Synthesis of photoactive bichromophoric dyads containing 2-styrylquinoline and 2-naphthol moieties

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A three-step approach to the synthesis of bichromophoric dyads of the general formula SQ—$(CH_2)_n$—Np (SQ is the 2-(4-oxystyryl)quinoline moiety, Np is the 3-oxy-2-naphthol moiety, n = 2, 4, 5) was developed from available reagents.

Key words: styrylquinoline, condensation, microwave irradiation, alkylation, bichromophoric dyads.

Nowadays, a large amount of works are devoted to the studies of principles of construction and functioning of molecular logical gates (MLG),[1—6] *i.e.*, molecular systems, which are transformed from one stable state to another upon an external action (the input signal). The properties of the initial and final states determine the type of an output signal, whereas the input/output signal proportion is determined by the table of the truth of logical function.

We have shown[7,8] that 2-styrylquinoline (2SQ) derivatives can be used in the construction of different MLG, which are able to function both in solutions and polymeric matrices. Exposure to light and addition of an acid are the input signals for such MLG, whereas optical density on a certain wavelength is the output signal.

To return the 2SQ-derived MLG to the initial state (reversibility is a necessary condition for the MLG functioning), an acid should be neutralized, for example, by addition of an alkali. However, the use of extra reagents (acids, alkalis) sets limits on the applicability of MLG.

The optimum are completely photon MLG,[9] in which both the isomerization and protonation reactions proceed upon the action of light. Photoacids, for example naphthols, can be used for the latter reaction. The compound 2SQ has an acidity constant $pK_a = 4.8$.[10] For 2-naphthol (2Np) the acidity constants in the ground and the lowest singlet excited states are equal to 9.5 and 2.8, respectively.[11] Therefore, the ground (S_0) state of the 2SQ—2Np system has the proton on the hydroxy oxygen atom, and there are thermodynamic prerequisites for the proton to be phototransferred upon excitation of 2Np. In this case, instead of addition of an acid one can use exposure to the light from the region of absorption of 2Np, that can lead to the formation of the protonated form of 2SQ.

To sum up, a photon MLG is a molecular photoswitch capable to exist in several states, whose interconversions can be accomplished upon the action of light. In order to simulate the functioning of such switches, we synthesized bichromophoric dyads containing the 2SQ and 2Np moieties, which are bound with an oxypolymethylene "bridge" (Scheme 1).

Results and Discussion

There are several approaches to the synthesis of bichromophoric dyads containing fragments of 2SQ and 2Np from available reagents (quinaldine, 4-hydroxybenzaldehyde, 2,3-dihydroxynaphthalene, and dibromoalkane) (see Scheme 1).

Method *A* suggests a condensation of 4-hydroxybenzaldehyde with quinaldine in the first step to form 2-(4-hydroxystyryl)quinoline (**1**), which is further alkylated with dibromoalkane to the corresponding bromoalkoxystyrylquinoline **2**. Compound **2** can be also obtained by method *B*, which includes an initial preparation of bromoalkoxybenzaldehyde **3**, followed by the condensation reaction.

We studied this possibility using alkylation of 4-hydroxybenzaldehyde with 1,2-dibromoethane and 1,4-dibromobutane as examples. The reactions were carried out under various conditions described in the literature: in the alcoholic alkali[12] or in DMF in the presence of potassium carbonate.[13] In both cases, the mixtures of mono- and dialkylated products were obtained and the yields of the target bromoalkoxybenzaldehyde **3** did not exceed 45%. To increase the yield of monoalkylated product, we used a dibromoalkane excess, however, the latter complicated isolation of the target product from the reaction mixture.

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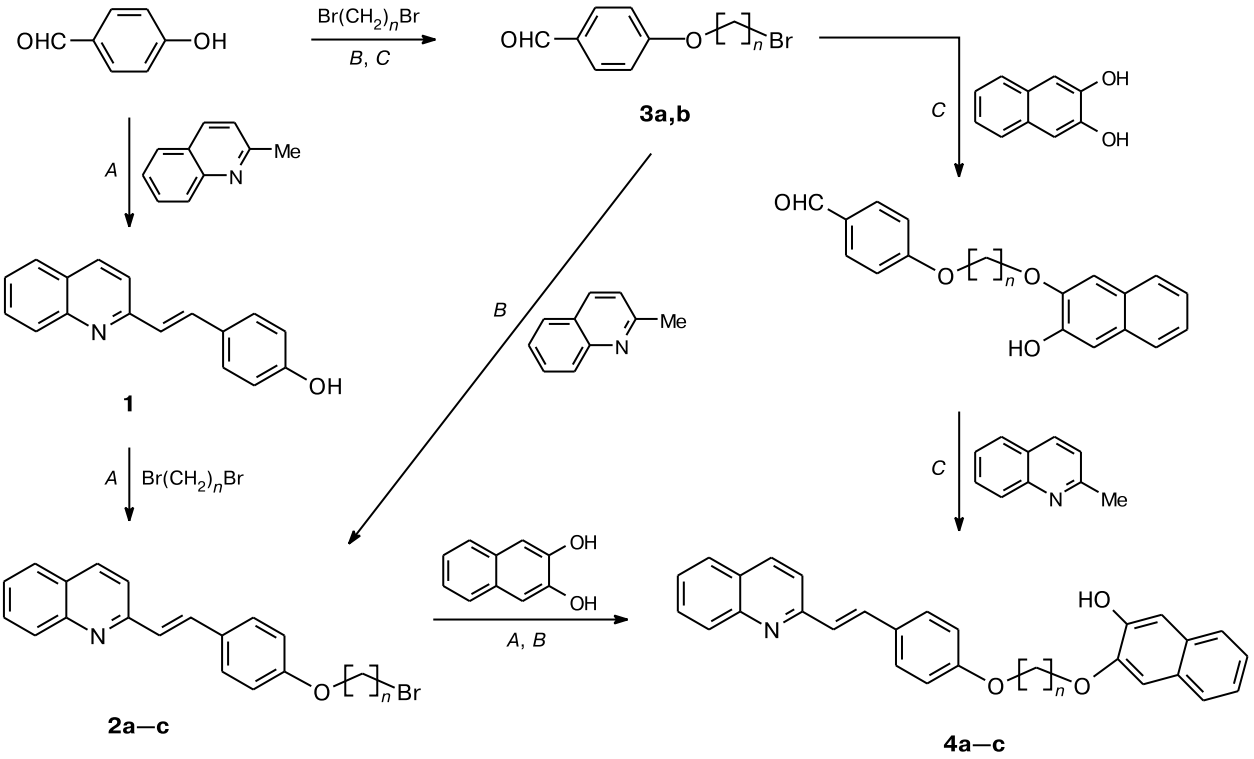
Scheme 1



n = 2 (**a**), 4 (**b**), 5 (**c**)

The aldehydes **3a** and **3b** obtained were further used in the condensation with quinaldine for the synthesis of the corresponding styrylquinolines **2a** and **2b**. The reaction was carried out in acetic anhydride, the reaction mixture was heated for 14 h. The total two-step yield of styrylquinolines was <24% and required laborious purification by column chromatography, large amounts of reagents and solvents. We did not try method *C* (the reaction of **3** with dihydroxynaphthalene) because of the low yields of bromoalkoxybenzaldehydes **3** and their complicated isolation. We did not consider another synthesis either, which uses an alkylation of dihydroxynaphthalene with dibromoalkane in the first step, since in this case both reactants have two equivalent functional groups, that can lead to the formation of several by-products (oligomers and cyclic structures).

Method *A* proved to be the most efficient, whose first step includes the condensation of quinaldine with 4-hydroxybenzaldehyde. This condensation can be accomplished by different ways. It is commonly carried out in the presence of acetic anhydride.[14] The disadvantages of this way are a prolonged heating and the use of acetic anhydride as a solvent and a catalyst, which reacts with the hydroxy group to form 2-(4-acetoxystyryl)quinoline, which should be hydrolyzed to the target hydroxy derivative **1**. The reaction virtually proceeds in two steps and requires purification of 2-(4-acetoxystyryl)quinoline obtained in the first step on a column with silica gel with its subsequent recrystallization. We have suggested a convenient one-step solvent- and catalyst-free approach to the synthesis of 4-hydroxystyrylquinolines upon the action of microwave irradiation.[15] The condensation in this case is completed within 9—12 min. Hydroxystyrylquinoline **1** can be easily isolated by simple work-up of the reaction mixture with aqueous alcohol, with the yield being as high as 90%. Further, we carried out alkylation of compound **1** with different dibromoalkanes: 1,2-dibromoethane, 1,4-dibromobutane, and 1,5-dibromopentane. The phenoxide anion was generated using potassium carbonate, whereas 2-butanone was a solvent, since in acetone the reaction was too slow. We used a tenfold excess of dibromoalkane to suppress the dialkylation reaction. The ability of the starting compound **1** to form a water soluble sodium salt was used for the separation of the product from it. Compounds **2a—c** were converted to hydro chlorides for the products to be separated from excess dibromoalkane, since, unlike dibromoalkanes, they are insoluble in hexane. Thus, bromoalkoxystyrylquinolines **2a—c** were synthesized in 62—91% yields.

The thus obtained bromoalkoxystyrylquinolines **2** were further involved into the reaction with 2,3-dihydroxynaphthalene. The naphthoxide anion was also generated

using potassium carbonate, the reaction was carried out in 2-butanone, since in acetone it was very slow because of its low boiling point. We used excess of 2,3-dihydroxynaphthalene to suppress alkylation of the second hydroxy group. This method furnished the target compounds **4a**—**c** in 42—85% yields.

When the two methods for the construction of dyads **4a**,**b** containing a quinoline and a naphthalene moieties are compared, it becomes obvious that the synthesis based on the use of hydroxystyrylquinoline **1** as the intermediate (way *A*) is more efficient than the alternative approach (way *B*), when 4-hydroxybenzaldehyde is alkylated in the first step (Table 1).

The structures of compounds **2a**—**c** and **4a**—**c** were confirmed by the ^{1}H NMR, IR, and UV-visible spectroscopic data. The ^{1}H NMR spectra of these compounds exhibit signals for the olefin protons of the styryl fragment in the region δ 7—8 as doublets with the vicinal spin-spin coupling constants 16—17 Hz, that indicates the *trans*-arrangement of the double bond. The presence of the band of out-of-plane bending vibrations of the C—H bonds at the C=C double bond in the region 968—982 cm^{-1} of the IR spectra confirms the *trans*-arrangement of the double bond. In addition, the IR spectra of compounds **2a**—**c** exhibit a characteristic band of stretching vibrations of the C—Br bond in the region 510—515 cm^{-1}, whereas a broad band characteristic of the OH group is observed for compounds **4a**—**c** in the region 2400—3600 cm^{-1}.

The UV spectra of compounds **4a**—**c** virtually are the sum of the spectra of model compounds, 2-(4-ethoxystyryl)quinoline and 3-methoxynaphthol-2, as it is shown in Fig. 1 for compound **4b** taken as an example. Comparison with the spectra of model compounds shows that an absorption band in the region 230 nm is basically related to the absorption of naphthol, whereas styrylquinoline absorbs exclusively in the region of wavelengths higher 350 nm, that creates the prerequisites for the selective excitation of different chromophoric groups depending on the wavelength of the acting light.

Preliminary studies of photochemical activity of compounds **4a**—**c** showed that their exposure to the UV light produces spectral changes characteristic of the *trans*—*cis*-photoisomerization, that creates prerequisites for the simulation of functioning of controlled molecular photoswitches on their basis. Measurement of quantum yields of the reaction, their dependence from the length of the bridged group in the supramolecular system and from the pH of the medium, as well as determination of the type of logical operations, which can be accomplished by compounds **4a**—**c**, are subjects of our further studies.

Table 1. Comparison of different methods for the synthesis of compounds **4a**,**b**

Method	Total yield (%)	Compound	Yield (%)
A	26—77	**1**	90
		2a,**b**	62—91
		4a,**b**	42—85
B	<20	**3a**,**b**	37—44
		2a,**b**	51—52
		4a,**b**	42—85

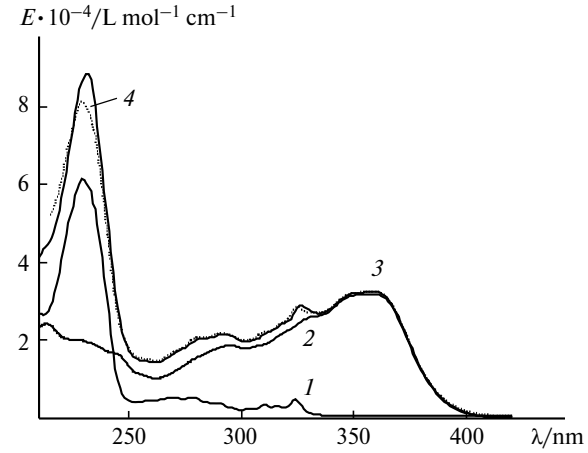


Fig. 1. Absorption spectra (in ethanol) of 3-methoxynaphth-2-ol (*1*), 2-(4-ethoxystyryl)quinoline (*2*), and compound **4b** (*3*), as well as the sum of the first two spectra (*4*).

In conclusion, starting from available reagents we developed an efficient three-step synthesis of bichromophoric dyads **4a**—**c** containing styrylquinoline and naphthol moieties, which are bound with oxypolymethylene bridge. These compounds are promising models for the studies of principles of functioning of photocontrolled molecular switches and logical gates.

Experimental

^{1}H NMR spectra were recorded on a Bruker Avance III spectrometer (500 MHz) in $CDCl_3$ and DMSO-d_6, Me_4Si was used as an internal standard. IR spectra were recorded on a Spectrum BX-2 Fourier-spectrometer in KBr pellets. Electron absorption spectra were recorded on a Specord M-400 spectrophotometer.

Melting points were measured on a Kofler heating stage at the rate of heating 4 °C min^{-1}. TLC analysis was performed on ALUGRAM SIL G/UV$_{254}$ plates, which were visualized under the UV light. Commercially available (Aldrich) 1,3-dibromoethane, 1,4-dibromobutane, 1,5-dibromopentane, 4-hydroxybenzaldehyde, quinaldine, and 2,3-dihydroxynaphthalene were used as purchased. 2-Butanone was distilled before use, potassium carbonate was calcined.

2-(*E*)-(4-Hydroxystyryl)quinoline (1). A glass test-tube containing quinaldine (0.29 g, 2 mmol) and 4-hydroxybenzaldehyde (0.49 g, 4 mmol) was placed in a glass with water and irradiated with microwaves in a consumer oven (600 W) 3 times for 3 min with 30 s intervals (the total time of irradiation was 9 min). The reaction progress was controlled by TLC (eluent: acetone—hex-

ane (1 : 1)). To isolate compound **1,** the reaction mixture was worked-up with aqueous ethanol, the undissolved precipitate was filtered off, washed with hot ethanol (3×5 mL), dried in a drying oven. Compound **1** (0.44 g, 90%) was obtained as light yellow crystals, m.p. 268 °C (from 2-propanol) (*cf.* Ref. 14: m.p. 268—270 °C). ^{1}H NMR ($CDCl_3$), δ: 6.76 (d, 2 H, *o*-C_6H_4O, J = 8.4 Hz); 7.18 (d, 1 H, =CH—, J = 16.2 Hz); 7.47—7.55 (m, 3 H, *m*-C_6H_4O, quinoline); 7.66—7.72 (m, 2 H, —CH=, quinoline); 7.78 (d, 1 H, quinoline, J = 8.6 Hz); 7.88 (d, 1 H, quinoline, J = 8.0 Hz); 7.92 (d, 1 H, quinoline, J = 8.4 Hz); 8.26 (d, 1 H, quinoline, J = 8.6 Hz); 10.25 (br.s, 1 H, OH). IR, ν/cm^{-1}: 1636 ($\nu_{C=C}$), 968 (out-of-plane. δ *trans*-HC=C—H), 2430—3090 (OH).

4-(2-Bromoethoxy)benzaldehyde (3a). Aqueous 12 *M* NaOH (2.1 mL) was added dropwise to a stirred solution of 4-hydroxybenzaldehyde (3.05 g, 25 mmol) in 95% ethanol (45 mL) at ~20 °C, the mixture was refluxed for 30 min, followed by addition of 1,2-dibromoethane (9.4 g, 50 mmol). The reaction mixture that obtained was refluxed for another 4.5 h. After the solvent was evaporated on a rotary evaporator, the residue was diluted by small amounts of water and diethyl ether, which was accompanied by precipitation of bis-4-formylphenoxyethane, the latter was filtered off. The ethereal layer was washed with 10% aq. KOH and water and dried with sodium sulfate. After the solvent was evaporated, 50% aq. ethanol was added to the residue, and a precipitate of the target product was separated. Compound **3a** (2.10 g, 37%) was obtained as white crystals, m.p. 53—55 °C (*cf.* Ref. 16: m.p. 55—58 °C).

4-(4-Bromobutoxy)benzaldehyde (3b). Potassium carbonate (10 g, 72 mmol) was added to a solution of 4-hydroxybenzaldehyde (4.88 g, 40 mmol) in anhydrous DMF (40 mL), the mixture was refluxed for 30 min, followed by addition of 1,4-dibromobutane (17.3 g, 80 mmol) and the mixture that obtained was refluxed for 15 h with stirring. The reaction progress was monitored by TLC (acetone—hexane (1 : 5)). After cooling, the reaction mixture was treated with water and extracted with benzene (3×100 mL), the solvent was evaporated on a rotary evaporator, hexane was added to the residue. The hexane extract was separated from the oil using a separatory funnel and purified by column chromatography on Silpearl (eluent: hexane—chloroform (1 : 1)). Compound **3b** (4.48 g, 44%) was obtained as white crystals, m.p. 42—44 °C (*cf.* Ref. 17: m.p. 43 °C).

Synthesis of 2-[4-(*p*-bromoalkoxy)styryl]quinolines 2a,b (method *B*, general procedure). The corresponding 4-(*p*-bromoalkoxy)benzaldehyde **3** (2 mmol) and acetic anhydride (5 mL) were added to quinaldine (1 mmol). The reaction mixture was refluxed for 14 h, cooled, treated with aq. $NaHCO_3$, then extracted with diethyl ether (2×25 mL), and passed through a thin layer of silica gel. Diethyl ether was evaporated on a rotary evaporator, the residue was recrystallized from hexane.

2-(*E*)-[4-(2-Bromoethoxy)styryl]quinoline (2a). The yield was 0.18 g (51%), white crystals after recrystallization from hexane, m.p. 135—136 °C. Found (%): C, 64.24; H, 4.68; N, 3.70. $C_{19}H_{16}BrNO$. Calculated (%): C, 64.42; H, 4.55; N, 3.95. ^{1}H NMR ($CDCl_3$), δ: 3.67 (t, 2 H, CH_2Br, J = 6.3 Hz); 4.34 (t, 2 H, CH_2O, J = 6.3 Hz); 6.95 (d, 2 H, *o*-C_6H_4O, J = 8.7 Hz); 7.30 (d, 1 H, =CH—, J = 16.3 Hz); 7.49 (t, 1 H, quinoline, J = 7.6 Hz); 7.59 (d, 2 H, *m*-C_6H_4O, J = 8.7 Hz); 7.62—7.68 (m, 2 H, quinoline, —CH=); 7.71 (t, 1 H, quinoline, J = 7.7 Hz); 7.78 (d, 1 H, quinoline, J = 7.9 Hz); 8.08 (d, 1 H, quinoline, J = 8.4 Hz); 8.12 (d, 1 H, quinoline, J = 8.6 Hz). IR, ν/cm^{-1}: 3035, 2930, 2869 (CH_2), 1636 (C=C), 1597, 1513, 1248 (COC), 1231, 1185, 959 (—CH=CH), 826, 756, 510 (CBr).

2-(*E*)-[4-(4-Bromobutoxy)styryl]quinoline (2b). The yield was 0.20 g (52%), white crystals after recrystallization from hexane, m.p. 92—93 °C. Found (%): C, 65.62; H, 5.23; N, 3.47. $C_{21}H_{20}BrNO$. Calculated (%): C, 65.98; H, 5.27; N, 3.66. ^{1}H NMR ($CDCl_3$), δ: 1.94—2.01 (m, 2 H, CH_2); 2.05—2.13 (m, 2 H, CH_2); 3.51 (t, 2 H, CH_2Br, J = 6.6 Hz); 4.04 (t, 2 H, CH_2O, J = 6.0 Hz); 6.92 (d, 2 H, *o*-C_6H_4O, J = 8.6 Hz); 7.28 (d, 1 H, =CH—, J = 16.4 Hz); 7.48 (t, 1 H, quinoline, J = 7.6 Hz); 7.57 (d, 2 H, *m*-C_6H_4O, J = 8.6 Hz); 7.60—7.66 (m, 2 H, quinoline, —CH=); 7.69 (t, 1 H, quinoline, J = 7.6 Hz); 7.77 (d, 1 H, quinoline, J = 8.0 Hz); 8.06 (d, 1 H, quinoline, J = 8.4 Hz); 8.10 (d, 1 H, quinoline, J = 8.6 Hz). IR, ν/cm^{-1}: 3033, 2953, 2871 (CH_2), 1633 (C=C), 1598, 1515, 1249 (COC), 1231, 1184, 958 (—CH=CH), 826, 757, 511 (CBr).

Synthesis of 2-[4-(*p*-bromoalkoxy)styryl]quinolines 2a—c (method *A*, general procedure). Potassium carbonate (0.41 g, 3 mmol) was added to compound **1** (0.25 g, 1 mmol) in 2-butanone (10 mL). The reaction mixture was refluxed for 30 min with magnetic stirring, then a dibromoalkane (n = 2, 4, 5) (10 mmol) was added, followed by reflux for another 6—24 h until compound **1** disappeared. The reaction progress was monitored by TLC (acetone—hexane (1 : 5)). After the reaction was completed, the reaction mixture turned the color from yellow to white. Aqueous alkali was added to the reaction mixture, the organic layer was separated and diluted with hydrochloric acid. The orange precipitate thus formed was filtered off, washed with hexane (5×3 mL), and dried. Then, acetone (5 mL) and saturated aq. $NaHCO_3$ (for neutralization) were added to the precipitate, the mixture was stirred for ~30 min. A white precipitate that formed was filtered off, dried in air and recrystallized from hexane.

2-(*E*)-[4-(2-Bromoethoxy)styryl]quinoline (2a). The yield was 0.22 g (62%), white crystals after recrystallization from hexane, m.p. 135—136 °C.

2-(*E*)-[4-(4-Bromobutoxy)styryl]quinoline (2b). The yield was 0.35 g (91%), white crystals after recrystallization from hexane, m.p. 92—93 °C.

2-(*E*)-[4-(5-Bromopentoxy)styryl]quinoline (2c). The yield was 0.34 g (85%), white crystals after recrystallization from hexane, m.p. 88—89 °C. Found (%): C, 66.40; H, 5.69; N, 3.44. $C_{22}H_{22}BrNO$. Calculated (%): C, 66.67; H, 5.60; N, 3.53. ^{1}H NMR ($CDCl_3$), δ: 1.64—1.71 (m, 2 H, CH_2); 1.82—1.90 (m, 2 H, CH_2); 1.94—2.02 (m, 2 H, CH_2); 3.48 (t, 2 H, CH_2Br, J = 6.8 Hz); 4.04 (t, 2 H, CH_2O, J = 6.3 Hz); 6.94 (d, 2 H, *o*-C_6H_4O, J = 8.7 Hz); 7.33 (d, 1 H, =CH—, J = 16.2 Hz); 7.51 (t, 1 H, quinoline, J = 7.4 Hz); 7.60 (d, 2 H, *m*-C_6H_4O, J = 8.7 Hz); 7.64—7.70 (m, 2 H, quinoline, —CH=); 7.72 (t, 1 H, quinoline, J = 7.7 Hz); 7.79 (d, 1 H, quinoline, J = 7.8 Hz); 8.08—8.16 (m, 2 H, quinoline). IR, ν/cm^{-1}: 3038, 2945, 2867 (CH_2), 1637 (C=C), 1592, 1513, 1254 (COC), 1174, 972 (—CH=CH), 835, 752, 515 (CBr).

Synthesis of 2-{4-[*p*-(3-hydroxynaphthalen-2-yloxy)alkoxy]-styryl}quinolines 4a—c (general procedure). Potassium carbonate (0.18 g, 1.3 mmol) was added to 2,3-dihydroxynaphthalene (0.40 g, 2.5 mmol) in 2-butanone (40 mL). The reaction mixture was refluxed for 30 min with magnetic stirring, then the corresponding bromoalkoxystyrylquinoline **2** (n = 2, 4, 5) (0.5 mmol) was added and the mixture was refluxed for 6—24 h until compound **2** disappeared. The reaction progress was monitored by TLC (acetone—hexane (1 : 5)). After almost all 2-butanone was

evaporated, a dilute hydrochloric acid was added to the reaction mixture to pH 6. A precipitate that formed was filtered off, washed with diethyl ether and several portions of aq. acetone, dried in air, and recrystallized from ethanol.

2-(*E*)-{4-[2-(3-Hydroxynaphthalen-2-yloxy)ethoxy]styryl}-quinoline (4a). The yield was 0.09 g (42%), a white powder, m.p. 212—213 °C. Found (%): C, 80.54; H, 5.17; N, 3.15. $C_{29}H_{23}NO_3$. Calculated (%): C, 80.35; H, 5.35; N, 3.23. ^{1}H NMR (DMSO-d_6), δ: 4.42—4.48 (m, 4 H, CH_2); 7.08 (d, 2 H, *o*-C_6H_4O, J = 8.8 Hz); 7.16 (s, 1 H, naphthalene); 7.20—7.26 (m, 2 H, naphthalene); 7.31—7.37 (m, 2 H, =CH—, naphthalene); 7.53 (t, 1 H, quinoline, J = 7.5 Hz); 7.59 (d, 1 H, naphthalene, J = 6.8 Hz); 7.66—7.74 (m, 4 H, *m*-C_6H_4O, naphthalene, quinoline); 7.79 (d, 1 H, —CH=, J = 16.3 Hz); 7.83 (d, 1 H, quinoline, J = 8.6 Hz); 7.91 (d, 1 H, quinoline, J = 8.1 Hz); 7.96 (d, 1 H, quinoline, J = 8.4 Hz); 8.31 (d, 1 H, quinoline, J = 8.6 Hz); 11.05 (br.s, 1 H, OH). IR, ν/cm^{-1}: 3600—2400 (OH), 3053, 3043, 2944, 2867 (CH_2), 1633 (C=C), 1598, 1510, 1452, 1263, 1238 (COC), 1176, 966 (—CH=CH).

2-(*E*)-{4-[4-(3-Hydroxynaphthalen-2-yloxy)butoxy]styryl}-quinoline (4b). The yield was 0.19 g (82%), a white powder, m.p. 191—192 °C. Found (%): C, 80.44; H, 5.66; N, 2.84. $C_{31}H_{27}NO_3$. Calculated (%): C, 80.67; H, 5.90; N, 3.03. ^{1}H NMR (DMSO-d_6), δ: 1.94—2.04 (m, 4 H, CH_2); 4.09—4.23 (m, 4 H, CH_2); 7.03 (d, 2 H, *o*-C_6H_4O, J = 8.4 Hz); 7.15 (s, 1 H, naphthalene); 7.20—7.26 (m, 2 H, naphthalene); 7.28 (s, 1 H, naphthalene); 7.34 (d, 1 H, =CH—, J = 16.3 Hz); 7.54 (t, 1 H, quinoline, J = 7.6 Hz); 7.61 (d, 1 H, naphthalene, J = 6.7 Hz); 7.65—7.71 (m, 3 H, *m*-C_6H_4O, naphthalene); 7.74 (t, 1 H, quinoline, J = 7.6 Hz); 7.79 (d, 1 H, —CH=, J = 16.3 Hz); 7.84 (d, 1 H, quinoline, J = 8.6 Hz); 7.93 (d, 1 H, quinoline, J = 8.1 Hz); 7.97 (d, 1 H, quinoline, J = 8.3 Hz); 8.32 (d, 1 H, quinoline, J = 8.6 Hz); 9.42 (s, 1 H, OH). IR, ν/cm^{-1}: 3600—2400 (OH), 3057, 3040, 2940, 2857 (CH_2), 1635 (C=C), 1597, 1511, 1262, 1236, (COC), 1176, 976 (—CH=CH).

2-(*E*)-{4-[5-(3-Hydroxynaphthalen-2-yloxy)pentoxy]styryl}-quinoline (4c). The yield was 0.20 g (85%), a white powder, m.p. >180 °C (decomp.). Found (%): C, 80.66; H, 6.23; N, 2.80. $C_{32}H_{29}NO_3$. Calculated (%): C, 80.82; H, 6.15; N, 2.95. ^{1}H NMR (DMSO-d_6), δ: 1.61—1.72 (m, 2 H, CH_2); 1.81—1.95 (m, 4 H, CH_2); 4.08 (t, 2 H, CH_2, J = 6.4 Hz); 4.13 (t, 2 H, CH_2, J = 6.4 Hz); 7.02 (d, 2 H, *o*-C_6H_4O, J = 8.6 Hz); 7.14 (s, 1 H, naphthalene); 7.20—7.28 (m, 3 H, naphthalene); 7.34 (d, 1 H, =CH—, J = 16.3 Hz); 7.52—7.61 (m, 3 H, naphthalene, quinoline); 7.69 (d, 2 H, *m*-C_6H_4O, J = 8.6 Hz); 7.74 (t, 1 H, quinoline, J = 7.5 Hz); 7.80 (d, 1 H, —CH=, J = 16.3 Hz); 7.84 (d, 1 H, quinoline, J = 8.6 Hz); 7.94 (d, 1 H, quinoline, J = 7.9 Hz); 7.98 (d, 1 H, quinoline, J = 8.3 Hz); 8.33 (d, 1 H, quinoline, J = 8.6 Hz). IR, ν/cm^{-1}: 3600—2400 (OH), 3061, 3038, 2951, 2866 (CH_2), 1629 (C=C), 1598, 1514, 1473, 1260 (COC), 1171, 1113, 979 (—CH=CH).

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