Efficient Synthesis of New 4-Arylideneimidazolin-5-ones Related to the GFP Chromophore by 2+3 Cyclocondensation of Arylideneimines with Imidate Ylides

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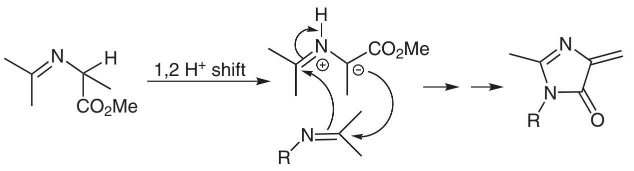
Abstract: A 2+3 condensation of a wide assortment of Schiff bases, prepared from aromatic aldehydes and primary amines, with methyl 2-(1-ethoxyethylideneamino)acetate allows convenient access to an extensive family of substituted 4-arylideneimidazolin-5-one analogues of the green fluorescent protein (GFP) chromophore.

Key words: 4-arylideneimidazolin-5-one, azomethine ylide, Schiff bases, heterocycle, 2+3 cycloaddition

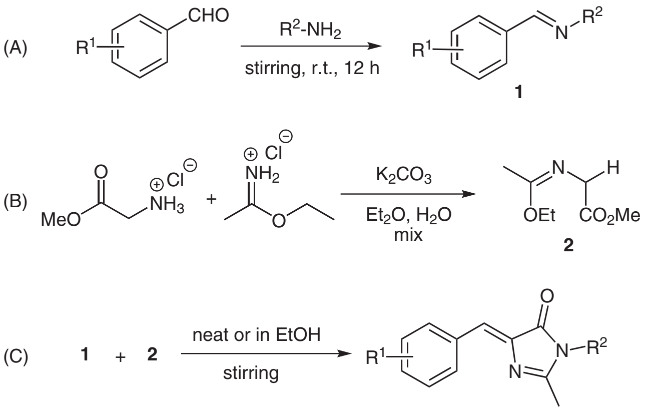
The chromophore of the green fluorescent protein (GFP) has gained significant attention in the literature due to its unusual photophysical and photochemical properties.[1] Denaturation of the protein β-barrel leads to a loss in emission quantum yield, and numerous studies have sought to regain that brightness by incorporation into rings[2,3] or restriction in hydrophobic capsules.[4] In order to study the mechanisms by which these phenomena arise, convenient access to a wide spectrum of substituted arylideneimidazolinones is required. Thus, we sought a high-yielding, functional group-tolerant methodology adaptable to a combinatorial approach.

The Plöchl–Erlenmeyer synthesis,[5] which is an old classic in organic chemistry, provides access to arylideneimidazolinones[6] and continues to dominate the synthesis of GFP chromophores as well as supplement[7] more recent methods. This two-step methodology requires initial preparation of an arylideneoxazolone followed by reaction with amines to yield respective imidazolinones.[8] Alternative methods include the *de novo* formation of the imidazolinone ring[9] or interconversions of imidazolinones.[10] A recent excellent review of the former approach has appeared.[11]

Despite this progress, the need for reliable, quick and convenient access to a variety of substituted imidazolinones with varying substitution patterns remains, since such chromophores are of increasing interest in other disciplines,[12] including biosciences and medicine.[13] Such synthetic methods must provide efficiency, directness and a diversity of functional groups. We have found that the methodology proposed by Bazureau et al.,[9c] which is a very clever adaptation of earlier chemistry developed by Grigg et al.[14] and other authors, is most adaptable for our purposes. In this paper we expand upon that synthesis to provide a general approach to arbitrarily substituted arylideneimidazolin-5-ones.



Scheme 1 Mode of [2+3] cycloaddition via ylide mechanism



Scheme 2 The synthesis of 4-arylideneimidazolin-5-ones by [2+3] cycloaddition

The synthesis begins with iminoesters of α-aminoacid esters, which owe their synthetic versatility to easy equilibration (self-enolization) to a bipolar nitrogen ylide via a facile 1,2-prototropic shift (Scheme 1).The resulting stabilized imine ylide is an adaptable enophile in a [2+3] cycloaddition that can lead to an assortment of heterocycles, including arylideneimidazolinones.[15] The required iminoglycine methyl ester is readily produced from the reaction of ethyl acetimidate hydrochloride with glycine methyl ester hydrochloride (Scheme 2, B). The requisite Schiff base, acting as a dipolarophile, is conveniently synthesized in high yields by a condensation of aromatic aldehydes and primary amines (Scheme 2, A). In the resulting 4-arylideneimidazolin-5-one, the Schiff base provides the aromatic substituent as well as the amide nitrogen of the imidazolinone with its substituent, while the second reagent, (1-ethoxyethylideneamino) acetate, which is common for all reactions, contributes all other

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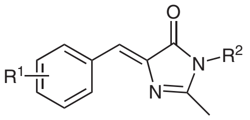
atoms in the imidazolinone ring (Scheme 2). Since both aromatic aldehydes and aliphatic amines are commercially available, the synthetic method provides convenient access to extensive structural variety using an assortment of amines and aldehydes, all of which are readily tolerated.

Syntheses of the various Schiff bases were carried out according to the literature by combining the given aromatic aldehyde (1 mmol) with the corresponding amine (1.1 mmol). In cases where either the aldehyde or the amine was solid, ethanol (~3 mL) was used to solubilize the reagents. The reaction was allowed to stir under ambient conditions for 12 hours. In cases where a precipitate was noted, the product was isolated by filtration and washed with cold ethanol (~2 mL) to afford pure product. When both reagents were initially liquids, the solvents and excess amine were removed in vacuo. All Schiff base reactions gave at, or near, quantitative yields[16] (Scheme 2, A).

Synthesis of the imidate was carried out according to the literature.[17] The cycloaddition itself was carried out by mixing the corresponding Schiff base (1 equiv) with the imidate (1.1 equiv). In cases where the Schiff base contained acidic groups, a spontaneous reaction took place with the generation of considerable amounts of heat. The exothermic nature of this reaction was not as sizable when acidic groups were absent. For better heat control, minimal amounts of ethanol were used as solvent. Magnetic stirring overnight under ambient conditions generally resulted in precipitation of a pure reaction product. In cases where no solid was obtained, the reaction product was isolated and purified by column chromatography.

Table 1 Synthesized Compounds Grouped by General Substitution Patterns Discussed in this Paper[a]



	R^1	R^2	Yield (%)[b]		R^1	R^2	Yield (%)[b]		R^1	R^2	Yield (%)[b]
1a	4-Me	Me	81[c]	**7b**	4-N(Me)$_2$	*n*-Pr	48[d]	**13g**	3-Me	Me	70[c]
1b	4-Me	*n*-Pr	84[c]	**7c**	4-N(Me)$_2$	*i*-Pr	46[d]	**13h**	3-Me	*n*-Pr	72[c]
1c	4-Et	*n*-Pr	63[d]	**8a**	1-naphthyl	Me	95[c]	**14a**	4-OH	Me	69[c]
1d	4-Et	Me	55[c]	**8b**	1-naphthyl	Et	90[c]	**14b**	4-OH	*n*-Pr	50[c]
1e	4-*t*-Bu	Me	66[c]	**8c**	2-naphthyl	Me	69[c]	**14c**	4-OH	*n*-Pentyl	44[c]
1f	4-*i*-Pr	*n*-Pr	70[d]	**9a**	2,4-Me	Me	70[c]	**14d**	4-OH	*n*-Bu	46[c]
2a	4-NO$_2$	Me	99[c]	**9b**	2,5-Me	Me	55[c]	**14e**	4-OH	C$_{16}$H$_{33}$	94[c]
2b	3-NO$_2$	Me	75[c]	**9c**	2,6-Me	Me	45[c]	**15a**	4-OBz	Me	64[c]
3a	2,3-OMe	Me	72[c]	**10a**	3-indole	Me	71[c]	**16a**	4-OH	C$_3$H$_6$CO$_2$H	74[c]
3b	2,4,5-OMe	Me	80[c]	**11a**	2-tetralin	Me	42[c]	**17a**	2-quinoline	Me	75[c]
3c	2,5-OMe	Me	96[c]	**12a**	2-F	Me	67[c]	**18a**	4-OH	CH$_2$(CF$_2$)$_6$CF$_3$	30[e]
3d	3-OMe	Me	54[c]	**12b**	3-F	Me	60[d]	**19a**	4-CF$_3$	Me	76[c]
4a	4-CO$_2$H	Me	65[c]	**12c**	4-F	Me	60[c]	**19b**	4-CF$_3$	*n*-Pr	43[d]
5a	4-CN	Me	96[c]	**13a**	2-Me	Me	49[c]	**20a**	3,5-*t*-Bu, 4-OH	Me	46[c]
6a	4-N(Et)$_2$	Me	49[c]	**13b**	2-Et	Me	59[c]	**21a**	H	Me	64[c]
6b	4-N(Et)$_2$	*i*-Pr	62[c]	**13c**	2-Me	*n*-Pr	72[d]	**22a**	3-OH	Me	79[c]
6c	4-N(Et)$_2$	*n*-Pr	72[c]	**13d**	2-Me	Et	57[d]	**22b**	3-OH	C$_{16}$H$_{33}$	96[c]
6d	2-OH, 4-N(Et)$_2$	Me	85[c]	**13e**	2-Et	Et	60[d]	**23a**	4-Cl	Me	71[c]
7a	4-N(Me)$_2$	Me	64[c]	**13f**	2-Et	*n*-Pr	60[d]	**24a**	4-OH	C$_2$NHC(O)-X[f]	70

[a] Full characterization of each compound can be found in Table 2.

[b] Yields indicate pure product following washing/purification.

[c] Precipitation with overnight stirring.

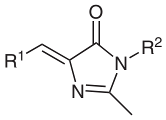
[d] Precipitation at 0 °C.

[e] Column chromatography, silica gel (hexane–EtOAc, 1:1).

[f] X = cholesterol (as substituent).

The yields were good to very good, which made the process amenable to a combinatorial approach. The reaction outcomes and yields are noted in Table 1, and analytical data are collected in Table 2.

Table 2 Characterization of 4-Arylideneimidazolin-5-ones



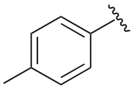
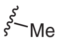
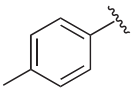
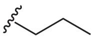
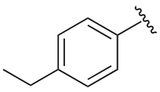
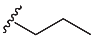
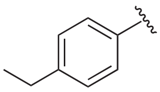
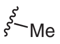
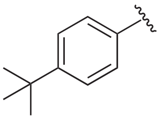
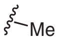
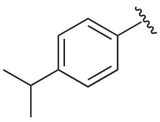
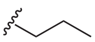
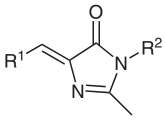
Comp	R^1	R^2	^{1}H NMR (ppm)^{a,b}	^{13}C NMR (ppm)^a	MS [M]$^+$ (%)	Anal.^{c}	Mp (°C)
1a[18]			2.35 (s, 3 H), 2.37 (s, 3 H), 3.16 (s, 3 H), 7.08 (s, 1 H), 7.21 (d, J_{HH} = 8.2 Hz, 2 H), 8.01 (d, J_{HH} = 7.7 Hz, 2 H)	15.87, 21.89, 26.81, 127.77, 129.73, 131.68, 132.38, 138.40, 140.89, 162.17, 171.00	214.1 (45), 55.6 (100)		141–143
1b			0.95 (t, J_{HH} = 7.2 Hz, 3 H), 1.65 (sext, J_{HH} = 7.7 Hz, 2 H), 2.37 (s, 3 H), 3.55 (t, J_{HH} = 7.0 Hz, 2 H), 7.07 (s, 1 H), 7.21 (d, J_{HH} = 7.8 Hz, 2 H), 8.01 (d, J_{HH} = 8.4 Hz, 2 H)	11.15, 15.71, 21.61, 22.57, 42.09, 122.15, 127.31, 129.44, 131.45, 132.04, 137.86, 140.52, 161.90, 170.76	242.1 (100), 225.1 (24), 185.1 (24), 159.1 (21), 130.1 (20), 84.1 (34), 55.0 (17)	Calcd (**1b**·1/4H$_2$O): C, 73.59; H, 7.61; N, 11.44. Found: C, 73.26; H, 7.58; N, 11.52	109–110
1c			0.93 (t, J_{HH} = 7.1 Hz, 3 H), 1.22 (t, J_{HH} = 7.1 Hz, 3 H), 1.64 (sext, J_{HH} = 7.1 Hz, 2 H), 2.36 (s, 3 H), 2.65 (q, J_{HH} = 7.7 Hz, 2 H), 3.54 (t, J_{HH} = 7.1 Hz, 2 H), 7.07 (s, 1 H), 7.22 (d, J_{HH} = 8.2 Hz, 2 H), 8.03 (d, J_{HH} = 8.2 Hz, 2 H)	11.11, 15.23, 15.65, 22.51, 28.84, 42.03, 127.28, 128.19, 131.61, 132.08, 137.84, 146.75, 161.90, 170.71	256.1 (100), 239.2 (15), 185.2 (23), 130.1 (12), 83.9 (27), 54.6 (12)		Oil
1d			1.24 (t, J_{HH} = 7.6 Hz, 3 H), 2.37 (s, 3 H), 2.67 (q, J_{HH} = 7.8 Hz, 3 H), 3.18 (s, 3 H), 7.10 (s, 1 H), 7.25 (d, J_{HH} = 9.0 Hz, 2 H), 8.04 (d, J_{HH} = 7.5 Hz, 2 H)	15.27, 15.62, 26.52, 28.89, 127.51, 128.24, 131.60, 132.14, 137.95, 146.84, 161.88, 170.56	228.1 (100), 213.1 (21), 199.1 (14), 58.0 (95), 56.0 (97)		85–86
1e			1.32 (s, 9 H), 2.36 (s, 3 H), 3.16 (s, 3 H), 7.10 (s, 1 H), 7.43 (d, J_{HH} = 8.2 Hz, 2 H), 8.04 (d, J_{HH} = 8.8 Hz, 2 H)	15.62, 26.52, 31.05, 34.86, 122.13, 125.66, 127.36, 131.35, 131.84, 138.12, 153.53, 161.90	256.0 (82), 241.0 (100), 55.5 (95)		141–142
1f			0.95 (t, J_{HH} = 7.7 Hz, 3 H), 1.24 (d, J_{HH} = 6.6 Hz, 6 H), 1.65 (sext, J_{HH} = 7.2 Hz, 2 H), 2.37 (s, 3 H), 2.92 (sept, J_{HH} = 7.2 Hz, 1 H), 3.55 (t, J_{HH} = 7.7 Hz, 2 H), 7.08 (s, 1 H), 7.27 (d, J_{HH} = 8.3 Hz, 2 H), 8.04 (d, J_{HH} = 8.8 Hz, 2 H)	11.11, 15.64, 22.51, 23.62, 34.07, 42.03, 126.75, 127.27, 131.76, 132.08, 137.89, 151.26, 161.88, 170.71	270.2 (100), 255.1 (82), 185.1 (32), 144.1 (21), 84.1 (49), 55.0 (23)		73–74

Table 2 Characterization of 4-Arylideneimidazolin-5-ones (continued)



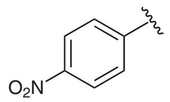
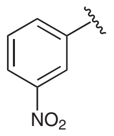
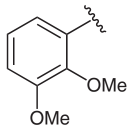
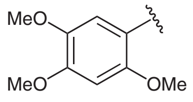
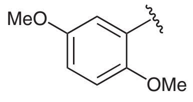
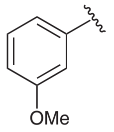
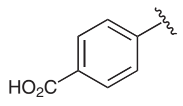
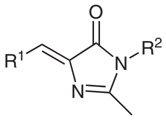
Comp	R1	R2	1H NMR (ppm)[a,b]	13C NMR (ppm)[a]	MS $[M]^+$ (%)	Anal.[c]	Mp (°C)
2a		Me	2.41 (s, 3 H), 3.20 (s, 3 H), 7.04 (s, 3 H), 8.19–8.29 (m, 4 H)	16.08, 26.95, 123.52, 123.94, 132.69, 140.63, 141.61, 147.91, 165.65, 170.55	245.1 (100), 215.2 (75), 199.2 (14), 55.1 (97)	Calcd: C, 58.77; H, 4.52; N, 17.13. Found: C, 58.39; H, 4.47; N, 16.74	173–174
2b		Me	2.37 (s, 3 H), 3.19 (s, 3 H), 7.49 (s, 2 H), 7.66 (t, J_{HH} = 7.7 Hz, 1 H), 7.99 (d, J_{HH} = 8.2 Hz, 1 H), 8.46 (d, J_{HH} = 7.7 Hz, 1 H)	15.74, 26.65, 120.85, 124.61, 128.74, 129.68, 132.89, 133.62, 133.62, 141.25, 141.75, 165.21, 169.86	245.0 (28), 215.0 (21), 199.0 (24), 119.0 (85), 91.9 (78), 55.5 (100)		171–172
3a		Me	2.37 (s, 3 H), 3.18 (s, 3 H), 3.87 (s, 3 H), 3.88 (s, 3 H), 6.94 (dd, J_{HH} = 7.8, 1.8 Hz, 1 H), 7.12 (t, J_{HH} = 8.1 Hz, 1 H), 7.57 (s, 1 H), 8.31 (dd, J_{HH} = 8.1, 1.3 Hz, 1 H)	15.96, 26.84, 56.05, 62.03, 114.32, 121.62, 124.41, 124.46, 139.43, 145.50, 149.77, 152.83, 162.80, 170.90	260.1 (30), 229.1 (95), 55.6 (100)	Calcd (**3a**·1/8H_2O): C, 64.05; H, 7.23; N, 10.67. Found: C, 63.95; H, 6.20; N, 10.54	144–145
3b		Me	2.34 (s, 3 H), 3.17 (s, 3 H), 3.87 (s, 3 H), 3.92 (s, 3 H), 3.93 (s, 3 H), 6.46 (s, 1 H), 7.62 (s, 1 H), 8.54 (s, 1 H)	15.71, 26.52, 55.89, 56.22, 56.38, 95.90, 114.70, 115.20, 121.39, 136.07, 143.15, 152.26, 155.33, 160.15, 170.67	290.1 (94), 259.1 (87), 181.1 (20), 154.1 (32), 137.1 (28), 56.0 (100)		178–179
3c		Me	2.35 (s, 3 H), 3.17 (s, 3 H), 3.82 (s, 3 H), 3.83 (s, 3 H), 6.80 (d, J_{HH} = 8.8 Hz, 1 H), 6.90 (dd, J_{HH} = 9.3, 3.4 Hz, 2 H), 7.62 (s, 1 H), 8.41 (d, J_{HH} = 2.7 Hz, 1 H)	15.70, 26.53, 55.71, 56.12, 111.74, 116.90, 117.83, 121.12, 123.65, 138.30, 153.80, 161.90, 170.64	260.1 (100), 229.1 (99), 188.1 (49), 160.1 (47), 137.0 (31), 55.1 (95)		142–143
3d		Me	2.36 (s, 3 H), 3.16 (s, 3 H), 3.84 (s, 3 H), 6.92 (dd, J_{HH} = 8.2, 1.2 Hz, 1 H), 7.06 (s, 1 H), 7.31 (t, J_{HH} = 7.8 Hz, 1 H), 7.63 (d, J_{HH} = 7.5 Hz, 1 H), 7.80 (s, 1 H)	15.99, 26.84, 55.51, 116.63, 116.78, 125.17, 127.41, 129.82, 135.63, 139.11, 159.85, 162.86, 170.96	230.1 (40), 149.0 (12), 68.8 (27), 55.6 (100)		139–140
4a		Me	In DMSO-d_6: 2.36 (s, 3 H), 3.10 (s, 3 H), 6.95 (s, 1 H), 7.88 (d, J_{HH} = 8.2 Hz, 2 H), 8.10 (d, J_{HH} = 8.2 Hz, 2 H)	In DMSO-d_6: 15.32, 26.20, 122.90, 124.71, 129.07, 130.91, 134.03, 138.60, 164.22, 169.83	244.1 (16), 111.8 (17), 55.1 (100)	Calcd (**4a**·4H_2O): C, 49.84; H, 5.46; N, 8.94. Found: C, 50.05; H, 5.06; N, 8.77	274 (dec)

Table 2 Characterization of 4-Arylideneimidazolin-5-ones (continued)



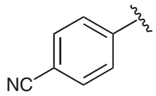
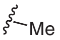
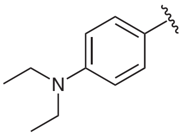
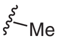
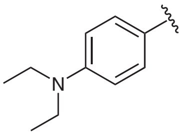
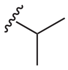
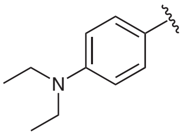
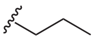
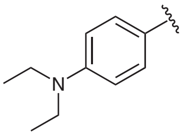
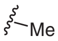
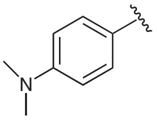
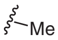
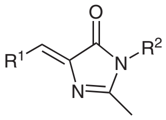
Comp	R¹	R²	¹H NMR (ppm)[a,b]	¹³C NMR (ppm)[a]	MS [M]⁺ (%)	Anal.[c]	Mp (°C)
5a			2.39 (s, 3 H), 3.18 (s, 3 H), 6.99 (s, 1 H), 7.65 (d, J_{HH} = 9.0 Hz, 1 H), 8.19 (d, J_{HH} = 8.1 Hz, 1 H)	15.76, 26.65, 112.47, 118.70, 123.88, 132.11, 132.14, 138.44, 140.94, 164.88, 170.29	225.1 (22), 58.0 (100), 56.0 (41)	Calcd (**5a**·1/8H$_2$O): C, 68.64; H, 4.98; N, 18.47. Found: C, 68.66; H, 4.87; N, 18.44	209–210
6a			1.17 (t, J_{HH} = 7.2 Hz, 6 H), 2.33 (s, 3 H), 3.15 (s, 3 H), 3.39 (q, J_{HH} = 7.2 Hz, 4 H), 6.64 (d, J_{HH} = 8.7 Hz, 2 H), 7.05 (s, 1 H), 8.01 (d, J_{HH} = 9.0 Hz, 2 H)	12.55, 15.52, 26.47, 44.45, 111.16, 121.36, 128.89, 134.21, 134.39, 149.09, 158.48, 170.65	271.2 (87), 256.1 (100), 227.1 (29), 143.1 (18), 56.0 (79)	Calcd: C, 70.82; H, 7.80; N, 15.49. Found: C, 70.57; H, 7.80; N, 15.42	146–147
6b			1.17 (t, J_{HH} = 7.1 Hz, 6 H), 1.45 (d, J_{HH} = 7.1 Hz, 3 H), 2.38 (s, 3 H), 3.39 (q, J_{HH} = 7.1 Hz, 4 H), 4.26 (sept, J_{HH} = 7.1 Hz, 1 H), 6.65 (d, J_{HH} = 8.8 Hz, 2 H), 6.99 (s, 1 H), 8.00 (d, J_{HH} = 8.8 Hz, 2 H)	12.55, 16.96, 20.61, 44.42, 44.92, 111.16, 121.51, 122.13, 128.28, 134.27, 149.00, 158.54, 170.74	299.2 (88), 284.2 (100), 242.1 (11), 187.1 (12), 172.1 (11), 143.1 (18)		124–125
6c			0.94 (t, J_{HH} = 7.1 Hz, 3 H), 1.18 (t, J_{HH} = 7.1 Hz, 6 H), 1.64 (sext, J_{HH} = 7.7 Hz, 2 H), 2.35 (s, 3 H), 3.40 (q, J_{HH} = 6.6 Hz, 4 H), 3.55 (t, J_{HH} = 7.7 Hz, 2 H), 6.65 (d, J_{HH} = 9.3 Hz, 2 H), 7.04 (s, 1 H), 8.01 (d, J_{HH} = 8.8 Hz, 2 H)	11.17, 12.55, 15.59, 22.61, 41.97, 44.43, 111.16, 121.52, 128.73, 134.17, 134.35, 149.06, 158.50, 170.67	299.1 (72), 284.0 (100), 162.1 (32), 143.0 (12), 83.9 (12), 68.7 (15), 54.5 (27)		76–77
6d			1.19 (t, J_{HH} = 7.1 Hz, 6 H), 2.33 (s, 3 H), 3.20 (s, 3 H), 3.38 (q, J_{HH} = 6.6 Hz, 4 H), 6.16 (s, 1 H), 6.22 (dd, J_{HH} = 8.8, 2.7 Hz, 1 H), 7.12 (s, 1 H), 7.11 (d, J_{HH} = 8.8 Hz, 1 H)	12.70, 14.85, 26.61, 44.52, 99.15, 104.50, 109.34, 122.13, 127.56, 131.35, 138.57, 152.89, 160.82, 167.72	287.2 (100), 272.1 (83), 232.1 (72), 217.0 (32), 56.1 (73)		203–204
7a			2.35 (s, 3 H), 3.04 (s, 6 H), 3.17 (s, 3 H), 6.69 (d, J_{HH} = 9.3 Hz, 2 H), 7.08 (s, 1 H), 8.04 (d, J_{HH} = 9.0 Hz, 2 H)	15.70, 26.58, 55.78, 61.77, 114.06, 121.36, 124.15, 124.20, 139.17, 145.24, 149.51, 152.57, 162.54, 170.53	243.1 (94), 159.1 (10), 134.1 (11), 56.0 (100)	Calcd (**7a**·1/8H$_2$O): C, 68.48; H, 7.07; N, 17.11. Found: C, 68.51; H, 7.01; N, 17.05	199–200

Table 2 Characterization of 4-Arylideneimidazolin-5-ones (continued)



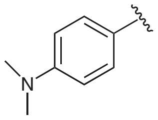
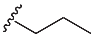
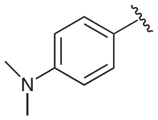
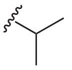
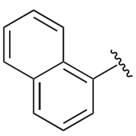
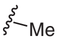
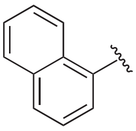
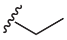
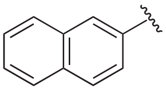
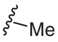
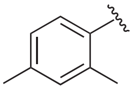
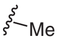
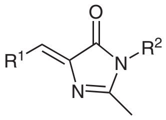
Comp	R^1	R^2	^{1}H NMR (ppm)[a,b]	^{13}C NMR (ppm)[a]	MS [M]$^+$ (%)	Anal.[c]	Mp (°C)
7b			0.95 (t, J_{HH} = 7.2 Hz, 3 H), 1.65 (sext, J_{HH} = 7.7 Hz, 2 H), 2.36 (s, 3 H), 3.04 (s, 6 H), 3.55 (t, J_{HH} = 7.5 Hz, 2 H), 6.70 (d, J_{HH} = 8.7 Hz, 2 H), 7.06 (s, 1 H), 8.05 (d, J_{HH} = 9.3 Hz, 2 H)	11.20, 15.65, 22.64, 40.01, 42.03, 111.69, 122.16, 122.24, 128.62, 134.04, 151.38, 159.01, 170.71	271.2 (100), 254.2 (13), 229.1 (15), 159.1 (35), 143.1 (15), 134.1 (13), 84.1 (38)		117–118
7c			1.45 (d, J_{HH} = 7.1 Hz, 6 H), 2.39 (s, 3 H), 3.03 (s, 6 H), 4.26 (sept, J_{HH} = 7.1 Hz, 1 H), 6.69 (dd, J_{HH} = 6.6, 2.2 Hz, 2 H), 7.01 (s, 1 H), 8.03 (d, J_{HH} = 8.8 Hz, 2 H)	17.02, 20.64, 40.03, 45.01, 110.95, 111.71, 122.33, 128.22, 133.98, 151.35, 159.07, 170.80	271.0 (100), 229.0 (14), 159.1 (36), 143.0 (11), 134.1 (12), 83.9 (17)		oil
8a			2.40 (s, 3 H), 3.23 (s, 3 H), 7.47–7.62 (m, 3 H), 7.83–7.90 (m, 2 H), 7.98 (s, 1 H), 8.31 (d, J_{HH} = 8.4 Hz, 1 H), 8.79 (d, J_{HH} = 7.2 Hz, 1 H)	15.65, 26.56, 122.89, 123.15, 125.69, 125.88, 126.83, 128.80, 129.90, 130.55, 131.19, 132.40, 133.54, 139.38, 163.22, 170.48	250.1 (93), 167.1 (21), 139.1 (11), 56.0 (100)	Calcd (**8a**·1/4H_2O): C, 75.43; H, 5.73; N, 10.99. Found: C, 75.20; H, 5.61; N, 10.93	186–187
8b			1.27 (t, J_{HH} = 7.1 Hz, 3 H), 2.40 (s, 3 H), 3.68 (q, J_{HH} = 7.1 Hz, 2 H), 7.48–7.62 (m, 3 H), 7.84–7.91 (m, 2 H), 7.97 (s, 1 H), 8.31 (d, J_{HH} = 8.2 Hz, 1 H), 8.80 (d, J_{HH} = 8.2 Hz, 1 H)	14.62, 15.64, 35.36, 122.74, 123.18, 125.69, 125.88, 126.81, 128.82, 129.96, 130.52, 131.16, 132.43, 133.56, 139.41, 163.01, 170.33	264.1 (100), 235.1 (15), 166.1 (39), 141.1 (20), 139.1 (25), 70.1 (81), 51.0 (16)		101–102
8c			2.40 (s, 3 H), 3.19 (s, 3 H), 7.45–7.54 (m, 2 H), 7.84–7.91 (m, 3 H), 8.42 (s, 1 H), 8.43 (d, J_{HH} = 7.7 Hz, 1 H)	15.71, 26.59, 126.32, 127.37, 127.65, 128.10, 128.30, 128.88, 131.92, 133.12, 133.21, 133.89, 138.82, 162.48, 170.71	250.1 (82), 141.1 (10), 56.0 (100)		192–193
9a			2.36 (s, 3 H), 2.37 (s, 3 H), 2.43 (s,3 H), 3.18 (s, 3 H), 7.07 (s, 2 H), 7.36 (s, 1 H), 8.40 (s, 1 H)	15.65, 19.62, 21.12, 26.55, 122.15, 124.68, 130.28, 130.94, 132.21, 132.33, 135.65, 136.38, 138.36, 170.96	228.1 (91), 213.1 (36), 156.1 (68), 145.1 (67), 129.1 (14), 115.0 (19), 56.0 (100)	Calcd: C, 73.66; H, 7.06; N, 12.27. Found: C, 73.59; H, 7.03; N, 12.31	120–121

Table 2 Characterization of 4-Arylideneimidazolin-5-ones (continued)



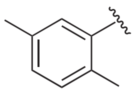
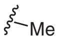
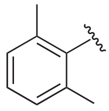
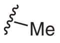
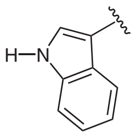
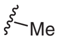
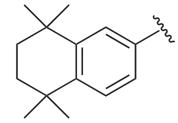
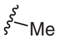
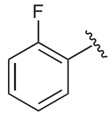
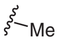
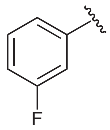
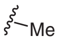
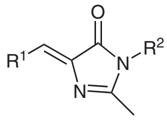
Comp	R¹	R²	¹H NMR (ppm)[a,b]	¹³C NMR (ppm)[a]	MS [M]⁺ (%)	Anal.[c]	Mp (°C)
9b			2.32 (s, 3 H), 2.36 (s, 3 H), 2.45 (s,3 H), 3.18 (s, 3 H), 7.02 (s, 1 H), 7.08 (d, J_{HH} = 8.2 Hz, 1 H), 7.37 (s, 1 H), 8.53 (d, J_{HH} = 7.7 Hz, 1 H)	15.64, 19.97, 21.47, 26.55, 124.52, 127.19, 129.83, 131.20, 131.96, 137.93, 139.33, 140.41, 162.50, 170.73	228.1 (60), 213.1 (11), 156.1 (34), 145.1 (28), 56.0 (100)		137–138
9c			2.26 (s, 6 H), 2.30 (s, 3 H), 3.18 (s, 3 H), 7.05 (d, J_{HH} = 7.7 Hz, 2 H), 7.13 (t, J_{HH} = 8.2 Hz, 1 H), 7.32 (s, 1 H)	15.61, 20.88, 26.55, 127.60, 128.19, 128.42, 132.54, 136.72, 140.49, 162.63, 169.50	228.0 (98), 213.0 (48), 156.0 (92), 145.1 (85), 128.0 (36), 115.0 (34), 55.5 (100)		70–71
10a			In DMSO-d_6: 2.34 (s, 3 H), 3.10 (s, 3 H), 7.09–7.21 (m, 2 H), 7.30 (s, 1 H), 7.47 (dd, J_{HH} = 7.1, 1.1 Hz, 1 H), 8.20 (d, J_{HH} = 7.1 Hz, 1 H), 8.39 (s, 1 H), 11.93 (s, 1 H)	In DMSO-d_6: 15.23, 26.12, 111.01, 112.07, 119.38, 120.64, 122.43, 126.61, 132.65, 133.89, 136.28, 159.28, 169.10	239.0 (88), 155.0 (12), 130.0 (10), 55.5 (100)	Calcd (**10a**·1/4MeOH): C, 69.22; H, 5.70; N, 16.99. Found: C, 69.17; H, 5.35; N, 17.17	144–145
11a			1.28 (s, 6 H), 1.30 (s, 6 H), 1.68 (s, 4 H), 2.36 (s, 3 H), 3.17 (s, 3 H), 7.09 (s, 1 H), 7.35 (d, J_{HH} = 8.2 Hz, 1 H), 7.91 (d, J_{HH} = 1.7 Hz, 1 H), 8.03 (dd, J_{HH} = 8.2, 1.7 Hz, 1 H)	15.68, 26.53, 31.56, 31.76, 34.46, 34.83, 34.89, 127.04, 128.00, 128.92, 131.04, 131.43, 137.96, 147.60, 161.58, 170.80	310.1 (77), 295.1 (100), 253.0 (21), 55.6 (78)	Calcd (**11a**·1/4EtOH): C, 76.48; H, 8.60; N, 8.70. Found: C, 76.80; H, 8.54; N, 9.03	173–174
12a			2.37 (s, 3 H), 3.18 (s, 3 H), 7.04 (s, 1 H), 7.08 (AA′ of a AA′BB′X spin system, 2 H), 8.12 (BB′ of a AA′BB′X spin system, 2 H)	15.65, 26.56, 115.82 (J_{CF} = 21.8 Hz), 122.16, 125.85, 130.44, 134.13 (J_{CF} = 8.0 Hz), 138.24, 162.64, 163.57 (J_{CF} = 252.4 Hz), 170.59	218.1 (92), 199.1 (45), 134.0 (12), 107.0 (16), 56.0 (100)	Calcd: C, 66.05; H, 5.08; N, 12.84. Found: C, 65.83; H, 4.98; N, 12.78	168–169
12b			2.37 (d, J_{HH} = 0.6 Hz, 3 H), 3.17 (s, 3 H), 7.02 (s, 1 H), 7.00–7.10 (m, 1 H), 7.30–7.4 (m, 1 H), 7.70–7.75 (m, 1 H), 8.00–8.08 (m, 1 H)	15.67, 26.58, 116.75 (J_{CF} = 22.0 Hz), 118.25 (J_{CF} = 22.0 Hz), 125.45, 127.97, 130.01 (J_{CF} = 7.7 Hz), 136.20, 139.51, 162.69 (J_{CF} = 245.5 Hz), 163.4, 170.50	218.1 (64), 56.1 (100)		150–151

Table 2 Characterization of 4-Arylideneimidazolin-5-ones (continued)



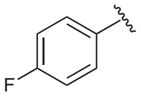
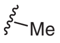
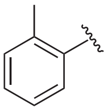
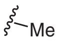
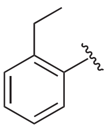
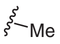
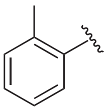
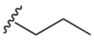
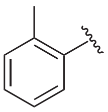
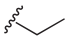
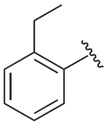
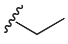
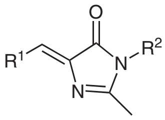
Comp	R¹	R²	¹H NMR (ppm)[a,b]	¹³C NMR (ppm)[a]	MS [M]⁺ (%)	Anal.[c]	Mp (°C)
12c			2.35 (s, 3 H), 3.16 (s, 3 H), 7.03 (s, 1 H), 7.08 (AA′ of a AA′BB′X spin system, 2 H), 8.12 (BB′ of a AA′BB′X spin system, 2 H)	15.01, 26.53, 115.79 (J_{CF} = 21.8 Hz), 125.81, 130.43, 134.10 (J_{CF} = 9.2 Hz), 162.64, 163.54 (J_{CF} = 252.4 Hz), 170.56	218.0 (93), 148.8 (10), 58.0 (17), 56.1 (100)		151–152
13a			2.37 (s, 3 H), 2.48 (s, 3 H), 3.19 (s, 2 H), 7.18–7.21 (m, 1 H), 7.22–7.29 (m, 2 H), 7.39 (s, 1 H), 8.59 (dd, J_{HH} = 6.1, 2.8 Hz, 1 H)	15.70, 20.09, 26.59, 124.4, 126.32, 129.96, 130.40, 131.95, 132.59, 138.65, 139.29, 162.75, 170.70	214.1 (83), 199.1 (19), 142.0 (31), 131.1 (44), 115.0 (17), 56.0 (100)	Calcd (**13a**·1/2H$_2$O): C, 69.94; H, 6.77; N, 12.55. Found: C, 70.98; H, 6.41; N, 12.68	109–110
13b			1.23 (m, 6 H), 2.38 (s, 3 H), 2.83 (q, J_{HH} = 7.1 Hz, 2 H), 3.66 (q, J_{HH} = 7.1 Hz, 2 H), 7.19–7.22 (m, 1 H), 7.22–7.31 (m, 2 H), 7.40 (s, 1 H), 8.51–8.60 (m, 1 H)	14.60, 15.61, 16.02, 26.61, 35.30, 124.00, 126.22, 128.85, 130.05, 132.16, 138.72, 145.41, 162.41, 170.45	228.1 (84), 213.1 (53), 199.2 (23), 156.1 (37), 145.2 (42), 128.1 (21), 115.0 (20), 55.6 (100)		90–91
13c			0.97 (t, J_{HH} = 7.1 Hz, 3 H), 1.23 (t, J_{HH} = 7.7 Hz, 3 H), 1.67 (sext, J_{HH} = 7.1 Hz, 2 H), 2.38 (s, 3 H), 2.84 (q, J_{HH} = 7.7 Hz, 2 H), 3.57 (t, J_{HH} = 7.1 Hz, 2 H), 7.15–7.21 (m, 1 H), 7.22–7.30 (m, 2 H), 7.41 (s, 1 H), 8.57–8.63 (m, 1 H)	11.11, 15.65, 19.97, 22.49, 42.05, 124.06, 126.20, 129.82, 130.29, 131.83, 132.52, 138.46, 139.17, 162.72, 170.65	242.1 (100), 199.2 (28), 142.1 (25), 131.1 (34), 115.0 (24), 103.0 (19), 83.9 (78)		64–65
13d			1.26 (t, J_{HH} = 7.1 Hz, 3 H), 2.39 (s, 3 H), 2.48 (s, 3 H), 3.67 (q, J_{HH} = 7.1 Hz, 2 H), 7.17–7.23 (m, 1 H), 7.23–7.31 (m, 2 H), 7.38 (s, 1 H), 8.57–8.62 (m, 1 H)	14,65, 15.65, 20.07, 35.35, 124.20, 126.31, 129.91, 130.38, 130.61, 131.92, 132.62, 139.27, 162.52, 170.48	228.0 (98), 199.0 (31), 142.0 (37), 131.0 (51), 115.0 (29), 102.9 (24), 69.7 (100)		128–129
13e			1.15–1.34 (m, 6 H), 2.38 (s, 3 H), 2.83 (q, J_{HH} = 7.1 Hz, 2 H), 3.66 (q, J_{HH} = 7.1 Hz, 2 H), 7.16–7.32 (m, 3 H), 7.40 (s, 1 H), 8.53–8.63 (m, 1 H)	14.60, 16.61, 16.06, 26.61, 35.30, 124.00, 126.22, 128.85, 130.05, 131.72, 132.16, 138.73, 145.41, 162.41, 170.45	242.1 (100), 227.1 (29), 213.0 (31), 155.9 (23), 144.9 (27), 70.0 (67)		73–74

Table 2 Characterization of 4-Arylideneimidazolin-5-ones (continued)



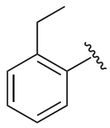
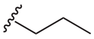
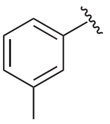
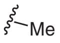
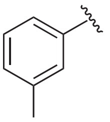
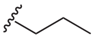
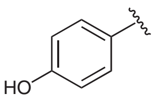
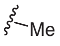
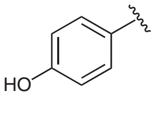
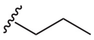
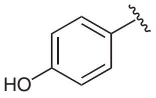
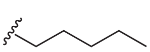
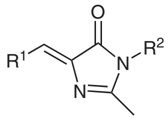
Comp	R^1	R^2	^1H NMR (ppm)[a,b]	^{13}C NMR (ppm)[a]	MS $[M]^+$ (%)	Anal.[c]	Mp (°C)
13f			0.97 (t, J_{HH} = 7.7 Hz, 3 H), 1.23 (t, J_{HH} = 7.7 Hz, 3 H), 1.67 (sext, J_{HH} = 7.7 Hz, 2 H), 2.38 (s, 3 H), 2.84 (q, J_{HH} = 7.7 Hz, 2 H), 3.57 (t, J_{HH} = 7.1 Hz, 2 H), 7.19–7.25 (m, 1 H), 7.25–7.32 (m, 2 H), 7.41 (s, 1 H), 8.55–8.62 (m, 1 H)	11.17, 15.71, 16.05, 22.54, 26.59, 42.11, 123.97, 126.20, 128.83, 130.03, 131.73, 132.16, 138.65, 145.41, 162.66, 170.71	256.0 (100), 241.0 (35), 213.0 (27), 156.0 (29), 145.1 (31), 83.9 (68), 57.6 (30)		74–75
13g			2.38 (s, 3 H), 2.39 (s, 3 H), 3.18 (s, 3 H), 7.08 (s, 1 H), 7.18 (d, J_{HH} = 7.7 Hz, 1 H), 7.30 (t, J_{HH} = 7.7 Hz, 1 H), 7.93 (d, J_{HH} = 9.4 Hz, 2 H)	15.67, 21.40, 26.58, 127.65, 128.57, 129.33, 131.00, 132.60, 134.03, 138.27, 138.47, 162.38, 170.74	214.1 (100), 199.1 (21), 130.1 (13), 115.1 (22), 103.0 (20), 77.1 (21), 56.0 (97)		148–149
13h			In DMSO-d_6: 0.85 (t, J_{HH} = 7.7 Hz, 3 H), 1.56 (sext, J_{HH} = 7.1 Hz, 2 H), 2.32 (s, 3 H), 2.37 (s, 3 H), 3.52 (t, J_{HH} = 7.2 Hz, 2 H), 6.91 (s, 1 H), 7.22 (d, J_{HH} = 7.2 Hz, 1 H), 7.33 (t, J_{HH} = 7.2 Hz, 1 H), 7.98 (s, 1 H), 8.04 (d, J_{HH} = 7.7 Hz, 1 H)	In DMSO-d_6: 10.96, 15.35, 20.93, 21.81, 41.36, 124.82, 128.34, 128.48, 129.03, 130.62, 132.24, 133.92, 137.64, 163.92, 169.88	242.1 (100), 225.0 (53), 158.9 (47), 143.9 (40), 130.9 (52), 83.9 (63), 55.1 (19)		121–122
14a[19]			In DMSO-d_6: 2.31 (s, 3 H), 3.07 (s, 3 H), 6.82 (d, J_{HH} = 8.8 Hz, 2 H), 6.88 (s, 1 H), 8.07 (d, J_{HH} = 8.8 Hz, 2 H), 10.11 (s, 1 H)	In DMSO-d_6: 15.20, 26.12, 115.67, 125.29, 125.41, 134.03, 136.20, 159.50, 162.20, 169.75	216.1 (48), 82.5 (14), 68.4 (16), 55.2 (100)		137–138
14b			0.94 (t, J_{HH} = 7.8 Hz, 3 H), 1.65 (sext, J_{HH} = 7.1 Hz, 2 H), 2.36 (s, 3 H), 3.56 (t, J_{HH} = 7.2 Hz, 2 H), 6.82 (d, J_{HH} = 8.1 Hz, 2 H), 7.09 (s, 1 H), 7.94 (d, J_{HH} = 9.0 Hz, 2 H)	11.18, 15.42, 22.58, 42.26, 116.10, 126.07, 128.85, 134.33, 135.59, 158.95, 161.24, 170.85	242.1 (100), 225.1 (24), 185.1 (24), 159.1 (21), 130.1 (20), 84.1 (34), 55.0 (17)	Calcd (**14b**·1/4H_2O): C, 68.21; H, 6.64; N, 11.36. Found: C, 68.28; H, 6.55; N, 11.36	139–140
14c			0.88 (t, J_{HH} = 7.0 Hz, 3 H), 1.25–1.40 (m, 4 H), 1.60 (pent, J_{HH} = 7.3 Hz, 2 H), 2.36 (s, 3 H), 3.58 (t, J_{HH} = 7.0 Hz, 2 H), 6.83 (d, J_{HH} = 8.7 Hz, 2 H), 7.08 (s, 1 H), 7.94 (d, J_{HH} = 8.7 Hz, 2 H)	13.88, 15.47, 22.26, 28.82, 29.01, 40.70, 116.06, 126.13, 128.59, 134.30, 135.75, 158.92, 161.19, 170.78	272.1 (100), 255.1 (81), 216.1 (31), 161.0 (32), 146.1 (23), 132.0 (25), 71.1 (26), 55.0 (37)		98–99

Table 2 Characterization of 4-Arylideneimidazolin-5-ones (continued)



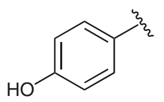
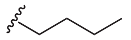
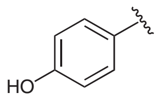
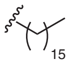
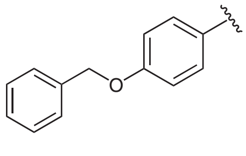
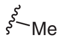
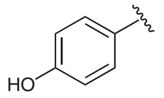
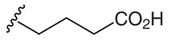
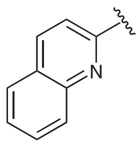
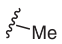
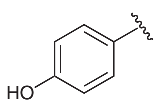
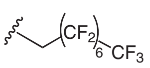
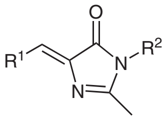
Comp	R^1	R^2	^{1}H NMR (ppm)[a,b]	^{13}C NMR (ppm)[a]	MS [M]$^+$ (%)	Anal.[c]	Mp (°C)
14d			0.94 (t, J_{HH} = 7.2 Hz, 3 H), 1.36 (sext, J_{HH} = 7.7 Hz, 2 H), 1.60 (pentet, J_{HH} = 7.7 Hz, 2 H), 2.38 (s, 3 H), 3.60 (t, J_{HH} = 7.2 Hz, 2 H), 6.82 (d, J_{HH} = 8.7 Hz, 2 H), 7.09 (s, 1 H), 7.95 (d, J_{HH} = 8.7 Hz, 2 H)	13.65, 15.41, 19.97, 31.36, 40.51, 116.08, 126.11, 128.82, 134.32, 135.62, 158.89, 161.28, 170.82	258.1 (100), 241.1 (88), 216.1 (58), 161.1 (58), 133.1 (40), 57.1 (62)		141–142
14e			0.88 (t, J_{HH} = 6.7 Hz, 3 H), 1.18–1.37 (m, 26 H), 1.60 (t, J_{HH} = 7.0 Hz, 2 H), 2.38 (s, 3 H), 3.59 (t, J_{HH} = 7.6 Hz, 2 H), 6.85 (d, J_{HH} = 8.5 Hz, 2 H), 7.07 (s, 1 H), 8.02 (d, J_{HH} = 8.8 Hz, 2 H)	14.12, 15.47, 22.67, 26.78, 26.78, 29.21, 29.34, 29.47, 29.54, 29.60, 29.63, 29.66, 31.90, 40.76, 116.10, 126.14, 128.62, 134.32, 135.75, 158.95, 161.17, 170.77	426.2 (100), 409.2 (14), 216.1 (12), 56.2 (11)		109–111
15a			2.35 (s, 3 H), 3.17 (s, 3 H), 5.11 (s, 2 H), 7.00 (d, J_{HH} = 8.7 Hz, 2 H), 7.29–7.49 (m, 5 H), 8.10 (d, J_{HH} = 9.0 Hz, 2 H)	15.64, 26.56, 69.98, 115.13, 122.18, 127.30, 127.45, 128.09, 128.62, 134.00, 136.43, 136.95, 160.35, 161.28, 170.73	306.1 (84), 215.1 (58), 91.0 (100), 65.0 (17), 56.0 (87)	Calcd (**15a**·1/2H$_2$O): C, 72.09; H, 5.72; N, 8.75. Found: C, 72.37; H, 6.07; N, 8.88	180–181
16a			In DMSO-d_6: 1.67 (pentet, J_{HH} = 7.6 Hz, 2 H), 1.91 (t, J_{HH} = 7.0 Hz, 2 H), 2.34 (s, 3 H), 3.53 (t, J_{HH} = 7.6 Hz, 2 H), 6.77 (d, J_{HH} = 8.5 Hz, 2 H), 6.83 (s, 1 H), 8.01 (d, J_{HH} = 8.8 Hz, 2 H)	In DMSO-d_6: 15.19, 25.75, 34.24, 116.25, 123.81, 126.02, 134.12, 135.18, 161.10, 162.01, 169.77, 175.99	288.2 (10), 274.1 (100), 146.1 (18), 132.1 (15), 114.1 (23), 86.1 (65), 55.1 (25)	Calcd (**16a**·1/2H$_2$O): C, 60.81; H, 5.44; N, 9.46. Found: C, 60.58; H, 4.99; N, 9.96	237 (dec)
17a			2.40 (s, 3 H), 3.18 (s, 3 H), 7.42 (s, 1 H), 7.54 (td, J_{HH} = 8.2, 1.1 Hz, 1 H), 7.70 (td, J_{HH} = 8.2, 1.1 Hz, 1 H), 7.79 (d, J_{HH} = 8.2 Hz, 1 H), 8.10 (d, J_{HH} = 8.8 Hz, 1 H), 8.17 (d, J_{HH} = 8.8 Hz, 1 H), 8.85 (d, J_{HH} = 8.8 Hz, 1 H)	15.82, 26.61, 123.95, 127.15, 127.40, 127.51, 129.64, 129.76, 135.96, 141.79, 154.03, 164.79, 170.50	251.1 (52), 223.1 (12), 168.1 (12), 140.1 (10), 56.0 (100)	Calcd (**18a**·1/8H$_2$O): C, 71.06; H, 5.26; N, 16.57. Found: C, 71.13; H, 5.15; N, 16.59	169–170
18a			In acetone-d_6: 2.46 (d, J_{HF} = 0.6 Hz, 3 H), 4.59 (tt, J_{HF} = 16.5 Hz, 2 H), 6.93 (AA′ part of AA′BB′ spin system, 2 H), 7.02 (s, 1 H), 8.18 (BB′ part of AA′BB′ spin system, 2 H), 9.06 (br s, 1 H)		584.1 (98), 565.1 (18), 424.0 (100), 132.1 (9), 69.0 (12)	Calcd: C, 39.06; H, 1.90; F, 48.77; N, 4.79. Found: C, 39.01; H, 1.84; F, 49.07; N, 4.77	207–209

Table 2 Characterization of 4-Arylideneimidazolin-5-ones (continued)



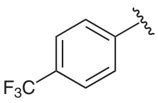
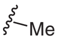
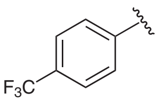
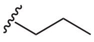
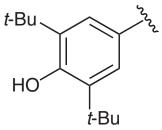
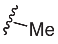
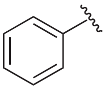
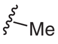
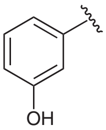
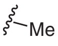
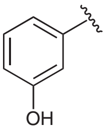
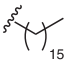
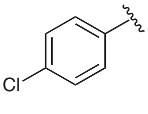
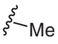
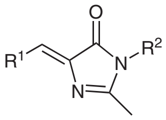
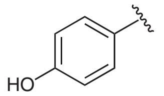
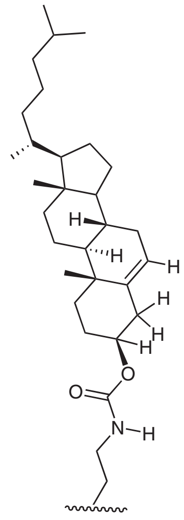
Comp	R1	R2	1H NMR (ppm)[a,b]	13C NMR (ppm)[a]	MS [M]+ (%)	Anal.[c]	Mp (°C)
19a			2.39 (s, 3 H), 3.19 (s, 3 H), 7.07 (s, 1 H), 7.64 (d, J_{HH} = 8.2 Hz, 2 H), 8.21 (d, J_{HH} = 8.2 Hz, 2 H)	15.74, 26.63, 124.79, 125.36 (J_{CF} = 4.4 Hz), 125.47 (J_{CF} = 4.4 Hz), 131.98, 137.42, 140.30, 144.50, 164.16, 170.46	268.1 (79), 249.1 (10), 55.2 (100)	Calcd (**19a**·1/4H_2O): C, 57.25; H, 4.25; N, 10.27; F, 20.89. Found: C, 57.55; H, 4.07; N, 10.48; F, 20.93	152–153
19b			0.96 (t, J_{HH} = 7.3 Hz, 3 H), 1.66 (sext, J_{HH} = 7.3 Hz, 2 H), 2.40 (s, 3 H), 3.60 (t, J_{HH} = 7.3 Hz, 2 H), 7.05 (s, 1 H), 7.64 (d, J_{HH} = 7.9 Hz, 2 H), 8.22 (d, J_{HH} = 8.2 Hz, 2 H)	11.16, 15.80, 22.55, 42.24, 124.57, 125.36 (J_{CF} = 3.3 Hz), 125.46 (J_{CF} = 3.3 Hz), 130.71, 131.95, 137.49, 140.24, 164.22, 170.53	296.1 (100), 279.1 (14), 185.0 (42), 198.1 (15), 54.2 (18)		76–77
20a			1.47 (s, 18 H), 2.35 (s, 3 H), 3.18 (s, 3 H), 5.59 (s, 2 H), 7.08 (s, 1 H), 8.06 (s, 2 H)	15.77, 26.55, 30.16, 34.34, 125.91, 129.00, 130.07, 136.19, 156.21, 160.38, 170.88		Calcd: C, 73.14; H, 8.59; N, 8.53. Found: C, 73.07; H, 8.60; N, 8.50	163–164
21a[9a]			2.36 (s, 3 H), 3.16 (s, 3 H), 7.09 (s, 1 H), 7.31–7.44 (m, 3 H), 8.11 (dd, J_{HH} = 8.2, 2.2 Hz, 2 H)	15.67, 26.56, 127.24, 128.63, 130.00, 132.05, 134.10, 138.66, 162.57, 170.68	200.0 (100), 116.0 (14), 101.9 (12), 88.9 (18), 55.6 (97)		107–108
22a[20]			In DMSO-d_6: 2.33 (s, 3 H), 3.07 (s, 3 H), 6.79 (dd, J_{HH} = 7.8, 2.0 Hz, 1 H), 6.84 (s, 1 H), 7.21 (t, J_{HH} = 7.6 Hz, 1 H), 7.50 (d, J_{HH} = 7.8 Hz, 1 H), 7.72 (s, 1 H), 9.58 (s, 1 H)	In DMSO-d_6: 16.07, 26.93, 118.08, 118.59, 124.02, 125.63, 130.20, 135.84, 139.47, 158.04, 164.97, 170.56	216.1 (45), 55.6 (100)		188–189
22b			0.87 (t, J_{HH} = 7.0 Hz, 3 H), 1.19–1.39 (m, 26 H), 1.60 (t, J_{HH} = 7.0 Hz, 2 H), 2.34 (s, 3 H), 3.57 (t, J_{HH} = 7.6 Hz, 2 H), 6.86 (dd, J_{HH} = 8.2, 2.1 Hz, 1 H), 7.09 (s, 1 H), 7.24 (t, J_{HH} = 7.9 Hz, 1 H), 7.44 (d, J_{HH} = 7.6 Hz, 1 H), 7.78 (s, 1 H)	14.10, 15.55, 22.66, 26.76, 29.19, 29.34, 29.45, 29.53, 29.58, 29.63, 29.66, 31.90, 40.74, 117.82, 124.49, 127.77, 129.86, 135.10, 138.08, 156.38, 163.19, 170.47	426.1 (100), 411.1 (17), 216.1 (21), 203.1 (19), 56.2 (14)		83–84
23a[18]			2.36 (s, 3 H), 3.16 (s, 3 H), 7.01 (s, 1 H), 7.36 (d, J_{HH} = 8.5 Hz, 2 H), 8.05 (d, J_{HH} = 8.8 Hz, 2 H)	15.64, 26.55, 125.53, 128.86, 132.58, 133.16, 135.88, 138.91, 162.97, 170.46	234.1 (72), 55.2 (100)		154–155

Table 2 Characterization of 4-Arylideneimidazolin-5-ones (continued)



Comp	R^1	R^2	^{1}H NMR (ppm)[a,b]	^{13}C NMR (ppm)[a]	MS $[M]^+$ (%)	Anal.[c]	Mp (°C)
24a			In 1,1,2,2-tetrachloroethane-d_2 at 80 °C: 0.73 (s, 3 H), 0.92 (d, J_{HH} = 6.6 Hz, 6 H), 0.97 (d, J_{HH} = 6.3 Hz, 3 H), 1.04 (s, 3 H), 1.29–1.05 (m, 10 H), 1,70–1.29 (m, 13 H), 2.10–1.79 (m, 6 H), 2.40–2.25 (m, 3 H), 2.41 (s, 3 H), 3.43 (q, J_{HH} = 6 Hz, 2 H), 3.76 (t, J_{HH} = 6 Hz, 2 H), 4.50 (sept, J_{HH} = 4.8 Hz), 4.95 (t, J_{HH} = 5.7 Hz, 1 H), 5.38 (d, J_{HH} = 4.5 Hz, 1 H), 6.92 (d, J_{HH} = 8.7 Hz, 2 H), 7.06 (s, 1 H), 8.09 (d, J_{HH} = 8.7 Hz, 2 H)	In 1,1,2,2-tetrachloroethane-d_2 at 80 °C: 11.73, 15.27, 18.68, 19.12, 20.97, 22.39, 22.57, 23.77, 24.12, 27.76, 27.99, 31.76, 31.82, 35.53, 36.15, 36.44, 36.89, 38.33, 39.42, 39.72, 39.97, 40.37, 42.25, 50.08, 56.25, 56.60, 74.03, 74.86, 115.79, 122.35, 127.02, 127.44, 134.31, 136.47, 139.70, 156.04, 157.76, 160.70, 170.83.	657.5 (3), 386.2 (100), 368.2 (81), 353.2 (33), 301.2 (33), 289.1 (91), 275.3 (45), 271.1 (62), 255.2 (24), 213.3 (28), 161.2 (34), 145.1 (39), 133.1 (30), 119.0 (27), 106.9 (42), 94.8 (41), 80.6 (43)	Calcd: C, 74.85; H, 9.04; N, 6.39. Found: C, 74.48; H, 9.30; N, 6.06	230–231

[a] Unless otherwise noted, NMR spectra were recorded in $CDCl_3$.

[b] In cases where ^{1}H NMR spectra were not of the first order, the H–H and H–F coupling constants were not optimized but were assigned by visual inspection.

[c] Compounds are grouped by general phenyl substitution for elemental analysis, which was performed for one compound in each block.

In summary, the synthetic preparation presented here enables convenient access to a variety of arylideneimidazolinones through a 1,3-dipolar, [2+3] cycloaddition of an imide ylide with aromatic Schiff bases. The reaction produces the required products in good to excellent yields (30–99%) with minimal purification required. New applications and studies of these arylideneimidazolinones are currently underway.

Melting points were measured on an Electrothermal melting point apparatus and are uncorrected. ^{1}H NMR spectra were determined with Varian Mercury Vx 300 spectrometer operating at 300 MHz (^{1}H) and at 75 MHz (^{13}C), in appropriate solvents, as indicated in Table 2. Chemical shifts were referenced to TMS. Low-resolution MS spectra (EI, 70 eV) were measured on a Micromass AutoSpec spectrometer. Elemental analyses were performed by the Atlantic Microlab, Inc., Norcross, Georgia (USA). TLC was carried out on Analtech Uniplate Silica Gel GF plates. Column chromatography was performed using Sorbent Technologies 40–63 μm standard grade silica gel. The organic solvents and the reagents used in this study were used as received from commercial sources (Acros Organics, Fisher Scientific, Aldrich). The (3*S*,8*S*,9*S*,10*R*,13*R*,17*R*)-10,13-dimethyl-17-((*R*)-6-methylheptan-2-yl)-2,3,4,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1*H*-cyclopenta[*a*]phenanthren-3-yl (2-aminoethyl)carbamate, an amine employed in entry **24a**, was prepared according to the reported procedure.[21]

Synthesis of Imidate 2 (Scheme 2, B)[17b]

K_2CO_3 (50 mmol) and methyl glycinate hydrochloride (50 mmol) were suspended in Et_2O (125 mL), followed by addition of H_2O (20 mL) then addition of ethyl acetimidate hydrochloride (50 mmol). The mixture was shaken for 6 min then the ether was decanted off. An additional portion of Et_2O (75 mL) was added, the mixture was shaken for 6 min then the Et_2O was decanted off. The combined organic portions were dried over anhydrous $MgSO_4$ and the solvent was removed in vacuo to afford the pure imidate (4.30 g, 54%) as confirmed by NMR analysis.

General Procedure (Scheme 2, C)

The required aromatic Schiff base **1** (1 mmol) was combined with the imidate **2** (1.1 mmol) in absolute EtOH (~1 mL) and the reaction was allowed to stir in a capped vial overnight under ambient conditions. In cases where the Schiff base was solid, additional EtOH was used to solubilize the reactants. In some cases, as indicated in Table 1, the precipitated product was filtered and washed sequentially with Et_2O (~2 mL) and EtOH (~1 mL) to yield the pure product. In cases where precipitation did not occur at r.t., the reaction mixture was held at 0 °C for 1–4 d to allow precipitation to occur. Following this, the product was filtered and washed sequentially with cold Et_2O (~2 mL) and cold EtOH (~1 mL). If precipitation did not occur by either method, flash column chromatography on silica gel was performed.

Acknowledgment

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