Synthesis and spectroscopic properties of benzo- and naphthofuryl-3-hydroxychromones

Andrey S. Klymchenko, Turan Ozturk, Vasyl G. Pivovarenko, and Alexander P. Demchenko

Abstract: With the focus of designing new fluorescent probes, four new 3-hydroxy-chromone derivatives bearing benzofuran and naphthofuran groups were synthesized. They show bathochromic absorption shifts relative to 3-hydroxyflavone with the ability of retention to display the excited-state proton transfer. Disruption of the planarity by the methyl group in the furan ring leads to a decrease of both the extinction coefficient and the contribution of long wavelength absorption band, while molecules without a methyl group showed two distinct absorption bands. Shifts to longer wavelengths are also observed in fluorescent spectra, and the absence of the methyl group results in a dramatic increase of fluorescence quantum yield and lifetime. Of the extended 3-hydroxychromone derivatives, 3-hydroxy-2-naphtho[2,1-*b*]furan-2-yl-chromone has shown comparable, and in some cases better, absorption and fluorescence properties than the 3-hydroxychromones synthesized so far, which make it a highly promising candidate as molecular probe for analytical chemistry, biophysics, and cellular biology.

Key words: benzo- and naphthofuryl-3-hydroxyflavone, synthesis, electronic spectra, fluorescence, excited state proton transfer.

Résumé : Dans le but de développer de nouvelles sondes fluorescentes, on a synthétisé quatre nouveaux dérivés de la 3-hydroxychromone portant des groupes benzofurane et naphtofurane. Par rapport à la 3-hydroxyflavone, ils présentent des déplacements bathochromes d'absorption tout en conservant leur habilité à donner lieu à un transfert de proton dans l'état excité. La présence du groupe méthyle dans le noyau furane conduit à un manque de planéité qui provoque une diminution du coefficient d'extinction ainsi que de la contribution de la bande d'absorption de grande longueur d'onde alors que les molécules sans groupe méthyle présentent deux bandes d'absorption distinctes. On observe aussi des déplacements vers les longueurs d'onde plus élevées dans les spectres de fluorescence et l'absence du groupe méthyle conduit à une augmentation dramatique du rendement quantique de fluorescence et du temps de vie. Parmi les dérivés de la 3-hydroxychromone allongés, il a été démontré que, comparées à celles des 3-hydroxychromones synthétisés jusqu'à maintenant, l'absorption et les propriétés de fluorescence de la 3-hydroxy-2-naphto[2,1-*b*]furan-2-ylchromone sont au moins comparables et, quelquefois meilleures; il s'agit donc d'un candidat plein de promesses comme sonde moléculaire pour la chimie analytique, la biophysique et la biologie cellulaire.

Mots clés : benzo- et naphtofuryl-3-hydroxyflavone, synthèse, spectres électroniques, fluorescence, transfert de proton dans l'état excité.

Introduction

3-Hydroxyflavones (**1a**–**d**) have interesting specific spectroscopic properties, which make them important chromophores for the preparation of new fluorescence probes and molecular sensing devices for applications in analytical chemistry, biophysics, and cellular biology (1, 2). They exhibit dual fluorescence due to excited state intramolecular proton transfer (ESIPT) from the 3-hydroxy moiety to the carbonyl group. The latter is characterized by a significant Stokes shift of about 10 000 cm^{-1} (3). This results in the isomerization of the normal excited form of the flavonol to a phototautomer. These two excited isomers return to the ground state with the emission of photons of different energies separated by 5000–6000 cm^{-1} (60–80 nm). The positions and the ratio of intensities of these two bands exhibit strong dependence on solvent polarity (4) and hydrogen bonding with the solvent molecules (2, 4, 5). These particular features suggest that 3-hydroxyflavones can be effectively used as fluorescence probes to investigate the structure and physical properties of biological membranes such as polarity, hydration, transmembrane potential, and the transformations of their structure under various conditions (6, 7). For example, interdigitated gel phase formation of lipid membrane bilayer in the presence of alcohols (8, 9) can be followed by 3-hydroxyflavone probes (10).

So far, 4-amino derivatives of 3-hydroxyflavone (**1a**–**d**) have been widely investigated as fluorescent membrane probes and fluorescent chelators (11, 12). However, most modifications of the structure were focused on extensions of 3-hydroxyflavone system at the chromone fragment, while extensions of phenyl side have not been extensively explored.

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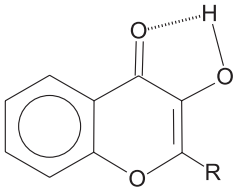

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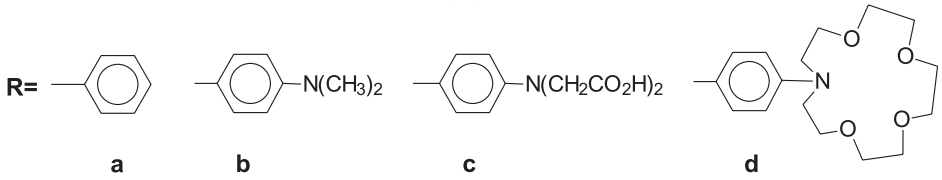

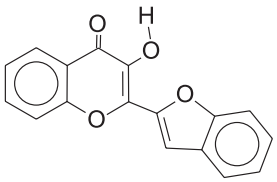

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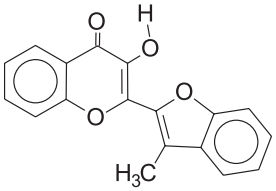

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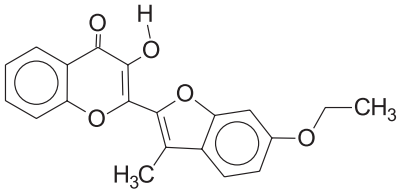

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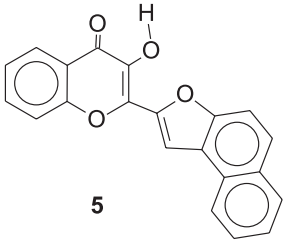

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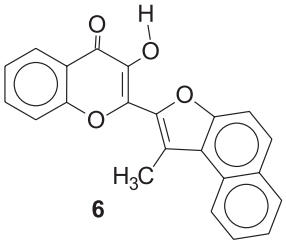

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To modify and improve the chromophore properties, we have synthesized four new chromones bearing benzofuran (**3** and **4**) and naphtofuran groups (**5** and **6**). It is expected that such systems may display improved fluorescent properties due to the following reasons: (*i*) their conjugation systems are larger than 3-hydroxyflavone, therefore, absorption and emission bands are expected to shift to longer wavelengths; (*ii*) furan oxygen might compete for the 3-hydroxy group's proton, which should increase the sensitivity of the molecule to hydrogen bonding interactions with the surrounding molecules; (*iii*) the presence of methyl group in the furan ring should lead to a decrease of planar structure stability, which is a crucial factor for fluorescence properties; and (*iv*) the furan ring is a π-electron-abundant system, and it is known that an electron donor in position two of the chromone ring increases the transfer of electron density to the carbonyl group in the excited state, which usually leads to the enhancement of the proton transfer and stabilizes the proton transferred tautomeric form. Furthermore, having shifted the absorption and emission bands to longer wavelengths, such heterocyclic systems are expected to serve better in biological systems, since most cells respond poorly to short wavelength excitation (13), and intrinsic cellular pigments interfere with the analysis. Therefore, it is highly desirable to locate the emission peaks in a region where background fluorescence (auto-fluorescence) from cellular pigments is very low. It is, also, well known that longer wavelength light is much less attenuated, and reduced Raleigh and Raman scattering with longer wavelength would yield much lower background signal. Obviously, having extended conjugation systems would be advantagous to reach these goals.

Although all the chromones (**2**–**6**) have shown absorption and fluorescence spectra at longer wavelengths compared with the 3-hydroxyflavone (**1a**), naphthofurylhydroxychromone **5** exhibits superior properties of both higher quantum yields and relatively longer wavelength absorption and fluorescence spectra. These properties make it one of the best fluorescence probe candidates among the 3-hydroxychromones synthesized so far.

Experimental

Melting points were determined on a Kofler hostage microscope melting point apparatus and are uncorrected. Microanalyses were performed with a Carlo Erba 1106 Elemental Analyzer. Proton NMR spectra were recorded at 200 MHz on JEOL PMX 270 MHz spectrometer. Tetramethylsilane (TMS) was used as the internal standard in all NMR spectra run in $CDCl_3$ or DMSO-d_6. Mass spectra were recorded on a Kratos MS-25 mass spectrometer with an ionization potential of 70 eV. All column chromatography were performed on silica gel (Merck, Kieselgel 60H, Art 7736). Absorption spectra were recorded on a Cary 3 Bio-spectrophotometer (Varian) in the concentration range of 10^{-5} M. Fluorescence measurements were recorded on a Quanta Master spectrofluorometer (Photon Technology International). Quantum yields were measured by reference to 3-hydroxyflavone (ϕ_F = 0.046 in acetonitrile, 0.024 in ethanol, 0.29 in toluene). Fluorescence lifetimes with ≈0.5 ns resolution were recorded on Strobe Master time-resolved fluorometer (Photon Technology International), which has nitrogen-filled pulsed lump as a light source (excitation

380 nm) and stroboscopic principle for registration of emission decay curves.

3-Hydroxy-2-(benzo[*b*]furan-2-yl)chromone (**2**) was synthesized using the procedure described elsewhere (15).

3-Hydroxy-2-(3-methylbenzo[*b*]furan-2-yl)chromone (3)

To a solution of 3-methylbenzo[*b*]furan-2-carbaldehyde (**9**) (0.1 g, 0.63 mmol) and 2-hydroxyacetophenone (**7**) (0.085 mL, 0.71 mmol) in ethanol (5 mL) was added 70% potassium hydroxide (0.11 g, 2 mmol) dropwise. The mixture was left stirring at room temp for 24 h, and to the resultant red (*E*)-1-(2-hydroxyphenyl)-3-(3-methylbenzo[*b*]furan-2-yl)-2- propen-1-one (**14**) solution was added 30% hydrogen peroxide (0.5 mL, 4.4 mmol). After stirring for an additional 2 h, the precipitate was filtered, washed with ethanol (5 mL), and crystallized from ethanol to obtain **2** (40 mg, 22%), mp 172°C. EI-MS *m*/*z*: 292.1 (M^+), 275.0, 263.1, 249.0, 235.1, 221.0, 171.0, 144.0, 121.0, 115.0. ^{1}H NMR (200 MHz, $CDCl_3$) δ: 2.58 (s, 3H), 6.90 (s, 1H, H-exchangeable), 7.29–7.78 (m, 7H), 8.28 (dd, *J* = 8.0, 1.3 Hz, 1H). Anal. calcd. for $C_{18}H_{12}O_4$: C 73.97, H 4.14; found: C: 73.75, H: 4.14.

General procedure for synthesis of 1-(2-hydroxyphenyl)-2-propen-1-one derivatives

To a solution of appropriate benzo- or naphtho[*b*]furan-2-carbaldehyde (0.57 mmol) and 2-hydroxyacetophenone (**7**) (0.07 mL, 0.58 mmol) in ethanol (5 mL) was added 70% potassium hydroxide (0.07 g, 1.25 mmol) dropwise, and the mixture was left stirring for 24 h. In the case of the naphtho-derivatives, the mixture was heated in water bath at 50°C for the same time. Then, the mixture was poured into water (20 mL), neutralized with dilute HCl, and the resultant precipitate was filtered and washed with water to yield the product, which is pure enough to use for the next step.

*(*E*)-3-(6-Ethoxy-3-methylbenzo[*b*]furan-2-yl)-1-(2-hydroxyphenyl)-2-propen-1-one (**15**)*

Purified over silica gel column (hexane–ethyl acetate, 5:1), yield 49%, mp 106°C. EI-MS *m*/*z*: 322.1 (M^+), 305.1, 276.1, 265.1, 229.1, 202.1, 189.1, 174.1, 161.0, 147.0, 133.0, 121.0. ^{1}H NMR (200 MHz, $CDCl_3$) δ: 1.48 (t, *J* = 7.1 Hz, 3H), 2.41 (s, 3H), 4.11 (q, *J* = 7.1 Hz, 2H) 6.87–7.05 (m, 4H), 7.41–7.55 (m, 4H), 7.65 (d, *J* = 14.8 Hz, 1H), 7.89 (d, *J* = 14.8 Hz, 1H), 8.00 (dd, *J* = 8.0, 1.1 Hz, 1H), 13.05 (s, 1H, H-exchangeable). Anal. calcd. for $C_{20}H_{18}O_4$: C 74.52, H 5.63; found: C 73.8, H 5.56.

*(*E*)-1-(2-Hydroxyphenyl)-3-naphtho[2,1-*b*]furan-2-yl-2-propen-1-one (**16**)*

Crystallized from acetonitrile, yield 95%, mp 198°C. EI-MS *m*/*z*: 314.1 (M^+), 297.1, 285.1, 257.1, 239.1, 221.0, 194.1, 181.1, 165.1. ^{1}H NMR (200 MHz, $CDCl_3$) δ: 6.99 (d, *J* = 15.9 Hz, 1H), 7.03 (d, *J* = 15.9 Hz, 1H), 7.30–8.18 (m, 10H,), 8.15 (d, *J* = 8.0 Hz, 1H), 12.91 (s, 1H, H-exchangeable). Anal. calcd. for $C_{21}H_{14}O_3$: C 80.24, H 4.49; found: C 80.03, H 4.44.

*(*E*)-1-(2-Hydroxyphenyl)-3-(1-methylnaphto[2,1-*b*]furan-2-yl)-2-propen-1-one (**17**)*

Crystallized from butanol, yield 64%, mp 174°C. EI-MS *m*/*z*: 328.1 (M^+), 310.1, 235.1, 208.1, 195.1, 178.1, 121.0. ^{1}H NMR (200 MHz, $CDCl_3$) δ: 2.83 (s, 3H) 6.98 (d, *J* = 15.9 Hz, 1H), 7.02 (d, *J* = 15.9 Hz, 1H), 7.48–8.07 (m, 9H), 8.40 (d, *J* = 8.1 Hz, 1H), 13.03 (s, 1H, H-exchangeable). Anal. calcd. for $C_{22}H_{16}O_3$: C 80.47, H 4.91; found: C 80.30, H 4.87.

General procedure for synthesis of 3-hydroxychromone derivatives

To a solution of appropriate 1-(2-hydroxyphenyl)-2-propen-1-one derivative (**15**–**17**) (0.22 mmol) in ethanol (5 mL) was added subsequently 70% potassium hydroxide (0.1 g, 1.8 mmol) and 30% hydrogen peroxide (0.4 mL, 3.5 mmol). The mixture was then heated at reflux for 1 h, cooled to room temp, and the precipitate was filtered, washed with water, and crystallized from appropriate solvent.

*2-(6-Ethoxy-3-methylbenzo[*b*]furan-2-yl)-3-hydroxychromone (**4**)*

Crystallized from acetonitrile, yield 31%, mp 186°C. EI-MS *m*/*z*: 336.1 (M^+), 307.1, 265.1, 251.1, 237.1, 223.1, 187.1, 165.1, 160.1, 154.1, 140.1, 131.1, 121.0, 77.0. ^{1}H NMR (200 MHz, $CDCl_3$) δ: 1.46 (t, *J* = 7.1 Hz, 3H), 2.55 (s, 3H), 4.09 (q, *J* = 7.1 Hz, 2H), 6.85 (s, 1H, H- exchangeable), 6.94 (dd, *J* = 8.6, 2.1 Hz, 1H), 7.09 (d, *J* = 2.0 Hz, 1H), 7.39–7.59 (m, 2H), 7.72 (td, *J* = 6.8, 1.4 Hz, 1H), 8.26 (dd, *J* = 8.1, 1.4 Hz, 1H). Anal. calcd. for $C_{20}H_{16}O_5$: C 71.42, H 4.79; found: C 71.38, H 4.73.

*3-Hydroxy-2-naphtho[2,1-*b*]furan-2-yl-chromone (**5**)*

Crystallized from acetic acid, yield 40%, mp 253°C. EI-MS *m*/*z*: 328.1 (M^+), 299.1, 271.1, 215.1, 164.1, 152.1. ^{1}H NMR (200 MHz, DMSO-d_6) δ: 7.47–8.01 (m, 7H), 8.09 (d, *J* = 7.8 Hz, 1H), 8.16 (d, *J* = 7.8 Hz, 1H), 8.30 (s, 1H), 8.43 (d, *J* = 7.8 Hz, 1H), 10.35 (s, 1H, H-exchangeable). Anal. calcd. for $C_{21}H_{12}O_4$: C 76.82, H 3.68; found: C 76.61, H 3.69.

*3-Hydroxy-2-(1-methylnaphtho[2,1-*b*]furan-2-yl)-chromone (**6**)*

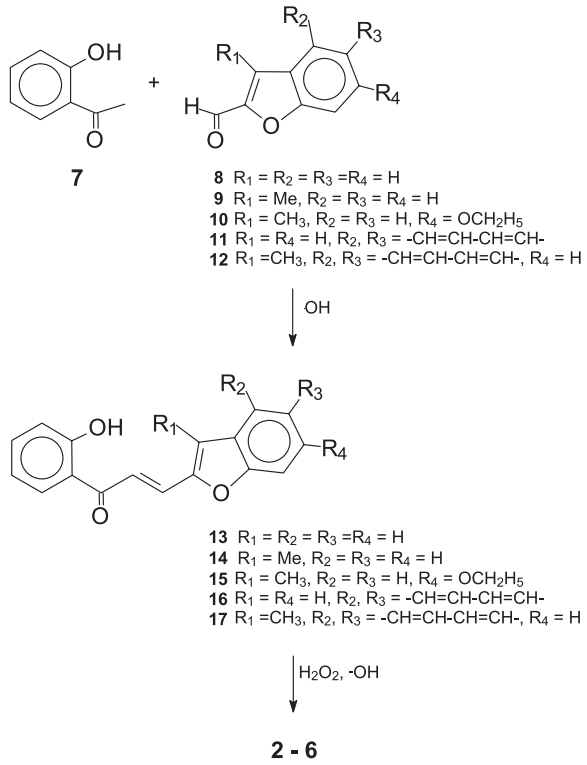
Crystallized from acetic acid, yield 31%, mp 187°C. EI-MS *m*/*z*: 342.1 (M^+), 299.1, 285.1, 271.1, 185.1. ^{1}H NMR (200 MHz, DMSO-d_6) δ: 2.77 (s, 3H) 7.47–8.00 (m, 7H), 8.11 (d, *J* = 8.0 Hz, 1H), 8.17 (d, *J* = 8.0 Hz, 1H), 8.52 (d, *J* = 8.2 Hz, 1H), 9.68 (s, 1H, H-exchangeable). Anal. calcd. for $C_{22}H_{14}O_4$: C 77.19, H 4.12; found: C 77.1, H 4.05.

Results and discussion

The syntheses of the target molecules **2**–**6** were carried out by employing the well-established Algar–Flynn–Oyamada reaction (14). Condensation of 2-hydroxyacetophenone (**7**) with the aldehydes **8**–**12**, synthesized as described elsewhere (15–19), in basic solution gave the intermediates **13**–**17**, respectively (Scheme 1). Treatment of these intermediates with hydrogen peroxide in basic ethanol solution led to the formation of 3-hydroxychromones **2**–**6**, respectively.

All the 3-hydroxychromones (**2**–**6**) possess absorption spectra at longer wavelengths compared with 3-hydroxyflavone (**1a**) in various solvents (Fig. 1: acetonitrile (*A*), ethanol (*E*), toluene (*T*)), and of all the 3-hydroxychromones (**2**–**6**), 3-hydroxy-2-naphthofurylchromone (**5**) is found to

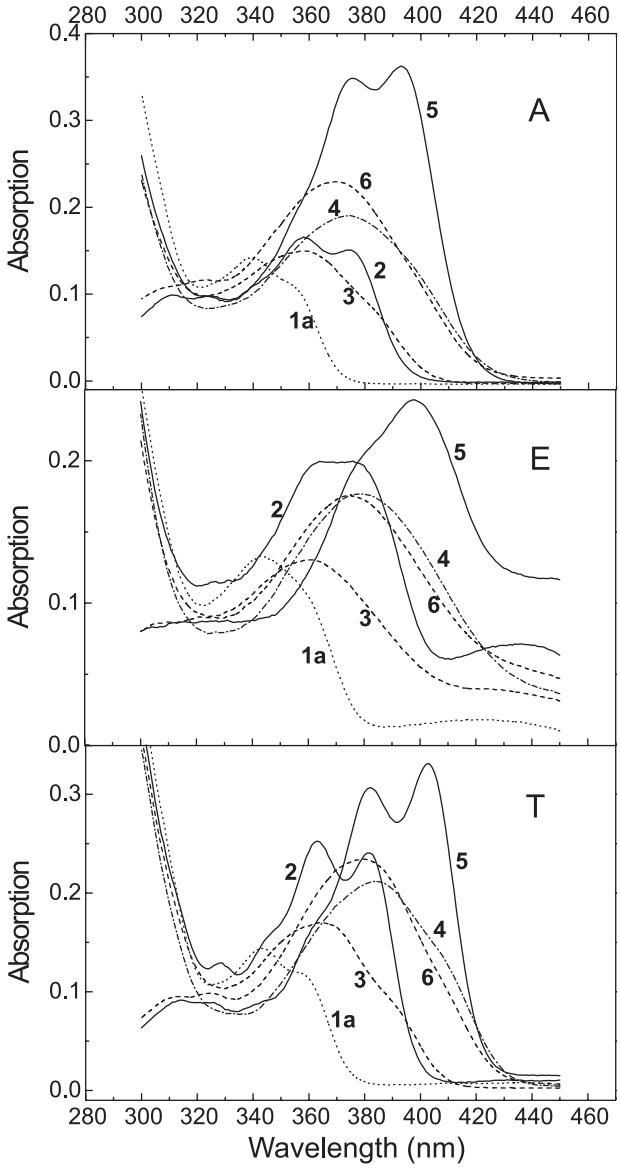
Scheme 1.



have the longest wavelength position of absorption spectrum. This result is related to the extension of the π-conjugation system. The effect of addition of methyl group at C-3 position of the furan ring can be observed as decrease of absorption at long-wavelength part of the spectra. Thus, the absorption spectra of chromones **3**, **4**, and **6** bearing methyl group at C-3 position of the furan ring, show only one absorption band at shorter wavelengths, with a small shoulder at longer wavelengths, while compounds without a methyl group (**2** and **5**) show two distinct absorption bands. One of the possible suggestions for these observed differences could be that the methyl group dramatically effects the hydrogen bonding capabilities of 3-OH group with solvent, but it is unlikely in view of the following reasons. First, this cannot explain the presence of long-wavelength band in absorption spectra of compounds **2** and **5** for all the solvents, including nonpolar toluene. Second, it is in contradiction with observed small differences between absorption spectra of chromones **2** and **5** in toluene and in acetonitrile, where the blue shift is correlated with the increase of polarity (Figs. 1*A* and *T*). The latter means that hydrogen bonding of 3-OH group with acetonitrile is either very weak, even for the case of non-methylated chalcones, or unimportant for energetic profile of the molecules. The critical role of methyl group in absorption of compounds **3**, **4**, and **6** can be explained by a steric factor that may lead to statistical non-planarity between benzo- and naphthofuran and chromone rings, which has been already studied on 2′-, 3′-, and 4′-methyl-3-hydroxyflavones (20). Therefore, it can be suggested that planarity of the chromone molecule is the necessary condition for existence of the long-wavelength band.

In the light of the previous studies (20) we can assume that the absorption at short-wavelength is due to the normal

Fig. 1. Absorption spectra of chromones **1a**, **2**–**6** in different solvents: acetonitrile (*A*); ethanol (*E*); and toluene (*T*).



excitation of 3-hydroxychromone ring, and the long wavelength absorption, as in the case of planar compounds **2** and **5**, is the result of charge transfer from the benzo- and naphthofuran part to the 3-hydroxychromone system. Small long-wavelength absorption shoulders in the spectra of **3**, **4**, and **6** can be explained by less efficient π-electron delocalization between the furan and chromone parts as a result of distortion of the planarity. Non-planarity results not only in a decrease of intensity of the long-wavelength absorption band, but also in a decrease of the extinction coefficient (Table 1), while the introduction of a strong electron donating group, such as ethoxy, to the benzofuryl group (**4**), shifts the absorption band to longer wavelengths in comparison with its analogues (**2** and **3**) (Figs. 1*A*, *E*, and *T*).

Fluorescence spectra of **2**–**6** showed dual fluorescence in all solvents which were used for the absorption measurements (Figs. 2*A*, *E*, and *T*). Dual fluorescent behavior is well explained to be due to the excited state intramolecular proton

Table 1. Spectral properties of chromones **1a**, **2**–**6**.

	Solvent	Absorption wavelength (nm)	Position of long-wavelength peak (nm)	Extinction coefficient ($\times 10^{-5}$) (mol^{-1} cm^{-1})	Fluorescence quantum yield	Lifetime of long-wavelength band (ns)
1a	Acetonitrile	339	525	0.143	0.046	0.94
	Ethanol	343	531.5	0.133	0.024	0.5
	Toluene	343	528	0.144	0.29	2.66
2	Acetonitrile	338	542	0.165	0.177	2.09
	Ethanol	367	544	0.198	0.122	1.41
	Toluene	365	547	0.253	0.396	3.87
3	Acetonitrile	357	565	0.15	0.033	0.68
	Ethanol	361	560	0.131	0.061	0.71
	Toluene	364	572.5	0.171	0.134	2.15
4	Acetonitrile	373	580	0.190	0.0272	≤0.5
	Ethanol	378	—	0.177	0.118	≤0.5
	Toluene	383	586	0.212	0.058	0.71
5	Acetonitrile	376	559	0.348	0.14	1.93
	Ethanol	398	555	0.243	0.22	1.77
	Toluene	403	562.5	0.331	0.371	3.08
6	Acetonitrile	370	576	0.229	0.052	0.83
	Ethanol	375	—	0.176	0.129	≤0.5
	Toluene	379	582	0.234	0.09	0.87

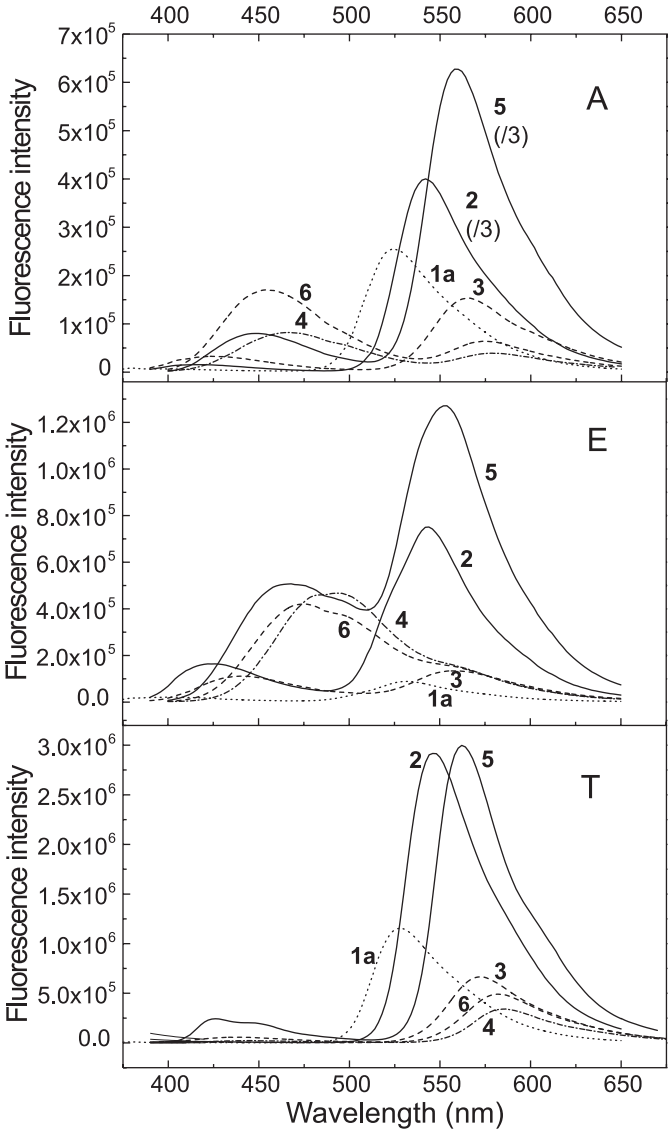
transfer (ESIPT), which is the result of the partial isomerization of the excited normal isomer to a phototautomer. These two forms, then, return to the ground state with the emission of different energies exhibiting two fluorescent bands, at short and long wavelengths for the normal and phototautomer excited forms, respectively.

Fluorescent measurements of compounds **2**–**6** indicate that replacement of the phenyl group of 3-hydroxyflavone (**1a**) for longer aromatic systems, such as benzo- or naphthofuryl, leads to a significant red shift (ca. 50 nm) (Table 1). In polar solvents, such as acetonitrile and ethanol, two distinctive fluorescent bands are observed, while only the long-wavelength band is recorded in nonpolar solvent (toluene). The exception is naphthofurylchromone **5**, which showed considerable short-wavelength fluorescence band in both polar and nonpolar solvents. It appears that the strongest among the solvent effects is the change in ratio of intensities of normal excited form emitting at shorter wavelength to phototautomer form emitting at longer wavelength (I_{N^*}/I_{T^*}). This can be explained as the preference of hydrogen bonding of the 3-OH group with the solvent as compared to intramolecular hydrogen bonding of 3-OH with the carbonyl group. However, in acetonitrile this ratio is still very small, especially for the case of non-methylated chromones (**2** and **5**), which supports the above statement based on absorption data that hydrogen bonding of 3-OH group of the chromones with acetonitrile is very weak and does not significantly change the energetic profile of the molecules.

The fluorescence quantum yield of compounds **2** and **5**, was found to be higher than that of 3-hydroxyflavone, and the addition of methyl group in C-3 position decreases the fluorescence quantum yield considerably (Table 1). Furthermore, the effect of methyl group was found to cause an increase in the I_{N^*}/I_{T^*} ratios for compounds **3**, **4**, and **6**. These results correspond to the increased I_{N^*}/I_{T^*} ratio for 3-hydroxyflavone with a methyl group at position 2 of the phenyl ring (20).

It is interesting to note that the molecules with methyl group in furan ring (**3**, **4**, and **6**) demonstrate stronger red shifted (by 22–28 nm, which is 670–880 cm^{-1}) fluorescent bands compared with the corresponding non-methylated derivatives (**2** and **5**) (Table 1). Taking into account that the position of the long-wavelength maximum of 3-hydroxyflavones is not very sensitive to 2- or 3- substituents of the phenyl ring, the fact of the red shift, caused by such a weak electron donor as methyl group, is important and requires further investigation. Since a red shift is observed in both polar and nonpolar solvents arguments regarding the differences in hydrogen bonding between solvent and molecules **2** and **3**, and **5** and **6** do not explain this effect. It could be suggested that the non-planar molecules, with the steric hindrance of the methyl group, relax to a more stable planar excited conformation characterized by lower energies with an emission at longer wavelengths. Red shifts in fluorescence due to flattening of a molecule in an excited state is known for some heterocyclic compounds (21). Since, fluorescence of the phototautomer of 3-hydroxychromones requires a planar conformation between the 2-aryl and chromone rings (20), it is understandable that the red shift, caused by flattening of the non-planar chromones with the methyl group in furan ring **3**, **4**, and **6**, is much stronger for the long-wavelength fluorescence band. For instance, in acetonitrile the long-wavelength band of **3** (compared with **2**) is red shifted by 24 nm (782 cm^{-1}), whereas the short-wavelength band is red shifted by just 6 nm (339 cm^{-1}).

Fig. 2. Fluorescence spectra of chromones **1a**, **2**–**6** in different solvents: acetonitrile (*A*); ethanol (*E*); and toluene (*T*) (excitation for: **1a** (340 nm); **2** and **3** (360 nm); **4**–**6** (390 nm)).



Furthermore, the methyl group causes the decrease of fluorescence lifetime (Table 1) and lowers the fluorescence intensity, which also indicates its dramatic influence on relaxation pathways.

In conclusion, we have synthesized a series of 3-hydroxychromones, which have comparable, and in some respects better, absorption and fluorescence properties than the 3-hydroxychromones synthesized so far. They have comparably higher quantum yield, display absorption and fluorescence at longer wavelengths in different solvents, and some of them have longer fluorescent lifetimes. These properties make benzo- and naphthofuryl-3-hydroxychromones highly promising candidates for fluorescence probes design. Currently, the preparation of membrane probes and fluorescent chalators using the chromophoric systems **2** and **5** are underway, and the results will be published in due course.

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