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SUBSTITUENT EFFECTS IN THIACARBOCYANINE DYES ON THEIR SPECTRAL-FLUORESCENT RESPONSE IN THE PRESENCE OF NUCLEIC ACIDS AND SERUM ALBUMINS

Aim. *The aim of this work was to study a spectral-fluorescent response in the presence of nucleic acids and serum albumins for a series of thiacarbocyanine dyes with various substituents in the benzothiazole end groups and trimethine chain.* ***Methods.*** *UV-vis absorption and fluorescence spectroscopy.* ***Results.*** *The highest responses to the DNA and RNA presence (with significant preference for RNA) were observed for the dyes with OH groups at the 5,5' or 6,6' positions and N-methyls in the benzothiazole rings, and with methyl or ethyl group at the β-position of the trimethine chain. Replacing OH groups with O-methyl ones at the 5,5' or 6,6' positions does not noticeably affect the dye's fluorescent response in the presence of human (HSA), bovine, and equine serum albumins. At the same time, increasing the length of the benzothiazole N-alkyl groups leads to an enhanced fluorescent response to all three serum albumins studied.* ***Conclusions.*** *Dyes* **7515** *and* **7520** *are promising for further development as RNA-sensitive fluorescent probes. Dye* **7642** *shows potential as the fluorescent HSA-sensitive probe.*

Keywords: *cyanine dyes, fluorescent probes, nucleic acids, serum albumins.*

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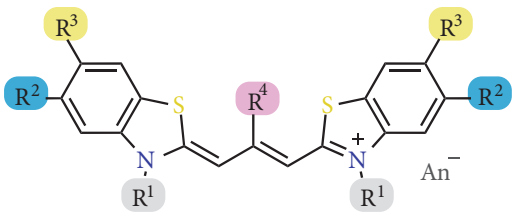
Introduction

Design of novel fluorescent probes for biological molecules remains an important area of research [1, 2]. An effective approach involves modification of a chromophore with favorable fluorescent and target-binding properties with affinity-modifying substituents, which can enhance or tune its affinity to specific biomolecular targets [3]. One such chromophore is the symmetrical benzothiazole trimethine cyanine dye (thiacarbocyanine).

While thiacarbocyanines with unsubstituted trimethine chain exhibit relatively high intrinsic fluorescence intensity, substitution within this chain leads to a decrease in fluorescence quantum yield [4], creating the potential for a pronounced fluorescence enhancement upon binding to biological targets [5]. Moreover, variation of the substituent at the β-position of the trimethine chain affects the dye behavior in the presence of nucleic acids [6]. Thus, the dye **Cyan 2**, bearing a methyl group at the β-position, was shown to intercalate into dsDNA [7], while **Cyan βiPr** with an isopropyl substituent at the same position forms J-aggregates within the DNA groove [8].

Additionally, 6,6'-benzoylamino-disubstituted trimethine cyanines demonstrated high sensitivity to DNA, along with a pronounced selectivity for DNA over RNA [9]. Thiacarbocyanines have also been explored as probes for non-canonical DNA structures, including poly(dG-dG)-poly(dC) triplex and G-quadruplex DNA [10]. Finally, we have studied the effect of substituents at the *N*,*N*'-positions [11], as well as O-methyl and OH groups at the 5,5'- or 6,6'-positions of the benzothiazole end groups [12], on the fluorescent response of thiacarbocyanines toward the protein amyloid aggregates.

Here, we investigated a series of thiacarbocyanine dyes bearing either O-methyl or OH groups at the 5,5'- or 6,6'-positions of the benzothiazole rings, *N*-alkyl substituents of varying chain length, and methyl, ethyl, or no substituent at the β-position of the trimethine chain. For these dyes, some of which were previously studied as fluorescent probes for the protein amyloid aggregates [12], their spectral-fluorescent responses in the presence of nucleic acids (dsDNA and RNA), as well as human, bovine, and equine serum albumins, were systematically studied.



	R^1	R^2	R^3	R^4
7513	CH_3	OCH_3	H	H
7514	CH_3	OCH_3	H	C_2H_5
7515	CH_3	OH	H	CH_3
7520	CH_3	H	OH	C_2H_5
7544	CH_3	H	OCH_3	H
7545	CH_3	H	OCH_3	C_2H_5
7724	C_2H_5	OCH_3	H	H
7642	C_5H_{11}	OCH_3	H	CH_3
7647	C_5H_{11}	OH	H	CH_3
7748	C_3H_7	OH	H	CH_3

An^- = TsO^-: **7513, 7514, 7515, 7520, 7544, 7724**

An^- = ClO_4^-: **7545** An^- = I^-: **7642, 7647, 7748**

Fig. 1. Structures of the studied thiacarbocyanine dyes

Materials and Methods

Thiacarbocyanine dyes (Fig. 1) were synthesized in a straightforward one-step procedure, described elsewhere [13]. Among them, compounds **7513** [CAS# 1351354-67-0], **7514** [CAS# 1351354-69-2], **7515** [CAS# 1351354-59-0], **7520** [CAS# 1351354-65-8], **7544** [CAS# 1351354-63-6], **7545** [CAS# 1351354-57-8] are described in [12], **7724** [CAS# 59735-89-6] — in [14]. For the synthesis of dyes **7642**, **7647**, and **7748** — which are just homologues of the above ones — the same general method was employed, starting from the respective benzothiazole salts and ethyl-orthoacetate. The structures and

purity of the studied compounds were confirmed by ^{1}H NMR spectroscopy and elemental analysis.

Dimethyl sulfoxide (DMSO) and 50 mM Tris–HCl buffer (pH 8.0) were used as solvents. Double-stranded DNA from salmon testes, yeast total RNA, and bovine (BSA), human (HSA), and equine (ESA) serum albumins were acquired from Sigma-Aldrich Co.

Stock solutions of the dyes were prepared in DMSO at a concentration of 2 mM. Stock solutions of DNA and RNA were prepared in buffer at concentrations of 6 mM base pairs (b.p.) and 12 mM bases (b.), respectively. Solutions of BSA, HSA, and ESA were prepared in the same buffer at a concentration of 0.2 mg/mL, corresponding to approximately 3 μM.

Working solutions of free dyes were obtained by diluting the dye stock solutions with either buffer or DMSO. Working solutions of dyes in the presence of nucleic acids were prepared by adding appropriate aliquots of the dye and nucleic acid stock solutions to the buffer. Working solutions of dyes in the presence of serum albumins were prepared by adding aliquots of the dye stock solutions to the corresponding protein solutions. In all working solutions, the final concentrations of dyes, DNA, RNA, and serum albumins were 5 μM, 60 μM (b.p.), 120 μM (b.), and 0.2 mg/mL, respectively.

All spectral measurements were carried out immediately after preparation of the working solutions. Absorption spectra were recorded using a Genesys 20 Visible spectrophotometer (Thermo Fisher Scientific, USA) with wavelength accuracy of ±2.0 nm, and absorbance accuracy of ±0.003 and 1.0% for absorbance ranges 0.0—0.3 and 0.301—2.5 respectively. Fluorescence spectra were obtained with a Cary Eclipse fluorescence spectrophotometer (Varian, Australia) with wavelength accuracy of ±1.5 nm; as for the fluorescence intensity (which is measured in arbitrary units), it is determined by the concentration accuracy during the sample preparation. Fluorescent emission was excited at the wavelength of corresponding fluorescence excitation maximum. Measurements were performed in 10 × 10 mm quartz cuvettes at room temperature.

Results and Discussion

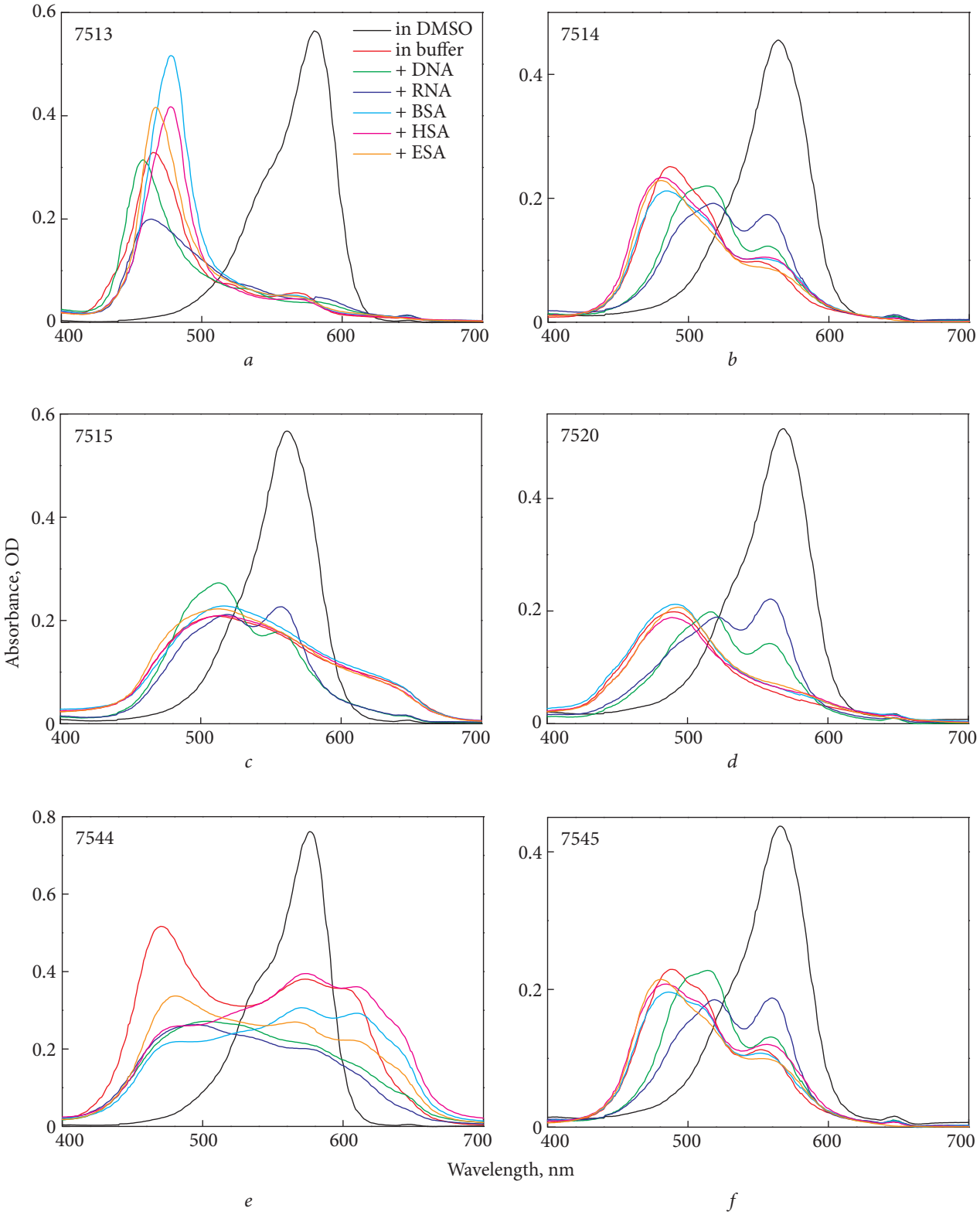
Spectral-fluorescent properties of free dyes

The absorption and fluorescence spectral parameters of the studied dyes in DMSO and in 50 mM Tris–HCl buffer (pH 8.0) are summarized in Table 1. Absorption spectra are shown in Fig. 2; fluorescence spectra of the dye **7515** are presented in Fig. 3. In DMSO, the absorption spectra of the dyes exhibit a single long-wavelength maximum in the range of 562—583 nm, while the corresponding fluorescence spectra display maxima between 596 and 606 nm and are mirror images of the absorption bands. The band shapes of absorption and

Table 1. **Spectral characteristics of trimethine cyanine dyes (5 μM) in DMSO and buffer**

Dye	DMSO				50 mM Tris–HCl buffer (pH 8.0)			
	λ_{abs}, nm	*A*	λ_{fl}, nm	*I*, a.u.	λ_{abs}, nm	*A*	λ_{fl}, nm	*I*, a.u.
7513	580	0.565	605	1363	466	0.330	587	104
7514	564	0.455	596	308	488	0.251	582	19
7515	562	0.568	597	172	511	0.210	581	7
7520	568	0.525	600	244	490	0.200	584	6
7544	577	0.764	601	1227	471	0.520	581	54
					573	0.380		
7545	566	0.439	596	270	489	0.230	578	21
					553	0.110		
7724	583	0.422	606	1500	523	0.227	588	342
					569	0.160		
7642	566	0.647	601	289	513	0.380	588	25
7647	569	0.555	600	187	553	0.254	—	4*
7748	568	0.475	603	183	524	0.217	586	9
					556	0.211		

Note: λ_{abs} — absorption maximum wavelength (nm); *A* — absorbance at λ_{abs}; λ_{fl} — fluorescence maximum wavelength (nm); *I* — dye fluorescence intensity at λ_{fl} (a.u.); * — intensity of noise where emission spectra could not be recorded.


7513
in DMSO
in buffer
+ DNA
+ RNA
+ BSA
+ HSA
+ ESA
a
7514
b
7515
c
7520
d
7544
e
7545
f
Absorbance, OD
Wavelength, nm

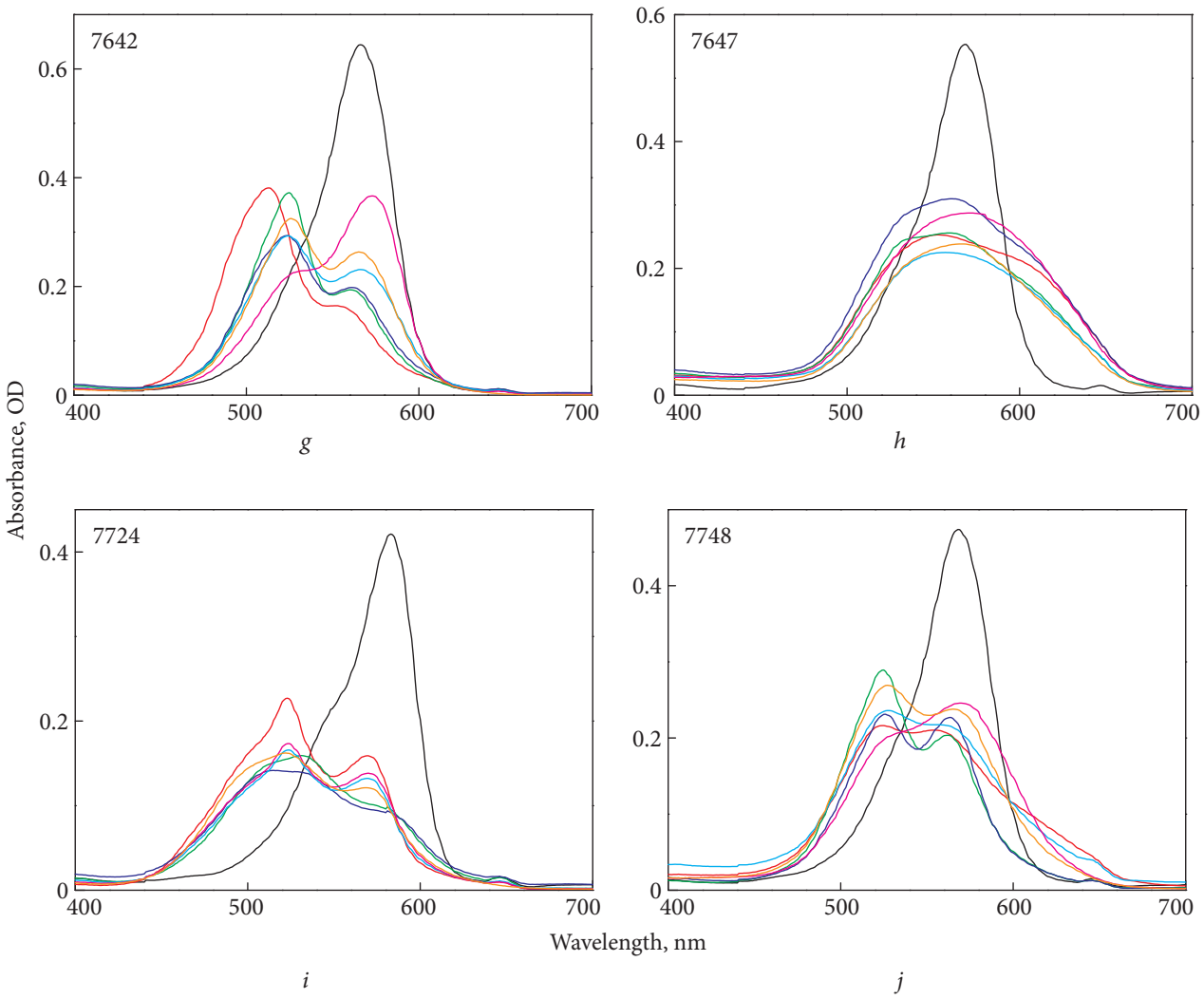


Fig. 2. Absorption spectra of the dyes **7513** (*a*), **7514** (*b*), **7515** (*c*), **7520** (*d*), **7544** (*e*), **7545** (*f*), **7642** (*g*), **7647** (*h*), **7724** (*i*) and **7748** (*j*) in DMSO, in 50 mM Tris–HCl buffer (pH 8.0) and in the presence of DNA (60 μM b.p.), RNA (120 μM b.), BSA, HSA and ESA (albumins concentrations 0.2 mg/mL). Dyes concentration 5 μM

emission spectra are characteristic of the monomeric form of cyanine dyes [15]. All dyes in DMSO show moderate to high fluorescence intensity, ranging from 172 to 1500 arbitrary units (a.u.).

In buffer, the absorption spectra of the dyes undergo pronounced changes. While the most intense absorption maximum shifts to shorter wavelengths by 16—114 nm, additional absorption features appear, either as well-resolved bands (the positions of the most prominent ones are listed in Table 1) or as shoulders (Fig. 2). Such spectral behavior is consistent with the formation of molecular aggregates by the dye molecules, a phenomenon commonly observed for trimethine cyanine dyes in aqueous media [5, 15], though isomerization *via* rotation around the methine bond cannot be excluded [16].

The emission spectra in buffer remain similar in shape to those recorded in DMSO (Fig. 3), with a single maximum in the range of 578—588 nm,

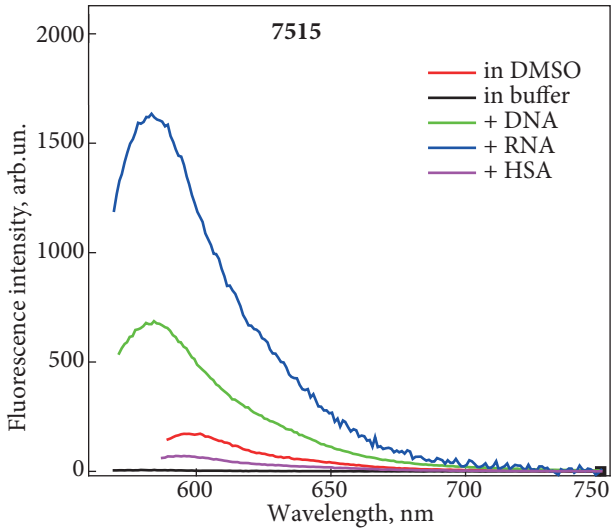


Fig. 3. Fluorescence emission spectra of the dye **7515** (5 μM) in DMSO, in 50 mM Tris–HCl buffer (pH 8.0) and in the presence of DNA (60 μM b.p.), RNA (120 μM b.), and HSA (0.2 mg/mL)

blue-shifted by 13—20 nm relative to the corresponding ones in DMSO (except for the dye **7647**, for which the fluorescence intensity was too low to determine reliably the emission maximum). Compared to DMSO solutions, the fluorescence intensities of the dyes in buffer decrease by factors of 4 to 47, yielding low to moderate values between 4 and 342 a.u.

Overall, the spectral data indicate that although the dyes predominantly exist as aggregates in buffer, the observed fluorescence arises primarily from the monomeric fraction.

Spectral-fluorescent properties of dyes in the presence of nucleic acids

The parameters of the absorption and fluorescence spectra of the studied dyes in buffer in the presence of DNA and RNA are summarized in Table 2.

Table 2. **Spectral characteristics of the studied dyes (5 μM) in 50 mM Tris–HCl buffer (pH 8.0) in the presence of DNA (60 μM b.p.) and RNA (120 μM b.)**

Dye	+ DNA					+ RNA				
	λ_{abs}, nm	*A*	λ_{fl}, nm	*I*, a.u.	ΔQ	λ_{abs}, nm	*A*	λ_{fl}, nm	*I*, a.u.	ΔQ
7513	458	0.315	602	348	3.3	464	0.200	604	580	5.6
7514	513 557	0.220 0.124	587	361	19.0	517 557	0.192 0.175	587	969	51.0
7515	513 556	0.274 0.179	585	683	98.0	519 557	0.212 0.227	584	1636	223.0
7520	516 559	0.199 0.143	585	562	94.0	521 559	0.190 0.222	584	1681	280.0
7544	503	0.272	595	408	7.5	495	0.264	597	675	12.5
7545	515 560	0.228 0.132	586	436	21.0	519 560	0.185 0.188	585	1500	71.0
7724	531	0.16	601	520	1.5	515	0.142	603	706	2.0
7642	524 561	0.374 0.196	591	409	16.4	524 562	0.294 0.199	588	673	27.0
7647	559	0.257	590	193	48.0	561	0.310	587	281	70.0
7748	525 563	0.290 0.204	590	464	51.5	526 563	0.231 0.228	587	1030	114.0

Note: ΔQ, the ratio of fluorescence intensities with and without nucleic acids.

Upon addition of nucleic acids, the absorption spectra of the dyes undergo complex changes, the nature and extent of which depend on the particular dye (Fig. 2). These spectral changes likely reflect a combination of partial disruption of dye aggregates present in buffer and binding of the dyes to DNA or RNA, either in monomeric form or through the formation of various aggregates on the nucleic acids.

Among the observed effects, an increase in the contribution of the monomer band is particularly notable for dyes **7515** (Fig. 2*c*), **7520** (Fig. 2*d*), and **7748** (Fig. 2*j*) in the presence of both DNA and RNA. In the case of RNA, this effect is more pronounced for all three dyes. A similar rise of the monomer band is also observed for **7514** (Fig. 2*b*) and **7545** (Fig. 2*f*) in the presence of RNA. Notice, that all dyes **7515**, **7520**, and **7748** contain hydroxy substituents.

The emission spectra of the dyes in the presence of DNA and RNA correspond to monomeric dye emission (Fig. 3). In most cases, the emission maxima are shifted to longer wavelengths by 1—17 nm relative to those of the free dyes in buffer. No spectral shift was observed for dyes **7520** and **7642**, while for **7647** the emission maximum of the free dye in buffer could not be determined.

The presence of both DNA and RNA results in an increase in fluorescence intensity for all studied dyes, with the enhancement being consistently higher in the presence of RNA compared to DNA. As shown in Table 2, the highest fluorescence intensities and intensity enhancement factors ΔQ were observed for dyes **7515** and **7520**. These dyes share common structural features, namely the presence of OH substituents at the 6,6' and 5,5' positions, respectively, and *N*-methyl groups on the benzothiazole rings. In the presence of RNA, the value of ΔQ for dyes is 223 and 280, respectively, while in the presence of DNA the corresponding enhancement factors are 98 and 94.

Dyes **7514**, **7545**, **7647**, and **7748** exhibit lower absolute fluorescence intensities and/or ΔQ ratios, but still display a substantial response to both nucleic acids, with ΔQ in the range of 51—114 and 19—51.5 in the presence of RNA and DNA respectively. Notably, the structures of these dyes lack one of the two structural features identified for **7515** and **7520**: either OH groups are replaced by O-methyl ones at the 5,5' or 6,6' positions (**7514** and **7545**), or larger *N*-alkyl substituents are present (**7647** and **7748**). Dye **7642**, which contains both O-methyl substituents and *N*-pentyl groups, demonstrates an even lower sensitivity toward RNA (ΔQ = 27) and DNA (ΔQ = 16). Finally, the least sensitive dyes **7513**, **7544**, and **7724** exhibit ΔQ ratios of only 2—12.5 in the presence of RNA and 1.5—7.5 in the presence of DNA. A common structural feature of these dyes is the absence of a substituent at the *β*-position of the trimethine chain.

Spectral-fluorescent properties of the dyes in the presence of serum albumins

The parameters of the absorption and fluorescence spectra of the studied dyes in buffer in the presence of BSA, HSA, and ESA are summarized in Table 3. Absorption spectra are presented in Fig. 2.

Upon addition of serum albumins, the absorption spectra of dyes **7513**, **7514**, **7515**, **7520**, **7545**, and **7724** largely retain their original shapes, exhibiting only shifts of the main maximum. In contrast, for **7544** the presence of serum albumins results in a redistribution of intensities among different aggregate bands, with a decrease in the contribution of short-wavelength maxima and an increase in the intensity of long-wavelength ones.

For dye **7642** (Fig. 2*g*), the addition of serum albumins leads to an intensity decrease and a bathochromic shift of the aggregate absorption maximum from 513 nm to 524—526 nm, and an intensity increase of the monomer band (566—573 nm). This increase is most pronounced in the presence of HSA, which may indicate the binding of **7642** to HSA predominantly in monomeric form, whereas interactions with BSA and ESA may involve both monomeric and aggregated dye species.

In the case of dyes **7647** (Fig. 2*h*) and **7748** (Fig. 2*j*), the spectral changes induced by serum

albumins involve several aggregate bands in addition to monomeric one. For **7748**, the monomer maximum becomes dominant in the presence of HSA (at 570 nm), while the addition of BSA and ESA results in less pronounced spectral changes. In contrast, for **7647** the absorption maxima are difficult to resolve due to strong overlap of broad spectral bands.

The fluorescence spectra of all studied dyes in the presence of the three serum albumins correspond to monomeric dye emission, with bathochromic shift by 8—16 nm, 8—14 nm, and 2—14 nm in the presence of HSA, ESA, and BSA, respectively, relative to the corresponding free dyes in buffer.

The presence of serum albumins leads to an increase in fluorescence intensity for all dyes. The largest ΔQ ratios of 33—78, 36.5—63, and 16.3—44 in the presence of HSA, ESA, and BSA, respectively are observed for **7642**, **7647**, and **7748**, all of which contain *N*-propyl or *N*-pentyl substituents on the benzothiazole rings. While **7642** demonstrates the highest ΔQ ratio in the presence of HSA (78-fold), **7647** and **7748** exhibit their strongest fluorescent responses upon addition of ESA (63- and 41-fold, respectively). Besides, **7642** shows a substantially higher absolute fluorescence intensity than the other two dyes.

In contrast, dyes **7513**, **7544**, and **7724** exhibit lower sensitivity toward all studied serum albumins, with ΔQ ratios of no more than 2.1-fold in their presence, except for **7544** in the presence of HSA (ΔQ = 11.6); this behavior is associated with the unsubstituted trimethine chain in all three dyes.

The dyes **7514**, **7515**, **7520**, and **7545** contain *N*-methyl substituents on the benzothiazole rings as well as methyl or ethyl groups at the *β*-position of the trimethine chain. These dyes exhibit ΔQ values

Table 3. **Spectral characteristics of trimethine cyanine dyes (5 μM) in the presence of HSA, BSA and ESA (proteins concentration 0.2 mg/mL)**

Dye	+ HSA					+ ESA					+ BSA				
	λ_{abs}, nm	*A*	λ_{fl}, nm	*I*, a.u.	ΔQ	λ_{abs}, nm	*A*	λ_{fl}, nm	*I*, a.u.	ΔQ	λ_{abs}, nm	*A*	λ_{fl}, nm	*I*, a.u.	ΔQ
7513	478	0.420	595	191	1.83	467	0.420	597	173	1.66	478	0.520	590	106	1.00
7514	481	0.230	596	466	24.50	481	0.230	593	178	9.40	485	0.210	594	117	6.20
	557	0.105													
7515	516	0.210	594	70	10.00	512	0.220	593	74	10.60	515	0.230	591	30	4.30
7520	490	0.190	595	186	31.00	494	0.206	596	125	21.00	491	0.210	596	44	7.30
7544	574	0.400	597	628	11.60	480	0.340	589	113	2.10	571	0.310	585	65	1.20
	611	0.360				568	0.270				610	0.290			
7545	484	0.210	592	548	26.10	481	0.220	592	362	17.20	486	0.196	592	177	8.40
	557	0.120									553	0.108			
7724	524	0.170	597	548	1.60	522	0.160	598	614	1.80	523	0.165	594	387	1.13
	571	0.140				571	0.120				569	0.130			
7642	573	0.370	599	1954	78.00	526	0.330	597	912	36.50	524	0.290	598	844	34.00
						566	0.260				567	0.230			
7647	570	0.288	600	158	39.50	566	0.240	599	251	63.00	558	0.225	597	176	44.00
7748	570	0.245	602	295	33.00	528	0.270	598	367	41.00	527	0.240	595	147	16.30
						567	0.240								

Note: ΔQ, the ratio of fluorescence intensities with and without serum albumins.

of 10—31, 9.4—21, and 4.3—8.4 in the presence of HSA, ESA, and BSA, respectively. While **7514**, **7520**, and **7545** show a noticeable preference for HSA over the other two proteins, **7515** displays comparable fluorescent responses toward HSA and ESA.

Discussion

The studied dyes are based on a symmetric thiacarbocyanine scaffold with various substituents at three positions: (1) O-methyl or OH groups at the 6,6' or 5,5' positions of the benzothiazole rings, (2) *N*-alkyl substituents of different chain length, and (3) methyl, ethyl, or no substituent at the β-position of the trimethine chain. The results obtained allow several general observations to be made regarding the influence of these substituents on the spectral-fluorescent properties of the dyes in the presence of nucleic acids and serum albumins.

First, the highest fluorescent response toward DNA and RNA is observed for dyes **7515** and **7520**, which contain OH substituents at the 6,6' and 5,5' positions of the benzothiazole heterocycles, respectively, *N*-methyl substituents on the benzothiazole rings, and methyl or ethyl substituents at the β-position of the trimethine chain. The results obtained for the other dyes suggest that all three structural features contribute to enhanced fluorescent response. Replacement of OH groups with O-methyl ones, elongation of the *N*-alkyl chains, or unsubstituted trimethine chain leads to a decrease in fluorescent response toward nucleic acids.

Possible reasons for the observed effects can be proposed. Longer *N*-alkyl chains may introduce steric hindrance to dye interaction with nucleic acids. In the case of OH groups, two factors may be relevant. First, O-methyl groups are bulkier than OH ones and may thus cause additional steric constraints on binding. Second, OH-groups can act as both H-bond donors and acceptors, whereas O-methyl groups can only be acceptors. The formation of H-bonds between the dye and suitable functional groups of nucleic acids could enhance the stability of dye-nucleic acid complexes and, consequently, the fluorescent response.

The mechanism of interaction between the studied dyes and nucleic acids is not obvious. Substituents at the 6,6' or 5,5' positions elongate the dye molecule and simultaneously introduce functional groups capable of H-bond formation, which may be favorable for groove binding. On the other hand, a pronounced preference for RNA over DNA may point to intercalation, which can occur even within single-stranded regions. At the same time, the coexistence of multiple binding modes cannot be excluded, and it is also possible that the dyes interact with DNA and RNA *via* different mechanisms.

A second set of conclusions concerns the sensitivity of the dyes toward serum albumins. Comparison of dyes **7642** and **7647**, as well as **7520** and **7545**, indicates that replacement of an OH group with an O-methyl one at the 6,6' or 5,5' positions does not significantly affect the fluorescent response of the dyes in the presence of albumins. At the same time, comparison of **7647**, **7748**, and **7515** shows that elongation of the *N*-alkyl substituents leads to an increased fluorescent response toward all three studied serum albumins. A possible explanation is that the hydrophobic alkyl chains of the dyes interact with hydrophobic regions of the protein globule, thereby enhancing dye-protein affinity.

Finally, the absence of a substituent at the β-position of the trimethine chain negatively affects the sensitivity of the dyes toward nucleic acids and serum albumins. This behavior can be attributed to the higher fluorescence intensity of free dyes with unsubstituted trimethine chains [5], as β-substitution may disturb chromophore planarity and lower the barrier for photoisomerization from *all-trans* to out-of-plane twisted conformation, thereby enhancing nonradiative decay [17].

Conclusions

The spectral-fluorescent responses of a series of thiacarbocyanine dyes bearing various substituents on the benzothiazole end groups and in the

trimethine chain were investigated in the presence of nucleic acids and serum albumins.

The highest fluorescent response toward DNA and RNA, with a pronounced preference for RNA, was observed for dyes containing OH groups at the 5,5' or 6,6' positions and *N*-methyl substituents on the benzothiazole rings, together with small *β*-substituents (methyl or ethyl) in the trimethine chain. In contrast, replacement of OH groups with O-methyl substituents, elongation of the *N*-alkyl chains, or absence of a substituent at the *β*-position of the trimethine chain leads to a decreased fluorescent response toward nucleic acids.

In the case of serum albumins, replacement of hydroxy groups with O-methyl ones at the 5,5' or 6,6' positions does not significantly affect the fluorescent response of the dyes toward BSA, HSA, and ESA. At the same time, elongation of the *N*-alkyl substituents results in enhanced fluorescent response toward all three studied serum albumins.

Dyes **7515** and **7520** appear promising for further development as RNA-sensitive fluorescent probes, while **7642** merits additional investigation as a fluorescent probe for human serum albumin.

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ВПЛИВ ЗАМІСНИКІВ У ТІАКАРБОЦІАНІНОВИХ БАРВНИКАХ НА ЇХ СПЕКТРАЛЬНО-ФЛУОРЕСЦЕНТНИЙ ВІДГУК У ПРИСУТНОСТІ НУКЛЕЇНОВИХ КИСЛОТ ТА СИРОВАТКОВИХ АЛЬБУМІНІВ

Мета. Метою цієї роботи було вивчення спектрально-флуоресцентного відгуку у присутності нуклеїнових кислот та сироваткових альбумінів для серії тіакарбоціанінових барвників з різними замісниками в бензотіазольних кінцевих групах та триметиновому ланцюзі. ***Методи.*** Спектроскопія поглинання в УФ- та видимому діапазонах та флуоресцентна спектроскопія. ***Результати.*** Найвищий відгук на присутність ДНК та РНК (зі значною переважністю до РНК) спостерігався для барвників з ОН-групами в 5,5'- або 6,6'-положеннях та N-метилами в бензотіазольних кільцях, а також з метильною або етиловою групою в β-положенні триметинового ланцюга. Заміна ОН-груп на О-метильні в 5,5'- або 6,6'-положеннях помітно не впливає на флуоресцентний відгук барвника в присутності людського (ЛСА), бичачого та кінського сироваткових альбумінів. Водночас збільшення довжини бензотіазольних N-алкільних груп призводить до посилення флуоресцентного відгуку на всі три досліджені сироваткові альбуміни. ***Висновки.*** Барвники **7515** і **7520** є багатообіцяючими для подальшої розробки на їх основі РНК-чутливих флуоресцентних зондів. Барвник **7642** демонструє перспективні властивості як ЛСА-чутливий флуоресцентний зонд.

***Ключові слова*:** ціанінові барвники, флуоресцентні зонди, нуклеїнові кислоти, сироваткові альбуміни.