¹H and ¹³C NMR spectral assignments for twenty-four novel naphthalenylphenylpyrazolines

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Introduction

Compounds bearing the pyrazoline scaffold have been known to show various biological activities, including antimicrobial, antiviral, anti-tubercular, cardiovascular, anti-inflammatory, anticancer, antidiabetic, analgesic, and monoamine oxidase inhibitory activities.¹⁻⁹ Pyrazolines are five-membered heterocycles with two nitrogens. The biological activities mentioned above vary based on the type and position of the substituents. For example, pyrazoline derivatives containing 1,3-diphenyl (Fig. 1A), 3,5-difuranyl (Fig. 1B), and 1,3,5-triphenyl (Fig. 1C) groups show anti-inflammatory, antimicrobial, and anti-tubercular activities, respectively.¹⁰⁻¹² We designed pyrazolines containing 3-phenyl and 5-naphthalenyl (Fig. 1D) groups and synthesized twenty-four novel derivatives. Six of these derivatives have the naphthalen-2-yl group and eighteen have the naphthalen-1-yl group, as listed in Table 1. Herein, complete assignment of the ¹H and ¹³C NMR spectral data is presented along with high-resolution mass spectrometric data. The data compiled in this report can be used as a reference for identifying newly synthesized pyrazoline derivatives.

Experimental

Syntheses

The general procedure for the synthesis of compound **16** as a representative pyrazoline (**1–18**) is presented.¹³ The plant-derived secondary metabolite chalcone is 1,3-diphenyl-prop-2en-1-one. If the α,β -unsaturated carbonyl group of chalcone is substituted with pyrazoline, 3,5-diphenyl-pyrazoline can be prepared. Therefore, the previously reported synthetic approach for preparing chalcone derivatives was applied.¹⁴ A solution of (*E*)-3-(2,3dimethoxynaphthalen-1-yl)-1-(2-hydroxy-4,5-dimethoxyphenyl)prop-2-en-1-one (1 mmol, 394 mg) was combined with (6.5 mmol, 0.6 ml) hydrazine monohydrate in 10 ml of anhydrous ethanol by addition of the latter without a catalyst and then refluxed for 4 h at 358 K. After cooling to room temperature, the reaction mixture produced a precipitate which was filtered and washed with cold ethanol. The crude solid was purified by recrystallization from hot ethanol to provide a pure pyrazoline compound (**16**, m.p. 130–136 °C, 64% yield). The general methods described above were applied to the synthesis of pyrazolines (**19-24**) for synthetic chalcone derived from 2-naphthylaldehyde. The synthesis protocol for the naphthalenylphenylpyrazolines is illustrated in Scheme 1.

NMR spectra

All naphthalenylphenylpyrazolines were dissolved in deuterated dimethyl sulfoxide (DMSOd₆). Because the NH proton peaks of derivatives **1**, **3**, **5**, **6**, and **13** were not observed in the ¹H NMR spectra, the ¹H NMR data for these species dissolved in deuterated chloroform were also collected. The NMR samples were prepared in 2.5 mm NMR tubes at a concentration of approximately 50 mM. All NMR data were collected on an Avance 400 spectrometer system (9.4 T; Bruker, Karlsruhe, Germany) at room temperature, and the chemical shifts were referenced to tetramethylsilane (TMS). The relaxation delay, 90° pulse, spectral width, number of data points, and digital resolution for the ¹H NMR experiments were 1 s, 11.8 μ s, 5,500 Hz, 32 K, and 0.34 Hz/point, respectively. The corresponding parameters for the ¹³C NMR and distortionless enhancement by polarization transfer (DEPT) experiments were 3 s, 15.0 μ s, 21,000 Hz, 64 K, and 0.64 Hz/point, respectively. Two-dimensional experiments, including correlation spectroscopy (COSY), heteronuclear multiple quantum correlation (HMQC), and heteronuclear multiple bond correlation (HMBC), were performed with a data set of 2 K × 256 (t₂ × t₁). The long-range coupling time for the HMBC was 70 ms. The NMR data were processed and analyzed in the same manner as reported.¹⁵

General experimental procedures

To confirm the structures determined by NMR spectroscopy, high-resolution mass spectrometry (HR/MS) was carried out on a ultraperformance liquid chromatography (UPLC)-hybrid quadrupole-time-of-flight mass spectrometer with a Waters Acquity UPLC system (Waters Corp., Milford, MA) with the help of Prof. Choong Hwan Lee at Konkuk University, Korea.¹⁶ All HR/MS data were collected in M^+ mode, except for the data for derivatives **1**, **14**, and **16** that were collected in $[M+H]^+$ mode.

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Results and discussion

Eighteen 5-(naphthalene-1-yl)-3-(2-hydroxyphenyl)pyrazoline derivatives (1-18) were analyzed; the procedure used to assign derivative 16, 5-(2,3-dimethoxynaphthalene-1yl)-3-(2-hydroxy-4,5-dimethoxyphenyl)pyrazoline, is described as a representative. The most deshielded ¹³C peak at 153.4 ppm was long-range coupled to three protons at 3.37, 3.68, and 6.81 ppm. In the HMQC spectrum, two protons with signals at 3.37 and 3.68 ppm were attached to the carbon with a peak at 40.4 ppm, which was determined to be a methylene carbon based on DEPT. Because derivative 16 contains only one methylene carbon, C-py4, the protons were assigned as H-py4. The carbon peak at 153.4 ppm mentioned above was assigned as C-py3. Because the proton with the peak at 6.81 ppm was attached to the carbon with the peak at 111.5 ppm, this proton was assigned as H-6'. Two methylene protons of Hpy4 were correlated with the proton at 5.74 ppm in the COSY spectrum, and were thus determined to be H-py5. Five protons at 7.30, 7.38, 7.39, 7.82, and 8.08 ppm were correlated with each other in the COSY spectrum. These protons were assigned as H-7, H-6, H-4, H-5, and H-8 of the naphthalenyl group, respectively, based on comparison with previously reported chemical shifts.¹⁴ The two carbons with peaks at 126.5 and 131.7 ppm were assigned as C-9 and C-10, respectively, because they were long-range coupled to H-4 and H-8, respectively, in the HMBC analysis. H-8 also showed long-range coupling with the carbon peak at 128.4 ppm; thus the carbon was assigned as C-1. The carbon peak at 147.9 ppm showed long-range coupling with H-4 and was assigned as C-2. Because this carbon was long-range coupled to the methoxy proton at 3.81 ppm, it was assigned as 2-OCH₃. The two carbons with signals at 150.6 and 152.3 ppm were long-range coupled to H-6' in the HMBC profile. They could be assigned as C-4' or/and C-2'. Because the former showed long-range coupling with the methoxy proton at 3.79 ppm, it was assigned as C-4'. Consequently, the latter was C-2' and this methoxy proton was 4'-OCH₃. The two carbon peaks that were deshielded below 100 ppm were not immediately assignable, that is, the signals at 108.0 and 151.3 ppm. Because C-1' of the phenyl ring and C-3 of the naphthalenyl group were not assigned, these peaks could be assigned to C-1' and C-3, respectively. H-3' was assigned based on the long-range coupling with C-1', with a signal at 6.64 ppm. The carbon peak at 141.8 ppm showed long-range coupling with H-3' and was assigned as C-5'. The methoxy proton at 3.68 ppm showed long-range coupling with C-5' and thus should be 5'-OCH₃. The remaining methoxy group could be assigned as 3-OCH₃. The two undetermined proton peaks at 7.73 and 11.17 ppm were assigned to NH and OH, respectively, based on comparison with

the chemical shifts reported previously.¹⁷ The important correlations obtained from the COSY and HMBC spectra are shown in Fig. 2A. The complete assignments of the ¹H and ¹³C NMR data for derivative **16**, 5-(2,3-dimethoxynaphthalene-1-yl)-3-(1-hydroxy-4,5-dimethoxyphenyl)pyrazoline, are listed in Tables 2 and 3, respectively. The NMR data for the other naphthalenylphenylpyrazolines containing the naphthalene-1-yl group were assigned in a similar manner, and the complete assignments of the ¹H and ¹³C NMR data are listed in Tables 2 and 3, respectively.

Of the six derivatives 19-24 with the naphthalen-2-yl group, the procedure used to assign derivative **21**, 5-(naphthalen-2-yl)-3-(2-hydroxy-6-methoxyphenyl)pyrazoline is described as a representative. As in the case of derivative 16, the methylene carbon and proton could be assigned because this compound contains only one methylene group. Seven protons at 7.48, 7.51, 7.57, 7.89, 7.898, 7.904, and 7.92 ppm showing correlations in the COSY spectrum were determined based on comparison of the chemical shifts with those reported previously.¹⁴ The three carbons signals at 132.4, 132.9, 140.1 ppm were assigned to C-10, C-9, and C-2, respectively, based on the long-range coupling with H-1, H-7, and H-4, respectively. Of the two carbons at 106.4 and 140.1 ppm that showed long-range coupling with H-py4, because the latter was assigned as C-2, the former was determined to be C-1'. Given that there is one non-aromatic methine group in this compound, the methine carbon at 62.1 ppm was determined to be C-py5. The carbon with a signal at 151.4 ppm showing longrange coupling with H-py5 (4.96 ppm) was assigned as C-py3. Because this compound contains one methoxy group, the methoxy proton (3.73 ppm) and carbon (55.56 ppm) were determined. The carbon peak at 158.0 ppm showing long-range coupling with the methoxy proton was assigned to C-6'. The three protons with signals at 6.51, 6.54, and 7.16 ppm were correlated with each other in the COSY spectrum and were determined to be H-5', H-3', and H-4', respectively, based on comparison with previously reported chemical shifts.¹⁶ The remaining carbon peak at 158.1 ppm should be C-2'. As with derivative 16, the two protons at 7.83 and 12.19 ppm were assigned as NH and OH, respectively. The important correlations obtained from the COSY and HMBC spectra are shown in Fig. 2B. The complete assignments of the ¹H and ¹³C NMR data for derivative **21**, 5-(naphthalen-2-yl)-3-(2hydroxy-6-methoxyphenyl)pyrazoline, are listed in Tables 2 and 3, respectively. The NMR data for the other naphthalenylphenylpyrazolines containing the naphthalene-2-yl group were assigned, and the complete assignments of the ¹H and ¹³C NMR data are listed in Tables 2 and 3, respectively. To confirm the structures of the twenty-four derivatives determined by

NMR, HR/MS data were obtained and compared with the calculated mass data, which are listed in Table 1. In this study, the NMR data of the eighteen derivatives with the naphthalen-1-yl group (1-18) and the six derivatives with the naphthalen-2-yl group (19-24) were assigned. As might be expected, a remarkable difference between the chemical shifts of the two derivatives was observed for H-py5 and C-py5. The proton chemical shifts of H-py5 for the derivatives with the naphthalen-1-yl group were more deshielded than those of the derivatives with the naphthalen-2-yl group. On the contrary, the carbon chemical shifts of the C-py5 of the derivatives with the naphthalen-1-yl group were more shielded than those of the derivatives with the naphthalen-2-yl group. Derivatives 1-18 contain the naphthalen-1-yl group. While R_1 of the naphthalen-1-yl group in derivatives 1-6 and 13-18 is the methoxy group, R_1 in derivatives 7-12 is proton. While in the derivatives containing the 2methoxynaphthalen-1-yl group (1-6 and 13-18) the difference of the chemical shifts of two py-4 methylene protons is less than 0.4 ppm, in the derivatives without the 2-methoxy group in the naphthalen-1-yl group (7-12) the difference of two py-4 methylene protons is more than 0.8 ppm. Among eighteen derivatives with the naphthalen-1-yl group, derivatives 3, 5, 9, 11, 15 contain the 6'-methoxy group and the others do not have substituents. The chemical shifts of two py-4 methylene protons of 6'-methoxylated derivatives are deshielded more than those of derivatives without the 6'-methoxy group. Therefore, the methoxy groups at 6'position and 2-position influence the chemical shifts of py-4 methylene protons in derivatives 1-18 containing the naphthalen-1-yl group. The ¹H and ¹³C NMR data compiled herein should aid in the identification of naphthalenylphenylpyrazolines. The spectra obtained from the NMR and HR/MS experiments are provided as Supplementary Material.

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Table 1. Structures and names of naphthopyrazolines **1-24**, and their mass data and melting points. All HR/MS data were collected in M^+ mode, except for those with an *, which denotes HR/MS data collected in $[M+H]^+$ mode



deriv	R_1	R_2	R ₃	R_4	R_5	R ₆	mass	name	melting
auve							(calcd./found)		point/ C
1	OCH ₃	Н	Н	Н	Н	Н	319.1447/319.1446*	5-(2-methoxynaphthalene-1-yl)-3-(2- hydroxyphenyl)pyrazoline	160-161
2	OCH ₃	Н	Н	Н	OCH ₃	Н	348.1474/348.1473	5-(2-methoxynaphthalene-1-yl)-3-(2-hydroxy-5- methoxyphenyl)pyrazoline	114
3	OCH ₃	Н	Н	Н	Н	OCH ₃	348.1474/348.1473	5-(2-methoxynaphthalene-1-yl)-3-(2-hydroxy-6- methoxyphenyl)pyrazoline	183-186
4	OCH ₃	Н	Н	OCH ₃	OCH ₃	Н	348.1474/348.1471	5-(2-methoxynaphthalene-1-yl)-3-(2-hydroxy- 4,5-dimethoxyphenyl)pyrazoline	110-113
5	OCH ₃	Н	Н	OCH ₃	Н	OCH ₃	378.1580/378.1578	5-(2-methoxynaphthalene-1-yl)-3-(2-hydroxy- 4,6-dimethoxyphenyl)pyrazoline	180-189

6	OCH ₃	Н	Н	OCH ₃	Н	Н	378.1580/378.1579	5-(2-methoxynaphthalene-1-yl)-3-(2-hydroxy-4- methoxyphenyl)pyrazoline	120
7	Н	Н	OCH ₃	Н	Н	Н	348.1474/348.1474	5-(4-methoxynaphthalene-1-yl)-3-(2- hydroxyphenyl)pyrazoline	149
8	Н	Н	OCH ₃	Н	OCH ₃	Н	318.1368/318.1369	5-(4-methoxynaphthalene-1-yl)-3-(2-hydroxy-5- methoxyphenyl)pyrazoline	146-147
9	Н	Н	OCH ₃	Н	Н	OCH ₃	348.1474/348.1471	5-(4-methoxynaphthalene-1-yl)-3-(2-hydroxy-6- methoxyphenyl)pyrazoline	163-164
10	Н	Н	OCH ₃	OCH ₃	OCH ₃	Н	348.1474/348.1472	5-(4-methoxynaphthalene-1-yl)-3-(2-hydroxy- 4,5-dimethoxyphenyl)pyrazoline	184-189
11	Н	Н	OCH ₃	OCH ₃	Н	OCH ₃	378.1580/378.1584	5-(4-methoxynaphthalene-1-yl)-3-(2-hydroxy- 4,6-dimethoxyphenyl)pyrazoline	184-192
12	Н	Н	OCH ₃	OCH ₃	Н	Н	378.1580/378.1578	5-(4-methoxynaphthalene-1-yl)-3-(2-hydroxy-4- methoxyphenyl)pyrazoline	157
13	OCH ₃	OCH ₃	Н	Н	Н	Н	348.1474/ 348.1476	5-(2,3-dimethoxynaphthalene-1-yl)-3-(2- hydroxyphenyl)pyrazoline	158-159
14	OCH ₃	OCH ₃	Н	Н	OCH ₃	Н	379.1658/ 379.1662*	5-(2,3-dimethoxynaphthalene-1-yl)-3-(2-hydroxy- 5-methoxyphenyl)pyrazoline	100-105
15	OCH ₃	OCH ₃	Н	Н	Н	OCH ₃	378.1580/ 378.1581	5-(2,3-dimethoxynaphthalene-1-yl)-3-(2-hydroxy- 6-methoxyphenyl)pyrazoline	168-172
16	OCH ₃	OCH ₃	Н	OCH ₃	OCH ₃	Н	409.1763/409.1753*	5-(2,3-dimethoxynaphthalene-1-yl)-3-(2-hydroxy- 4,5-dimethoxyphenyl)pyrazoline	130-136
17	OCH ₃	OCH ₃	Н	OCH ₃	Н	OCH ₃	408.1685/ 408.1681	5-(2,3-dimethoxynaphthalene-1-yl)-3-(2-hydroxy- 4,6-dimethoxyphenyl)pyrazoline	150-152
18	OCH ₃	OCH ₃	Н	OCH ₃	Н	Н	378.1580/ 378.1581	5-(2,3-dimethoxynaphthalene-1-yl)-3-(2-hydroxy- 4-methoxyphenyl)pyrazoline	126-127





derivative	R ₁	R ₂	R ₃	Mass (calcd./found)	Name	Melting point/ $^{\circ}\!\!C$
19	Н	Н	Н	288.1263/ 288.1265	5-(naphthalen-2-yl)-3-(2-hydroxyphenyl)pyrazoline	158-162
20	Н	OCH ₃	Н	318/1368/ 318.1369	5-(naphthalen-2-yl)-3-(2-hydroxy-5-methoxyphenyl)pyrazoline	120
21	Н	Н	OCH ₃	318.1368/ 318.1366	5-(naphthalen-2-yl)-3-(2-hydroxy-6-methoxyphenyl)pyrazoline	112-117
22	OCH ₃	OCH ₃	Н	348.1474/ 348.1473	5-(naphthalen-2-yl)-3-(2-hydroxy-4,5-dimethoxyphenyl)pyrazoline	126-130
23	OCH ₃	Н	OCH ₃	348.1474/ 348.1475	5-(naphthalen-2-yl)-3-(2-hydroxy-4,6-dimethoxyphenyl)pyrazoline	170-172
24	OCH ₃	Н	Н	318.1368/ 318.1366	5-(naphthalen-2-yl)-3-(2-hydroxy-4-methoxyphenyl)pyrazoline	114

Position	1	2	3	4	5	6	7	8
NH	-	7.81(br s)	-	7.57(br s)	-	-	7.90(d, 3.4)	7.90(d, 3.4)
	3.60(dd, 17.0,	3.62(dd, 17.0,	2 72/44 19 0	3.61(dd, 17.0,	3.682(dd, 17.9,	3.56(dd, 16.9,	3.852(dd, 16.5,	3.86(dd, 16.7,
H py/	13.0)	12.9)	5.72(aa, 18.0, 12.7)	12.6)	12.6)	12.7)	11.0)	11.1)
11-py4	3.31(dd, 17.0,	3.32(dd, 17.0,	12.7	3.30(dd, 17.0,	3.38(dd, 17.9,	3.27(dd, 16.9,	2.93(dd, 16.5,	2.95(dd, 16.7,
	12.1)	12.4)	5.45(uu,18.0, 12.7)	12.6)	12.6)	12.2)	10.4)	10.3)
H-ny5	5.87(dd, 13.0,	5.88(dd, 12.4,	5.80(dd, 12.7,	5 82(dd 12 6, 12 6)	5.76(ddd, 17.9,	5.82(dd, 12.7,	5.50(ddd, 11.0,	5.51(ddd, 11.1,
пруз	12.1)	12.9)	12.7)	5.02(dd,12.0, 12.0)	12.6, 5.5)	12.2)	10.4, 3.4)	10.3, 3.4)
H2	-	-	-	-	-	-	7.60(d, 8.2)	7.60(d, 8.2)
H3	7.45(d, 9.1)	7.46(d, 9.0)	7.44(d, 9.1)	7.45(d, 9.1)	7.44(d, 9.3)	7.45(d, 9.1)	6.95(d, 8.2)	6.95(d, 8.2)
H4	7.92(d, 9.1)	7.92(d, 9.0)	7.91(d, 9.1)	7.92(d, 9.1)	7.90(d, 9.3)	7.92(d, 9.1)	-	-
H5	7.89(dd, 8.0, 1.6)	7.89(dd, 8.1, 1.5)	7.88(dd, 8.0, 1.3)	7.89(dd, 8.1, 1.3)	7.88(dd, 8.0, 1.4)	7.88(dd, 7.9, 1.4)	8.23(dd, 8.3, 1.4)	8.23(dd, 8.2, 1.4)
H6	7.34(ddd, 8.0, 6.9,	7.35(ddd, 8.1, 6.8,	7.34(ddd, 8.0, 6.8,	7.34(ddd, 8.1, 6.8,	7.34(ddd, 8.0, 6.8,	7.35(ddd, 7.9, 6.8,	7.54(ddd, 8.3, 6.9,	7.55(ddd, 8.2, 6.8,
110	1.0)	1.0)	0.8)	1.2)	1.2)	1.0)	1.0)	1.0)
	7 43(ddd 8 6 6 9	7 42(ddd 8 5 6 8	7 43(ddd 8 2 6 8	7 42(ddd 8 5 6 8	7 42(ddd 8668	7 41(ddd 8 6 6 8	7.61(ddd 8.2.6.9	7 61(ddd 8 3 6 8
H7	1.6)	1.5)	1.3)	1.3)	1.4)	1.4)	1.4)	1.4)
	110)	1.0)	1.0)	1.0)		1)	11.1)	
H8	8.10(d, 8.6)	8.11(dd, 8.5, 1.0)	8.17(d, 8.2)	8.15(dd, 8.5, 1.2)	8.17(dd, 8.6, 1.2)	8.11(dd, 8.6, 1.0)	8.12(dd, 8.2, 1.0)	8.12(dd, 8.3, 1.0)
H3'	6.96(dd, 8.1, 1.1)	6.89(d, 8.8)	6.57(d, 8.3)	6.62(s)	6.17(d, 2.4)	6.54(d, 2.6)	6.92(dd, 8.1, 1.0)	6.84(d, 7.2)
H4'	7.25(ddd, 8.1, 7.5, 1.5)	6.85(dd, 8.8, 2.5)	7.17(dd, 8.3, 8.1)	-	-	-	7.22(ddd, 8.1, 7.3, 1.5)	6.82(dd, 7.2, 2.5)
H5'	6.89(ddd, 7.5, 7.5, 1.1)	-	6.51(d, 8.1)	-	6.09(d, 2.4)	6.48(dd, 8.6, 2.6)	6.85(ddd, 7.7, 7.3, 1.0)	-
H6'	7.27(dd, 7.5, 1.5)	6.82(d, 2.5)	-	6.80(s)	-	7.18(d, 8.6)	7.27(dd, 7.7, 1.5)	6.80(d, 2.5)
2-OCH ₃	3.88(s)	3.89(s)	3.88(s)	3.90(s)	3.88(s)	3.88(s)	-	-
4-0CH ₃	-	-	-	-	-	-	3.95(s)	3.96(s)
4'-OCH ₃	-	-	-	3.78(s)	3.67(s)	3.77(s)	-	-
5'-OCH ₃	-	3.69(s)	-	3.67(s)	-	-	-	3.67(s)
6'-OCH ₃	-	-	3.69(s)		3.76(s)	-	-	-
2'-OH	11.36(s)	10.87(s)	12.38(s)	12.38(s)	12.67(s)	-	11.26(s)	10.42(s)

 Table 2. ¹H NMR chemical shifts of naphthopyrazolines 1–24. Py denotes pyrazoline. Multiplicities d, s, and br s denote doublet, singlet, and broad singlet, respectively

Position	9	10	11	12	13	14	15	16
NH	7.74(d, 3.5)	7.65(d, 3.6)	7.53(d, 3.7)	7.67(d, 3.8)	-	7.96(br s)	7.76(d, 4.7)	7.73(s)
H-pv4	3.92.(dd, 17.5, 10.9)	3.84(dd, 16.6, 10.9)	3.88(dd, 17.5, 10.8)	3.81(dd, 16.6, 10.9)	3.68(dd, 17.0, 12.7)	3.65(dd, 17.0, 12.4)	3.76(dd, 18.0, 12.7)	3.68(dd, 17. 12.5)
	3.06(dd, 17.4, 10.1)	2.92(dd, 16.6, 10.2)	3.01(dd, 17.5, 10.2)	2.88(dd, 16.6, 10.4)	3.35(dd, 17.0, 12.7)	3.38(dd, 17.0, 12.4)	3.49(dd, 18.0, 12.7)	3.37(dd, 17. 12.5)
Н-ру5	5.44(ddd, 10.9, 10.1, 3.5)	5.46(ddd, 10.9, 10.2, 3.6)	5.39(ddd, 10.8, 10.2, 3.7)	5.45(ddd, 10.9, 10.4, 3.8)	5.77(ddd, 17.0, 12.7, 12.7)	5.79(dd, 12.4, 12.4)	5.70(ddd, 18.0, 12.7, 4.7)	5.74(dd, 12. 12.5)
H2	7.58(d, 8.0)	7.60(d, 8.1)	7.58(d, 8.1)	7.60(d, 8.1)	-	-	-	-
H3	6.95(d, 8.0)	6.95(d, 8.1)	6.94(d, 8.1)	6.95(d, 8.1)	-	-	-	-
H4	-	-	-	-	7.40(s)	7.40(s)	7.39(s)	7.39(s)
Н5	8.22(dd, 8.2, 1.4) 8.23(dd, 8.2		8.22(dd, 8.0, 1.3)	8.22(dd, 8.3, 1.4)	7.83(dd, 8.2, 1.2) 7.83(dd, 8.4, 1.0)		7.82(dd, 8.1, 1.4)	7.82(dd, 8.4, 1
H6	7.53(ddd, 8.2, 6.8, 7.54(ddd, 8.2, 6.8 1.2) 1.2)		7.53(ddd, 8.4, 6.8, 1.2)	7.54(ddd, 8.3, 7.2, 1.0)	7.382(ddd, 8.2, 6.9,1.2)	7.382(ddd, 8.2, 6.9, 1.2)7.389(ddd, 8.4, 6.8, 1.0)		7.38(ddd, 8.4, 1.0)
H7	7.60(ddd, 8.4, 6.8, 1.4)	7.61(ddd, 8.3, 6.8, 1.3)	7.59(ddd, 8.4, 6.8, 1.3)	7.59(ddd, 8.3, 7.2, 1.4)	7.29(ddd, 8.4, 6.9, 1.2)	7.30(ddd, 8.5, 6.8, 1.0)	7.31(ddd, 8.4, 6.9, 1.4)	7.30(ddd, 8.5, 1.2)
H8	8.11(d, 8.4)	8.13(d, 8.3)	8.11(d, 8.4)	8.12(dd, 8.3, 1.0)	8.03(dd, 8.4, 1.2)	8.03(dd, 8.5, 1.0)	8.10(dd, 8.4, 1.2)	8.08(dd, 8.5,
H3'	6.54(dd, 8.2, 0.8)	6.58(s)	6.14(d, 2.4)	6.50(d, 2.5)	6.96(dd, 8.2, 1.0)	6.90(d, 8.7)	6.57(dd, 8.3, 1.0)	6.64(s)
H4'	7.14(dd, 8.3, 8.2)	-	-	-	7.25(ddd, 8.2, 7.5, 1.6)	6.86(dd, 8.7, 2.7)	7.18(dd, 8.3, 8.3)	-
H5'	6.48(dd, 8.3, 0.8)	-	6.07(d, 2.4)	6.45(dd, 8.6, 2.5)	6.89(ddd, 7.6, 7.5, 1.0)	-	6.51(dd, 8.3, 1.0)	-
H6'		6.79(s)	-	7.19(d, 8.6)	7.28(dd, 7.6, 1.6)	6.83(d, 2.7)	-	6.81(s)
2-OCH ₃	-	-	-	-	3.79(s)	3.81(s)	3.79(s)	3.81(s)
3-OCH ₃	-	-		-	3.94(s)	3.94(s)	3.94(s)	3.94(s)
4-OCH ₃	3.95(s)	3.96(s)	3.95(s)	3.95(s)	-	-	-	-
4'-OCH ₃	-	3.76(s)	3.66(s)	3.74(s)	-	-	-	3.79(s)
5'-OCH ₃	-	3.66(s)	-	-	-	3.69(s)	-	3.68(s)
	3.68(s)	-	3.74(s)	-	-	-	3.69(s)	-

Position	17	18	19	20	21	22	23	24
NH	7.56(d, 5.4)	7.73(br s)	7.97(d, 3.6)	7.97(d, 3.0)	7.83(d, 3.6)	7.74(d, 3.8)	7.62(d, 4.0)	7.75(d, 3.8
	3.72(dd, 18.0,	3.63(dd, 16.9,	3.71(dd, 16.6,	3.70(dd, 16.8,	3.82(dd, 17.5,	3.70(dd, 16.6,	3.79(dd, 17.6,	3.66(dd, 16
H-nv4	13.0)	12.4)	10.8)	10.8)	10.9)	10.7)	10.9)	10.6)
II py i	3.44(dd, 18.0,	3.31(dd, 16.9,	3.10(dd, 16.6,	3.11(dd, 16.8,	3.18(dd, 17.5,	3.09(dd, 16.6,	3.12(dd, 17.6,	3.05(dd, 16
	13.0)	12.4)	10.8)	10.8)	10.9)	10.7)	10.9)	10.6)
H-ny5	5 65(ddd 18.0	5 72(dd 12 4	5 04(ddd 10 8	5.05(dd 10.8	4 96(ddd 10 9	4 99(ddd 10 7	4 91(ddd 10 9	4 98(ddd 1
п-руз	13.0. 5.4)	12.4)	10.8, 3.6)	10.8)	10.9. 3.6)	10.7. 3.8)	10.9.4.0)	10.6.3.8
H1	-	-	7.91(d, 1.7)	7.90(d, 1.6)	7.89(d, 1.6)	7.89(d, 1.6)	7.85(d, 1.6)	7.905(d, 1
H2		-	-	-	-	-	-	-
H3	-	-	7.57(dd, 8.5, 1.7)	7.570(dd, 8.5, 1.6)	7.57(dd, 8.5, 1.6)	7.57(dd, 8.4, 1.6)	7.56(dd, 8.5, 1.6)	7.56(dd, 8.5,
H4	7.38(s)	7.39(s)	7.93(d, 8.5)	7.93(d, 8.5)	7.92(d, 8.5)	7.92(d, 8.4)	7.91(d, 8.5)	7.93(d, 8.
H5	7.82(dd, 8.1, 1.3)	7.82(dd, 8.1, 1.2)	7.904(d, 8.3)	7.90(d, 9.2)	7.904(dd, 8.3, 1.6)	7.90(d, 8.4)	7.89(d, 8.4)	7.90(d, 8.
H6	7.38(ddd, 8.1, 6.9, 1.0)	7.38(ddd, 8.1, 6.9, 1.1)	7.49(ddd, 8.3, 6.8, 1.6)	7.49(ddd, 9.2, 7.2, 2.0)	7.48(ddd, 8.3, 6.8, 1.6)	7.49(ddd, 8.4, 6.9, 1.6)	7.48(ddd, 8.6, 6.8, 1.7)	7.49(ddd, 8.6 1.7)
H7	7.30(ddd, 8.5, 6.9, 1.3)	7.28(ddd, 8.3, 6.9, 1.2)	7.52(ddd, 8.3, 6.8, 1.6)	7.55(ddd, 9.2, 7.2, 2.0)	7.51(ddd, 8.3, 6.8, 1.6)	7.52(ddd, 8.4, 6.9, 1.6)	7.51(ddd, 8.4, 6.8, 1.7)	7.51(ddd, 8.6 1.7)
H8	8.09(d, 8.5)	8.04(dd, 8.3, 1.1)	7.908(dd, 8.3, 1.6)	7.90(dd, 9.2, 2.0)	7.898(dd, 8.3, 1.6)	7.905(dd, 8.4, 1.6)	7.89(dd, 8.6, 1.7)	7.90(dd, 8.6
H3'	6.17(d, 2.4)	6.55(d, 2.5)	6.93(dd, 8.6, 1.1)	6.87(d, 9.0)	6.54(dd, 8.2, 0.5)	6.53(s)	6.14(d, 2.4)	6.51(d, 2.
H4'	-	-	7.24(ddd, 8.6, 7.5, 1.6)	6.86(dd, 9.0, 1.1)	7.16(dd, 8.2, 8.2)	-	-	-
H5'	6.09(d, 2.4)	6.48(dd, 8.6, 2.5)	6.89(ddd, 7.7, 7.5, 1.1)	-	6.51(dd, 8.2, 0.5)	-	6.09(d, 2.4)	6.48(dd, 8.4
H6'	-	7.19(d, 8.6)	7.32(dd, 7.7, 1.6)	6.85(d, 1.1)	-	6.84(s)	-	7.23(d, 8.
2-OCH ₃	3.78(s)	3.79(s)	-	-	_	-	-	-
3-OCH ₃	3.93(s)	3.93(s)	-	-	-	-	-	-
4-OCH ₃	-	-	-	-	-	-	-	-
4'-OCH ₃	3.67(s)	3.76(s)	-	-	-	3.77(s)	3.72(s)	3.75(s)
5'-OCH ₃	-	-	-	3.70(s)	_	3.70(s)		-
6'-OCH ₃	3.77(s)		-	-	3.73(s)	-	3.75(s)	-
2'-OH	12.64(s)	11.52(s)	11.20(s)	10.73(s)	12.19(s)	11.05(s)	12.48(s)	11.40(s)

Position	1	2	3	4	5	6	7	8	9	10	11	12
C-py3	152.8	150.8	151.8	152.2	152.5	154.9	152.5	152.2	151.3	152.2	151.9	153.0
C-py4	39.2	39.3	43.4	39.7	43.4	39.3	40.6	40.7	44.8	41.1	44.7	40.8
C-py5	56.9	56.8	56.9	56.9	56.9	56.8	58.8	58.8	58.5	58.4	58.3	58.5
C1	121.2	121.2	121.5	121.3	121.6	121.2	129.5	129.6	129.8	129.8	129.9	129.6
C2	155.4	155.4	155.4	153.4	155.3	155.4	123.6	123.6	123.5	123.6	123.6	123.6
C3	114.2	114.1	114.1	114.1	114.1	114.1	103.7	103.7	103.8	103.7	103.8	103.7
C4	126.1	126.1	125.9	125.9	125.9	126.0	154.3	154.3	154.2	154.2	154.2	154.2
C5	128.9	128.9	128.9	128.9	128.8	128.9	122.2	122.1	122.2	122.1	122.2	122.1
C6	123.4	123.3	123.3	123.3	123.3	123.3	125.2	125.2	125.1	125.1	125.1	125.2
C7	129.6	129.8	130.0	129.7	129.6	129.7	126.7	126.7	126.7	126.7	126.7	126.7
C8	123.9	123.9	124.1	124.2	124.2	124.0	123.6	123.5	123.5	123.5	123.5	123.6
C9	132.9	131.9	131.9	131.9	131.9	131.9	131.4	131.3	131.3	131.4	131.4	131.4
C10	129.4	129.4	129.6	129.5	129.5	129.4	125.3	125.3	125.3	125.3	125.3	125.3
C1'	115.8	117.1	106.6	108.1	100.1	110.3	116.9	117.0	106.5	108.0	100.1	110.3
C2'	156.9	152.5	158.8	155.3	160.3	160.7	156.8	150.8	158.6	153.0	160.2	160.7
C3'	117.0	112.3	109.3	100.5	94.0	101.0	115.7	115.9	109.2	100.4	93.9	101.0
C4'	129.7	116.3	129.5	150.5	161.2	158.6	129.7	116.3	130.0	150.4	161.1	158.5
C5'	119.2	152.0	102.2	141.7	90.5	105.7	119.2	152.0	102.2	141.7	90.5	105.7
C6'	127.8	115.6	158.0	111.5	159.0	128.8	127.8	112.0	157.9	111.3	158.9	128.8
2-OCH ₃	53.1	53.3	53.0	53.0	52.8	52.8	-	-	-	_	-	-
4-OCH ₃	-	-	-	-	-	-	55.6	55.6	55.6	55.6	55.6	55.6
4'-OCH ₃	-	-	_	55.6	55.3	55.3	-	-	-	55.5	55.2	55.2
5'-OCH ₃	-	55.5	_	56.3	_	-	_	55.5	_	56.3	-	_
6'-OCH ₂	_	T	55.6		55.6	_	-	_	55.7		55.7	_

Table 3. ¹³C NMR chemical shifts of naphthopyrazolines 1–24. Py denotes pyrazoline

Position	13	14	15	16	17	18	19	20	21	22	23	24
С-ру3	152.0	152.0	151.8	153.4	152.4	152.0	152.6	152.4	151.4	153.2	152.0	153.1
C-py4	40.6	40.1	44.1	40.4	44.1	40.1	40.9	41.0	45.3	41.3	45.2	41.1
C-py5	54.3	54.0	53.7	53.7	53.5	53.6	62.2	62.3	62.1	62.1	61.9	62.0
C1	128.6	128.3	128.7	128.4	128.7	128.4	125.1	125.1	125.1	125.2	125.1	125.3
C2	148.6	148.0	148.0	147.9	147.9	147.9	139.8	139.8	140.1	141.7	140.2	139.9
C3	151.6	151.4	151.4	151.3	151.3	151.3	125.2	125.2	125.1	125.2	125.1	125.2
C4	108.4	107.7	107.7	107.6	107.5	107.6	128.3	128.2	128.2	128.2	128.2	128.2
C5	127.0	127.7	127.7	127.7	127.6	127.6	127.6	127.6	127.6	127.6	127.6	127.6
C6	124.7	125.0	125.0	125.0	124.9	125.0	125.9	125.9	125.8	125.9	125.8	125.9
C7	122.4	123.6	123.5	123.5	123.4	123.5	126.3	126.3	126.3	126.3	126.3	126.3
C8	124.3	124.4	124.5	124.6	124.5	124.4	127.7	127.7	127.7	127.7	127.7	127.7
C9	125.8	126.5	126.5	126.5	126.5	126.5	132.9	132.9	132.9	132.9	132.9	132.9
C10	132.3	131.8	131.7	131.7	131.7	131.7	132.4	132.4	132.4	132.4	132.4	132.4
C1'	117.3	117.0	106.5	108.0	100.1	110.2	116.8	116.9	106.4	111.4	100.0	110.2
C2'	157.3	152.6	158.8	152.3	160.3	158.6	156.8	152.0	158.7	155.6	160.2	158.5
C3'	116.5	115.7	109.3	100.5	94.0	101.0	115.8	112.2	109.3	100.5	93.9	101.0
C4'	130.7	116.4	130.1	150.6	161.2	160.8	129.8	116.4	130.1	152.3	161.2	160.8
C5'	118.4	150.9	102.2	141.8	90.5	105.8	119.2	150.8	102.2	150.6	90.5	105.8
C6'	128.4	112.3	158.0	111.5	159.0	128.9	127.8	115.8	158.0	107.9	159.0	128.9
2-OCH ₃	61.8	61.2	61.1	61.2	61.1	61.1	-	-	-	-	-	-
3-OCH ₃	56.3	55.6	55.6	55.6	55.6	55.6	-	-	-	-	-	-
4'-OCH ₃	-		-	55.6	55.2	55.3	-	-	-	55.6	55.7	55.3
5'-OCH ₃	-	55.5	-	56.3	-	_	-	55.5	-	56.3	-	-
6'-OCH ₃	-	-	55.6	-	55.6	-	-	-	55.7	-	55.2	_

Figure 1.



Figure 1. Structures of pyrazolines containing (A) 1,3-diphenyl, (B) 3,5-difuranyl, (C) 1,3,5-triphenyl, and (D) both 3-phenyl and 5-naphthalenyl groups.

Accept

Figure 2.



< (B)



Figure 2. Important correlations obtained from the COSY (dot lines) and HMBC (solid lines) spectra of (A) derivatives **16** and (B) **21**.

Acce

Scheme 1.



Scheme 1. Procedure for the preparation of 5-(naphthalene-1-yl)-3-(2-

hydroxyphenyl)pyrazolines 1–18 and 5-(naphthalene-2-yl)-3-(2-

hydroxyphenyl)pyrazolines 19–24.

Acce