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Synthesis and Alkylation of 1-Alkyl(aryl)-4-cyano-3-dicyanomethylene-Substituted Carbo[*c*]fused Pyridines. Molecular and Crystal Structure of 2-(4-Cyano-1-methyl-5,6,7,8-tetrahydroisoquinolin-3-yl)-2-(2-oxo-2-phenylethyl)malononitrile and 10-Amino-8-phenyl-5-(2-chlorophenyl)-1,2,3,4-tetrahydro-7*H*-pyrido[2',3':3,4]cyclopenta[1,2-*c*]isoquinoline-7,7,9-tricarbonitrile

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Abstract—Condensation of 2-acyl-1-(*N*-morpholinyl)cycloalkene with malononitrile dimer results in 1-alkyl-(aryl)-4-cyano-3-dicyanomethylene-substituted carbo[*c*]fused pyridines. Reaction of the latter with alkyl halides affords the corresponding 2-alkyl-2-(3-isoquinolinyl)malononitrile, 1-amino-2-(4-bromobenzoyl)-5-(2-chlorophenyl)-6,7,8,9-tetrahydro-3*H*-cyclopenta[*c*]isoquinoline-3,3-dicarbonitrile and 10-amino-8-phenyl-5-(2-chlorophenyl)-1,2,3,4-tetrahydro-7*H*-pyrido[2',3':3,4]cyclopenta[1,2-*c*]isoquinoline-7,7,9-tricarbonitrile. Structure of the latter and of 2-(1-methyl-4-cyano-5,6,7,8-tetrahydroisoquinolin-3-yl)-2-(2-oxo-2-phenylethyl)-malononitrile was investigated by XRD.

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Carbo[*c*]fused pyridine derivatives exhibit fungicidal [1, 2] and bactericidal [3–5] activity and can be used as poly(ADP-ribose)polymerase-1 inhibitor [6], anti-epileptic drugs [7 8], and as intermediates in alkaloids synthesis [9, 10]. Generally, a condensation of 2-acyl-cycloalkanones with cyanoacetamide [11] and cyano-thioacetamide [12, 13], cycloalkylidenemalononitrile with arylmethylenecyanothioacetamide [14, 15] or cyclopentylidenecyanoacetamide with benzaldehyde [16] is used to form carbo[*c*]fused pyridine ring.

In this work we studied the previously unknown representatives of compounds of this type, 1-alkyl(aryl)-4-cyano-3-dicyanomethylene-substituted carbo[*c*]fused pyridines **Ia**–**Ii**. Compounds **Ia**–**Ii** were obtained in 68–82% yields by the reaction of nucleophilic vinyl substitution (S_NVin) [17–19] of 2-acyl-1-(*N*-morpholinyl)cycloalkenes **IIa**–**IIi** with a malononitrile dimer **III**. The reaction occurs at room temperature in anhydrous ethanol in the presence of sodium ethoxide. Apparently, the reaction involves the formation of intermediates **A**, which further undergo an intramolecular cyclization. The previously obtained compound **Ig** (yield 47%) has been characterized only by elemental analysis [20].

The structure of compounds **Ia**–**Ii** was confirmed by the spectral characteristics. For example, their IR spectra contain absorption bands of stretching vibrations of conjugated cyano groups in the range of 2177–2218 cm^{-1}. In the ^{1}H NMR spectra along with the signals of the protons of R, R^1, and R^2 substituents there are the proton signals of cycloalkane moiety in the range of 1.73–3.25 ppm and of NH proton of pyridine ring as a broad singlet at 8.70–12.55 ppm. In some cases the signal of the NH-proton was not

Table 1. Bond lengths in the structure of **VIc**

Bond	*d*, Å	Bond	*d*, Å
$C^1–N^1$	1.321(3)	$C^{12}–H^{12}$	0.9300
$C^1–C^2$	1.392(3)	$C^{13}–C^{14}$	1.376(4)
$C^1–C^6$	1.550(3)	$C^{13}–H^{13}$	0.9300
$C^2–C^3$	1.406(3)	$C^{14}–C^{15}$	1.381(4)
$C^2–C^{17}$	1.438(3)	$C^{14}–H^{14}$	0.9300
$C^3–C^4$	1.380(3)	$C^{15}–C^{16}$	1.380(3)
$C^3–C^{18}$	1.514(3)	$C^{15}–H^{15}$	0.9300
$C^4–C^5$	1.404(3)	$C^{16}–H^{16}$	0.9300
$C^4–C^{21}$	1.506(3)	$C^{17}–N^4$	1.141(3)
$C^5–N^1$	1.345(3)	$C^{18}–C^{19}$	1.517(3)
$C^5–C^{22}$	1.493(3)	$C^{18}–H^{18A}$	0.9700
$C^6–C^8$	1.478(4)	$C^{18}–H^{18B}$	0.9700
$C^6–C^7$	1.487(3)	$C^{19}–C^{20}$	1.469(4)
$C^6–C^9$	1.544(3)	$C^{19}–H^{19A}$	0.9700
$C^7–N^2$	1.138(3)	$C^{19}–H^{19B}$	0.9700
$C^8–N^3$	1.131(3)	$C^{20}–C^{21}$	1.525(3)
$C^9–C^{10}$	1.514(3)	$C^{20}–H^{20A}$	0.9700
$C^9–H^{9A}$	0.9700	$C^{20}–H^{20B}$	0.9700
$C^9–H^{9B}$	0.9700	$C^{21}–H^{21A}$	0.9700
$C^{10}–O^1$	1.214(2)	$C^{21}–H^{21B}$	0.9700
$C^{10}–C^{11}$	1.482(3)	$C^{22}–H^{22A}$	0.9600
$C^{11}–C^{12}$	1.385(3)	$C^{22}–H^{22B}$	0.9600
$C^{11}–C^{16}$	1.388(3)	$C^{22}–H^{22C}$	0.9600
$C^{12}–C^{13}$	1.373(3)		

observed, apparently due to rapid deuterium exchange. The latter indicates the NH-proton lability and the ability of compounds **Ia**–**Ii** to undergo the prototropic tautomerism to form aromatic forms **IVa**–**IVi**. This is confirmed by the ^{13}C NMR spectrum of compound **Ia**, where a doubling of the signals of carbon atoms is observed. Furthermore, unfused pyridines containing dicyanomethylene moiety in the position 2 can exist as NH- [21] or CH-prototropic tautomers [22]. An ease of the proton elimination from the nitrogen atom of 1,2-dihydropyridine core resulting in aromatization was confirmed also by the X-ray analysis data of 5,6-dimethyl-2-dicyanomethylene-3-cyano-1,2-dihydropyridine, showing its planar structure and aromatic nature [23].

The aromatization of 1,2-dihydropyridine core of compounds **Ia**–**Ii** occurs in their reaction with halides **Va**–**Vh** in a DMF solution in the presence of KOH. Most likely, under the action of alkali carbanions **B** are formed, which undergo *C*-alkylation to give derivatives **VIa**–**VIk**. Note that on the basis of spectral data it is not possible to confirm reliably that the reaction involves an attack on the carbon atom of malononitrile fragment rather than on an alternative nitrogen atom of the pyridine ring (Scheme 1).

The structure of the alkylation products was unambiguously determined by an example of compound **VIc** using X-ray diffraction method (Fig. 1, Tables 1, 2). Such heterocyclic system was investigated by XRD for the first time. The lengths of carbon–carbon bonds in the pyridine ring $N^1–C^{1–5}$ are in the range of 1.380–1.406(3) Å. As expected, the C–C bonds with the nitrile groups are somewhat non-equivalent. Thus, the $C^6–C^7$ and $C^6–C^8$ bonds are somewhat longer than the $C^2–C^{17}$ bond, due to the different hybridization of the C^2 and C^6 atoms. At the same time the C≡N bonds are identical within 3σ. Phenyl ring $C^{11}–C^{16}$ is turned relative to the central pyridine ring by 3.35(3)°, while the atoms of the pyridine ring itself have a mean deviation from the plane of 0.0236 Å.

It is significant to stress that at the use of 2-(2-bromo-1-phenylethylidene)malononitrile **VII** as an alkylating agent the reaction acquires a cascade character. Thus, the reaction of 2-[1-(2-chlorophenyl)-4-cyano-5,6,7,8-tetrahydroisoquinolin-3(2*H*)-ylidene]malononitrile **Id** with malononitrile derivative **VII** in DMF solution in the presence of an aqueous KOH solution at 20°C results in a new heterocyclic system, 10-amino-8-phenyl-5-(2-chlorophenyl)-1,2,3,4-tetrahydro-7*H*-pyrido[2',3':3,4]cyclopenta[1,2-*c*]isoquinoline-7,7,9-tricarbonitrile **VIII** in a yield of 62%. Most likely, the reaction proceeds through a carbanion formation. The latter undergoes a domino process to give an intermediate **D** followed by the conversion into the target compound. This reaction pathway is confirmed by the synthesis of 1-amino-2-(4-bromobenzoyl)-5-(2-chlorophenyl)-6,7,8,9-tetrahydro-3*H*-cyclopenta[*c*]isoquinoline-3,3-dicarbonitrile **IX** as an analog of the intermediate **D** by reacting compound **Ie** with 4-bromophenacyl bromide **Va** via the formation of carbanion **D** (Scheme 1).

Table 2. Bond angles in the structure of **VIc**

Angle	ω, deg	Angle	ω, deg	Angle	ω, deg	Angle	ω, deg
$N^1C^1C^2$	122.6(2)	$C^{13}C^{14}C^{15}$	120.4(2)	$N^2C^7C^6$	175.0(3)	$H^{19A}C^{19}H^{19B}$	107.8
$N^1C^1C^6$	115.39(19)	$C^{13}C^{14}H^{14}$	119.8	$N^3C^8C^6$	176.2(3)	$C^{19}C^{20}C^{21}$	112.2(2)
$C^2C^1C^6$	122.0(2)	$C^{15}C^{14}H^{14}$	119.8	$C^{10}C^9C^6$	113.52(19)	$C^{19}C^{20}H^{20A}$	109.2
$C^1C^2C^3$	119.4(2)	$C^{14}C^{15}C^{16}$	119.9(3)	$C^{10}C^9H^{9A}$	108.9	$C^{21}C^{20}H^{20A}$	109.2
$C^1C^2C^{17}$	121.4(2)	$C^{14}C^{15}H^{15}$	120.0	$C^6C^9H^{9A}$	108.9	$C^{19}C^{20}H^{20B}$	109.2
$C^3C^2C^{17}$	119.2(2)	$C^{16}C^{15}H^{15}$	120.0	$C^{10}C^9H^{9B}$	108.9	$C^{21}C^{20}H^{20B}$	109.2
$C^4C^3C^2$	118.1(2)	$C^{15}C^{16}C^{11}$	120.0(2)	$C^6C^9H^{9B}$	108.9	$H^{20A}C^{20}H^{20B}$	107.9
$C^4C^3C^{18}$	122.5(2)	$C^{15}C^{16}H^{16}$	120.0	$H^{9A}C^9H^{9B}$	107.7	$C^4C^{21}C^{20}$	112.5(2)
$C^2C^3C^{18}$	119.5(2)	$C^{11}C^{16}H^{16}$	120.0	$O^1C^{10}C^{11}$	121.1(2)	$C^4C^{21}H^{21A}$	109.1
$C^3C^4C^5$	118.3(2)	$N^4C^{17}C^2$	179.2(3)	$O^1C^{10}C^9$	120.2(2)	$C^{20}C^{21}H^{21A}$	109.1
$C^3C^4C^{21}$	121.5(2)	$C^3C^{18}C^{19}$	113.0(2)	$C^{11}C^{10}C^9$	118.6(2)	$C^4C^{21}H^{21B}$	109.1
$C^5C^4C^{21}$	120.2(2)	$C^3C^{18}H^{18A}$	109.0	$C^{12}C^{11}C^{16}$	119.3(2)	$C^{20}C^{21}H^{21B}$	109.1
$N^1C^5C^4$	123.1(2)	$C^{19}C^{18}H^{18A}$	109.0	$C^{12}C^{11}C^{10}$	118.4(2)	$H^{21A}C^{21}H^{21B}$	107.8
$N^1C^5C^{22}$	115.2(2)	$C^3C^{18}H^{18B}$	109.0	$C^{16}C^{11}C^{10}$	122.4(2)	$C^5C^{22}H^{22A}$	109.5
$C^4C^5C^{22}$	121.7(2)	$C^{19}C^{18}H^{18B}$	109.0	$C^{13}C^{12}C^{11}$	120.7(2)	$C^5C^{22}H^{22B}$	109.5
$C^8C^6C^7$	109.33(19)	$H^{18A}C^{18}H^{18B}$	107.8	$C^{13}C^{12}H^{12}$	119.7	$H^{22A}C^{22}H^{22B}$	109.5
$C^8C^6C^9$	109.20(18)	$C^{20}C^{19}C^{18}$	112.5(2)	$C^{11}C^{12}H^{12}$	119.7	$C^5C^{22}H^{22C}$	109.5
$C^7C^6C^9$	109.9(2)	$C^{20}C^{19}H^{19A}$	109.1	$C^{12}C^{13}C^{14}$	119.8(3)	$H^{22A}C^{22}H^{22C}$	109.5
$C^8C^6C^1$	108.6(2)	$C^{18}C^{19}H^{19A}$	109.1	$C^{12}C^{13}H^{13}$	120.1	$H^{22B}C^{22}H^{22C}$	109.5
$C^7C^6C^1$	108.09(18)	$C^{20}C^{19}H^{19B}$	109.1	$C^{14}C^{13}H^{13}$	120.1	$C^1N^1C^5$	118.21(19)
$C^9C^6C^1$	111.65(18)	$C^{18}C^{19}H^{19B}$	109.1				

The IR spectrum of compound **IX** contains the absorption bands of stretching and bending vibrations of amino group at 1641 and 3445 cm^{-1}, respectively, and the absorption band of the stretching vibrations of the non-conjugated cyano and carbonyl groups at 2255 and 1687 cm^{-1}, respectively. In the ^{1}H NMR spectrum, along with the signals of the protons of aromatic substituents and tetramethylene, there is a broad singlet of the protons of conjugated amino group at 8.80 ppm. The ^{13}C NMR spectrum of the heterocyclic system **IX** contains the signals of all carbon atoms in their respective areas.

In addition to the spectral methods the XRD method was used to prove the structure of compound **VIII** (Tables 3 and 4). The general view of the molecule and the atom numbering scheme is shown in Fig. 2. The central bipyridocyclopentane system is planar within 0.05 Å (according Cambridge Structural Database, similar structures have not been studied

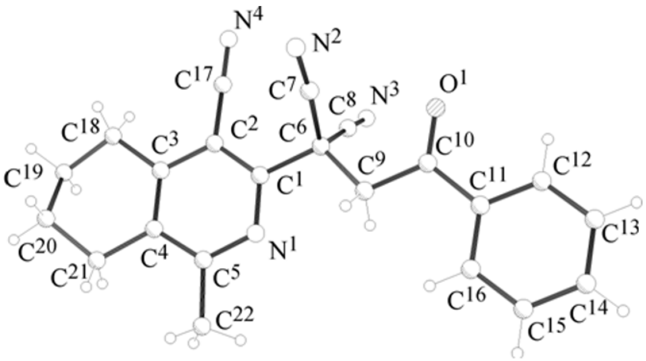
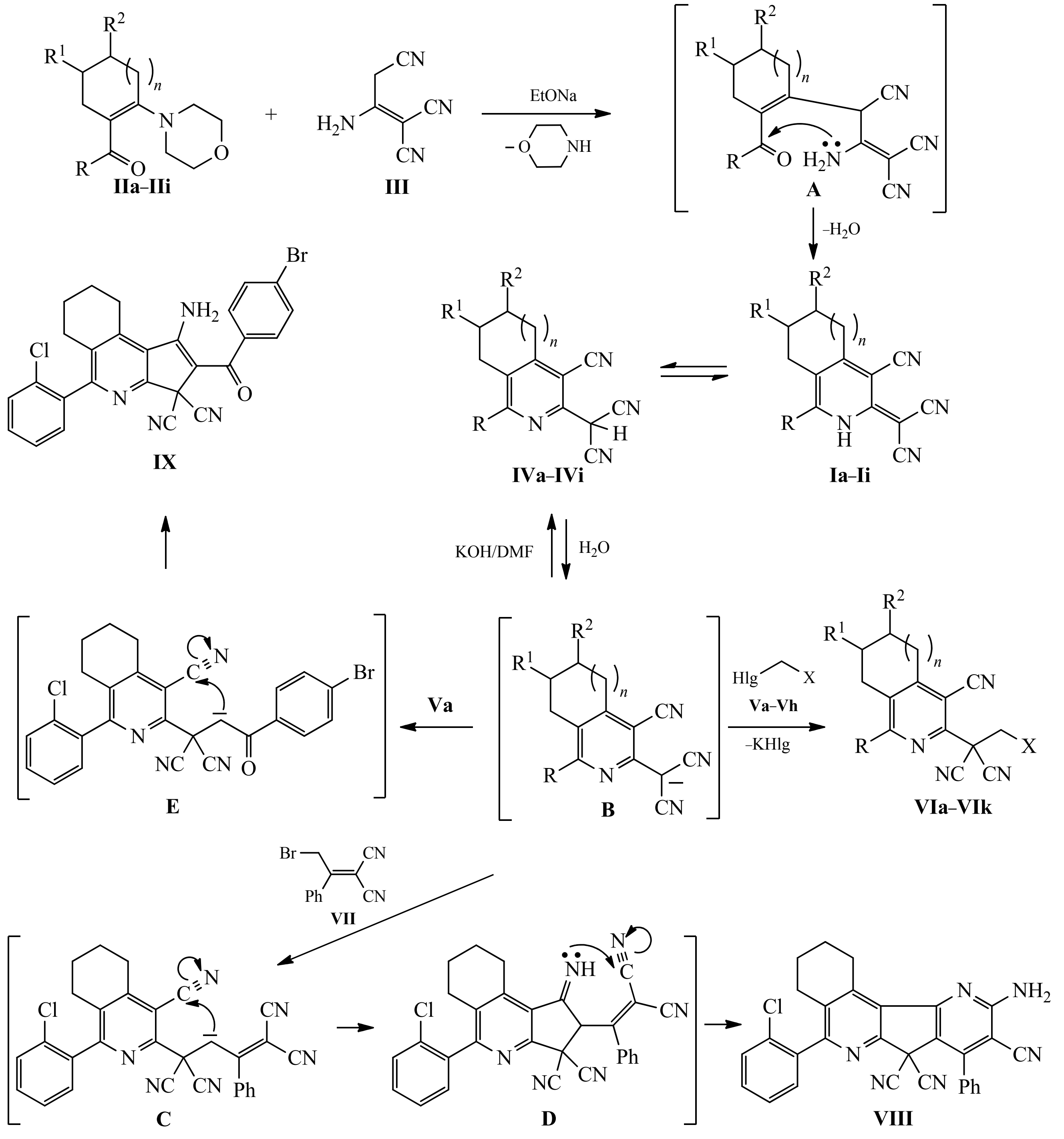


Fig. 1. General view and the numbering of the atoms of the molecule of **VIc**.

Scheme 1.



I, **II**: $n = 0$ (**a**, **b**), 1 (**c**–**i**); R = Me, $R^1 = R^2$ = H (**a**); R = Ph, $R^1 = R^2$ = H (**b**); R = Ph, R^1 = H, R^2 = Me (**c**); R = Me, R^1 = Ph, R^2 = H (**d**); R = 2-ClC_6H_4, $R^1 = R^2$ = H (**e**); R = R^2 = Me, R^1 = H (**f**); R = Me, $R^1 = R^2$ = H (**g**); R = Ph, $R^1 = R^2$ = H (**h**); R = $CH(Me)_2$, $R^1 = R^2$ = H (**i**); **V**: Hlg = Br (**a**–**g**), Hlg = Cl (**h**); X = 4-BrC_6H_4CO (**a**), PhCO (**b**), C≡CH (**c**), coumarin-3-ylcarbonyle (**d**), CH=CH_2 (**e**), 3,4-$(OH)_2C_6H_3CO$ (**f**), 4-ClC_6H_4CO (**g**), Ph (**h**); **VI**: $n = 0$ (**a**), 1 (**b**–**k**), R = Ph, $R^1 = R^2$ = H, X = C≡CH (**a**); R = Me, $R^1 = R^2$ = H, X = Ph (**b**); R = Me, $R^1 = R^2$ = H, X = PhCO (**c**); R = *i*-Pr, $R^1 = R^2$ = H, X = 4-BrC_6H_4CO (**d**); R = *i*-Pr, $R^1 = R^2$ = H, X = C≡CH (**e**); R = *i*-Pr, $R^1 = R^2$ = H, X = coumarin-3-ylcarbonyle (**f**); R = 2-ClC_6H_4, $R^1 = R^2$ = H, X = C≡CH (**g**); R = Ph, $R^1 = R^2$ = H, X = CH=CH_2 (**h**); R = Ph, R^1 = H, R^2 = Me, X = CH=CH_2 (**i**); R = R^2 = Me, R^1 =H, X = 3,4-$(OH)_2C_6H_3CO$ (**j**); R = *i*-Pr, $R^1 = R^2$ = H, X = 4-ClC_6H_4CO (**k**).

Table 3. Bond lengths in the structure of **VIII**

Bond	*d*, Å	Bond	*d*, Å
C^{1}–N^{1}	1.314(5)	C^{13}–C^{14B}	1.35(2)
C^{1}–C^{5}	1.387(5)	C^{13}–C^{14A}	1.423(17)
C^{1}–C^{11}	1.550(5)	C^{15}–C^{14B}	1.517(16)
C^{2}–N^{1}	1.367(5)	C^{15}–C^{14A}	1.578(12)
C^{2}–C^{3}	1.403(6)	C^{16}–N^{5}	1.138(5)
C^{2}–C^{25}	1.492(6)	C^{17}–N^{4}	1.137(5)
C^{3}–C^{4}	1.397(6)	C^{18}–C^{19}	1.390(6)
C^{3}–C^{12}	1.516(6)	C^{18}–C^{23}	1.394(6)
C^{4}–C^{5}	1.397(5)	C^{19}–C^{20}	1.380(6)
C^{4}–C^{15}	1.520(6)	C^{20}–C^{21}	1.376(7)
C^{5}–C^{6}	1.469(5)	C^{21}–C^{22}	1.376(7)
C^{6}–N^{2}	1.329(5)	C^{22}–C^{23}	1.386(7)
C^{6}–C^{10}	1.389(5)	C^{24}–N^{6}	1.153(6)
C^{7}–N^{3}	1.341(5)	C^{25}–C^{30}	1.370(7)
C^{7}–N^{2}	1.349(5)	C^{25}–C^{26}	1.481(7)
C^{7}–C^{8}	1.429(6)	C^{26}–C^{27}	1.381(7)
C^{8}–C^{9}	1.400(5)	C^{27}–C^{28}	1.369(8)
C^{8}–C^{24}	1.421(6)	C^{28}–C^{29}	1.340(7)
C^{9}–C^{10}	1.395(5)	C^{29}–C^{30}	1.412(7)
C^{9}–C^{18}	1.476(5)	C^{30}–Cl^{1}	1.721(5)
C^{10}–C^{11}	1.520(5)	C^{31}–O^{1}	1.343(7)
C^{11}–C^{16}	1.472(6)	C^{31}–C^{32}	1.399(11)
C^{11}–C^{17}	1.484(6)	C^{32}–C^{33}	1.589(15)
C^{12}–C^{13}	1.512(12)	C^{33}–C^{34}	1.439(15)

previously). The atom C^{14} of alicyclic fragment of compound **VIII** is disordered by two equally occupied positions **A** and **B** (Fig. 2).

The solvate molecules of butanol bind the neighboring molecules of **VIII** into endless zigzag chains via the hydrogen bonds (N–H···O–H···N) (Fig. 3). The butanol molecules occupy the cavities between the molecules of **VIII**. Thus, it is possible to assume the molecular recognition between the aliphatic part of butanol and alicyclic moiety of compound **VIII**.

Table 4. Bond angles in the structure of **VIII**

Angle	ω, deg	Angle	ω, deg
$C^{14A}C^{14B}$	1.13(3)	$C^{14B}C^{13}C^{14A}$	47.8(11)
$N^{1}C^{1}C^{5}$	126.8(4)	$C^{14B}C^{13}C^{12}$	122.5(9)
$N^{1}C^{1}C^{11}$	122.7(3)	$C^{14A}C^{13}C^{12}$	112.7(8)
$C^{5}C^{1}C^{11}$	110.4(3)	$C^{14B}C^{15}C^{4}$	111.1(8)
$N^{1}C^{2}C^{3}$	122.5(4)	$C^{14B}C^{15}C^{14A}$	42.7(10)
$N^{1}C^{2}C^{25}$	115.4(4)	$C^{4}C^{15}C^{14A}$	108.9(6)
$C^{3}C^{2}C^{25}$	121.9(4)	$N^{5}C^{16}C^{11}$	177.0(4)
$C^{4}C^{3}C^{2}$	120.2(4)	$N^{4}C^{17}C^{11}$	178.3(5)
$C^{4}C^{3}C^{12}$	120.9(4)	$C^{19}C^{18}C^{23}$	118.6(4)
$C^{2}C^{3}C^{12}$	118.9(4)	$C^{19}C^{18}C^{9}$	120.5(4)
$C^{3}C^{4}C^{5}$	116.9(4)	$C^{23}C^{18}C^{9}$	120.8(4)
$C^{3}C^{4}C^{15}$	122.0(4)	$C^{20}C^{19}C^{18}$	120.9(4)
$C^{5}C^{4}C^{15}$	121.0(4)	$C^{21}C^{20}C^{19}$	120.2(5)
$C^{1}C^{5}C^{4}$	118.2(4)	$C^{22}C^{21}C^{20}$	119.4(5)
$C^{1}C^{5}C^{6}$	108.5(3)	$C^{21}C^{22}C^{23}$	121.2(5)
$C^{4}C^{5}C^{6}$	133.3(3)	$C^{22}C^{23}C^{18}$	119.6(5)
$N^{2}C^{6}C^{10}$	125.8(4)	$N^{6}C^{24}C^{8}$	174.3(5)
$N^{2}C^{6}C^{5}$	124.8(3)	$C^{30}C^{25}C^{26}$	119.3(4)
$C^{10}C^{6}C^{5}$	109.3(3)	$C^{30}C^{25}C^{2}$	123.1(4)
$N^{3}C^{7}N^{2}$	117.5(4)	$C^{26}C^{25}C^{2}$	117.6(4)
$N^{3}C^{7}C^{8}$	120.2(4)	$C^{27}C^{26}C^{25}$	115.1(5)
$N^{2}C^{7}C^{8}$	122.4(3)	$C^{28}C^{27}C^{26}$	123.5(5)
$C^{9}C^{8}C^{24}$	121.5(4)	$C^{29}C^{28}C^{27}$	121.7(5)
$C^{9}C^{8}C^{7}$	120.7(4)	$C^{28}C^{29}C^{30}$	118.7(5)
$C^{24}C^{8}C^{7}$	117.7(4)	$C^{25}C^{30}C^{29}$	121.6(5)
$C^{10}C^{9}C^{8}$	115.3(3)	$C^{25}C^{30}Cl^{1}$	120.1(4)
$C^{10}C^{9}C^{18}$	122.9(3)	$C^{29}C^{30}Cl^{1}$	118.3(4)
$C^{8}C^{9}C^{18}$	121.7(3)	$O^{1}C^{31}C^{32}$	118.6(7)
$C^{6}C^{10}C^{9}$	120.0(3)	$C^{31}C^{32}C^{33}$	118.8(9)
$C^{6}C^{10}C^{11}$	110.7(3)	$C^{34}C^{33}C^{32}$	101.5(10)
$C^{9}C^{10}C^{11}$	129.2(3)	$C^{14B}C^{14A}C^{13}$	62.9(12)
$C^{16}C^{11}C^{17}$	109.8(3)	$C^{14B}C^{14A}C^{15}$	65.7(10)
$C^{16}C^{11}C^{10}$	113.7(3)	$C^{13}C^{14A}C^{15}$	109.4(8)
$C^{17}C^{11}C^{10}$	112.8(3)	$C^{14A}C^{14B}C^{13}$	69.3(15)
$C^{16}C^{11}C^{1}$	108.9(3)	$C^{14A}C^{14B}C^{15}$	71.6(13)
$C^{17}C^{11}C^{1}$	110.3(3)	$C^{13}C^{14B}C^{15}$	117.1(15)
$C^{10}C^{11}C^{1}$	101.0(3)	$C^{1}N^{1}C^{2}$	115.4(3)
$C^{13}C^{12}C^{3}$	113.3(5)	$C^{6}N^{2}C^{7}$	115.7(3)

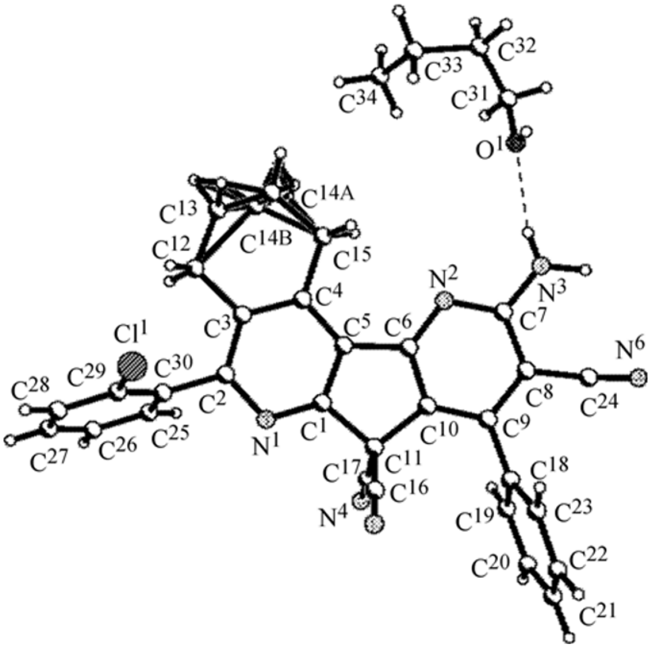


Fig. 2. General view and the numbering of atoms of the compound **VIII** molecule. Hydrogen bond with the solvate butanol molecule is marked by *dashed line*.

EXPERIMENTAL

X-Ray diffraction analysis. The crystals of compound **VIc** are monoclinic, $C_{22}H_{18}N_4O$, M 354.4, space group $P2_1/c$, a 13.5802(9), b 9.3607(7), c 14.4475(11) Å, β 100.675(4)°, V 1804.8(2) Å^3, Z 4, d_{calc} 1.304 g cm^{-3}, size 0.36×0.30×0.15 mm. The study was carried out at room temperature on a Bruker Smart Apex diffractometer ((λMoK_α-radiation, graphite monochromator, $\theta_{\max}$ 26.28°, $-16 \le h \le 16$, $-10 \le k \le 11$, $-17 \le l \le 17$). 15818 reflections were collected, 3635of which were independent (R-factor is 0.0664). The correction for extinction was done using SADABS program by multiscanning method ($T_{\min}/T_{\max}$= 0.650778). The structure was solved by the direct method and refined by the least squares method in the full-matrix anisotropic approximation using a Bruker SHELXTL program [24]. All hydrogen atoms were placed geometrically and their positions were refined in the *rider* model together with positions of the carbon atoms.

In the refinement 1849 reflections were utilized with $I > 2\sigma(I)$ (244 refined parameters, 7.6 reflections per parameter). The weight scheme used was $w = 1/[\sigma^2(Fo^2) + (0.0388P)^2]$ where $P = (Fo^2 + 2Fc^2)/3$, the ratio to the error of the maximum (mean) shift in the final cycle was 0.017 (0.002). The final values of the divergence factors were $R_1(F)$ 0.0604, $wR_2(F^2)$ 0.1090 for reflections with $I > 2\sigma(I)$, $R_1(F)$ 0.1421, $wR_2(F^2)$ 01321, GOF 1.168 for all independent reflections. The residual electron density for the difference Fourier series after the final refinement cycle was 0.20 and −0.20 e Å^{-3}. A complete set of the X-ray diffraction data was deposited at the Cambridge Structural Database (CCDC 854872).

The XRD experiment on a single crystal of compound **VIII** was performed on a CCD-diffracttometer Bruker Smart Apex (MoK_α-radiation, λ 0.71069 Å, $\theta_{\max}$ 26.49°, spherical segment $0 \le h \le 15$, $-17 \le k \le 17$, $-21 \le l \le 21$) at a temperature of 173 K. Overall number of 20418 reflections was collected, among them 6118 were independent. Crystals of compound **VIII** monoclinic, a 12.4004(17), b 14.013(2), c 17.260(3) Å, β 99.912(4), V 2954.5(8) Å^3, Z 4, d_{calc} 1.329 g cm^{-3}, μ 0.17 cm^{-1}, F(000) 1248, space group $P2_1/n$. The structure was solved by the direct method and refined by the least squares method in the full-matrix anisotropic approximation using a SHELX program [24]. In refining 3090 reflections with $I > 2\sigma(I)$ were used (453 refining parameters, 6.8 reflections per one parameter). Positions of most hydrogen atoms (including the atoms involved into the hydrogen bonds) were identified from the difference Fourier series and refined isotropically. The final values of the divergence factors are R_1 0.086 и R_w 0.222, GOF 1.046. By the difference Fourier series, the residual electron density is –0.65 and 0.66 e Å^{-3}. A

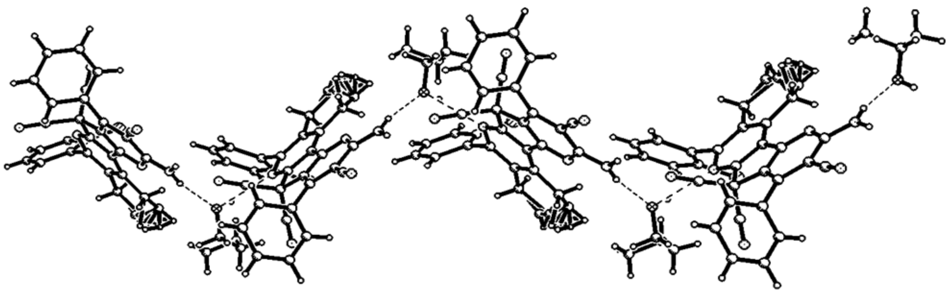


Fig. 3. Packing of molecules in the crystal of compound **VIII**.

complete set of the X-ray diffraction data was deposited at the Cambridge Structural Database (CCDC 874929).

The IR spectra were recorded on a SPECTRUM ONE (Perkin Elmer) FIR-spectrometer from KBr pellets. The ^{1}H NMR spectra were taken on a Bruker DR-500 spectrometer (500.13 MHz) in DMSO-d_6, internal reference TMS. The ^{13}C NMR spectra were registered on a Varian VXR-300 spectrometer (125.74 MHz) in DMSO-d_6, internal reference TMS. Mass spectra were recorded on a Chrommass GC/MC (Hewlett Packard) 5890/5972 instrument (column HP-5 MS, 70 eV) in CH_2Cl_2. Melting points were determined on a Koeffler heating block. The reaction progress and purity of compounds obtained were monitored by TLC on Silufol UV-254 plates eluting with an acetone–hexane mixture (3:5) and detecting with iodine vapor or UV irradiation.

1-Substituted 4-cyano-3-dicyanomethylenecarbo[*c*]fused pyridines (Ia–Ii). To a solution of 10 mmol of enaminoketone **II** and 1.32 g (10 mmol) of malononitrile dimer **III** in 20 ml of anhydrous ethanol at 20°C was added sodium ethoxide solution (prepared from 0.23 g of sodium metal and 10 ml of anhydrous ethanol). The mixture was stirred for 30 min and kept for 1 day. Then the reaction mixture was diluted with 10% aqueous hydrochloric acid to pH 3. The resulting precipitate was filtered off, washed with water, ethanol, and hexane.

2-{4-Cyano-1-methyl-6,7-dihydro-2*H*-cyclopenta[*c*]pyridin-3(5*H*)-ylidene}malononitrile (Ia). Yield 1.73 g (78%), yellow powder, fluoresces under UV irradiation, mp 230–232°C (AcOH). IR spectrum, ν, cm^{-1}: 3250 (NH), 2182, 2204 (C≡N). ^{1}H NMR spectrum, δ, ppm: 2.08 t (2H, CH_2, *J* 7.3 Hz), 2.39 s and 2.45 s (3H, Me), 2.79 m (2H, CH_2), 3.04 t (2H, CH_2, *J* 7.4 Hz). The signal of NH-proton does not occur, apparently due to fast deuterium exchange. ^{13}C NMR spectrum, δ_C, ppm: 17.75, 18.94, 21.43, 23.19, 28.29, 29.16, 32.51, 34.04, 94.06, 97.49, 113.38, 113.76, 117.51, 117.67, 128.42, 129.37, 149.47, 152.09, 152.70, 157.29, 159.32, 168.37. Mass spectrum, *m/z* (I_{rel}, %): 223 (100) $[M + 1]^+$. Found, %: C 70.04; H 4.44; N 25.52. $C_{13}H_{10}N_4$. Calculated, %: C 70.26; H 4.53; N 25.21. *M* 222.252.

2-{4-Cyano-1-phenyl-6,7-dihydro-2*H*-cyclopenta[*c*]pyridin-3(5*H*)-ylidene}malononitrile (Ib). Yield 2.24 g (79%), yellow powder, mp 263–265°C (AcOH). IR spectrum, ν, cm^{-1}: 2294 (NH), 2198, 2218 (C≡N). ^{1}H NMR spectrum, δ, ppm: 2.05 m (2H, CH_2), 2.88 t (2H, CH_2, *J* 7.6 Hz), 3.05 t (2H, CH_2, *J* 7.4 Hz), 7.45–7.72 m (5H, Ph). The signal of NH-proton does not occur, apparently due to fast deuterium exchange. Mass spectrum, *m/z* (I_{rel}, %): 285 (100) $[M + 1]^+$. Found, %: C 75.90; H 4.11; N 19.92. $C_{18}H_{12}N_4$. Calculated, %: C 76.04; H 4.25; N 19.71. *M* 284.324.

2-{4-Cyano-6-Methyl-1-phenyl-5,6,7,8-tetrahydroisoquinolin-3(2*H*)-ylidene}malononitrile (Ic). Yield 2.46 g (79%), yellow powder, fluoresces under UV irradiation, mp 248–251°C (BuOH). IR spectrum, ν, cm^{-1}: 3230 (NH), 2180, 2207 (C≡N). ^{1}H NMR spectrum, δ, ppm: 0.71 d (3H, Me, *J* 6.3 Hz), 1.05 m (2H, CH_2), 1.58 m (1H, C^6H), 1.77 m (2H, CH_2), 2.95 m (2H, CH_2), 7.49–7.54 m (5H, Ph). The signal of NH-proton does not occur, apparently due to fast deuterium exchange. Mass spectrum, *m/z* (I_{rel}, %): 313 (100) $[M + 1]^+$. Found, %: C 76.83; H 5.15; N 18.02. $C_{20}H_{16}N_4$. Calculated, %: C 76.90; H 5.16; N 17.94. *M*312.378.

2-{4-Cyano-1-Methyl-7-phenyl-5,6,7,8-tetrahydroisoquinolin-3(2*H*)-ylidene}malononitrile (Id). Yield 2.10 g (68%), yellow powder, mp 265–267°C (AcOH). IR spectrum, ν, cm^{-1}: 3314 (NH), 2196, 2205 (C≡N). ^{1}H NMR spectrum, δ, ppm: 1.25 s (3H, Me), 1.76–2.14 m (3H, C^6H_2 and C^7H), 2.66–2.91 m (4H, C^5H_2 and C^8H_2), 7.16–7.33 m (5H, Ph). The signal of NH-proton does not occur, apparently due to fast deuterium exchange. ^{13}C NMR spectrum, δ_C, ppm: 18.20, 28.08, 30.03, 32.43, 39.63, 98.01, 113.66, 118.34, 123.04, 126.94, 127.27, 128.95, 145.45, 151.41, 154.07, 159.68. Mass spectrum, *m/z* (I_{rel}, %): 313 (100) $[M + 1]^+$. Found, %: C 76.85; H 5.27; N 17.88. $C_{20}H_{16}N_4$. Calculated, %: C 76.90; H 5.16; N 17.94. *M*312.378.

2-[1-(2-Chlorophenyl)-4-cyano-5,6,7,8-tetrahydroisoquinolin-3(2*H*)-ylidene]malononitrile (Ie). Yield 2.4 g (72%), yellow powder, fluoresces under UV irradiation, mp 250°C (decomp.). IR spectrum, ν, cm^{-1}: 3248(NH), 2192, 2210(C≡N). ^{1}H NMR spectrum, δ, ppm: 1.52–1.64 m (2H, CH_2), 1.66–1.79 m (2H, CH_2), 2.09–2.21 m (2H, CH_2), 2.81–2.93 m (2H, CH_2), 7.48 d (1H, H_{arom}, *J* 7.5 Hz), 7.51 t (1H, H_{arom}, *J* 7.5 Hz), 7.57 t (1H, H_{arom}, *J* 8.0 Hz), 7.63 d (1H, H_{arom}, *J* 8.5 Hz). The signal of NH-proton does not occur, apparently due to fast deuterium exchange. ^{13}C NMR spectrum, δ_C, ppm: 20.82, 21.08, 24.72, 29.10, 38.39, 99.27, 113.57, 118.72, 122.68, 127.55, 129.45, 130.68, 131.58, 131.69, 132.81, 151.18, 152.79, 159.52. Mass spectrum, *m/z* (I_{rel}, %): 331 (100) $[M - 1]^+$. Found, %:

C 68.42; H 3.85; N 16.70. $C_{19}H_{13}ClN_4$. Calculated, %: C 68.57; H 3.94; N 16.84. *M* 332.796.

2-[4-Cyano-1,6-dimethyl-5,6,7,8-tetrahydroisoquinolin-3(2*H*)-ylidene]malononitrile (If). Yield 1.88 g (75%), yellow powder, fluoresces under UV irradiation, mp 250–252°C (BuOH). IR spectrum, ν, cm^{-1}: 3434 (NH), 2172, 2204 (C≡N). ^{1}H NMR spectrum, δ, ppm: 1.05 d (3H, Me, *J* 6.4 Hz), 1.21–1.36 m (1H, C^{6}H), 1.73–1.81 m (2H, CH_2), 2.35–2.45 m (2H, CH_2), 2.48 s (3H, Me), 2.64 m (1H, CH_2), 2.95 m (1H, CH_2). The signal of NH-proton does not occur, apparently due to fast deuterium exchange. ^{13}C NMR spectrum, δ_C, ppm: 17.68, 20.89, 23.79, 26.81, 28.91, 36.99, 97.52, 113.14, 117.94, 122.23, 150.88, 153.44, 159.38. Mass spectrum, *m/z* (I_{rel}, %): 249 (100) [*M* – 1]$^{+}$. Found, %: C 71.90; H 5.68; N 22.42. $C_{15}H_{14}N_4$. Calculated, %: C 71.98; H 5.64; N 22.38. *M* 250.306.

2-[4-Cyano-1-methyl-5,6,7,8-tetrahydroisoquinolin-3(2*H*)-ylidene]malononitrile (Ig). Yield 1.82 g (77%), yellow powder, fluoresces under UV irradiation, mp 265–267°C (AcOH) (mp 310°C [20]). IR spectrum, ν, cm^{-1}: 3256 (NH), 2177, 2202 (C≡N). ^{1}H NMR spectrum, δ, ppm: 1.73 m (4H, 2CH_2), 2.48 s (3H, Me), 2.51 m (2H, CH_2), 2.82 m (2H, CH_2), 12.55 br. s (1H, NH). ^{13}C NMR spectrum, δ_C, ppm: 17.54, 20.51, 20.91, 23.91, 29.17, 97.67, 113.05, 117.83, 122.69, 150.62, 153.43, 159.94. Mass spectrum, *m/z* (I_{rel}, %): 235 (100) [*M* – 1]$^{+}$. Found, %: C 71.22; H 5.10; N 23.68. $C_{14}H_{12}N_4$. Calculated, %: C 71.17; H 5.12; N 23.71. *M* 236.279.

2-[4-Cyano-1-phenyl-5,6,7,8-tetrahydroisoquinolin-3(2*H*)-ylidene]malononitrile (Ih). Yield 2.41g (81%), yellow powder, fluoresces under UV irradiation, mp 265–268°C (AcOH). IR spectrum, ν, cm^{-1}: 3435 (NH), 2179, 2203 (C≡N). ^{1}H NMR spectrum, δ, ppm: 1.62 m (2H, CH_2), 1.79 m (2H, CH_2), 2.38 m (2H, CH_2), 2. 92 m (2H, CH_2), 7.38–7.64 m (5H, Ph). The signal of NH-proton is not observed apparently due to fast deuterium exchange. ^{13}C NMR spectrum, δ_C, ppm: 20.70, 21.25, 25.52, 29.20, 98.95, 113.48, 118.45, 122.20, 128.41, 128.92, 130.06, 133.32, 152.10, 152.89, 159.81, 193.94. Mass spectrum, *m/z* (I_{rel}, %): 297 (100) [*M* – 1]$^{+}$. Found, %: C 76.30; H 4.83; N 18.87. $C_{19}H_{14}N_4$. Calculated, %: C 76.49; H 4.73; N 18.78. *M* 298.351.

2-[4-Cyano-1-isopropyl-5,6,7,8-tetrahydroisoquinolin-3(2*H*)-ylidene]malononitrile (Ii). Yield 2.16 g (82%), yellow powder, fluoresces under UV irradiation, mp 255–257°C (AcOH). IR spectrum, ν, cm^{-1}: 3335 (NH), 2175, 2202 (C≡N). ^{1}H NMR spectrum, δ, ppm: 1.27 d (6H, 2Me, *J* 6.8 Hz), 1.74 m (4H, 2CH_2), 2.61 m (2H, CH_2), 2.84 m (2H, CH_2), 3.30 m (1H, CH), 8.70 br. s (1H, NH). Mass spectrum, *m/z* (I_{rel}, %): 265 (100) [*M* + 1]$^{+}$. Found, %: C 72.65; H 6.14; N 21.21. $C_{16}H_{16}N_4$. Calculated, %: C 72.70; H 6.10; N 21.20. *M* 264.331.

2-Acyl-1-(*N*-morpholinyl)cycloalkenes IIa–IIi were prepared as described in [25].

Substituted 2-alkyl-2-(3-isoquinolinyl)malononitriles VIa–VIk. To a stirred solution of 10 mmol of compound **I** in 15 ml of DMF at 20°C were added in succession 5.6 ml (10 mmol) of 10% aqueous KOH and 10 mmol of alkylating agent **V**. The mixture was stirred for 2 h and kept for 1 day. Then the reaction mixture was diluted with an equal volume of water and allowed to stand for 48 h. The formed precipitate was filtered off, washed with water, ethanol and hexane.

2-(Prop-2-ynyl)-2-(4-cyano-1-phenyl-6,7-dihydro-5*H*-cyclopenta[*c*]pyridin-3-yl)malononitrile (VIa). Yield 2.01 g (64%), yellow needles, fluoresces under UV irradiation, mp 161–163°C (BuOH). IR spectrum, ν, cm^{-1}: 3271 (≡C–H), 2229 (C≡N). ^{1}H NMR spectrum, δ, ppm: 2.21 t (2H, CH_2, *J* 7.6 Hz), 3.24 t (2H, CH_2, *J* 7.2 Hz), 3.29 t (2H, CH_2, *J* 7.6 Hz), 3.51 s (1H, ≡CH), 3.81 s (2H, CH_2), 7.52–7.66 m (3H, Ph), 7.93–8.08 m (2H, Ph). ^{13}C NMR spectrum, δ_C, ppm: 24.46, 28.07, 32.50, 32.79, 43.45, 76.04, 77.57, 102.23, 112.78, 113.63, 128.63, 128.85, 130.30, 136.70, 139.54, 146.42, 154.51, 163.96. Mass spectrum, *m/z* (I_{rel}, %): 323 (100) [*M* + 1]$^{+}$. Found, %: C 78.19; H 4.35; N 17.46. $C_{21}H_{14}N_4$. Calculated, %: C 78.24; H 4.38; N 17.38. *M* 322.373.

2-Benzyl-2-(4-cyano-1-methyl-5,6,7,8-tetrahydroisoquinolin-3-yl)malononitrile (VIb). Yield 2.12 g (65%), yellow crystals, mp 140–143°C (BuOH). IR spectrum, ν, cm^{-1}: 2228 (C≡N). ^{1}H NMR spectrum, δ, ppm: 1.81 m (4H, 2CH_2), 2.51 s (3H, Me), 2.71 m (2H, CH_2), 2.97 m (2H, CH_2), 3.82 s (2H, $\underline{CH_2}$Ph), 7.39–7.44 m (5H, Ph). ^{13}C NMR spectrum, δ_C, ppm: 20.56, 21.07, 22.39, 25.05, 28.09, 42.37, 46.73, 105.09, 112.99, 161.02. Mass spectrum, *m/z* (I_{rel}, %): 327 (100) [*M* + 1]$^{+}$. Found, %: C 77.25; H 5.59; N 17.16. $C_{21}H_{18}N_4$. Calculated, %: C 77.28; H 5.55; N 17.17. *M* 326.404.

2-(4-Cyano-1-methyl-5,6,7,8-tetrahydroisoquinolin-3-yl)-2-(2-oxo-2-phenylethyl)malononitrile (VIc). Yield 2.37 g (67%), orange crystals, mp 215–217°C (BuOH). IR spectrum, ν, cm^{-1}: 2225 (C≡N), 1686

(C=O). ^{1}H NMR spectrum, δ, ppm: 1.80 m (4H, 2CH$_2$), 2.32 s (3H, Me), 2.67 m (2H, CH$_2$), 2.99 m (2H, CH$_2$), 4.69 s (2H, CH$_2$CO), 7.61 t (2H, Ph, *J* 7.5 Hz), 7.74 t (1H, Ph, *J* 7.5 Hz), 8.08 d (2H, Ph, *J* 7.5 Hz). ^{13}C NMR spectrum, δ$_C$, ppm: 20.54, 21.03, 22.18, 24.99, 28.08, 38.10, 43.01, 106.13, 113.33, 113.48, 128.13, 128.80, 133.68, 134.02, 135.15, 145.74, 152.27, 160.70, 193.45. Mass spectrum, *m/z* (*I*$_{rel}$, %): 355 (100) [*M* + 1]$^+$. Found, %: C 74.59; H 5.11; N 15.79. $C_{22}H_{18}N_4O$. Calculated, %: C 74.56; H 5.12; N 15.81. *M* 354.414.

2-[2-(4-Bromophenyl)-2-oxoethyl]-2-(1-isopropyl-4-cyano-5,6,7,8-tetrahydroisoquinolin-3-yl)-malononitrile (VId). Yield 3.3 g (71%), white powder, mp 158–159°C (AcOH). IR spectrum, ν, cm^{-1}: 2223 (C≡N), 1679 (C=O). ^{1}H NMR spectrum, δ, ppm: 0.89 d (6H, 2Me, *J* 6.6 Hz), 1.79 m (4H, 2CH$_2$), 2.76 m (2H, CH$_2$), 3.00 m (2H, CH$_2$), 3.11–3.26 m [1H, $\underline{\text{CH}}$(Me)$_2$], 4.78 s (2H, CH$_2$CO), 7.83 d and 8.04 d (4H, 4-BrC$_6$H$_4$, *J* 8.0 Hz). ^{13}C NMR spectrum, δ$_C$, ppm: 28.14, 28.37, 28.82, 31.64, 35.54, 37.37, 43.92, 48.67, 107.62, 114.24, 114.40, 128.24, 129.91, 131.55, 131.80, 133.35, 144.23, 151.08, 164.78, 187.60. Mass spectrum, *m/z* (*I*$_{rel}$, %): 462 (100) [*M* + 1]$^+$. Found, %: C 62.30; H 4.35; N 12.02. $C_{24}H_{21}BrN_4O$. Calculated, %: C 62.49; H 4.59; N 12.15. *M* 461.309.

2-(4-Cyano-1-isopropyl-5,6,7,8-tetrahydroisoquinolin-3-yl)-2-(prop-2-ynyl)malononitrile (VIe). Yield 1.78 g (59%), yellow crystals, mp 140–141°C (BuOH). IR spectrum, ν, cm^{-1}: 3338 (≡C–H), 2228(C≡N). ^{1}H NMR spectrum, δ, ppm: 1.22 d (6H, 2Me, *J* 6.8 Hz), 1.71–1.86 m (4H, 2CH$_2$), 2.74 m (2H, CH$_2$), 2.97 m (2H, CH$_2$), 3.31–3.39 m [1H, $\underline{\text{CH}}$(Me)$_2$], 3.46 s (1H, ≡CH), 3.71 s (2H, CH$_2$C≡). ^{13}C NMR spectrum, δ$_C$, ppm: 21.02, 21.55, 21.73, 24.77, 28.25, 28.97, 31.27, 43.94, 76.54, 77.94, 105.65, 113.27, 113.99, 132.98, 146.23, 146.25, 153.60, 168.64. Mass spectrum, *m/z* (*I*$_{rel}$, %): 303 (100) [*M* + 1]$^+$. Found, %: C 75.38; H 5.96; N 18.66. $C_{19}H_{18}N_4$. Calculated, %: C 75.47; H 6.00; N 18.53. *M* 302.382.

2-(4-Cyano-1-isopropyl-5,6,7,8-tetrahydroisoquinolin-3-yl)-2-[2-(coumarin-3-yl)-2-oxoethyl]malononitrile (VIf). Yield 3.2 g (72%), yellow crystals, fluoresces under UV irradiation, mp 191–193°C (BuOH). IR spectrum, ν, cm^{-1}: 2228 (C≡N), 1715, 1691 (C=O). ^{1}H NMR spectrum, δ, ppm: 1.11 d (6H, 2Me, *J* 4.0 Hz), 1.82 m (4H, 2CH$_2$), 2.80 m (2H, CH$_2$), 3.01 m (2H, CH$_2$), 3.18–3.36 m (1H, $\underline{\text{CH}}$Me$_2$), 4.70 s (2H, CH$_2$CO), 7.47 t (1H, H$_{arom}$, *J* 8.0 Hz), 7.52 d (1H, H$_{arom}$, *J* 8.0 Hz), 7.82 t (1H, H$_{arom}$, *J* 8.0 Hz), 8.02 d (1H, H$_{arom}$, *J* 8.0 Hz), 8.90 s (1H, C^{4}H, coumarin). ^{13}C NMR spectrum, δ$_C$, ppm: 20.99, 24.78, 28.99, 31.11, 31.22, 36.22, 39.74, 40.16, 46.96, 106.43, 113.75, 113.99, 116.75, 118.48, 122.72, 125.73, 131.75, 132.86, 135.92, 146.58, 149.59, 153.70, 155.32, 158.89, 162.72, 168.48, 190.58. Mass spectrum, *m/z* (*I*$_{rel}$, %): 451 (100) [*M* + 1]$^+$. Found, %: C 71.85; H 4.85; N 12.50. $C_{27}H_{22}N_4O_3$. Calculated, %: C 71.99; H 4.92; N 12.44. *M* 450.501.

2-(Prop-2-ynyl)-2-[1-(1-chlorophenyl)-4-cyano-5,6,7,8-tetrahydroisoquinolin-3-yl]malononitrile (VIg). Yield 2.44 g (66%), dark red crystals, mp 148–150°C (BuOH). IR spectrum, ν, cm^{-1}: 3304 (≡C–H), 2225 (C≡N). ^{1}H NMR spectrum, δ, ppm: 1.72 m (2H, CH$_2$), 1.83 m (2H, CH$_2$), 2.47 m (2H, CH$_2$), 3.09 m (2H, CH$_2$), 3.48 s (1H, ≡CH), 3.72 s (2H, CH$_2$C≡), 7.45 d (1H, H$_{arom}$, *J* 7.2 Hz), 7.51–7.58 m (2H, H$_{arom}$), 7.65 d (1H, H$_{arom}$, *J* 8.0 Hz). ^{13}C NMR spectrum, δ$_C$, ppm: 20.58, 20.84, 25.83, 28.08, 28.25, 43.46, 75.69, 77.76, 107.24, 112.65, 113.08, 127.54, 129.58, 130.30, 130.91, 131.14, 134.60, 136.46, 146.10, 154.53, 158.68. Mass spectrum, *m/z* (*I*$_{rel}$, %): 371 (100) [*M* + 1]$^+$. Found, %: C 71.14; H 3.98; N 15.18. $C_{22}H_{15}ClN_4$. Calculated, %: C 71.26; H 4.08; N 15.11. *M* 370.845.

2-Allyl-2-(4-cyano-1-phenyl-5,6,7,8-tetrahydroisoquinolin-3-yl)malononitrile (VIh). Yield 2.01 g (60%), dark red crystals, mp 85–86°C (MeOH). IR spectrum, ν, cm^{-1}: 2222 (C≡N). ^{1}H NMR spectrum, δ, ppm: 1.70 m (2H, CH$_2$), 1.87 m (2H, CH$_2$), 2.79 m (2H, CH$_2$), 3.08 m (2H, CH$_2$), 3.38 d (2H, $\underline{\text{CH}_2}$–CH=, *J* 7.0 Hz), 5.46 d (1H, =CH$_2$, *J*$_{cis}$ 9.45 Hz), 5.54 d (1H, =CH$_2$, *J*$_{trans}$ 17.38 Hz), 5.84–5.96 m (1H, CH=), 7.54 m (3H, Ph), 7.66 m (2H, Ph). ^{13}C NMR spectrum, δ$_C$, ppm: 20.61, 21.33, 27.19, 28.35, 40.83, 44.53, 105.95, 112.96, 113.45, 123.50, 128.19, 128.86, 129.10, 129.36, 133.19, 137.53, 147.06, 154.38, 159.84, 199.50. Mass spectrum, *m/z* (*I*$_{rel}$, %): 339 (100) [*M* + 1]$^+$. Found, %: C 78.01; H 5.25; N 16.74. $C_{22}H_{18}N_4$. Calculated, %: C 78.08; H 5.36; N 16.56. *M* 338.415.

2-Allyl-2-(4-cyano-6-methyl-1-phenyl-5,6,7,8-tetrahydroisoquinolin-3-yl)malononitrile (VIi). Yield 2.57 g (73%), white powder, mp 96–99°C (BuOH). IR spectrum, ν, cm^{-1}: 2224 (C≡N). ^{1}H NMR spectrum, δ, ppm: 1.11 d (3H, CH$_3$, *J* 6.4 Hz), 1.18–1.30 m (1H, $\underline{\text{CH}}$Me), 1.86 m (1H, CH$_2$), 1.97 m (1H, CH$_2$), 2.60–2.76 m (2H, CH$_2$), 2.87–3.17 m (1H, CH$_2$), 3.19–3.25 m (1H, CH$_2$), 3.37 d (2H, $\underline{\text{CH}_2}$CH=, *J* 6.44 Hz), 5.44 d (1H, =CH$_2$, *J*$_{cis}$ 9.55 Hz), 5.51 d (1H, =CH$_2$,

J_{trans} 17.41 Hz), 5.81–5.99 m (1H, CH=), 7.45–7.56 m (3H, Ph), 7.61–7.73 m (2H, Ph). ^{13}C NMR spectrum, δ_C, ppm: 21.14, 27.01, 27.09, 29.52, 36.49, 40.86, 44.56, 105.85, 112.97, 113.49, 123.57, 128.23, 128.89, 129.13, 129.41, 132.81, 137.63, 147.17, 154.25, 159.79. Mass spectrum, *m/z* (I_{rel}, %): 353 (100) $[M + 1]^+$. Found, %: C 78.27; H 5.81; N 15.92. $C_{23}H_{20}N_4$. Calculated, %: C 78.38; H 5.72; N 15.90. *M* 352.442.

2-[2-(3,4-Dihydroxyphenyl)-2-oxoethyl]-2-(4-cyano-1,6-dimethyl-5,6,7,8-tetrahydroisoquinolin-3-yl)malononitrile (VIj). Yield 2.56 g (64%), white powder, mp 199–201°C (BuOH). IR spectrum, ν, cm^{-1}: 3385 (OH), 2214, 2252 (C≡N), 1677 (C=O). ^{1}H NMR spectrum, δ, ppm: 1.07 d (3H, Me, *J* 6.4 Hz), 1.38 m (1H, CHMe), 1.81–1.99 m (2H, CH_2), 2.39 m (3H, Me), 2.51–2.64 m (2H, CH_2), 2.81 m (1H, CH_2), 3.04–3.09 m (1H, CH_2), 4.51 s (2H, CH_2CO) 6.89 d (1H, H_{arom}, *J* 8.0 Hz), 7.40 s (1H, H_{arom}), 7.74 d (1H, H_{arom}, *J* 8.0 Hz), 9.53 br. s (1H, OH), 10.13 br. s (1H, OH). ^{13}C NMR spectrum, δ_C, ppm: 20.94, 22.47, 24.98, 26.87, 29.13, 30.76, 36.77, 43.13, 105.81, 113.57, 113.66, 114.84, 115.22, 121.93, 126.92, 133.27, 145.42, 146.41, 151.74, 152.00, 160.73, 162.29, 191.19. Mass spectrum, *m/z* (I_{rel}, %): 401 (100) $[M + 1]^+$. Found, %: C 68.88; H 4.95; N 14.12. $C_{23}H_{20}N_4O_3$. Calculated, %: C 68.99; H 5.03; N 13.99. *M* 400.44.

2-(4-Cyano-1-isopropyl-5,6,7,8-tetrahydroisoquinolin-3-yl)-2-[2-(4-chlorophenyl)-2-oxoethyl]malononitrile (VIk). Yield 3.2 g (76%), white crystals, mp 186–188°C (BuOH). IR spectrum, ν, cm^{-1}: 2227 (C≡N), 1699 (C=O). ^{1}H NMR spectrum, δ, ppm: 0.90 d (6H, 2Me, *J* 5.0 Hz), 1.69–1.82 m (4H, $2CH_2$), 2.66–2.79 m (2H, CH_2), 2.88–3.05 m (2H, CH_2), 3.17–3.28 m (1H, $CHMe_2$), 4.78 s (2H, CH_2C=O), 7.69 d and 8.13 d (4H, C_6H_4, *J* 8.61 Hz). ^{13}C NMR spectrum, δ_C, ppm: 21.00, 21.22, 21.73, 24.77, 28.97, 30.96, 38.08, 40.10, 106.70, 113.84, 114.00, 129.53, 130.67, 132.77, 134.15, 137.71, 146.24, 153.56, 168.36, 192.71. Mass spectrum, *m/z* (I_{rel}, %): 417 (100) $[M + 1]^+$. Found, %: C 68.98; H 4.97; N 13.33. $C_{24}H_{21}ClN_4O$. Calculated, %: C 69.14; H 5.08; N 13.45. *M* 416.914.

10-Amino-5-(2-chlorophenyl)-8-phenyl-1,2,3,4-tetrahydro-7*H*-pyrido[2',3':3,4]cyclopenta[1,2-*c*]isoquinoline-7,7,9-tricarbonitrile (VIII). To a stirred solution of 3.33g (10 mmol) of compound **Id** in 15 ml of DMF at 20°C was added in succession 5.6 ml (10 mmol) of 10% aqueous KOH solution and 2.47 g (10 mmol) of 2-aminoprop-1-ene-1,1,3-tricarbonitrile **VII**. The mixture was stirred for 2 h and kept for 1 day. The reaction mixture was diluted with 20 ml of water. The resinous product was separated by decantation, dissolved in 20 ml of methanol, and allowed to stand for 48 h. The formed precipitate was filtered off, washed with ethanol and hexane, and recrystallized from butanol. Yield 3.1g (62%), dark red crystals, fluoresces under UV irradiation, mp 300–303°C. IR spectrum, ν, cm^{-1}: 3288–3442 (NH_2), 2224, 2246 (C≡N), 1648 [$\delta(NH_2)$]. ^{1}H NMR spectrum, δ, ppm: 1.21–1.34 m (2H, CH_2), 1.71–1.79 m (2H, CH_2), 1.81–1.96 m (2H, CH_2), 3.38–3.41 m (2H, CH_2), 7.45–7.68 m (9H, H_{arom}), 7.83 br. s (2H, NH_2). ^{13}C NMR spectrum, δ_C, ppm: 21.15, 21.75, 26.74, 26.96, 35.16, 60.87, 89.57, 112.79, 114.55, 115.92, 128.02, 128.77, 129.23, 129.52, 130.00, 130.70, 130.85, 131.02, 131.92, 133.02, 135.78, 137.97, 147.88, 153.48, 154.15, 159.52, 161.48, 162.85. Mass spectrum, *m/z* (I_{rel}, %): 497 (100) $[M - 1]^+$. Found, %: C 72.15; H 3.75; N 16.72. $C_{30}H_{19}ClN_6$. Calculated, %: C 72.21; H 3.84; N 16.84. *M* 498.979.

1-Amino-2-(4-bromobenzoyl)-5-(2-chlorophenyl)-6,7,8,9-tetrahydro-3*H*-cyclopenta[*c*]isoquinoline-3,3-dicarbonitrile (IX) was prepared similarly to compound **VI** from 3.33 g (10 mmol) of compound **Id** and 2.8 g (10 mmol) of 4-bromophenacylbromide **Va**. Yield 3.49 g (66%), yellow crystals, fluoresce under UV irradiation, mp 297–301°C (BuOH). IR spectrum, ν, cm^{-1}: 3445 (NH_2), 2255 (C≡N), 1687 (C=O), 1641 [$\delta(NH_2)$]. ^{1}H NMR spectrum, δ, ppm: 1.72 m (2H, CH_2), 1.83 m (2H, CH_2), 2.46 m (2H, CH_2), 3.29 m (2H, CH_2), 7.44 d (1H, H_{arom}, *J* 7.5 Hz), 7.47–7.55 m (2H, H_{arom}), 7.59 d and 7.77 d (4H, 4-BrC_6H_4, *J* 8.4 Hz), 7.64 d (1H, H_{arom}, *J* 8.5 Hz), 8.80 br. s (2H, NH_2). ^{13}C NMR spectrum, δ_C, ppm: 20.63, 20.79, 26.22, 26.72, 41.08, 98.88, 113.63, 113.69, 124.01, 127.24, 127.55, 128.73, 129.51, 130.22, 130.60, 131.26, 131.66, 134.95, 137.29, 138.95, 147.14, 152.54, 160.31, 161.20, 188.22. Mass spectrum, *m/z* (I_{rel}, %): 530 (100) $[M + 1]^+$. Found, %: C 61.11; H 3.29; N 10.47. $C_{27}H_{18}BrClN_4O$. Calculated, %: C 61.21; H 3.42; N 10.58. *M* 529.827.

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