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3-(4-Fluorophenyl)-1*H*-pyrazole-4-carbaldehyde in the Synthesis of Aza- and Diazaphenanthrene Derivatives

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Abstract—Condensation of 3-(4-fluorophenyl)-1*H*-pyrazole-4-carbaldehyde with 2-naphthyl- or 6-quinolylamine and CH-acids (acetone, acetophenone, cyclic mono- and β-diketones) provided new derivatives of benzo[*f*]quinoline, benzo[*a*]phenanthridine, benzo[*a*]acridine, and 4,7-phenanthroline. The arising in the course of the reaction [3-(4-fluorophenyl)-1*H*-pyrazole-4-ylmethylene]-2-naphthyl-(or 6-quinolyl)amines, [3-(4-fluorophenyl)-1*H*-pyrazole-4-ylmethylene]-1,3-indandione, and octahydro-1,8-xanthenedione derivatives were isolated.

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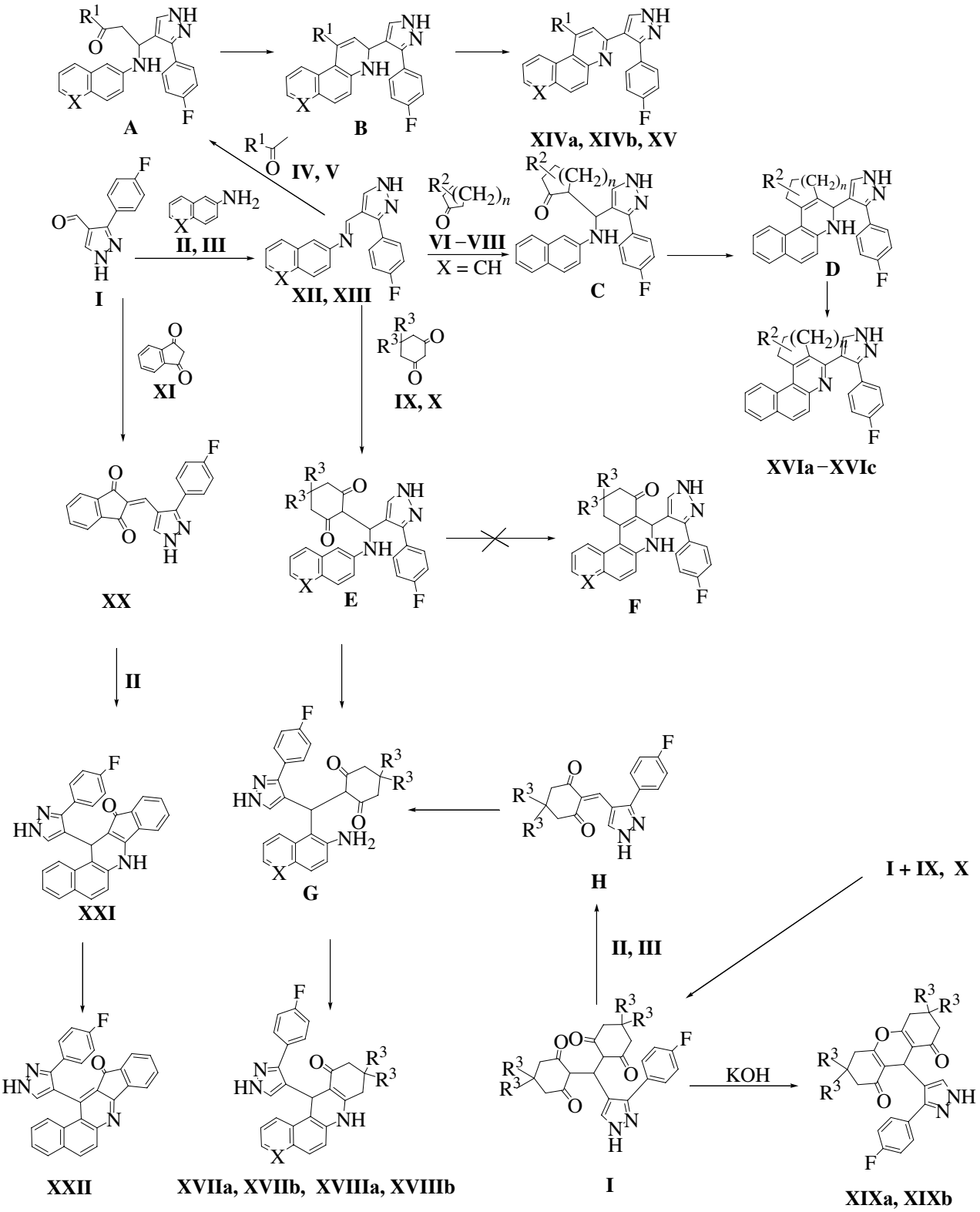
High and versatile biological activity of benzo[*f*]quinoline and 4,7-phenanthroline derivatives [1–6] calls for the search of new synthons for preparation of previously unknown compounds of these classes. New synthetic approaches that we develop for the preparation of fused nitrogen-containing heterocycles of aza- and diazaphenanthrene series, namely, benzo[*a*]phenanthridines, benzo[*f*]quinolines, benzo[*a*]acridines, and 4,7-phenanthrolines [1, 7, 8], are based on involvement of a wide range of aromatic aldehydes in condensation with 2-naphthyl-, 6-quinolylamines, and CH-acids. The aldehyde contributing a methine fragment and a phenyl ring with attached pharmacophore moieties into the structure of azaheterocycles plays an exceptional part in the synthesis of biologically active compounds: analogs of bactericides, cardioprotectors, enzyme inhibitors, analgesics, and alkaloids [1–6, 9, 10].

The condensation of heterocyclic aldehydes with 2-naphthyl-, 6-quinolylamines and CH-acids was studied mainly on pyridine- and quinolinecarbaldehydes [1, 11, 12]. No published data are known on the use in the synthesis of aza- and diazaphenanthrenes of aldehydes from the pyrazole series. At the same time it is expectable that introduction of a pyrazole ring into the molecule of azaphenanthrene can endow the compounds with new properties and extend the opportunities of their application as drugs, reagents for biochemical investigations, and for medicinal diagnostics.

In this study we investigated for the first time reactions of 3-(4-fluorophenyl)-1*H*-pyrazole-4-carbaldehyde (**I**) with 2-naphthyl- or 6-quinolylamines (**II** and **III**), and with CH-acids of various classes: methyl ketones [acetone (**IV**) and acetophenone (**V**)], cyclopentanone (**VI**), cyclohexanone (**VII**), 4-methylcyclohexanone (**VIII**), 1,3-cyclohexanedione (**IX**), dimedone (**X**), and 1,3-indandion (**XI**).

The condensation of aldehyde **I** with amines **II** and **III** and methyl ketones **IV** and **V** was performed by boiling a solution of the reagents in an aliphatic alcohol in the presence of a catalytic quantity of hydrochloric acid. Based on the data of [1, 8] we believe that in the three-component reagents mixture first the aldehyde reacts with arylamine to give azomethine **XII** and **XIII** whose condensation with CH-acid occurs via a sequence of stages: addition of the CH-acid to the C=N bond of the azomethine, cyclocondensation of the arising amine-ketone **A** into a dihydro derivative of the azaphenanthreneseries **B,** and dehydrogenation of the latter into a completely aromatic benzo[*f*]quinoline or 4,7-phenanthroline. In the condensation under study of pyrazolecarbaldehyde **I** with amines **II** and **III** and ketones **IV** and **V** under the above conditions we did not detect any intermediate compounds. As a result the reaction led to the selective formation in 39–55% yield of individual 1-methyl- (or phenyl)-3-[3-(4-fluorophenyl)-1*H*-pyrazol-4-yl]benzo[*f*]quinolines **XIVa** and **XIVb** and 1-phenyl-3-[3-(4-fluorophenyl)-1*H*-pyrazol-4-yl]-4,7-phenanthroline (**XV**).

From reaction carried out under milder conditions (20–50°C) both in the presence and absence of HCl we isolated



R^1 = Me (**IV, XIVa**), Ph (**V, XIVb, XV**); R^2 = H (**VI, VII, XVIà, XVIb**), 4-Me (**VIII**), 3-Me (**XVIc**); R^3 = H (**IX, XVIIa–XIXa**), Me (**X, XVIIb–XIXb**); X = CH (**II, XII, XIVà, XVIb, XVIIà, XVIIb**), N (**III, XIII, XV, XVIIIà, XVIIIb**); n = 1 (**VI, XVIa**), 2 (**VII, VIII, XVIb, XVIc**).

azomethines **XII** and **XIII**. The nitrogen atoms in the heteroaromatic ring of the aldehyde molecule activate the carbonyl group owing to the –*I*-effect in the stage of condensation with amine. In the arising azomethine molecule the effect of the nitrogens of the pyrazole ring on the activity of C=N bond is apparently less pronounced, and in the stage of methyl ketone addition the crucial importance belongs to sterical hindrances due to the presence of a fluorophenyl substituent in the pyrazole ring. Therefore the boiling of reagents and the use of catalyst to activate both azomethine and CH-acid becomes necessary. Therewith a fast cyclization occurs of aminoketones **A** and oxidation of 1,2-dihydropyridine derivatives **B** into the most thermodynamically feasible heteroaromatic reaction products **XIVa**, **XIVb**, and **XV**. In the presence of the catalyst (HCl) formed aza- and diazaphenanthrene hydrochlorides which when treated with ammonium hydroxide provide free bases **XIVa**, **XIVb**, and **XV**.

Azomethines **XII** and **XIII** previously unknown were synthesized by condensation of aldehyde **I** with amines **II** and **III** by boiling in ethanol without catalyst. Reacting with acetone (**IV**) and acetophenone (**V**) under the given conditions of the theree-component condensation compounds **XII** and **XIII** formed benzoquinolines **XIVa**, **XIVb** and phenanthroline **XV** in 42–48% yield.

In the IR spectra of compounds **XIVa**, **XIVb**, and **XV** absorption bands are present in the region 3070–3030 cm^{-1} (C–H) and 875–865, 840–835, 770–755 cm^{-1} [δ(C–H)]. NH group in the pyrazole ring gives rise to a strong band at 3200 cm^{-1}.

The mass spectra of azaphenanthrenes **XIVa**, **XIVb**, and **XV** contain molecular ion peaks $[M]^+$ corresponding to maximal abundance (100%), peaks of ions $[M - H]^+$ (I_{rel} 38–43%), and peaks of low intensity (I_{rel} 10–12%) of ions $[M - HCN]^+$ and $[M - H - HCN]^+$ whose presence is characteristic of nitrogen-containing heteroaromatic compounds.

Electron absorption spectra of compounds **XIVa**, **XIVb**, and **XV** are located in UV region (224–367 nm) and possess a structure characteristic of benzo[*f*]quinoline and 4,7-phenanthrolines [1, 11, 12]. The long-wave band (338–367 nm) was interpreted as Clar α-band (^1L_b according to Platt), and it suffers a red shift compared to the previously studied spectra of azaphenanthrenes [1, 11]. This shift apparently originates from the longer conjugation chain due to introducing *p*-fluorophenylpyrazole substituent. At the same time in the spectra of compounds **XIVa**, **XIVb**, and **XV** a smoothing of the vibronic structure of α-band was observed apparently caused by the presence of nitrogen atoms of the pyrazole ring. Bands at shorter waves in the region 283–291 and 224–263 nm are *r*- and β-bands (^1L_a and ^1B_b) respectively, and the *r*-band is more intensive than the β-band in conformity to the spectral pattern of compounds with angular structure (phenanthrene and its heterocyclic analogs).

In the ^1H NMR spectra of compounds **XIVa**, **XIVb**, and **XV** the signals from aromatic protons appear in the region 7.61–8.84 ppm. The proton of NH group and methine proton of the pyrazole ring appear respectively as a singlet at 11.02–13.30 ppm and a multiplet in the region 8.70–8.80 ppm. In the spectrum of benzoquinoline **XIVa** the methyl group protons give rise to a singlet at 3.00 ppm.

The condensation of aldehyde **I** and amine **II** or azomethine **XII** with cyclic ketones **VI–VIII** was carried out under the same conditions as used with methyl ketones **IV** and **V**. Therewith cyclopentanone **VI** and cyclohexanone **VII** formed products of dehydrocyclization of aminoketones **C**, 4-[3-(4-fluorophenyl)-1*H*-pyrazol-4-yl]-2,3-dihydro-1*H*-benzo[*f*]cyclopenta[*c*]quinoline (**XVIa**) and 5-[3-(4-fluorophenyl)-1*H*-pyrazol-4-yl]-1,2,3,4-tetrahydrobenzo[*a*]phenanthridine (**XVIb**) in 43–52% yield, and 4-methylcyclohexanone (**VIII**) gave according to ^1H NMR spectra a mixture of 3-methyl-5-[3-(4-fluorophenyl)-1*H*-pyrazol-4-yl]-1,2,3,4-tetrahydrobenzo[*a*]-phenanthridine (**XVIc**) and its precursor, 1,2,3,4,5,6-hexahydro derivative **D** in approximately equal amounts. The spectrum of reaction products obtained from ketone **VIII** alongside the signals from cycloaliphatic protons in the range 1.70–3.65 ppm, methyl group protons (0.95–1.17 ppm), aromatic protons (6.84–8.80 ppm), and the proton from NH of pyrazole ring at 13.30 ppm contained a broadened singlet of NH group proton at 4.20 ppm and a singlet of the methine proton at 5.34 ppm, both latter resonances characterisic of 1,2-dihydropyridine ring [13]. Inasmuch as we failed to isolate from the mixture individual compounds **D** and **XVIc**, we further performed the reaction in the presence of an oxidant (nitrobenzene) to convert completely intermediate **D** into final reaction product **XVIc**.

In the IR spectra of compounds **XVIa–XVIc** alongside the group of absorption bands of aromatic C–H bonds in the region 3060–3040 cm^{-1} and a stretching vibrations band of NH group in the pyrazole ring at 3210 cm^{-1} additionally appear characteristic bands of the stretching vibrations of cycloaliphatic C–H bonds in the range 2930–2855 cm^{-1}.

In the mass spectra of azaphenanthrenes **XVIa–XVIc** molecular ion peaks $[M]^+$ (I_{rel} 100%) are the most abundant, also appear peaks of ions $[M - FC_6H_4C_3H_2N_2]^+$ (I_{rel} 30–38%) and weak peaks (I_{rel} 5–10%) originating from CH_2 group elimination from the molecular ion (MeCH for compound **XVIc**).

UV spectra of compounds **XVIa–XVIc** are similar to those of benzoquinolines **XIVa** and **XIVb**, only the β-band (221–249 nm) undergoes a notable blue shift apparently due to introduction into the molecule of a fuzed carbocycle.

In the ^{1}H NMR spectra of compounds **XVIa–XVIc** the signals of cycloaliphatic protions were observed in the region 1.78–3.78 ppm that were lacking in the spectra of azaphenanthrenes **XIVa** and **XIVb**; in the spectrum of benzoquinoline **XVIc** appeared a doublet from the protons of a methyl group at 0.96 ppm.

The three-component condensation of aldehyde **I**, amines **II** and **III**, and β-diketones **IX** and **X** proceeded in 1-butanol without catalysts whose role played the proton of the dissociated enol form of the β-dicarbonyl compound. In keeping with the above scheme of reaction between aldehyde **I**, amines **II** and **III**, and monoketones **VI–VIII** it was presumable that the cyclization of the adduct formed from diones **IX** and **X** and azomethines **XII** and **XIII**, aminodiketone **E,** would let to the formation of pyrazolyl derivatives of hexahydrobenzo[*a*]phenanthridine and 4,7-phenanthroline **F** or to products of their aromatization. However it was established by means of ^{1}H NMR spectroscopy that the reaction products were compounds isomeric to structure **F,** aza- and diazaphenanthrenes with a stable against oxidation 1,4-dihydropyridine ring, 12-[3-(4-fluorophenyl)-1*H*-pyrazol-4-yl]-7,8,9,10,11,12-hexahydrobenzo[*a*]acridin-11-ones **XVIIa** and **XVIIb** and their benzo[*b*][4,7]-phenanthroline analogs **XVIIIa** and **XVIIIb** (yield 72–90%) whose formation may be regarded as a result of intermediate **E** transformation analogous to Hofmann–Martius rearrangement (migration of N-alkyl substituents of aniline into the aromatic ring [14]) followed by cyclocondensation of aminodiketone **G**.

Intermediate **E** transformation may also occur via its hydramine cleavage into amine **II** or **III** and α,β-unsaturated ketone **H** which contains a strongly activated double bond due to its conjugation with two contiguous carbonyl groups and reacts with the aromatic ring of amine **II** or **III** at the carbon possessing the highest electron density and located in the α-position with respect to the amino group. As a result forms aminodiketone **G** that undergoes dehydrocyclization into a system of benzo[*a*]acridinone **XVIIa** and **XVIIb**, and benzo[*b*]-[4,7]-phenanthrolinone **XVIIIa** and **XVIIIb**.

The attempt to prepare 2-[3-(4-fluorophenyl)pyrazol-4-yl]methylene-1,3-cyclohexanediones **H** by heating an equimolar mixture of aldehyde **I** and diones **IX** and **X** aiming at further reaction of the product with amines **II** and **III** led to the formation of bis-dicarbonyl derivatives **J** like in reaction of substituted benzaldehydes with cyclic diketones [15]. The heating with alkali solution converted bisdiketones **J** into octahydroxanthene derivatives **XIXa** and **XIXb**, and at treating with amines **II** and **III** compounds **J** eliminated cyclohexanedione and through intermediates **H** and **G** transformed into aza- and diazaphenanthrenes **XVIIa, XVIIb, XVIIIa**, and **XVIIIb**.

The IR spectra of compounds **XVIIa, XVIIb, XVIIIa**, and **XVIIIb** contain characteristic bands of stretching and bending vibrations of NH groups of pyrazole and dihydropyridine rings at 3130–3250 and 1635–1630 cm^{-1}. The stretching vibrations of the keto group conjugated to the enamine fragment appeared at 1605–1595 cm^{-1}. The stretching vibrations bands of cycloaliphatic CH bonds were observed in the region 2960–2870 cm^{-1}, those of CH bonds in the aromatic rings, at 3080–3045 cm^{-1}.

The mass spectra of azaphenanthrenes **XVIIa, XVIIb, XVIIIa**, and **XVIIIb** contain molecular ion peaks $[M]^+$ (I_{rel} 25–38%). The most abundant (100%) peak in the spectra is that of ion $[M - FC_6H_4C_3H_2N_2]^+$ (*m/z* 248 for compound **XVIIa**, 249 for phenanthroline **XVIIIa**, 276 and 277 for dimethyl derivatives **XVIIb** and **XVIIIb**). A sufficiently intensive (18–28%) ion peak (*m/z* 192 for acridones **XVIIa** and **XVIIb** and 193 for phenanthrolinones **XVIIIa** and **XVIIIb**) corresponds to elimination from the ion $[M - FC_6H_4C_3H_2N_2]^+$ of a fragment CH_2CH_2CO for compounds **XVIIa** and **XVIIIa**, and Me_2CCH_2CO for dimedone derivatives **XVIIb** and **XVIIIb**.

UV spectra of compounds **XVIIa, XVIIb, XVIIIa**, and **XVIIIb** have a pronounced vibronic structure. The molecules of partially hydrogenated acridones **XVIIa** and **XVIIb** and benzophenanthrolinones **XVIIIa** and **XVIIIb** contain three independent chromophore fragments: *p*-fluorophenylpyrazole substituent, carbonyl group, and naphthalene or quinoline ring. The latter contribute most into the system of π–π*-electronic transitions. Therefore the bands with λ_{max} 216–218, 245–250, 290–292 nm in the spectra of acridones **XVIIa** and **XVIIb** may be related to the 2-naphthylamine (**II**) system [UV spectrum, λ_{max}, nm (log ε): 204 (4.06), 246 (4.35), 280 (3.63)], and in

spectra of phenanthrolinones **XVIIIa** and **XVIIIb**, to the system of 6-quinolylamine (**III**) [UV spectrum, λ_{max}, nm (log ε): 206 (4.08), 247 (4.35), 279 (3.59)]. The considerable red shift and increased intensity of the first and the third bands in the spectra of compounds **XVIIa, XVIIb, XVIIIa**, and **XVIIIb** are caused apparently by overlapping with absorption bands of *p*-fluorophenylpyrazolyl substituent. Long-wave absorption bands (331–340, 370–388 nm) according to [15] are due to the presence of a carbonyl group.

^{1}H NMR spectra of compounds **XVIIa, XVIIb, XVIIIa**, and **XVIIIb** in the position and multiplicity of the signals of aromatic and cycloaliphatic protons are identical to previously published spectra of acridones and 4,7-phenanthrolinones [7, 15]. The structure of compounds **XVIIa, XVIIb, XVIIIa**, and **XVIIIb** is confirmed by the lack of the coupling between the proton of NH group from the azaphenanthrene skeleton and the proton at C^{12} atom linked to the fluorophenylpyrazolyl substituent that is expected in the alternative structure **F**. These proton signals appear as singlets at 9.80–9.87 and 5.70–5.82 ppm.

We established that in condensation of aldehyde **I** with amine **II** and 1,3-indandione (**XI**) in ethanol without catalyst before formation of the target product from the benzoidenoquinoline series 2-[3-(4-fluorophenyl)pyrazol-4-yl]methylene-1,3-indandione (**XX**) is present in the reaction mixture. This compound was obtained in an individual state by boiling an ethanol solution of an equimolar mixture of aldehyde **I** and dione **XI**. This compound with amine **II** under conditions of the three-component condensation (aldehyde **I** + amine **II** + diketone **XI**) gave 13-[3-(4-fluorophenyl)-1*H*-pyrazol-4-yl]-7,13-dihydro-12*H*-benzo[*f*]indeno[1,2-*b*]-quinolin-12-one (**XXI**). The synthesis of indenoquinoline **XXI** obviously proceeds through stages of dione **XX** addition to amine **II** at the electron-rich α-position of the naphthalene ring, and of cyclization of the intermediate aminodiketone similar to intermediate **E**. Dihydro compound **XXI** underwent dehydrogenation at boiling in nitrobenzene to yield 13-[3-(4-fluorophenyl)-1*H*-pyrazol-4-yl], 12*H*-benzo[*f*]indeno-[1,2-*b*]quinolin-12-one (**XXII**).

In the IR spectra of compounds **XXI** and **XXII** absorption bands of CO group stretching vibrations appear at 1660 (**XXI**) and 1690 cm^{-1} (**XXII**). The spectrum of dihydro derivative **XXI** contains three bands in the region 3280–3230 cm^{-1} corresponding to the stretching vibrations of NH groupd from azaphenanthrene skeleton and pyrazole substituent. In the spectrum of oxidized product **XXII** in this region a single band cor-responding to the amino group of the pyrazole ring is conserved.

In the mass spectra of compounds **XXI** and **XXII** peaks of molecular ions $[M]^+$ are of high intensity (65 and 100%). Also peaks of ions $[M - FC_6H_4C_3H_2N_2]^+$ (100% for compound **XXI** and 28% for oxidation product **XXII**) are observed. In the spectrum of compound **XXII** double-charged ions are present: molecular ion $[M]^{2+}$ and ion $[M - FC_6H_4C_3H_2N_2]^{2+}$.

UV spectrum of dihydro derivative **XXI** is identical in the number of bands to the spectra of benzoacridones **XVIIa** and **XVIIb**. In the spectrum of compound **XXI** a significant shift is observed of a long-wave maximum (476 nm) to the visible region originating apparently from the presence of the fused indenone structure in the molecule of the azaphenanthrene. In the UV spectrum of the dehydrogenation product **XXII** a strong band appeared at 285 nm and a less stong band with a vibronic structure at 225–253 nm. The presence of these bands (Clar β- and *r*-bands) endows the spectrum of compound **XXII** with a likeness to the spectra of benzoquinolines **XIVa** and **XIVb**. The long-wave band at 338–370 nm present in the spectrum of indenoquinoline **XXII** corresponds to the α-band in the spectra of benzoquinolines **XIVa** and **XIVb** but is shifted to red as compared to the latter.

^{1}H NMR spectra of compouns **XXI** and **XXII** contain aromatic protons signals in the region 7.29–8.60 ppm, signal of the proton from NH group, and the methine proton of the pyrazole ring at 12.89–13.04 and 8.73–8.79 ppm respectively. The signals present in the spectrum of dihydro compound **XXI** at 9.84 and 5.80 ppm corresponding respectively to the protons of groups NH and H^{12} of dihydropyridine ring disappeared in the oxidized product **XXII** indicating the aromatization of the azaphenanthrene ring in the latter.

Thus based on condensation of 3-(4-fluorophenyl)-4-pyrazolecarbaldehyde with 2-naphthyl- or 6-quinolylamine and CH-acids we developed new efficient methods of synthesis of previously unknown polynuclear heterocycles with a high nuitrogen content and an extended conjugation system, promising as luminophores, light-sensitive material, and bioactive substances of versatile effect.

EXPERIMENTAL

IR spectra were recorded on a Fourier spectrometer Nicolet Protege-460 from samples prepared as KBr pellets. Mass spectra were measured on Finnigan MAT INCOS-50 instrument at ionizing electrons energy 70eV,

and on GC-MS instrument Hewlett-Packard HP 5890/5972 in an electron impact mode at the energy 70 eV; column HP-5MS [30 m × 0.25 mm, film thickness of the stationary phase (5% PLMe Silicone) 0.25 μm]; vaporizer temperature 250°C. UV spectra of solutions in ethanol (C 10^{-4} mol l^{-1}) were obtained on a spectrometer Specord UV-Vis. NMR spectra were registered on spectrometers Bruker AC-500 (500 MHz) and Tesla BS-567 (100 MHz) from solutions in DMSO-d_6, benzene-d_6, and chloroform-d; internal reference TMS.

Melting points were measured on Koeffler heating block.

[3-(4-Fluorophenyl)-1*H*-pyrazole-4-ylmethylene]-2-naphthyl-(or 6-quinolyl)amines XII and XIII. A solution of 5 mmol of aldehyde **I**, 5 mmol of 2-naphthylamine (**II**) [or 6-quinolylamine (**III**)] in 20 ml of ethanol was boiled for 1 h. The precipitate separated on cooling was filtered off and recrystallized from ethanol.

[3-(4-Fluorophenyl)-1*H*-pyrazol-4-ylmethylene]-2-naphthylamine (XII). Yield 63%, mp 163–164°C. UV spectrum, λ_{max}, nm (log ε): 207 (4.49), 226 (4.43), 253 (4.60), 339 (4.11). ^{1}H NMR spectrum, δ, ppm: 7.25–8.35 m (12H, H_{arom}), 9.35 s (1H, CH=N), 10.60 s (1H, NH). Found, %: N 13.24. $C_{20}H_{14}FN_3$. Calculated, %: N 13.33.

[3-(4-Fluorophenyl)-1*H*-pyrazol-4-ylmethylene]-6-quinolylamine (XIII). Yield 59%, mp 177–178°C. UV spectrum, λ_{max}, nm (log ε): 208 (4.41), 229 (4.40), 253 (4.65), 339 (4.09). ^{1}H NMR spectrum, δ, ppm: 7.15–8.80 m (12H, H_{arom}, CH=N), 10.15 s (1H, NH). Found, %: N 17.54. $C_{19}H_{13}FN_4$. Calculated, %: N 17.72.

1-Methyl (or phenyl)-3-[3-(4-fluorophenyl)-1*H*-pyrazol-4-yl]benzo[*f*]quinolines XIVa and XIVb. (*a*) A mixture of 5 mmol of aldehyde **I**, 5 mmol of 2-naphthylamine (**II**), 10 mmol of acetone (**IV**) [or acetophenone (**V**)], 20 ml of ethanol, and 0.5 ml of concn. HCl was boiled for 12 h. The separated precipitate was filtered off, treated with 25% water solution of NH_4OH, washed with water, and recrystallized from a mixture ethanol–benzene, 3:1.

b. A solution of 5 mmol of azomethine **XII**, 10 mmol of acetone (**IV**) [or 5 mmol of acetophenone (**V**)], 20 ml of ethanol, and 0.5 ml of concn. HCl was boiled for 11 h. Reaction products **XIVa** and **XIVb** were isolated as described above.

1-Methyl-3-[3-(4-fluorophenyl)-1*H*-pyrazol-4-yl-benzo[*f*]quinoline (XIVa). Yield 52% (*a*), 54% (*b*), mp 247–248°C. UV spectrum, λ_{max}, nm (log ε): 225 (4.60), 263 (4.60), 283 (4.78), 338 (3.70), 367 (3.74). ^{1}H NMR spectrum, δ, ppm: 3.00 s (3H, Me), 6.61–8.05 m (10H, H_{arom}), 8.35 s (1H, H^2), 8.80 m (1H, =CH–NH), 13.30 br.s (1H, =CH–NH). Found, %: N 11.67. $C_{23}H_{16}FN_3$. Calculated, %: N 11.90.

1-Phenyl-3-[3-(4-fluorophenyl)-1*H*-pyrazol-4-yl]benzo[*f*]quinoline (XIVb). Yield 49% (*a*), 55% (*b*), mp 256–257°C. UV spectrum, λ_{max}, nm (log ε): 225 (4.66), 260 (4.59), 290 (4.89), 340 (3.92), 362 (3.63). ^{1}H NMR spectrum, δ, ppm: 7.15–8.50 m (16H, H_{arom}), 8.70 s (1H, =CH–NH), 11.02 br.s (1H, =CH–NH). Found, %: N 9.94. $C_{28}H_{18}FN_3$. Calculated, %: N 10.12.

1-Phenyl-3-[3-(4-fluorophenyl)-1*H*-pyrazol-4-yl]-4,7-phenanthroline (XV) was prepared in a similar fashion from 6-quinolylamine (**III**), acetophenone (**V**), and aldehyde **I** (method *a*) or ketone **V** and azomethine **XIII** (method *b*) by boiling in 1-butanol in the presence of HCl for 8–9 h. After neutralization with NH_4OH the reaction product was recrystallized from a mixture ethanol–benzene, 2:1. Yield 39% (*a*), 44% (*b*), mp 251–252°C. UV spectrum, λ_{max}, nm (log ε): 224 (4.58), 258 (4.52), 291 (4.90), 338 (3.90), 359 (3.67). ^{1}H NMR spectrum, δ, ppm: 7.22–8.84 m (16H, H_{arom}, =CH–NH), 11.10 br.s (1H,=CH–NH). Found, %: N 13.41. $C_{27}H_{17}FN_4$. Calculated, %: N 13.46.

4-[3-(4-Fluorophenyl)-1*H*-pyrazol-4-yl]-2,3-dihydro-1*H*-benzo[*f*]cyclopenta[*c*]quinoline (XVIa). A solution of 5 mmol of aldehyde **I**, 5 mmol of 2-naphthylamine (**II**), 5 mmol of cyclopentanone (**VI**) (method *a*) or 5 mmol of ketone **VI** and 5 mmol of azomethine **XII** (method *b*) in 20 ml of ethanol and 0.5 ml of concn. HCl was boiled for 6 h. Reaction product was isolated as described for compounds **XIVa** and **XIVb**. Yield 49% (*a*), 52% (*b*), mp 277–278°C. UV spectrum, λ_{max}, nm (log ε): 221 (4.49), 248 (4.62), 287 (4.84), 339 (3.70), 356 (3.68). ^{1}H NMR spectrum, δ, ppm: 2.12 m (2H, CH_2), 2.80 t (2H, CH_2), 3.78 t (2H, CH_2), 7.00–8.104 m (10H, H_{arom}), 8.70 m (1H, =CH–NH), 13.28 br.s (1H, =CH–NH). Found, %: N 10.90. $C_{25}H_{18}FN_3$. Calculated, %: N 11.08.

5-[3-(4-Fluorophenyl)-1*H*-pyrazol-4-yl]-1,2,3,4-tetrahydrobenzo[*a*]phenanthridine (XVIb) was obtained from aldehyde **I**, 2-naphthylamine (**II**), and cyclohexanone (**VII**) (method *a*) or ketone **VII** and azomethine **XII** (method *b*) similarly to compound **XVIa**. Yield 44% (*a*), 43% (*b*), mp 283–284°C. UV spectrum, λ_{max}, nm (log ε): 224 (4.51), 247 (4.60), 289 (4.83), 341 (3.89), 360 (3.80). ^{1}H NMR spectrum, δ, ppm: 1.78 m (4H, CH_2), 2.65 m (2H, CH_2), 3.58 m (2H, CH_2), 6.98–

8.20 m (10H, H_{arom}), 8.82 m (1H, =CH–NH), 13.30 br.s (1H, =CH–NH). Found, %: N 10.47. $C_{26}H_{20}FN_3$. Calculated, %: N 10.69.

3-Methyl-5-[3-(4-fluorophenyl)-1*H*-pyrazol-4-yl]-1,2,3,4-tetrahydrobenzo[*a*]phenanthridine (XVIc) was obtained from aldehyde **I**, 2-naphthylamine (**II**), and 4-methylcyclohexanone (**VIII**) (method *a*) or ketone **VIII** and azomethine **XII** (method *b*) similarly to compound **XVIa**, but in the presence of 1 ml of nitrobenzene. Yield 36% (*a*), 42% (*b*), mp 220–221°C. UV spectrum, λ_{max}, nm (log ε): 225 (4.53), 249 (4.58), 284 (4.85), 340 (3.94), 361 (3.80). ^{1}H NMR spectrum, δ, ppm: 0.96 s (3H, Me), 1.78 m (2H, CH_2), 1.94–2.86 m (3H, CH, CH_2), 3.62 m (2H, CH_2), 6.80–8.16 m (10H, H_{arom}), 8.80 m (1H, =CH–NH), 13.34 br.s (1H, =CH–NH). Found, %: N 10.17. $C_{27}H_{22}FN_3$. Calculated, %: N 10.31.

12-[3-(4-Fluorophenyl)-1*H*-pyrazol-4-yl]-7,8,9,10,11,12-hexahydrobenzo[*a*]acridin-11-ones XVIIa and XVIIb. *a*. A mixture of 5 mmol of aldehyde **I**, 5 mmol of 2-naphthylamine **II**, 5 mmol of 1,3-cyclohexanedione (**IX**) [or 5 mmol of dimedone (**X**)], and 20 ml of 1-butanol was boiled for 6 h. The solution was evaporated to 1/2 of volume. The separated precipitate was filtered off, compound **XVIIa** was recrystallized from methanol, acridone **XVIIb**, from ethanol.

b. A solution of 5 mmol of azomethine **XII**, 5 mmol of diketone **IX** of 5 mmol of dimedone (**X**) in 20 ml of 1-butanol was boiled for 6 h. Reaction products **XVIIa** and **XVIIb** were isolated as described above.

c. A solution of 5 mmol of aldehyde **I**, 5 mmol of dione **IX** or diketone **X** in 20 ml of 1-butanol was boiled for 1 h, 5 mmol of 2-naphthylamine (**II**) was added, and the reaction mixture was boiled for 4 h more. Reaction products **XVIIa** and **XVIIb** were isolated as described above.

12-[3-(4-Fluorophenyl)-1*H*-pyrazol-4-yl]-7,8,9,10,11,12-hexahydrobenzo[*a*]acridin-11-one (XVIIa). Yield 72% (*a*), 76% (*b*), 52% (*c*), mp 297–298°C. UV spectrum, λ_{max}, nm (log ε): 218 (4.52), 249 (4.46), 291 (4.21), 339 (3.93), 371 (3.93). ^{1}H NMR spectrum, δ, ppm: 1.98 m (2H, CH_2), 2.38 m (2H, CH_2), 2.76 m (2H, CH_2), 5.70 s (1H, H^{12}), 6.80–8.22 m (11H, H_{arom}, =CH–NH), 9.87 C (1H, NH), 12.58 br.s (1H, =CH–NH). Found, %: N 10.11. $C_{26}H_{20}FN_3O$. Calculated, %: N 10.27.

9,9-Dimethyl-12-[3-(4-fluorophenyl)-1*H*-pyrazol-4-yl]-7,8,9,10,11,12-hexahydrobenzo[*a*]acridin-11-one (XVIIb). Yield 86% (*a*), 90% (*b*), 66% (*c*), mp 221–222°C. UV spectrum, λ_{max}, nm (log ε): 216 (4.49), 250 (4.39), 292 (4.26), 338 (3.96), 376 (3.98). ^{1}H NMR spectrum, δ, ppm: 1.05 s (3H, Me), 1.10 s (3H, Me), 2.14 m (2H, CH_2), 2.58 m (2H, CH_2), 5.80 s (1H, H^{12}), 6.80–8.24 m (11H, H_{arom}, =CH–NH), 9.80 C (1H, NH), 12.61 br.s (1H, =CH–NH). Found, %: N 9.37. $C_{28}H_{24}FN_3O$. Calculated, %: N 9.61.

12-[3-(4-Fluorophenyl)-1*H*-pyrazol-4-yl]-7,8,9,10,11,12-hexahydrobenzo[*b*][4,7]-phenanthrolin-11-ones XVIIIa and XVIIIb were obtained from aldehyde **I**, 6-quinolylamine (**III**), and diketone **IX** or **X** (method *a*) or ketone **IX, X** and azomethine **XII** (method *b*), and also by boiling a butanol solution of amine **III** and the condensation product of aldehyde **I** with diketone **IX** or **X** (method *c*) similarly to compounds **XVIIa** and **XVIIb**. Benzophenanthrolinones **XVIIIa** and **XVIIIb** were recrystallized from a mixture ethanol–benzene, 4:1.

12-[3-(4-Fluorophenyl)-1*H*-pyrazol-4-yl]-7,8,9,10,11,12-hexahydrobenzo[*b*][4,7]-phenanthrolin-11-one (XVIIIa). Yield 80% (*a*), 79% (*b*), 63% (*c*), mp 283–284°C. UV spectrum, λ_{max}, nm (log ε): 216 (4.59), 243 (4.36), 290 (4.18), 337 (4.04), 378 (3.90). ^{1}H NMR spectrum, δ, ppm: 1.97 m (2H, CH_2), 2.40 m (2H, CH_2), 2.74 m (2H, CH_2), 5.78 s (1H, H^{12}), 7.07 d.d (1H, H^2), 7.28 m (4H, H_{arom}), 7.50 d, 7.78 d (2H, $H^{5,6}$), 8.29 m (2H, H^1, =CH–NH), 8.60 d (1H, H^3), 9.84 s (1H, NH), 13.40 br.s (1H, =CH–NH). Found, %: N 13.56. $C_{25}H_{19}FN_4O$. Calculated, %: N 13.66.

9,9-Dimethyl-12-[3-(4-fluorophenyl)-1*H*-pyrazol-4-yl]-7,8,9,10,11,12-hexahydrobenzo[*b*][4,7]phenanthrolin-11-one (XVIIIb). Yield 82% (*a*), 86% (*b*), 67% (*c*), mp 236–237°C. UV spectrum, λ_{max}, nm (log ε): 217 (4.57), 246 (4.34), 292 (4.19), 338 (4.96), 377 (3.92). ^{1}H NMR spectrum, δ, ppm: 1,04 s (3H, Me), 1.12 s (3H, Me), 2.20 m (2H, CH_2), 2.59 m (2H, CH_2), 5.82 s (1H, H^{12}), 7.04 d.d (1H, H^2), 7.30 m (4H, H_{arom}), 7.52 d, 7.80 d (2H, $H^{5,6}$), 8.30 m (2H, H^1, =CH–NH), 8.61 d (1H, H^3), 9.83 s (1H, NH), 13.50 br.s (1H, =CH–NH). Found, %: N 12.58. $C_{27}H_{23}FN_4O$. Calculated, %: N 12.79.

9-[3-(4-Fluorophenyl)-1*H*-pyrazol-4-yl]-2,3,4,5,6,7,8,9-octahydro-1*H*-xanthene-1,8-diones XIXa and XIXb. A solution of 5 mmol of aldehyde **I** and 5 mmol of diketone **IX** or dimedone (**X**) in 20 ml of ethanol or 1-butanol was boiled for 1 h, 1 ml of a saturated solution of KOH in alcohol was added, and the mixture was boiled for 2 h more. The precipitate was filtered off, washed with methanol, with ether, and dried.

9-[3-(4-Fluorophenyl)-1*H*-pyrazol-4-yl]-2,3,4,5,6,7,8,9-octahydro-1*H*-xanthene-1,8-dione (XIXa). Yield 54%, mp 223–224°C. UV spectrum, λ_{max}, nm (log ε): 206 (4.69), 252 (4.61), 279 (4.27), 330 (3.84). ^{1}H NMR spectrum, δ, ppm: 1.75–2.60 m (12H, CH_2), 4.80 s (1H, CH), 7.02–7.80 m (5H, H_{arom}, =CH–NH), 10.60 br.s (1H, =CH–NH). Found, %: N 7.25. $C_{22}H_{19}FN_2O_3$. Calculated, %: N 7.41.

3,3,6,6-Tetramethyl-9-[3-(4-fluorophenyl)-1*H*-pyrazol-4-yl]-2,3,4,5,6,7,8,9-octahydro-1*H*-xanthene-1,8-dione (XIXb). Yield 49%, mp 180–181°C. UV spectrum, λ_{max}, nm (log ε): 207 (4.61), 254 (4.58), 273 (4.19), 333 (3.76). ^{1}H NMR spectrum, δ, ppm: 0.99 m (12H, 4Me), 1.80–2.30 m (8H, CH_2), 5.60 s (1H, CH), 6.92–7.40 m (5H, H_{arom}, =CH–NH), 10.50 br.s (1H, =CH–NH). Found, %: N 6.39. $C_{26}H_{27}FN_2O_3$. Calculated, %: N 6.45.

2-[3-(4-Fluorophenyl)-1*H*-pyrazol-4-yl]-methylene-1,3-indandione (XX). A solution of 5 mmol of aldehyde **I** and 5 mmol of diketone **XI** in 20 ml of ethanol was boiled for 3 h, the precipitate formed on cooling was filtered off, washed with ether, and recrystallized from a mixture ethanol–benzene, 1:1. Yield 95%, mp 289–290°C. UV spectrum, λ_{max}, nm (log ε): 204 (4.25), 247 (4.15), 259 (4.08), 301 (3.51), 370 (4.26). ^{1}H NMR spectrum, δ, ppm: 7.30–7.95 m (9H, H_{arom}, –C=CH), 9.30 m (1H, =CH–NH), 13.8 br.s (1H, =CH–NH). Found, %: N 8.66. $C_{19}H_{11}FN_2O_2$. Calculated, %: N 8.80.

13-[3-(4-Fluorophenyl)-1*H*-pyrazol-4-yl]-7,13-dihydro-12*H*-benzo[*f*]indeno[1,2-*b*]quinolin-12-one (XXI). A solution of 5 mmol of aldehyde I, 5 mmol of 2-naphthylamine (**II**), 5 mmol of 1,3-indandione (**XI**) (method *a*) or 5 mmol of amine **II** and 5 mmol of dione (**XX**) (method *b*) in 20 ml of butanol was boiled for 6 h. The precipitate was boiled with benzene and washed with ether. Yield 62% (*a*), 66% (*b*), mp 340–341°C. UV spectrum, λ_{max}, nm (log ε): 204 (4.70), 234 (4.69), 267 (4.67), 349 (4.12), 479 (3.18). ^{1}H NMR spectrum, δ, ppm: 5.75 s (1H, CH), 6.85–8.20 m (15H, H_{arom}, =CH–NH), 10.80 s (1H, NH), 13.8 br.s (1H, =CH–NH). Found, %: N 9.25. $C_{29}H_{18}FN_3O$. Calculated, %: N 9.48.

13-[3-(4-Fluorophenyl)-1*H*-pyrazol-4-yl]-12*H*-benzo[*f*]indeno[1,2-*b*]quinolin-12-one (XXII). A solution of 1 mmol of dihydro derivative **XXI** in 10 ml of nitrobenzene was boiled for 8 h. The reaction product was recrystallized from a mixture toluene–nitrobenzene, 2:1. Yield 71%, mp 299–300°C. UV spectrum, λ_{max}, nm (log ε): 225 (4.42), 253 (4.34), 285 (4.74), 338 (4.00), 378 (3.98). ^{1}H NMR spectrum, δ, ppm: 6.98–8.22 m (15H, H_{arom}, =CH–NH), 13.55 br.s (1H, =CH–NH). Found, %: N 9.41. $C_{29}H_{16}FN_3O$. Calculated, %: N 9.52.

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