

Article

Scope and Limitations of a Novel Synthesis of 3-Arylazonicoticates

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Abstract: The reaction of 3-oxo-3-phenyl-2-phenylhydrazonal with functionally substituted and heteroaromatic substituted acetonitrile to yield arylazonicotinic acid derivatives and 5-arylsubstituted pyridines was established. In some cases the produced nicoticates could not be isolated as they underwent thermally induced 6π -electrocyclization yielding polynuclear pyridine derivatives.

Keywords: 3-oxo-3-phenyl-2-phenylhydrazonal; arylazonicotinic acid; pyridine; electrocyclization; heteroaromatics

1. Introduction

3-oxo-3-Substituted-2-arylhyaazonals **1** are versatile, readily obtainable reagents [1] that have been extensively utilized in the synthesis of polyfunctional substituted aromatics and heteroaromatics [2,3]. In the past we have reported novel synthesis of polyfunctional pyridazines **4** via heating **1** with dimethyl acetylenedicarboxylate (**2**) as well as acrylonitrile (**3**) in presence of triphenylphosphine or a tertiary amine base [4,5] (Scheme 1). We have also reported that condensing active methylene nitriles **5** with **1** affords products that were believed to be the pyridazine imines **6** [6]. Recently however Al-Mousawi *et al.* [7,8] realized that this structure cannot be correct as reported ¹³C-NMR data for the

product lacked a carbonyl carbon at $\delta < 175$ ppm. It was revealed that the products of condensing **1** with ethyl cyanoacetate are really the arylazonicotinates **7** (cf. Scheme 1), as clearly revealed by the X-ray crystal structure (Figure 1).

Scheme 1. Chemical reactivities of 3-oxo-3-substituted-2-arylhydrazonals **1**.

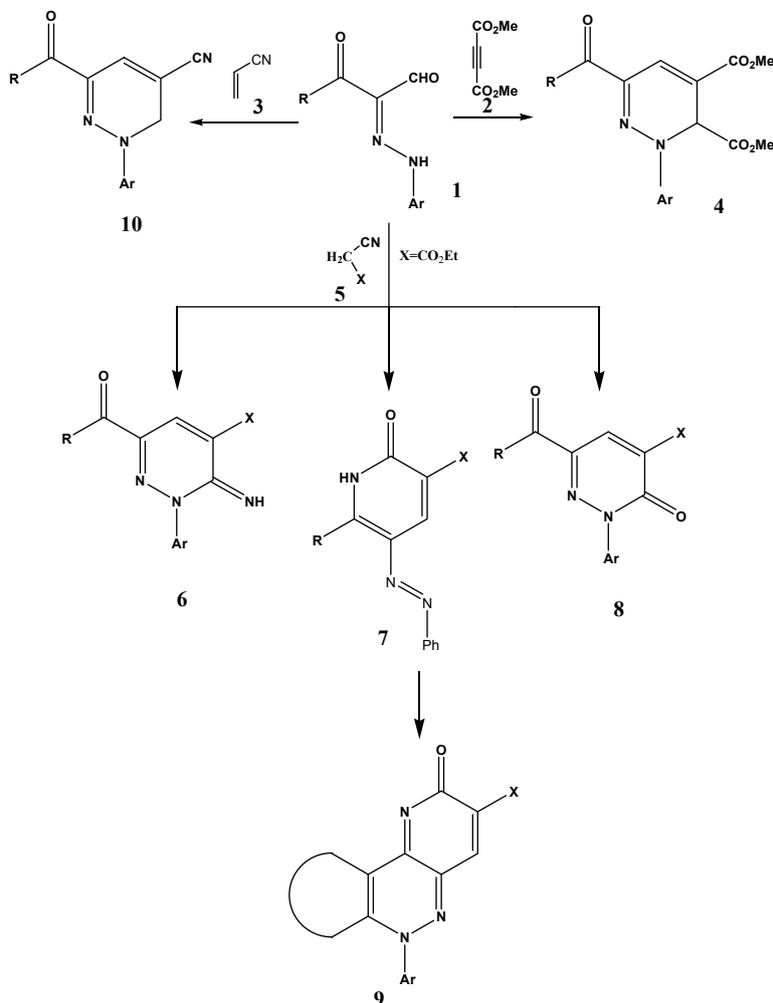
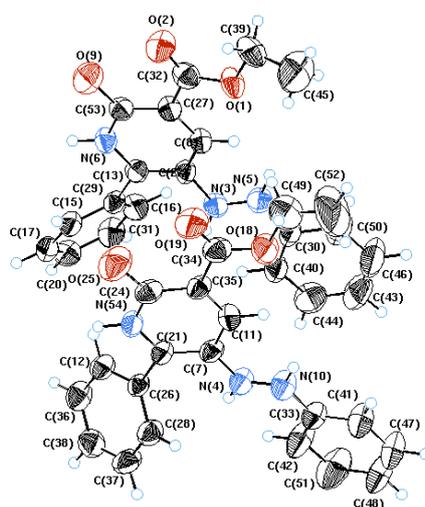


Figure 1. X-ray structure of compound **7**.

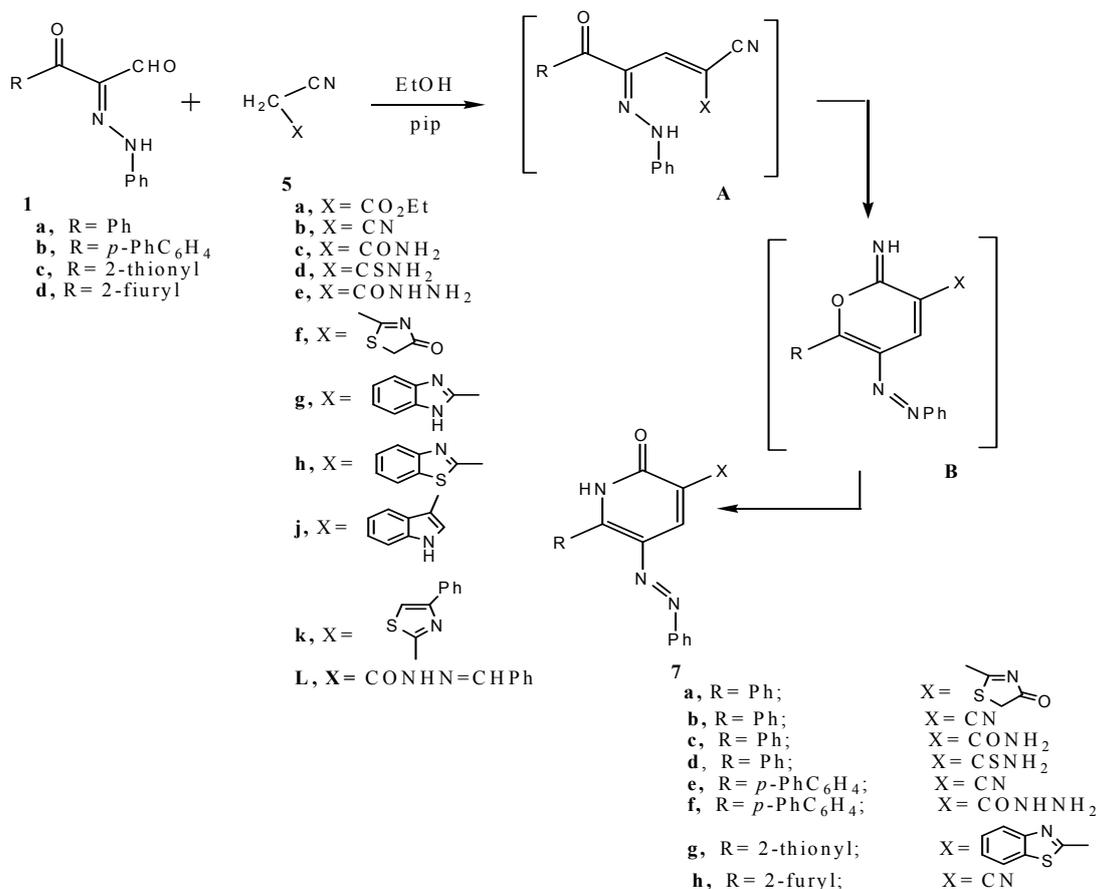


However, in some case pyridazinones **8** were the reaction products rather than nicotinates. In light of the enormous potential of arylazonicotinates both as new pyridone dyes [9] and as biologically active compounds with anticonvulsant activity that act due to synaptic and non-synaptic mechanisms and some studies that have proved their antitumor and antimicrobial activities [10], we were interested in defining further the behavior of **1** toward **5** to see if the reaction would afford **7** or **8**. In the present article we report on the reactivity of **1a–d** toward a variety of derivatives of **5** where we noted that this reaction may produce derivatives of **7** or **8** depending on the nature of **5**. Distinguishing between **7** and **8** could be easily accomplished based on ^{13}C -NMR data as the absence of a carbonyl carbon signal would mean that the product is not an arylpyridazine derivative. Also with some derivatives of **7** electrocyclization and loss of hydrogen leading to novel 6-aryl-6H-pyrido[3,2-c]cinnolin-2-ones **9** seems probable.

2. Results and Discussion

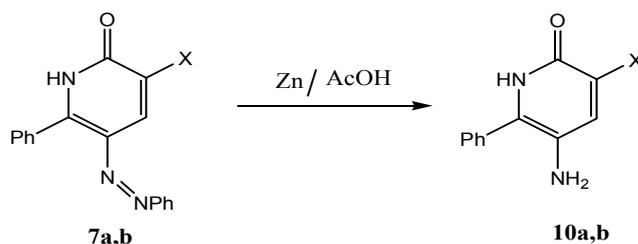
Compounds **1a–d** reacted with malononitrile **5b** yielding the arylazonicotinonitriles **7b,h**, respectively as indicated by the absence of carbonyl carbon absorptions in the ^{13}C -NMR of the products. Similar to their behavior toward malononitrile compounds, **1a–d** condensed with **5a,c–k** to yield phenylazonicotinates **7a,c–g** (Scheme 2).

Scheme 2. Syntheses of phenylazonicotinates **7a,c–g**.



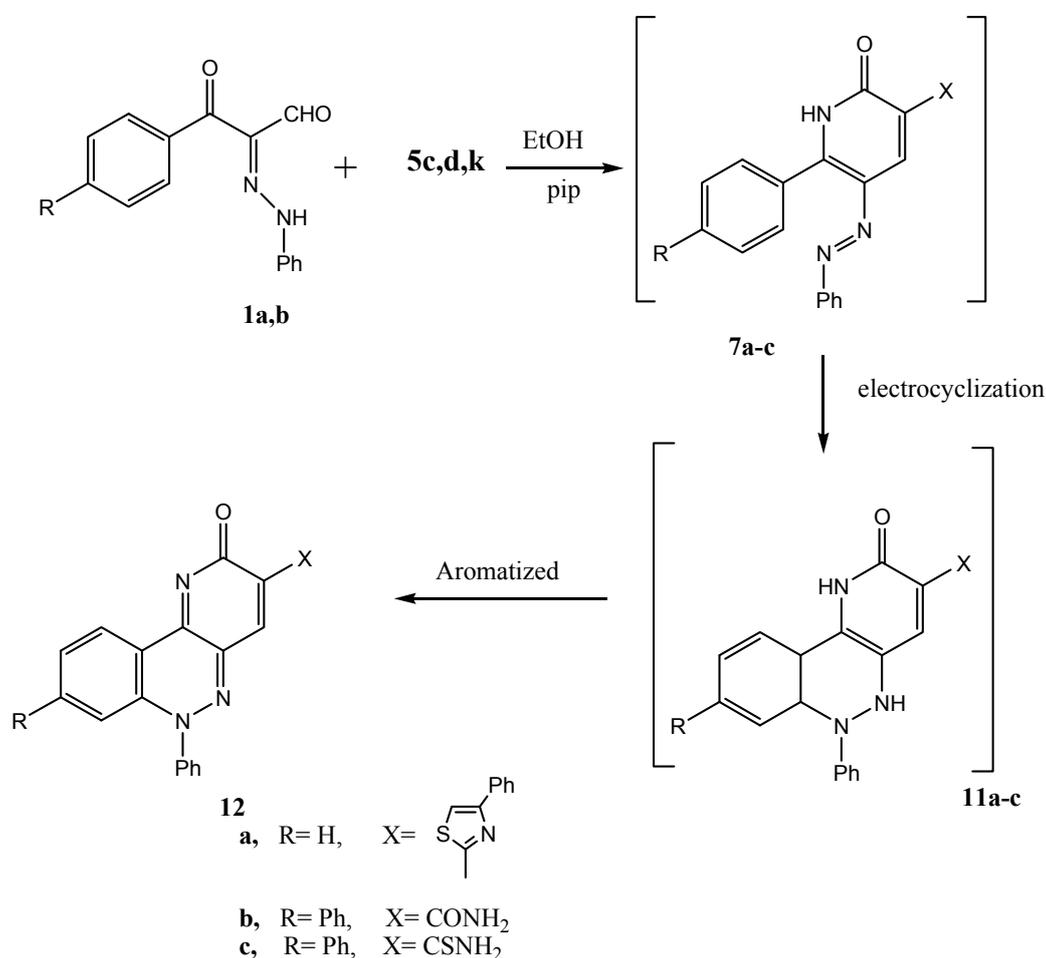
Phenylazonicotinates **7a,b** were converted to aminopyridinones **10a,b** by reduction using Zn/AcOH (Scheme 3).

Scheme 3. Syntheses of aminopyridinones 10a,b.

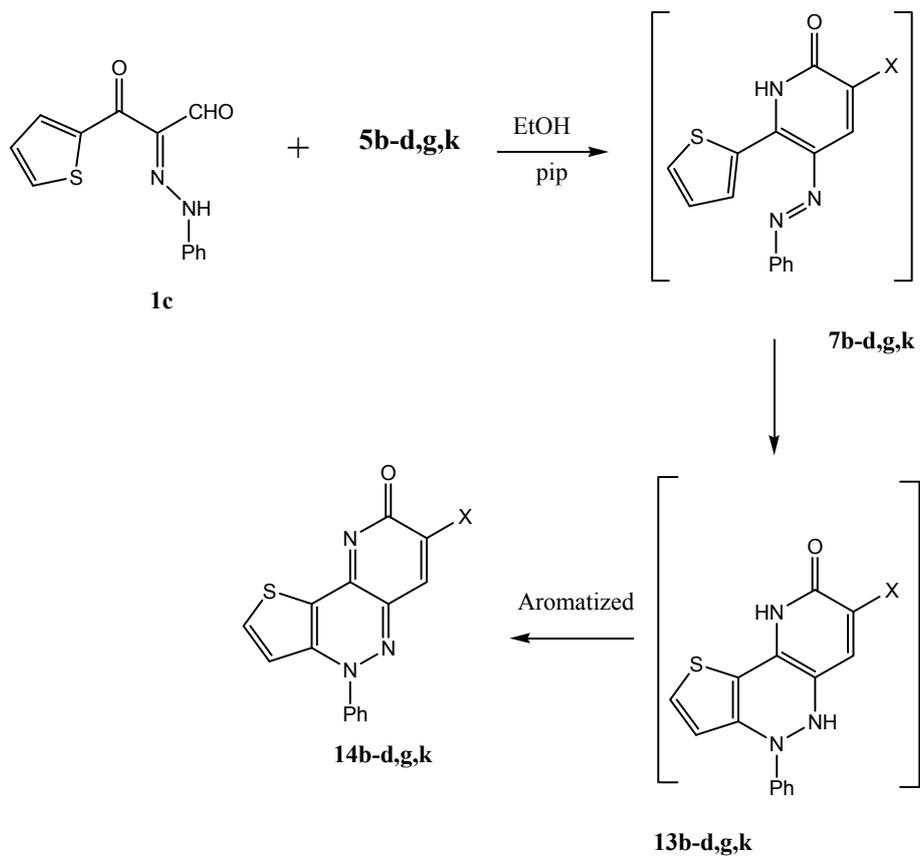


The reaction of **1a,b** with **5c,d,k** in ethanolic piperidine solution resulted in the formation of **12a–c**. It is believed that the initially formed derivative of **7** readily underwent a 6π electrocyclization yielding **11a–c** that then aromatized to the final products **12a–c** (Scheme 4).

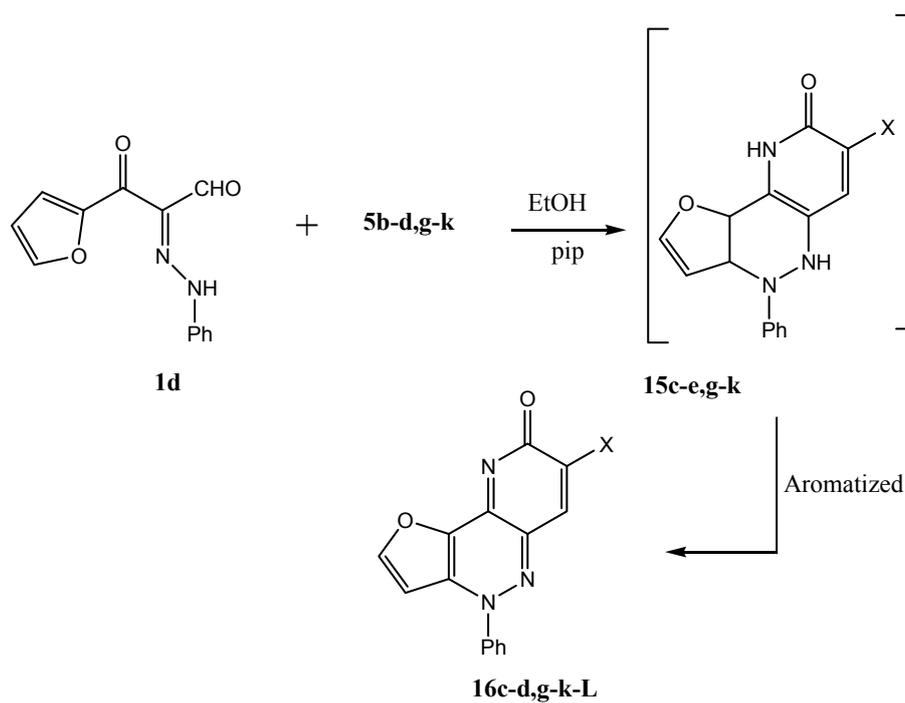
Scheme 4. Syntheses of compounds 12a–c.



We believe that the decreased aromaticity of the thiophene ring as compared to benzene is behind this ready electrocyclization, and in support of this conclusion we have found that **1c** also afforded **14b–d,g,k** upon reaction with **5b–d,g,k**; again the initially formed derivative of **7** underwent electro-cyclization to **13** and then aromatized to yield **14b–d,g,k** (Scheme 5).

Scheme 5. Syntheses of compounds **14b–d,g,k**.

Similar to this behavior compound **1d** reacted with **5c–e,g–k** to afford compounds **16c–e,g–k** under the same reaction conditions (Scheme 6).

Scheme 6. Syntheses of compounds **16c–e,g–k**.

In summary, we could clearly demonstrate that the structures of the products obtained by reacting **1a–d** with active methylenes can be readily concluded via inspection of position of the carbonyl carbon signals in the corresponding ^{13}C -NMR spectra. When a arylhydrazone moiety in the intermediates cyclises via addition to a CN function subsequent hydrolysis of the formed imine usually occurred leading to pyridazinones.

3. Experimental Section

3.1. General

Melting points are reported uncorrected and were determined with a Sanyo (Gallaenkamp) instrument. Infrared spectra were recorded using KBr pellets and a Perkin-Elmer 2000 FT-IR instrument. ^1H - and ^{13}C -NMR spectra were determined using a Bruker DPX instrument at 400 MHz for ^1H -NMR and 100 MHz for ^{13}C -NMR and DMSO- d_6 solutions with TMS as internal standard. Chemical shifts are reported in δ (ppm). Mass spectra were measured using a VG Autospec Q MS 30 and MS 9 (AEI) spectrometers, using the EI (70 EV) mode. Elemental analyses were carried out using a LEO CHNS-932 Elemental Analyzer

3.2. General Procedure for the Synthesis of Compounds **7a,c–g**

A mixture of **1a–d** (0.01 mmol), and active methylenenitrile derivatives **5a–l** (0.01 mmol) in the presence of piperidine (5 drops) and ethanol (10 mL) as a solvent was refluxed for 1–2 h. The reaction mixture was evaporated. The solid product, so formed, was crystallized from a suitable solvent.

3-(4-Oxo-4,5-dihydrothiazol-2-yl)-6-phenyl-5-phenylazo-1H-pyridin-2-one (7a). Red crystals from ethanol, yield 95%; m.p. up 300 °C; Anal. Calcd. for $\text{C}_{20}\text{H}_{14}\text{N}_4\text{O}_2\text{S}$ (374) calcd: C, 64.16; H, 3.77; N, 14.96. Found: C, 64.00; H, 3.54; N, 14.83; IR (KBr) ν_{max} : 1,629 (CN), 1,670 (CO); ^1H -NMR (DMSO- d_6): δ = 1.3 (s, 2H, CH_2); 7.0–8.1 (m, 10H, Ph-H); 10.0 (br, 1H, NH, D_2O exchangeable); ^{13}C -NMR (DMSO- d_6): δ = 163.7, 162.9, 143.0, 137.0, 134.9, 129.0, 128.4, 127.7, 126.2, 124, 100.0, 39.0; MS: m/z (%) 373 (M^+ , 10), 299 (85), 224 (5), 140 (20).

2-Oxo-6-phenyl-5-phenylazo-1,2-dihydropyridine-3-carbonitrile (7b). Dark yellow crystals from ethanol, yield 95%; m.p. 153 °C; Anal. Calcd. for $\text{C}_{18}\text{H}_{12}\text{N}_4\text{O}$ (300): C, 71.99; H, 4.03; N, 18.66. Found: C, 71.80; H, 3.99; N, 18.53; IR (KBr): ν_{max} : 3,264 (NH), 1,660 (CO); ^{13}C -NMR (DMSO- d_6): δ = 162.9, 156.9, 137, 134.9, 129.0, 128.4, 127.7, 126.2, 117.2, 106.7, 100.0; MS: m/z (%) 301 (M^+ , 50), 275 (20), 194 (15).

2-Oxo-6-phenyl-5-phenylazo-1,2-dihydropyridine-3-carboxylic acid amide (7d). Orange crystals from ethanol, yield 98%, m.p. 190 °C; Anal. Calcd. for $\text{C}_{18}\text{H}_{14}\text{N}_4\text{OS}$ (334): C, 64.65; H, 4.22; N, 16.75. Found: C, 64.59; H, 4.21; N, 16.62; IR (KBr): ν_{max} : 3,399–3,266 (NH_2), 1,614(CN), 1,680 (CO); ^1H -NMR (DMSO- d_6): δ = 7.4–7.9 (m, 10H, Ph-H); 10.6 (br, 2H, NH_2 , D_2O exchangeable); ^{13}C -NMR (DMSO- d_6): δ = 164.7, 135.7, 133.0, 130.3, 128.1, 126.4; MS: m/z (%) 334 (M^+ , 100), 105 (30), 77 (25).

6-Biphenyl-4-yl-2-oxo-5-phenylazo-1,2-dihydropyridine-3-carbonitrile (7e). Green crystals from AcOH, yield 95%; m.p. 145 °C; Anal. Calcd. for C₂₄H₁₆N₄O (376.13): C, 76.58; H, 4.28; N, 14.88. Found: C, 76.57; H, 4.21; N, 14.62; IR (KBr) ν_{\max} : 3,343 (NH), 2,202 (CN), 1,655 (CO); ¹³C-NMR (DMSO-*d*₆): δ = 162.0, 156.9, 137.0, 136.6, 135.8, 132.8, 129.0, 127.4, 126.7, 117.2, 106.7, 100.0; MS: *m/z* (%) 377 (M⁺, 90), 244 (20), 152 (50), 77 (30).

6-Biphenyl-4-yl-2-oxo-5-phenylazo-1,2-dihydropyridine-3-carboxylic acid hydrazide (7f). Buff crystals from ethanol, yield 95%; m.p. 237 °C; Anal. Calcd. For C₂₄H₁₉N₅O₂ (409): C, 70.40; H, 4.68; N, 17.10. found: C, 70.39; H, 4.61; N, 17.02; IR (KBr): ν_{\max} : 3,412–3,331 (NH₂), 1,660 (CO); ¹³C-NMR (DMSO-*d*₆): δ = 165.9, 162.9, 148.5, 137.0, 136.6, 135.8, 133.8, 131.3, 129.0, 127.4, 126.7, 100.0; MS: *m/z* (%) 409 (M⁺, 50) 324 (80), 181 (75), 77 (70).

3-Benzothiazol-2-yl-5-phenylazo-6-thiophen-2-yl-1H-pyridin-2-one (7g). Yellow crystals from ethanol/AcOH, yield 98%; m.p. 242 °C; Anal. Calcd. for C₂₂H₁₄N₄OS₂ (414): C, 63.75; H, 3.40; N, 13.52. Found: C, 63.71; H, 3.31; N, 13.42; IR (KBr): ν_{\max} : 3,264 (NH), 1,680 (CO); ¹H-NMR (DMSO-*d*₆): δ = 7.2–7.3 (t, 3H, thiol-H); 7.6–8.2 (m, 9H, Ph-H); 8.6 (br, 1H, NH, D₂O exchangeable); 9.0 (s, 1H, nicotine-H); ¹³C-NMR (DMSO-*d*₆): δ = 162.9, 156.0, 153.0, 137.7, 136.6, 133.0, 130.0, 129.0, 127.8, 126.4, 125.0, 124.0, 123.0, 122.0, 106; MS: *m/z* (%) 413(M⁺, 100), 304 (25), 111 (40), 77 (10).

6-Furan-2-yl-2-oxo-5-phenylazo-1,2-dihydropyridine-3-carbonitrile (7h). Green crystals from ethanol, yield 95%; m.p. 214 °C; Anal. Calcd. for C₁₆H₁₀N₄O₂ (290): C, 66.20; H, 3.47; N, 19.30. Found: C, 66.19; H, 3.31; N, 19.30; IR(KBr): ν_{\max} : 3,322 (NH), 1,631 (CO); ¹H-NMR (DMSO-*d*₆): δ = 6.7–7.4 (m, 3H, furan-H); 7.6 (m, 2H, Ph-H); 8.1 (m, 2H, Ph-H); 8.1 (m, 1H, Ph-H); ¹³C-NMR (DMSO-*d*₆): δ = 149.1, 148.7, 133.3, 130.4, 129.9, 126.1, 123.3, 112.8, 79.1; MS: *m/z* (%) 289 (M⁺, 100), 197 (5), 130 (5), 77 (50).

Synthesis of 5-Amino-3-(4-oxo-thiazolidin-2-yl)-6-phenyl-1H-pyridin-2-one (10a). A mixture of **7a** (3.6 g, 0.1 mol) and Zn powder (2 gm) in acetic acid (20 mL) was refluxed for 2 h. then filtered while hot. The reaction mixture was cooled to room temperature and then poured onto ice-water. The solid thus formed was collected by filtration and crystallized from AcOH to give black crystals, yield 70%; m.p. up 300 °C; Anal. Calcd. for C₁₄H₁₃N₃O₂S (287): C, 58.52; H, 4.56; N, 14.62. Found: C, 58.50; H, 4.54; N, 14.53; IR (KBr): ν_{\max} : 3,432, 3,213 (NH₂), 1,658 (CO); ¹³C-NMR (DMSO-*d*₆): δ = 164.0, 162.9, 134.9, 128.4, 127.7, 126.2, 121.0, 108.0, 51.4, 39.0; MS: *m/z* (%) 287 (M⁺, 50), 207 (10), 93 (65), 55 (40).

Synthesis of 5-Amino-2-oxo-6-phenyl-1,2-dihydropyridine-3-carbonitrile (10b). A mixture of **7b** (0.1 mol) and Zn powder (2 gm) in acetic acid (20 mL) was refluxed for 2 h. then filtered while hot. The reaction mixture was cooled to room temperature and then poured onto ice-water. The solid thus formed was collected by filtration and crystallized from AcOH to give pale brown crystals, yield 70%; m.p. 190 °C; Anal. Calcd. for C₁₂H₉N₃O (211): C, 68.24; H, 4.29; N, 19.89. Found: C, 68.20; H, 4.19; N, 19.83; IR (KBr): ν_{\max} : 3,432, 3,312, (NH₂), 1,640 (CO); ¹³C-NMR (DMSO-*d*₆): δ = 162.0,

156.9, 134.9, 128.4, 127.7, 126.0, 121.1, 117.2, 108.0, 106.7; MS: m/z (%) 211 (M^+ , 10), 129 (25), 77 (80).

6-Phenyl-3-(4-phenylthiazol-2-yl)-6H-pyrido[3,2-c]cinnolin-2-one (12a). Deep red crystals from ethanol, Yield 98%; m.p. 150 °C; Anal. Calcd. for $C_{26}H_{16}N_4OS$ (432): C, 72.20; H, 3.73; N, 12.95. Found: C, 72.19; H, 3.61; N, 12.92; IR (KBr): ν_{max} : 1,614 (CN), 1,680 (CO); 1H -NMR (DMSO- d_6): δ = 7.2 (s, 1H, thiazole-H); 7.3–8.1 (m, 14H, Ph-H); 8.3 (s, 1H, nicotine-H); ^{13}C -NMR (DMSO- d_6): δ = 157.2, 154.9, 149.2, 141.1, 140.6, 136.1, 134.3, 133.3, 133.2, 131.1, 130.8, 130.7, 130.1, 129.3, 128.8, 128.5, 127.0, 126.6, 121.3, 120.9; MS: m/z (%) 433 (M^+ , 100), 329 (10), 105 (20), 77 (15).

2-Oxo-6,8-diphenyl-2,6-dihydropyrido[3,2-c]cinnoline-3-carboxylic acid amide (12b). Red crystals from ethanol, yield 90%; m.p. 230 °C; Anal. Calcd. for $C_{24}H_{16}N_4O_2$ (392): C, 73.46; H, 4.11; N, 14.28. Found: C, 73.35; H, 4.00; N, 14.11; IR (KBr): ν_{max} : 3,267, 3,189 (NH_2); ^{13}C -NMR (DMSO- d_6): δ = 165.0, 150.0, 148.9, 144.2, 139.8, 136.6, 130.0, 129.4, 127.4, 119.5, 118.0, 117.0; MS: m/z (%) 393 (M^+ , 100), 181 (75), 77 (50).

2-Oxo-6,8-diphenyl-2,6-dihydropyrido[3,2-c]cinnoline-3-carbothioic acid amide (12c). Orange crystals from AcOH, yield 95%; m.p. 170 °C; Anal. Calcd. for $C_{24}H_{16}N_4OS$ (408): C, 70.57; H, 3.95; N, 13.72. Found: C, 70.49; H, 3.71; N, 13.52; IR (KBr): ν_{max} 3,399, 3,298 (NH_2), 1670 (CO); ^{13}C -NMR (DMSO- d_6): δ = 164.0, 155.0, 144.0, 143.2, 141.0, 139.8, 136.6, 130.6, 129.0, 127.0, 119.5, 118.0, 116.9; MS: m/z (%) 407 (M^+ , 25), 391 (50), 151 (40), 51 (50).

8-Oxo-4-phenyl-4,8-dihydro-1-thia-4,5,9-triazacyclopenta[a]naphthalene-7-carbonitrile (14b). Yellow crystals from ethanol, yield 97%; m.p. 210 °C; Anal. Calcd. for $C_{16}H_8N_4OS$ (304): C, 63.15; H, 2.65; N, 18.14. Found: C, 63.05; H, 2.52; N, 18.11. IR (KBr): ν_{max} : 1,640 (CO); 1H -NMR (DMSO- d_6): δ = 7.2–7.5 (m, 2H, thiazole-H); 7.6–7.7 (m, 5H, Ph-H); ^{13}C -NMR (DMSO- d_6): δ = 141.4, 138.7, 138.4, 136.8, 136.9, 135.8, 134.9, 132.7, 131.7, 129.7, 129.0, 128.2, 127.8, 126.1, 117.2, 79.16; MS: m/z (%) 305 (M^+ , 80), 195 (5), 83 (15), 77 (25).

8-Oxo-4-phenyl-4,8-dihydro-1-thia-4,5,9-triazacyclopenta[a]naphthalene-7-carboxylic acid amide (14c). Orange crystals from ethanol, yield 98%; m.p. 270 °C; Anal. Calcd. for $C_{16}H_{10}N_4O_2S$ (322): C, 59.62; H, 3.13; N, 17.83. Found: C, 59.59; H, 3.11; N, 17.80. IR (KBr): ν_{max} : 3,400, 3,312 (NH_2), 1,615 (CN), 1,680 (CO); 1H -NMR (DMSO- d_6): δ = 7.2–7.2 (t, 2H, thiol-H); 7.6–8.0 (m, 5H, Ph-H); 8.1 (s, 1H, nicotine-H); ^{13}C -NMR (DMSO- d_6): δ = 147.5, 139.3, 139.0, 138.1, 137.2, 136.2, 133.3, 133.0, 130.3, 129.9, 128.8, 128.2, 126.1, 115.0, 114.2; MS: m/z (%) 323 (M^+ , 100), 306 (15), 111 (90), 77 (30).

8-Oxo-4-phenyl-4,8-dihydro-1-thia-4,5,9-triazacyclopenta[a]naphthalene-7-carbothioic acid amide (14d). Brown crystal from ethanol/AcOH, yield 90%; m.p. 195 °C; Anal. Calcd. for $C_{16}H_{10}N_4OS_2$ (338): C, 56.79; H, 2.98; N, 16.56. Found: C, 56.65; H, 2.82; N, 16.41; IR (KBr): ν_{max} : 1,640 (CO), 1,620 (CN); ^{13}C -NMR (DMSO- d_6): δ = 164.15, 146.7, 144.0, 141.0, 129.3, 127.0, 126.0, 118.5, 115.1; MS: m/z (%) 339 (M^+ , 25), 111 (75), 77 (50).

7-(1H-Benzoimidazol-2-yl)-4-phenyl-4H-1-thia-4,5,9-triazacyclopenta[a]naphthalen-8-one (14g). Yellow crystals from ethanol, yield 95%; m.p. 230 °C; Anal. Calcd. for $C_{22}H_{13}N_5OS$ (395): C, 66.82; H, 3.31;

N, 17.71. Found: C, 66.70; H, 3.21; N, 17.68; IR (KBr): ν_{\max} : 1,670 (CO), 1,620 (CN); $^1\text{H-NMR}$ (DMSO- d_6): δ = 7.2–7.2 (t, 1H, NH, D₂O exchangeable); 7.2–7.3 (m, 2H, thiol-H); 7.5–8.1 (m, 9H, Ph-H); 8.4 (s, 1H, nicotine-H); $^{13}\text{C-NMR}$ (DMSO- d_6): δ = 151.9, 147.0, 138.5, 136.9, 136.0, 129.1, 128.9, 128.4, 128.1, 126.5, 123.3, 121.0; MS: m/z (%) 396 (M⁺, 100), 286 (25), 195 (15), 111 (90), 77 (30).

4-Phenyl-7-(4-phenylthiazol-2-yl)-4H-1-thia-4,5,9-triazacyclopenta[a]naphthalen-8-one (14K). Yellow crystals from ethanol, yield 95%; m.p. 200 °C; Anal. Calcd. for C₂₄H₁₄N₄OS₂ (438): C, 65.73; H, 3.22; N, 12.78. Found: C, 65.70; H, 3.11; N, 12.68; IR (KBr): ν_{\max} : 1,680 (CO), 1,620 (CN); $^1\text{H-NMR}$ (DMSO- d_6): δ = 7.2–7.4 (t, 2H, thiol-H); 7.4–8.1 (m, 10H, Ph-H); 8.41 (s, 1H, thiazole-H); 8.6 (s, 1H, nicotine-H); $^{13}\text{C-NMR}$ (DMSO- d_6): δ = 154.4, 140.2, 138.5, 137.0, 136.2, 133.8, 130.7, 130.3, 129.7, 128.9, 128.3, 128.1, 126.6, 126.1, 121.0, 119.52; MS: m/z (%) 439 (M⁺, 100), 368 (5), 236 (10), 111 (20).

8-Oxo-4-phenyl-4,8-dihydro-1-oxa-4,5,9-triazacyclopenta[a]naphthalene-7-carboxylic acid amide (16c). Yellow crystals from ethanol, yield 95%; m.p. 288 °C; Anal. Calcd. for C₁₆H₁₀N₄O₃ (306): C, 62.74; H, 3.29; N, 18.29. Found: C, 56.40; H, 3.44; N, 16.32; IR (KBr): ν_{\max} : 1,685 (CO), 1,620 (CN); $^1\text{H-NMR}$ (DMSO- d_6): δ = 6.7–6.7 (m, 2H, furan-H); 7.0 (s, 1H, nicotine-H); 7.5–8.4 (m, 5H, Ph-H), 8.7 (br, 2H, NH₂, D₂O exchangeable); $^{13}\text{C-NMR}$ (DMSO- d_6): δ = 162.6, 149.0, 148.9, 139.9, 130.4, 129.8, 127.2, 126.5, 123.1, 112.7; MS: m/z (%) 307 (M⁺, 100), 290 (15), 95 (50), 77 (25).

8-Oxo-4-phenyl-4,8-dihydro-1-oxa-4,5,9-triaza-cyclopenta[a]naphthalene-7-carbothioic acid amide (16d). Deep brown crystal from ethanol, yield 95%; m.p. 220 °C; Anal. Calcd. for C₁₆H₁₀N₄O₂S (322): C, 59.62; H, 3.13; N, 17.38. Found: C, 59.40; H, 3.0; N, 17.3. IR (KBr): ν_{\max} : 1,638 (CO), 1,620 (CN); $^{13}\text{C-NMR}$ (DMSO- d_6): δ = 164.0, 155.0, 146.7, 143.0, 141.0, 129.3, 118.5, 115.1, 110.0; MS: m/z (%) 323 (M⁺, 25), 305 (75), 289 (60), 95 (80), 51 (40).

7-(1H-Benzoimidazol-2-yl)-4-phenyl-4H-1-oxa-4,5,9-triaza-cyclopenta[a]naphthalen-8-one (16g). Yellow crystals from ethanol, Yield 98%; m.p. 278 °C; Anal. Calcd. for C₂₂H₁₃N₅O₂ (379): C, 69.65; H, 3.45; N, 18.46. Found: C, 69.59; H, 3.41; N, 18.42; IR (KBr): ν_{\max} : 1,614 (CN), 1,670 (CO); $^{13}\text{C-NMR}$ (DMSO- d_6): δ = 151.9, 149.1, 148.7, 146.9, 138.8, 129.2, 128.4, 126.5, 123.0, 120.9, 112.7; MS: m/z (%) 380 (M⁺, 100), 286 (15), 195 (25), 95 (50), 77 (20).

7-Benzothiazol-2-yl-4-phenyl-4H-1-oxa-4,5,9-triazacyclopenta[a]naphthalen-8-one (16h). Orange crystals from ethanol, yield 98%; m.p. 258 °C; Anal. Calcd. for C₁₈H₁₄N₄O₃ (396): C, 66.6; H, 3.05; N, 14.13. Found: C, 66.59; H, 3.00; N, 14.12; IR (KBr): ν_{\max} : 1,614 (CN), 1,680 (CO); $^1\text{H-NMR}$ (DMSO- d_6): δ = 6.7 (s, 1H, furan-H); 7.3 (s, 1H, furan-H); 7.4–7.7 (m, 9H, Ph-H); 8.6 (s, 1H, nicotine-H); $^{13}\text{C-NMR}$ (DMSO- d_6): δ = 158.8, 151.4, 151.4, 149.0, 148.9, 148.8, 140.1, 140.0, 137.8, 131.0, 130.4, 129.8, 126.6, 126.6, 125.7, 123.3, 123.1, 122.1, 121.6, 112.8; MS: m/z (%) 397 (M⁺, 100), 303 (5), 212 (10), 95 (40), 77 (10).

4-Phenyl-7-(4-phenylthiazol-2-yl)-4H-1-oxa-4,5,9-triaza-cyclopenta[a]naphthalen-8-one (16k). Yellow crystals from ethanol, yield 98%; m.p. 230 °C; Anal. Calcd. for C₂₄H₁₄N₄O₂S (422): C, 68.23; H, 3.34; N, 13.26. Found: C, 68.19; H, 3.21; N, 13.12; IR (KBr): ν_{\max} : 1,614 (CN), 1,680 (CO); $^{13}\text{C-NMR}$

(DMSO-*d*₆): δ = 164.0, 155.0, 154.0, 146.7, 143.0, 139.0, 136.2, 129.3, 128.0, 127.0, 118.0, 115.1, 114.0, 110.0; MS: *m/z* (%) 423 (*m*⁺, 100), 329 (5), 238 (5), 95 (25), 77 (10).

8-Oxo-4-phenyl-4,8-dihydro-1-oxa-4,5,9-triazacyclopenta[a]naphthalene-7-carboxylic acid benzylidene hydrazide (161). Orange crystals from ethanol, yield 98%; m.p. 266 °C; Anal. Calcd. for C₂₃H₁₅N₅O₃ (409): C, 67.48; H, 3.69; N, 17.11. Found: C, 67.45; H, 3.59; N, 17.00; IR (KBr): ν_{\max} : 1,559 1,614 (CN), 1,680 (CO); ¹H-NMR (DMSO-*d*₆): δ = 6.7 (s, 1H, CH); 7.2 (s, 1H, nicotine-H); 7.4–7.5 (t, 2H, furan-H); 7.7–8.3 (m, 10H, Ph-H); ¹³C-NMR (DMSO-*d*₆): δ = 130.5, 128.8, 127.4, 112.8, 106.4, 55.8, 18.9; MS: *m/z* (%) 410 (*M*⁺, 50), 291 (10), 105 (5), 77 (10).

4. Conclusions

In conclusion it has been found that **5** condenses with **1a** to yield pyridazinones **7** as indicted from the presence of a carbonyl carbon as δ = 165 ppm in the ¹³C-NMR. Initially formed imines **6** in this case are readily hydrolysed under the reaction conditions to yield the final products. In fact this finding supports our belief that heterocyclic imines like **6** are difficult to isolate as they readily afford the more stable aromatic derivative.

Supplementary Materials

Supplementary materials can be accessed at: <http://www.mdpi.com/1420-3049/17/5/5924/s1>.

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References and Notes

1. Elnagdi, M.H.; Elgemele, G.E.H. The chemistry of 3-oxoalkanenitriles. *Synthesis* **1984**, *1*, 1–26.
2. John, C.K.; Cupps, J.C.; Wese, T.L.; Ownsend, L.B.T An efficient one-step synthesis of 3-oxoalkanenitriles. *Synthesis* **1983**, *4*, 308–309.
3. Al-Matar, M.H.; Khalil, K.D.; Adam, A.Y.; Elnagdi, M.H. Studies with 3-oxoalkanenitriles: Novel rearrangements observed while exploring the utility of 2-cyanoacetyl-1-methylpyrrole as a precursor to pyrrole substituted heterocyclic compounds. *Molecules* **2012**, *17*, 897–909.
4. Al-Shiekh, M.A.; Medrassi, H.Y.; Elnagdi, M.H.; Hafez, E.A. Studies with 2-arylhydrazono-3-oxopropanals: Routes for the synthesis of pyridazine-3,4-dicarboxylate and 3,5-diaroylpyrazoles. *ARKIVOC* **2008**, *xvii*, 36–47.
5. Al-Shiekh, M.A.; Salaheldin, A.M.; Hafez, E.A.; Elnagdi, M.H. 2-Arylhazono-3-oxopropanals in heterocyclic synthesis: Synthesis of arylazopyrazole, arylazoisoxazole and dialkylpyridazine-5,6-dicarboxylate derivatives. New one-step synthesis of arylazopyrimidines. *J. Heterocycl. Chem.* **2004**, *41*, 647–654.

6. Al-Omran, F.; Abdelkhalik, M.M.; El-Khair, A.A.; Elnagdi, M.H. Studies with functionally substituted heteroaromatics. A novel route for the synthesis of 1-aryl-6-pyridazinones, 1-arylpyridazin-6-imines, and 1-aryl-6-imino-4-pyridazinals. *Synthesis* **1997**, *1*, 91–94.
7. Al-Mousawi, S.M.; Moustafa, M.S.; Abdelkhalik, M.M.; Elnagdi, M.H. Polyfunctional nitriles in organic syntheses: A novel route to aminopyrroles, pyridazines and pyrazolo[3,4-c]pyridazines. *Molecules* **2009**, *14*, 798–806.
8. Al-Mousawi, S.M.; Moustafa, M.S.; Abdelshafy, I.A.; Elnagdi, M.H. Reassignment of the structures of condensation products of α -keto α' -formylarylhydrazones with ethyl cyanoacetate: A novel route to ethyl 5-aryloxy-2-hydroxynicotinates. *Tetrahedron Lett.* **2011**, *52*, 202–204.
9. Sheikhshoaie, I.; Fabian, W.M.F. Theoretical insights into material properties of Schiff bases and related azo compounds. *Curr. Org. Chem.* **2009**, *13*, 149–171.
10. Edafiogho, I.O.; Phillips, O.A.; Udo, E.E.; Samuel, S.; Rethish, B. Synthesis, antibacterial and anticonvulsant evaluations of some cyclic enaminones. *Eur. J. Med. Chem.* **2009**, *44*, 967–975.

Sample Availability: Samples of the all compounds are available from the authors.

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