHz) δ: 1.38 (t, $J = 7.2$ Hz, 3H), 4.28 (q, $J = 7.2$ Hz, 2H), 5.65 (s, 1H), 7.09–8.00 (m, 11H), 9.25 (d, 1H), 10.80 (d, 1H); ^{13}C NMR ($CDCl_3$; 125 MHz) δ: 14.29, 37.25, 61.02, 87.51, 116.24, 117.98, 123.35, 125.32, 126.75, 127.26, (double intensity): 128.29, (double intensity): 128.39, 128.65, 129.37, 130.71, 131.67, 144.65, 146.37, 152.25, 159.62, 167.76; IR (KBr) ν_{CO}: 1680–1700, ν_{NH}: 3244 cm^{-1}.

4-(o-Chlorophenyl)-3-ethoxycarbonyl-2-formylamino-4*H*-naphtho[2,1-b]-pyran (3′b). Yield 75%, mp 173–176 °C; ^{1}H NMR ($CDCl_3$; 300 MHz) δ: 1.20 (t, $J = 7.0$ Hz, 3H), 4.15 (q, $J = 7.0$ Hz, 2H), 5.95 (s, 1H), 7.09–8.00 (m, 11H, Ar-H), 9.15 (d, 1H), 10.90 (d, 1H); ^{13}C NMR ($CDCl_3$; 75 MHz) δ: 14.81, 34.83, 61.49, 87.24, 116.72, 118.31, 124.19, 125.86, (double intensity): 127.83, 128.52, 129.06, 130.05, 130.28, 131.47, 131.96, 131.99, 132.62, 142.84, 146.81, 153.18, 160.02, 168.41; IR (KBr) ν_{CO}: 1696–1676, ν_{NH}: 3207 cm^{-1}.

General Procedure for 11-Aryl-1,12-dihydro-11*H*-naphthopyrano[2,3-d]pyrimidin-12-ones 4a–j

The appropriate primary amine (0.01 mmol) was added to the suitable imidate **3** (0.01 mmol), and the mixture was stirred at reflux of toluene (10 ml) for 48 h. After cooling, the precipitated solid was filtered, washed with cold ether, and dried to obtain compounds **4a–j**.

Selected Data

11-(o-Chlorophenyl)-1,12-dihydro-2-methyl-1-phenyl-11*H*-naphthopyrano[2,3-d]pyrimidin-12-one (4a). Yield 67%, mp 314–317 °C; ^{1}H NMR ($CDCl_3$; 300 MHz) δ: 2.21 (s, 3H), 6.24 (s, 1H), 6.99–7.80 (m, 15H, Ar-H); ^{13}C NMR ($CDCl_3$; 75 MHz) δ: 23.94, 34.66, 101.67, 117.56, 123.94, 125.07, 127.02, 127.14, 127.31, (double intensity): 127.76, 127.95, 128.54, (double intensity): 128.88, 129.48, 129.65, 130.01, 130.99, 131.48, 131.83, 132.56, 133.20, 137.07, 141.42, 148.18, 158.76, 162.41. Anal. calcd. for $C_{28}H_{19}ClN_2O_2$: C, 74.58; H, 4.25; N, 6.21; Cl, 7.86. Found: C, 74.35; H, 4.21; N, 6.32; Cl, 7.75. IR (KBr) ν_{CO}: 1678 cm^{-1}; MS (APCI+): m/z 451 $(M+H)^+$.

1-Benzyl-11-(o-chlorophenyl)-1,12-dihydro-2-methyl-11*H*-naphthopyrano[2,3-d]pyrimidin-12-one (4b). Yield 30%, mp 230–232 °C; ^{1}H NMR ($CDCl_3$; 500 MHz) δ: 2.47 (s, 3H), 4.90 (d, $J = 7.2$ Hz, 1H), 5.61 (d, $J = 7.2$ Hz, 1H), 6.32 (s, 1H), 7.05–7.83 (m, 15H, Ar-H); ^{13}C NMR ($CDCl_3$; 125 MHz) δ: 22.98, 34.67, 47.14, 101.03, 116.57, 117.50, 123.86, 125.02, (double intensity): 126.45, 127.10, 127.26, 127.75, 127.94, 128.48, (double intensity): 128.93, 129.60, 129.87, 131.38, 131.39, 131.71, 133.05, 135.05, 141.49, 148.05, 159.01, 159.72, 162.35. Anal. calcd. for $C_{29}H_{21}ClN_2O_2$: C, 74.91; H, 4.55; N, 6.03; Cl, 7.63. Found: C, 74.66; H, 4.62; N, 5.80; Cl, 7.74; IR (KBr) ν_{CO}: 1672 cm^{-1}; MS (APCI+): m/z 465 $(M+H)^+$.

1,12-Dihydro-11-(o-methoxyphenyl)-2-methyl-1-phenyl-11*H*-naphthopyrano[2,3-d]pyrimidin-12-one (4c). Yield 77%, mp 290–292 °C; ^{1}H NMR ($CDCl_3$; 500 MHz) δ: 2.20 (s, 3H), 3.82 (s, 3H), 6.15 (s, 1H), 6.77–7.51 (m, 15H, Ar-H); ^{13}C NMR ($CDCl_3$; 125 MHz) δ: 23.91, 32.04, 55.80, 101.32, 111.66, 117.31, 117.33, 120.76, 123.87, 124.63, 126.76, 127.71, 127.76, 127.93, 128.29, 128.77, 129.31, 129.90, 129.92, 131.13, 131.31, 131.52, 132.12, 137.20, 148.19, 156.82, 158.02, 160.46, 162.47. Anal. calcd. for $C_{29}H_{22}N_2O_3$: C, 78.01; H, 4.97; N, 6.27. Found: C, 77.87; H, 5.12; N, 6.21. IR (KBr) ν_{CO}: 1677 cm^{-1}; MS (APCI+): m/z 447 $(M+H)^+$.

1-Benzyl-1,12-dihydro-11-(o-methoxyphenyl)-2-methyl-11*H*-naphthopyrano[2,3-d]pyrimidin-12-one (4d). Yield 41%, mp 238–240 °C; ^{1}H NMR ($CDCl_3$; 500 MHz) δ: 2.42 (s, 3H), 3.85 (s, 3H), 4.80 (d, $J = 7.2$ Hz, 1H), 5.56 (d, $J = 7.2$ Hz, 1H), 6.21 (s, 1H), 6.76–7.72 (m, 15H, Ar-H); ^{13}C NMR ($CDCl_3$; 125 MHz) δ: 23.01, 32.25, 47.13, 55.90, 101.04, 111.71, 117.12, 117.35, 120.75, 123.89, 124.65, (double intensity): 126.52, 126.79, 127.70, (double intensity): 128.04, 128.31, 128.82, 128.91, 131.04, 131.30, 131.56, 132.20, 135.29, 148.15, 156.89, 158.37, 160.10, 162.44. Anal. calcd. for $C_{30}H_{24}N_2O_3$: C, 78.24; H, 5.25; N, 6.08. Found: C, 77.98; H, 5.08; N, 6.01; IR (KBr) ν_{CO}: 1670 cm^{-1}. MS (APCI+): m/z 461 $(M+H)^+$.

1-Cyclohexyl-1,12-dihydro-11-(o-methoxyphenyl)-2-methyl-11*H*-naphthopyrano[2,3-d]pyrimidin-12-one (4e). Yield 30%, mp 184–186 °C; ^{1}H NMR ($CDCl_3$; 300 MHz) δ: 2.20 (s, 3H), 4.18 (s, 3H), 5.72 (s, 1H), 6.47–9.49 (m, 20H, Ar-H); ^{13}C NMR ($CDCl_3$; 75 MHz) δ: 24.92, 25.01, 25.33, 25.72, 25.87, 28.91, 34.20, 48.02, 55.32, 109.47, 116.91, 119.84, 122.32, 123.00, 124.42, 126.65, 127.34, 128.28, (double intensity): 128.39, (double intensity): 130.51, 130.85, 131.31,

134.97, 147.07, 152.05, 158.50, 168.97. Anal. calcd. for $C_{29}H_{28}N_2O_3$: C, 76.97; H, 6.24; N, 6.19. Found: C, 76.99; H, 6.31; N, 6.35; IR (KBr) ν_{CO}: 1651 cm^{-1}.

1-Furan-2-yl-1,12-dihydro-11-phenyl-2-methyl-11*H*-naphthopyrano[2,3-d]pyrimidin-12-one (4f). Yield 25%, mp 257–259 °C; ^1H NMR ($CDCl_3$; 500 MHz) δ: 2.70 (s, 3H), 4.82 (d, $J = 7.2$ Hz, 1H), 5.46 (d, $J = 7.2$ Hz, 1H), 5.90 (s, 1H), 6.31 (dd, 1H), 6.39 (d, $J = 2$ Hz, 1H), 7.10–7.93 (m, 12H, Ar-H); ^{13}C NMR ($CDCl_3$; 75 MHz) δ: 22.99, 36.73, 101.57, 109.83, 110.71, 116.50, 117.41, 123.64, 124.90, 126.65, 127.06, (double intensity): 128.35, 128.43, (double intensity): 128.46, 129.33, 131.03, 131.46, (double intensity): 142.55, 143.75, 148.08, 148.45, 158.17, 159.30, 162.01. Anal. calcd. for $C_{27}H_{20}N_2O_3$: C, 77.13; H, 4.79; N, 6.66. Found: C, 76.89; H, 4.72; N, 6.85. IR (KBr) ν_{CO}: 1667 cm^{-1}; MS (APCI+): m/z 421 $(M + H)^+$.

2-Ethyl-1,12-dihydro-11-(p-methylphenyl)-1-phenyl-11*H*-naphthopyrano[2,3-d]pyrimidin-12-one (4g). Yield 63%, mp 264–266 °C; ^1H NMR ($CDCl_3$; 400 MHz) δ: 1.04 (t, $J = 7.1$ Hz, 3H), 2.10 (s, 3H), 2.22 (q, $J = 7.1$ Hz, 2H), 5.68 (s, 1H), 6.93–7.95 (m, 15H, Ar-H); ^{13}C NMR ($CDCl_3$; 100 MHz) δ: 10.16, 20.53, 28.42, 35.63, 100.72, 116.56, 117.42, 123.45, 125.02, 125.34, 127.26, 128.11, 128.24, 128.35, 128.60, 128.91, 128.92, 129.15, 129.53, 129.54, 129.60, 130.44, 131.11, 135.68, 136.76, 141.15, 147.82, 159.45, 161.89, 162.02; IR (KBr) ν_{CO}: 1671 cm^{-1}; MS (APCI+): m/z 445 $(M + H)^+$.

1-Benzyl-2-ethyl-11-(p-methylphenyl)-1,12-dihydro-11*H*-naphthopyrano[2,3-d]pyrimidin-12-one (4h). Yield 45%, mp 204–206 °C; ^1H NMR ($CDCl_3$; 300 MHz) δ: 1.27 (t, $J = 7.2$ Hz, 3H), 2.22 (s, 3H), 2.71 (q, $J = 7.2$ Hz, 2H), 4.92 (d, 1H), 5.60 (d, 1H), 5.94 (s, 1H), 7.01–7.98 (m, 15H, Ar-H); ^{13}C NMR ($CDCl_3$; 75 MHz) δ: 11.16, 21.45, 28.45, 36.88, 46.92, 102.01, 117.22, 117.95, 124.18, 125.34, (double intensity): 126.84, 127.50, 128.14, 128.81, (double intensity): 128.87, 129.37, 129.50; 129.67, 131.60, 131.95, 135.93, 136.63, 141.48, 148.68, 160.03, 162.43, 163.17. Anal. calcd. for $C_{31}H_{26}N_2O_2$: C, 81.20; H, 5.72; N, 6.11. Found: C, 81.08; H, 5.77; N, 6.05. IR (KBr) ν_{CO}: 1664 cm^{-1}; MS (APCI+): m/z 459 $(M + H)^+$.

2-Ethyl-1,12-dihydro-11-(o-methoxyphenyl)-1-phenyl-11*H*-naphthopyrano[2,3-d]pyrimidin-12-one (4i). Yield 72%, mp 281–283 °C; ^1H NMR ($CDCl_3$; 300 MHz) δ: 1.30 (t, $J = 7.2$ Hz, 3H), 2.41 (q, $J = 7.2$ Hz, 2H), 3.84 (s, 3H), 6.18 (s, 1H), 6.79–7.50 (m, 15H, Ar-H); ^{13}C NMR ($CDCl_3$; 75 MHz) δ: 11.37, 29.20, 32.42, 56.29, 101.65, 112.13, 117.86, 121.21, 124.34, 125.06, 125.73, 127.18, 128.34, 128.48, 128.66, 129.18, 129.47, 129.69, 130.24, 130.29, 131.60, 131.74, 131.98, 132.71, 137.24, 148.74, 157.26, 161.19, 162.25, 163.07. Anal. calcd. for $C_{30}H_{24}N_2O_3$: C, 78.24; H, 5.25; N, 6.08. Found: C, 77.94; H, 5.46; N, 5.83. IR (KBr) ν_{CO}: 1678 cm^{-1}; MS (APCI+) m/z 461 $(M + H)^+$.

1-Benzyl-2-ethyl-1,12-dihydro-11-(o-methoxyphenyl)-11*H*-naphthopyrano[2,3-d]pyrimidin-12-one (4j). Yield 43%, mp 234–236 °C; ^1H NMR ($CDCl_3$; 300 MHz) δ: 1.30 (t, $J = 7.2$ Hz, 3H), 2.69 (q, $J = 7.2$ Hz, 2H), 3.90 (s, 3H), 4.90 (d, 1H), 5.64 (d, 1H), 6.24 (s, 1H), 6.83–8.30 (m, 15H, Ar-H); ^{13}C NMR ($CDCl_3$; 75 MHz) δ: 11.16, 28.40, 32.53, 46.67, 56.39, 101.37, 112.16, 117.69, 117.87,

121.20, 124.35, 125.07, (double intensity): 126.78, 127.20, 128.02, 128.42, 128.73, 129.20, (double intensity): 129.30, 131.49, 131.72, 132.01, 132.82, 136.06, 148.68, 157.29, 160.74, 162.35, 163.00. Anal. calcd. for $C_{31}H_{26}N_2O_3$: C, 78.46; H, 5.52; N, 5.90. Found: C, 78.62; H, 5.54; N, 5.71. IR (KBr) ν_{CO}: 1668 cm^{-1}; MS (APCI+): m/z 475 $(M+H)^+$.

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