

Cevher Gündoğdu, Derya Topkaya, Gülsiye Öztürk, Serap Alp,
and Yavuz Ergün*

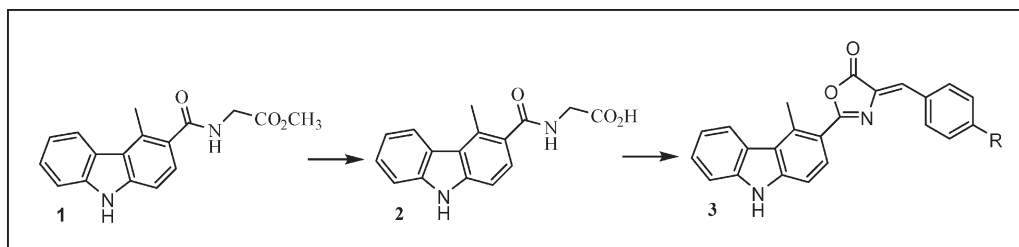
Department of Chemistry, Faculty of Arts and Sciences, Dokuz Eylül University,
Kaynaklar Campus, 35160, Buca-Izmir, Turkey

*E-mail: yavuz.ergun@deu.edu.tr

Received February 1, 2010

DOI 10.1002/jhet.499

Published online 27 August 2010 in Wiley Online Library (wileyonlinelibrary.com).



Novel carbazolyl-oxazolones, **3a–d**, were synthesized with 3-[*N*-(2-hydroxycarbonylmethyl)-carboxamide]-4-methyl-9*H*-carbazole and several aryl aldehydes for the first time. Photo physical characterization of synthesized 2-carbazolyl-4-arylidene-5-oxazolones (**3a–d**) in dichloromethane, chloroform, and toluene was performed.

J. Heterocyclic Chem., **47**, 1450 (2010).

INTRODUCTION

Carbazole [1–6] and oxazolone [7,8] moieties have received great attention by chemist not only because of their biological properties, but also for their technological importance. Oxazolones that are internal anhydrides of acyl amino acids are important class of five-membered heterocycles. They are highly versatile intermediates used for the synthesis of several organic molecules, including amino acids, peptides, antimicrobial or antitumor compounds, immunomodulators, heterocyclic precursors, for biosensors coupling, and/or photosensitive composition devices for proteins. They can be easily prepared from *N*-acyl amino acids by dehydration. 5-Oxazolones also have a wide range of applications including their use in semiconductor devices because of their promising photophysical and photochemical activities [9]. Carbazole derivatives are important optical materials due to their special photorefractive, electrical, and chemical properties [2–6].

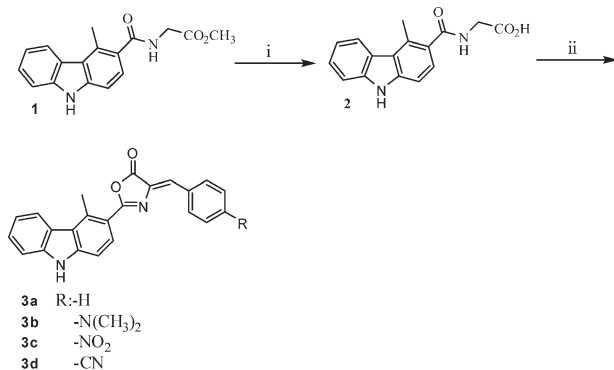
2-Aryl-4-carbazolyliden-5-oxazolones were first synthesized *via* an Erlenmeyer reaction of the carbazole aldehyde derivatives with several *N*-benzoyl glycine derivatives and their optical properties were studied [10,11]. We recently synthesized several 5-oxazolone derivatives and investigated their basic photophysical and sensor characteristics by using UV-vis and fluorescence spectroscopy [12–18]. Herein, we prepared novel 2-carbazolyl-4-arylidene-5-oxazolones (**3a–d**) with a carbazole glycine derivative for the first time. This work also describes

the photophysical characterization of 2-carbazolyl-4-arylidene-5-oxazolones (**3a–d**) in dichloromethane, chloroform, and toluene. We also examined the correlation between the molecular structures and their fluorescent properties.

RESULTS AND DISCUSSION

We synthesized novel 2-carbazolyl-4-arylidene-5-oxazolones (**3a–d**) with a carbazole glycine derivative for the first time (Fig. 1). Thus, we aimed to combine the advantages of carbazole structures and 5-oxazolone derivatives. We used a carbazole glycine ester 1 derivative as a starting material, which was synthesized previously by our group [19]. Then, the hydrolysis of carbazole glycine ester 1 in basic conditions gave the glycine derivative of carbazole 2 [20]. Finally, 2-carbazolyl-4-arylidene-5-oxazolones were synthesized with carbazole glycine derivative 2 and several aryl aldehydes by an Erlenmeyer reaction.

Also, the absorption and emission spectral properties of (**3a–d**) were also investigated in dichloromethane, chloroform, and toluene (Table 1). The results obtained show that the nature of the substituent groups on the aryl moiety influences the absorption and fluorescence emission maxima. The absorption maxima of **3a–d** derivatives were observed between 393 and 470 nm (Table 1, Fig. 2). The excitation wavelengths were chosen as 410, 473, 442, and 441 nm for **3a–d**, respectively, and the emission spectra were recorded.



Reagent and Conditions: i) LiOH.H₂O, ethanol; ii) NaOAc, Ac₂O, ArCHO

Figure 1. The synthesis route and structural formulas of **3a–d**.

Emission and related excitation spectra of **3c** in dichloromethane are shown in Figure 3. The excitation spectral data were acquired by exciting the molecule at its emission maximum. The chromophore system is affected by the electron donor group (carbazolyl groups) and electron acceptor groups (4-nitrophenyl and cyano-phenyl) of **3c** and **3d** derivatives. Thus, the emission maxima are red shifted for **3c** and **3d** in comparison to **3a**. As the nitro group is a stronger electron acceptor than a cyano group, **3c** has a longer emission wavelength maximum. A bathochromic shift was also observed for **3b**, which has an *N,N*-dimethylamino moiety, a strong electron donor group. The Stokes' shift values were calculated for all derivatives and the highest Stokes' shift values were obtained for **3c** and **3d**. For all derivatives studied, the Stokes shift values are higher in chloroform and dichloromethane, in comparison to the values obtained in toluene. This result indicates that as the solvents polarity decreases, the Stokes shift values decrease as well.

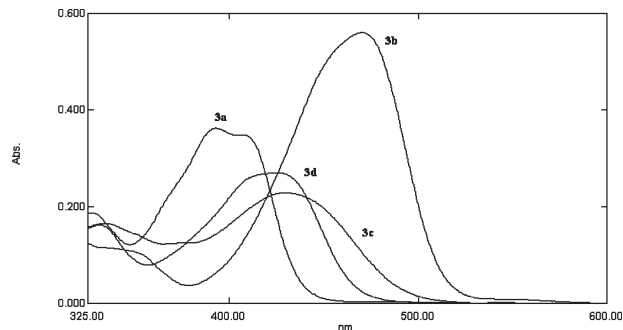


Figure 2. Absorption spectra of compounds **3a–d** measured in dichloromethane ($1 \times 10^{-5} M$).

HPTS was used as reference quantum yield standard $\lambda_{\text{ex}} = 400 \text{ nm}$, quantum yield = 1, in acidic water for **3a**; and $\lambda_{\text{ex}} = 470 \text{ nm}$, quantum yield = 1, in basic water for **3c–d**. Fluorescence quantum yields (Φ_F) were determined by the formula [21]:

$$\Phi = \Phi_{\text{std}} \times (FA_{\text{std}}\eta^2)/(FA_{\text{std}}\eta_{\text{std}}^2)$$

where F and F_{std} are the areas under the fluorescence emission curves of the samples and the standard, respectively. A and A_{std} are the respective absorbance of the samples and standard at the excitation wavelength, respectively, and η and η_{std} the refractive indexes of solvents used for the samples and standard, respectively. **3c** and **3d** in toluene exhibited the highest quantum yield values of 0.7675 and 0.9323, respectively. This can be explained by the charge transfer efficiency of the molecules in the excited state. Electron accepting 4-nitro and cyano substituents increase π -electron mobility much more than the electron donating 4-dimethylamino substituent at the same position resulting in high charge separation properties of **3c** and **3d**. This can also be attributed to the fact that, more polar solvents provide

Table 1

Absorption and fluorescence emission data for compounds **3a–d** (λ , nm and ϵ , $1 \text{ mol}^{-1} \text{ cm}^{-1}$), Stokes shifts, $\Delta\lambda$ (nm), singlet energy, E_s (kcal mol^{-1}), and fluorescence quantum yield, Φ in solutions.

Compound	Solvent	$\lambda_{\text{max}}^{\text{ab}}$	ϵ_{max}	$\lambda_{\text{max}}^{\text{f}}$	$\Delta\lambda$	E_s	Φ
3a	Chloroform	412	9600	484	72	69.2	0.2462
3b		462	18000	514	52	61.7	0.0025
3c		439	11600	565	126	64.9	0.0535
3d		432	34000	522	90	66.0	0.2274
3a	Toluene	414	33000	438	24	68.8	0.3374
3b		467	14400	496	29	61.0	0.0056
3c		453	5000	508	55	62.9	0.7675
3d		436	9200	475	39	65.4	0.9323
3a	Dichloromethane	393	36000	479	86	72.6	0.3710
3b		470	56000	520	50	60.7	0.0026
3c		430	22000	592	162	66.3	0.0300
3d		423	27000	523	100	65.5	0.1172

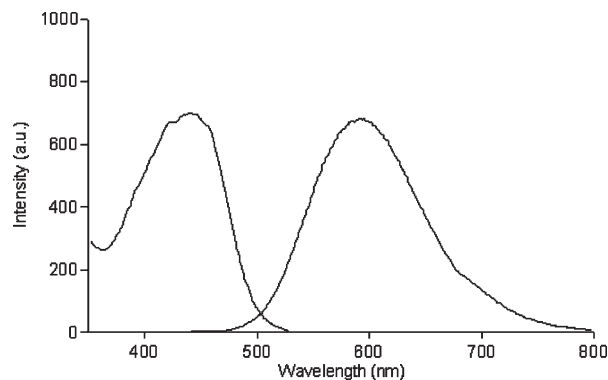


Figure 3. Emission and excitation spectra of **3c** in dichloromethane.

3c and **3d** freedom to rotate and vibrate which serve as the nonradiative transitions.

The photostabilities of **3a–d** derivatives were recorded with a steady-state spectrofluorimeter in dichloromethane, chloroform, and toluene (Fig. 4). The data were acquired at their maximum emission wavelengths after exposure to xenon arc lamp for 1 h of monitoring. All derivatives exhibited excellent photostability in three of the solvents studied.

CONCLUSION

Four different carbazolyl–oxazolones derivatives were synthesized for the first time. All derivatives displayed emission maxima in the range of 438–592 nm and excellent photostabilities. The highest quantum yield value was determined for **3d** in toluene, 0.9323, which is quite promising. Considering the absorption and fluorescence emission maxima, **3c** and **3d** are expected to be good probes for biological applications. Our next goal is to investigate their performance as ion sensors for biological applications.

EXPERIMENTAL

All solvents were of analytical grade and purchased from Merck (Darmstadt, Germany), Fluka (Buchs, Switzerland), and Riedel (Seelze, Germany). All melting points were measured in sealed tubes using an electrothermal digital melting points apparatus (Southend, UK) and are uncorrected. Infrared spectra were recorded on a Perkin Elmer (Massachusetts, USA) FTIR infrared spectrometer (spectrum BX-II). ^1H NMR spectra were obtained on a high resolution fourier transform Bruker WH-400 NMR spectrometer (Coventry, UK) with tetramethylsilane as an internal standard. Mass spectra were determined on the electron impact mode by direct insertion at 70 eV with a Micromass UK Platform II LC-MS spectrometer (Manchester, UK). Combustion analysis of compounds was obtained on a CHNS-932-LECO (St. Joseph, MI). Analytical and preparative thin layer chromatographies (TLC) were carried out using silica gel 60 F₂₅₄ (Merck). Column chromatography was carried out by using 70–230 mesh silica gel (0.063–0.2 mm,

Merck). UV/visible absorption spectra were recorded with Shimadzu UV-1601 spectrophotometer (Tokyo, Japan). All fluorescence measurements were undertaken by using Varian-Carry Eclipse spectrofluorimeter (Mulgrave, Australia). 1-hydroxypyrene-3,6,8-trisulfonate trisodium salt (HPTS) purchased from Fluka was used as reference standard for fluorescence quantum yield calculations of **3a–d**.

3-[N-(2-Hydroxycarbonylmethyl)-carboxamide]-4-methyl-9H-carbazole (2). A solution of **1** (1.5 g, 5 mmol) and lithium hydroxide monohydrate (0.21 g, 5 mmol) in 25 mL of ethanol was stirred for 2 h. The solvent was removed under reduced pressure and the residue was diluted with water and acidified with concentrated hydrochloric acid. The solution was extracted with ethyl acetate and the organic layer was dried over anhydrous magnesium sulphate. The solvent was evaporated under reduced pressure and the resulting residue was recrystallized from ether to afford 1.30 g (91%) of **2** as a white solid, mp 273°C; ir (potassium bromide): ν 3403(NH), 3260 (NH), 2921 (CH), 1703 (ester C=O), 1631 (amide C=O) cm^{-1} ; ^1H NMR (d_6 -dimethyl sulfoxide): δ 2.88 (s, 3H, CH₃), 3.92 (d, 2H, CONHCH₂, $J = 6.0$ Hz), 7.18 (d, 1H, $J = 8.0$ Hz, ArH), 7.33 (d, 1H, $J = 8.4$ Hz, ArH), 7.37–7.44 (m, 1H, ArH) 7.50 (d, 1H, $J = 8.4$ Hz, ArH), 8.18 (d, 1H, $J = 8.4$ Hz, ArH), 8.42 (t, 1H, $J = 6.0$ Hz, CONHCH₂), 11.40 (s, 1H, NH), 12.50 (bs, 1H, OH); ms (70 eV): m/z : 284 (7.7), 283 (65), 209 (13.1), 208 (100), 73 (26.7). Anal. Calcd. for C₁₆H₁₄N₂O₃: C, 65.11; H, 5.46; N, 10.85. Found: C, 65.03; H, 5.38; N, 10.91.

General methods for the synthesis of phenyl carbazole oxazolones (3a–d). Aldehyde (6 mmol), 3-[N-(2-hydroxycarbonylmethyl)-carboxamide]-4-methyl-9H-carbazole (6 mmol), acetic anhydride (2.49 mL, 12 mmol), and sodium acetate (0.87 g, 6 mmol) was heated until the mixture just liquefied, and then heating was continued for further 2 h. After completion of the reaction (determined by thin layer chromatography), ethanol (25 mL) was added and mixture was kept at room temperature for 18 h. The solid product thus obtained was purified by washing with cold ethanol, hot water, and small amount of hexane. The solid was recrystallized from hot ethanol to afford carbazolyl-oxazolone.

2-(4-Methyl-9H-carbazol-3-yl)-4-benzylidene-oxazol-5(4H)-one (3a). mp: 152°C; ir (potassium bromide): ν 3365 (NH), 1770 (–O–C=O), 1644(–C=N–), 1167(–O–C=O) cm^{-1} ; ^1H NMR (d_6 -dimethyl sulfoxide): δ 3.39 (s, 3H, CH₃), 7.19 (s, 1H, Ar-CH=C), 7.24 (t, 1H, $J = 7.2$ Hz, ArH), 7.43–7.56 (m, 6H, ArH), 8.00 (d, 1H, $J = 8.4$ Hz, ArH), 8.24–8.29 (m, 3H, ArH), 11.8 (s, 1H, NH); ms (70 eV): m/z % 354 (26.9),

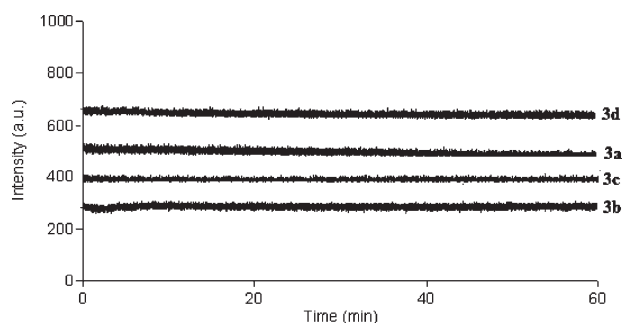


Figure 4. The photostability test result of **3a–d** in toluene after 1 h of monitoring.

353 (100), 314 (24.9), 286 (28.6), 284 (24.4), 258 (19.9), 256 (12), 230 (11.2), 208 (71.1), 73 (51.1). Anal. Calcd. for $C_{23}H_{16}N_2O_2$: C, 78.39; H, 4.58; N, 7.95. Found: C, 78.23; H, 4.52; N, 8.04.

2-(4-Methyl-9H-carbazol-3-yl)-4-(4-(dimethylamino)benzylidene)-oxazol-5(4H)-one (3b). mp 139°C; ir (potassium bromide): ν 3269 (NH), 1747 ($-OC=O$), 1620 ($-C=N-$), 1162 ($-O-C=O$) cm^{-1} ; 1H NMR (d_6 -dimethyl sulfoxide): δ 3.11 (s, 6H, $N(CH_3)_2$), 3.40 (s, 3H, CH_3), 6.77 (d, 2H, $J = 8$ Hz, ArH), 7.13 (s, 1H, Ar-CH=C), 7.24–7.52 (m, 6H, ArH), 8.14 (d, 2H, $J = 8$ Hz, ArH), 11.9 (s, 1H, NH); ms (70 eV): $m/z\%$ 397 (16), 396 (100), 356 (8.0), 340 (7.1), 334 (4.9), 304 (11.5), 236 (18.5), 214 (75.7), 198 (69.1). Anal. Calcd. for $C_{25}H_{21}N_3O_2$: C, 75.93; H, 5.35; N, 10.63. Found: C, 75.71; H, 5.41; N, 10.69.

2-(4-Methyl-9H-carbazol-3-yl)-4-(4-nitrobenzylidene)-oxazol-5(4H)-one (3c). mp 143°C; ir (potassium bromide): ν 3419 (NH), 1784 ($-OC=O$), 1650 ($-C=N-$), 1539 and 1508 ($-NO_2$), 1171 ($-O-C=O$) cm^{-1} ; 1H NMR (d_6 -dimethyl sulfoxide): δ 3.34 (s, 3H, CH_3), 7.25 (s, 1H, Ar-CH=C), 7.45–7.51 (m, 4H, ArH), 7.57 (d, 1H, $J = 8.0$ Hz, ArH), 8.05 (d, 1H, $J = 8.8$ Hz, ArH), 8.30 (d, 2H, $J = 8.8$ Hz, ArH), 8.47 (d, 2H, $J = 8.4$ Hz, ArH), 11.9 (s, 1H, NH); ms (70 eV): $m/z\%$ 398 (4.8), 397 (30.1), 396 (100), 314 (14.5), 286 (16.7), 258 (19), 230 (77), 208 (7.5), 73 (36.7). Anal. Calcd. for $C_{23}H_{15}N_3O_4$: C, 69.52; H, 3.80; N, 10.57. Found: C, 69.40; H, 3.73; N, 10.63.

2-(4-Methyl-9H-carbazol-3-yl)-4-(4-cyanobenzylidene)-oxazol-5(4H)-one (3d). mp 138°C; ir (potassium bromide): ν 3340 (NH), 2227 (CN), 1793 ($-OC=O$), 1644 ($-C=N-$), 1165 ($-O-C=O$) cm^{-1} ; 1H NMR (d_6 -dimethyl sulfoxide): δ 3.24 (s, 3H, CH_3), 7.11 (s, 1H, Ar-CH=C), 7.22 (t, 1H, $J = 7.6$ Hz, ArH), 7.42 (d, 2H, $J = 8.4$ Hz, ArH), 7.52 (d, 1H, $J = 8.0$ Hz, ArH), 7.84 (d, 2H, $J = 8.0$ Hz, ArH), 7.96 (d, 1H, $J = 8.4$ Hz, ArH), 8.22 (d, 1H, $J = 8.0$ Hz, ArH), 8.28 (d, 2H, $J = 8.4$ Hz, ArH), 11.8 (s, 1H, NH); ms (70 eV): $m/z\%$ 378 (0.9), 377 (0.2), 360 (8.9), 315 (24), 314 (100), 286 (78.7), 258 (72.3), 230 (96), 73 (80.6). Anal. Calcd. for $C_{24}H_{15}N_3O_2$: C, 76.38; H, 4.01; N, 11.13. Found: C, 76.51; H, 4.06; N, 11.04.

REFERENCES AND NOTES

- [1] Knölker, H. J.; Reddy, K. R. *Chem Rev* 2002, 102, 4303.
- [2] Yoon, K. R.; Ko, S. O.; Lee S. M.; Lee, H. *Dyes Pigm* 2007, 75, 567.
- [3] Ying, Q. *Dyes Pigm* 2008, 76, 277.
- [4] Xing, Y.; Xu, X.; Zhang, P.; Tian, W.; Yu, G.; Lu, P.; Liu Y.; Zhu, D. *Chem Phys Lett* 2005, 408, 169.
- [5] Mishra, A. K.; Jacob J.; Müllen, K. *Dyes Pigm* 2007, 75, 1.
- [6] Bai, G.; Li, J.; Li, D.; Dong, C.; Han X.; Lin, P. *Dyes Pigm* 2007, 75, 93.
- [7] Grigoras M.; Antonoiaia, N. C. *Eur Polym J* 2005, 41, 1079.
- [8] Khan, K. M.; Mughal, U. R.; Khan, M. T. H.; Ullah, Z.; Perveenb S.; Choudhary, M. I. *Bioorg Med Chem* 2006, 14, 6027.
- [9] Ozturk, G.; Alp S.; Ertekin, K. *Dyes Pigm* 2007, 72, 150.
- [10] Diaz, J. L.; Villacampa, B.; Lopez-Calalhorraa, F.; Velasco, D. *Tetrahedron Lett* 2002, 43, 4333.
- [11] Diaz, J. L.; Villacampa, B.; Lopez-Calalhorra, F.; Velasco, D. *Chem Mater* 2002, 14, 2240.
- [12] Ozturk, G.; Alp S.; Ergun, Y. *Tetrahedron Lett* 2007, 48, 7347.
- [13] Icli, S.; Doroshenko, A. O.; Alp, S.; Abmanova, N. A.; Egoorova, S. I.; Astley, S. T. *Spectrosc Lett* 1999, 32, 553.
- [14] Icli, S.; Icil, H.; Alp, S.; Koc, H.; McKillop, A. *Spectrosc Lett* 1994, 27, 1115.
- [15] Ertekin, K.; Alp, S.; Karapire, C.; Yenigül, B.; Henden, E.; Icli, S. *J Photochem Photobiol A Chem* 2000, 137, 155.
- [16] Ertekin, K.; Karapire, C.; Alp, S.; Yenigül, B.; Icli, S. *Dyes Pigm* 2003, 56, 125.
- [17] Ertekin, K.; Cinar, S.; Aydemir, T.; Alp, S. *Dyes Pigm* 2005, 67, 133.
- [18] Ertekin, K.; Alp, S.; Yalcın, I. *Dyes Pigm* 2005, 65, 33.
- [19] Ergün, Y.; Güllü, S.; Çagdas, A. B.; Göçmentürk, M.; Okay, G. *Asian J Chem* 2010, 22, 1853.
- [20] Sharma, V.; Lansdell, T. A.; Jin, G.; Tepe, J. J. *J Med Chem* 2004, 47, 3700.
- [21] Ozturk, G.; Förstel, M.; Ergun, Y.; Alp, S.; Rettig, W. *J Fluoresc* 2008, 18, 1007.