Synthesis of novel polypyridylcarbonylpyridines from triazolopyridines. Building blocks in supramolecular chemistry

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Dedicated to Professor Guy Quèguiner on the occasion of his 70th birthday

Abstract
The synthesis from triazolopyridines 1, of novel triazolopyridylcarbonylpyridylcarbonyltriazolopyridines (TPyCOPyCOTPy) (tpcpctp) 7, and polypyridylcarbonylpyridines (pPyCOPy) (ppcp) 14, building blocks in supramolecular chemistry, is described. These compounds are interesting polynitrogenated ligands as potential molecular sensors, new magnetic materials, single molecular magnets, or in the emerging science of nanomaterials.

Keywords: Triazolopyridines, pyridylcarbonylpyridines, polynitrogenated ligands, nanomaterials supramolecular receptors, chemosensors, clusters, fluorescent compounds, magnetic materials

Introduction
We are involved in a project whose objectives spread from the preparation of new molecular receptors to the building up of hybrid nano-materials containing organic and inorganic components. Parts of the organic receptors are based on triazolopyridine and carbonylpyridine units. These molecules may have ability to complex heavy metals and other cationic, neutral or anionic species of biomedical or environmental relevance. The supramolecular compounds that could be formed may have interesting magnetic or fluorescent properties and can act as luminescent molecular chemosensors. In this context we have recently reported the synthesis of new polynitrogenated ligands 2-6 from triazolopyridines 1 (Figure 1), by Suzuki cross-coupling reactions (compounds 2 and 3),1 or by regioselective lithiation at -40 °C, subsequent reaction with ethyl picolinate (compound 4),2 and then triazolo ring opening by SeO₂ with loss of dinitrogen (compound 5).3 When the co-reagent for the reaction with lithio derivative was cyanopyridine, compound 6 was formed.4 We have study different properties of these ligands.
Compounds 2 and 3 are highly fluorescent with very high quantum yield.\textsuperscript{1} We have synthesized, study the crystal structure, and the interesting antiferromagnetic behavior of the tetranuclear cubane compound $[\text{Cu}(4*)]_4(\text{NO}_3)_4\cdot8\text{H}_2\text{O}$ where the ligand $4*$ is the hemiacetal of 4 formed in situ.\textsuperscript{5} The triazolopyridine system 6 is a molecular chemosensor for metal ions, anions and amino acids. The crystal structure of the $[\text{Zn}(6)(\text{H}_2\text{O})_3](\text{ClO}_4)_2\cdot\text{H}_2\text{O}$ complex shows the coordination of $\text{Zn}^{2+}$ through the terpyridine moiety.\textsuperscript{6} Compound 5, a dipyridylcarbonylpyridine (dPyCOPy) (dpcp), have form the first icosanuclear Co\textsuperscript{II} cluster exhibiting superparamagnetic relaxation, which is also a rare example of 3d-metal clusters with O and N ligation.\textsuperscript{7} Other reports by Mak and co-workers on a series of Cu\textsuperscript{II,8} Fe\textsuperscript{III,9} Cu\textsuperscript{I} and Ag\textsuperscript{10} complexes emphasizes the versatility of 5 as supramolecular ligand. We therefore have supposed that bigger terms of pyridylcarbonylpyridines (PyCOPy) (pcp) family, with additional donor atoms, could have even more interesting behavior as receptor with different applications based on its potential rich photo-physical and photo-chemical properties,\textsuperscript{11} as luminescent molecular sensors,\textsuperscript{12} helicating ligands,\textsuperscript{13} new magnetic materials,\textsuperscript{14} single molecular magnets,\textsuperscript{15-18} or in the emerging science of nanomaterials.\textsuperscript{19} With this objective in mind we wish to report here the synthesis of triazolopyridylcarbonylpyridylcarbonyltriazolopyridines (TPyCOPyCOTPy) (tpcpcpt) 7, and polypyridylcarbonylpyridines (pPyCOPy) (ppcp) 14 from triazolopyridines 1, as building blocks in supramolecular chemistry.

\begin{figure}
  \centering
  \includegraphics[width=\textwidth]{figure1}
  \caption{Figure 1}
\end{figure}
Results and Discussion

Lithiation of triazolopyridines 1a-d and reaction with ethyl picolinate, followed by triazolo ring opening reaction was the methodology used by us to synthesize dpcp 5. Now we have change the co-reagent in the second step by diethyl 2,6-pyridindicarboxilate with the aim to obtain tpectp 7 (Scheme 1).

\[
1) \text{n-BuLi / Toluene} \\
2) \text{EtO}_2\text{C} \text{O} \text{N} \text{N} \text{R} \text{N} \text{O} \text{N} \text{CO}_2\text{Et}
\]

Scheme 1

When the reaction was done with 1a, a unique yellow solid compound was isolated (43%) from a complex polymeric mixture, characterized as 7a by analytical and spectral properties. The \(^1\)H and \(^{13}\)C NMR data reveal a great symmetry (C\(_2\) axis), the \(^1\)H- NMR show an AMX system corresponding to two equivalent 7-substituted triazolopyridines and an AB\(_2\) system from one 2,6-disubstituted pyridine (see table). The reaction with 1b was more difficult to manipulate and a complex mixture was found. The majority isolated, a fluorescent yellow compound, was identified as 7b (47%). A minor component (14%) was also isolate and identified as 8 (Z,Z isomer) (Figure 2), similar dienes have been previously reported, as secondary compounds in triazolopyridines lithiation reactions, and its stereochemistry discussed. With 1d as starting material the reaction give 7d as a florescent yellow solid in 75% yield.

\[
\text{N} \text{N} \text{N} \text{N} \text{N} \\
\text{N} \text{N} \text{N} \text{N} \text{N} \text{N} \text{N} \text{N} \text{N} \text{N}
\]

Figure 2
Table 1. $^1$H NMR data from compounds 7

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<th>2H6</th>
<th>2H7</th>
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<td>6.89, dd, J1=6.8 J2=6.8</td>
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<td>8.39, d, J=7.9 J1=8.19, t, J=7.9 J1=8.39, d, J=7.9</td>
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<td>6.88, dd, J1=8.6 J2=6.8</td>
<td>6.81, dd, J1=6.8 J2=6.8</td>
<td>-</td>
<td>8.39, d, J=7.7 J1=8.16, d, J=7.7 J1=8.39, d, J=7.7</td>
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<td>6.89, ddd, J1=8.8 J2=6.8</td>
<td>8.63, d, J=7.0 J1=8.3 J2=6.3, d, J=8.37, dd, J1=7.9, J2=1.1, 2H3’</td>
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More complicated was the reaction with 1c; three compounds were isolated from a complex mixture. In the $^1$H- NMR spectrum of the major compound (50%), the δ and J values prove that it has a pyridyltriazolopyridine (PyTPy) structure with great symmetry (C2 axis). The signal at δ=8.63, d, J=7.0Hz, 2H characteristic of H7 triazolopyridine protons show that there are two equivalent 3-substituted triazolopyridines. Two different AB2 systems indicate the presence of two types of 2,6-disubstituted pyridines. All these data are in agree with the structure 7c’ (Scheme 2). We know that 7-substituted 3-(2-pyridyl)-triazolopyridines are in equilibrium between a type A isomer, 3-(2-pyridyl)-[1,2,3]triazolo[1,5-α]pyrid-7-yl derivative, and a type B isomer, 6-[[1,2,3]triazolo[1,5-α]pyrid-3-yl]-2-pyridyl derivative, through a diazo intermediate.22 To account for structure 7c’ we assume that this equilibrium is shifted to the B isomer, as we have described when the substituent is electron-withdrawing as pyridylcarbonyl.22 The second compound isolated, 9 (10%) (Scheme 3), is a surprising new compound, that could be formed if in the lithiation reaction the intermediate 10 had been formed, in a similar manner as we described for triazolopyridine 1b,20 then treatment with water give 9. The last compound isolated was 12 (Figure 2), a dimer isolated also as secondary compound in lithiation reactions of triazolopyridines.2
Triazolo ring opening reactions$^{23}$ of compounds 7 have been studied. Compounds 7a,b,d reacted with aqueous sulfuric acid to give in quantitative yields the keto alcohols 13a,b,d. Nevertheless, in the same conditions, compound 7c' gave tetra-2-pyridylcarbonylpyridine 14c. With selenium dioxide as co-reagent in sulfuric acid medium, compound 7c' gave again compound 14c in 100% yield as expected. However, with this reagent and compounds 7a,b unexpected results were found, and again compounds 13a,b were obtained. In similar conditions, compound 7d gave a mixture of 13d and 14d (Scheme 4).
Polynitrogenated ligands are very interesting structures. Carbonyl fragments give additional possibilities for creating different coordination compounds. All new synthesized compounds should be able to form polynuclear complexes with different metal ions. As we have mentioned in the Introduction, the supramolecular compounds that could be formed may have interesting magnetic or fluorescent properties, and act as luminescent molecular chemosensors. We are at present investigating these possibilities.

### Experimental Section

**General Procedures.** Melting points were determined on a Kofler heated stage and are uncorrected. NMR spectra were recorded on a Bruker AC300MHz in CDCl₃ as solvent. COSY experiments were done for all compounds. HRMS (EI) determinations were made using a VG Autospec Trio 1000 (Fisons). Infrared spectra were recorded in KBr discs on a Bio-Rad FTS-7. Ultraviolet spectra were recorded on a Shimazu UV-2101 instrument. Chromatography was performed on a Chromatotron, using 2 cm plates of Merck Pf254 silica.

[1,2,3]Triazolo[1,5-\(a\)]pyridine (1a), 3-methyl-[1,2,3]triazolo[1,5-\(a\)]pyridine (1b), 3-(2-pyridyl)-[1,2,3]triazolo[1,5-\(a\)]pyridine (1c), and 3-phenyl-[1,2,3]triazolo[1,5-\(a\)]pyridine (1d) were prepared as described elsewhere.²³-²⁶

**General procedure for lithiation of [1,2,3]triazolo[1,5-\(a\)]pyridines 1a-d and reaction with diethyl 2,6-pyridinedicarboxylate.** To a solution of the corresponding [1,2,3]triazolo[1,5-\(a\)]pyridine 1 in anhydrous toluene at –40°C, a solution of \(n\)-butyllithium in hexane (2.5\(M\)) was added with stirring. A deep red color developed. The mixture was kept at –40°C (4 h). Treatment
with a dry toluene solution (10 mL) of diethyl 2,6-pyridinedicarboxylate produced a color change to yellow. The mixture was left at –40ºC (2 h) and allowed at room temperature overnight, then was treated with a saturated solution of ammonium chloride. The organic layer was separated and the aqueous layer extracted with dichloromethane. After drying over anhydrous Na₂SO₄ and evaporation of the organic solvents, a residue was obtained. Precipitation with ethyl acetate gave compounds 7a–d as brown or yellow solids. In some cases the filtrate was evaporated to dryness and the residue obtained was purified. The yield and conditions of purification are given for each compound.

\[1,2,3\]Triazolo[1,5-\(a\)]pyridin-7-yl-6-\([1,2,3\]triazolo[1,5-\(a\)]pyridin-7-ylcarbonyl]-2-pyridylmethanone (7a). \(1a\) (1.50 g, 12.6 mmol), toluene (50 mL), \(n\)-BuLi (6 mL), diethyl 2,6-pyridinedicarboxylate (1.65 g, 7.4 mmol). The precipitate was purified by recrystallization from ethyl acetate giving \(7a\) (0.70 g), additional amount of \(7a\) (0.30 g) was isolate by purification on chromatotron from the filtrate (total yield 43 %). Mp > 300ºC. HRMS found for M²⁻N₂ 341.0847; C₁₉H₁₁N₅O₂ requires 341.0786. \(\nu\)max (KBr) (cm⁻¹) 1694 (CO), 1328, 1058, 843, 808, 748. \(\lambda\)max (nm) (log ε) (EtOH) 290.5 (3.87), 358 (3.61). \(^{13}\)C NMR δ 186.90 (CO), 151.22 (C), 140.35 (CH), 133.17 (C), 132.57 (C), 125.79 (CH), 124.71 (CH), 123.69 (CH), 120.61 (CH), 117.72 (CH). MS m/z (%) 341(94), 313(46), 285(51), 257(99.7), 256(100), 231(21), 230(27), 179(25), 140(24), 63(32).

3-Methyl-[1,2,3]triazolo[1,5-\(a\)]pyridin-7-yl-6-(3-methyl-[1,2,3]triazolo[1,5-\(a\)]pyridin-7-ylcarbonyl]-2-pyridylmethanone (7b). \(1b\) (1.50 g, 11.3 mmol), toluene (50 mL), \(n\)-BuLi (5.5 mL), diethyl 2,6-pyridinedicarboxylate (1.26 g, 5.65 mmol). The precipitate was purified by recrystallization from ethyl acetate giving \(7b\) (0.65 g), additional amount of \(7b\) (0.15 g) was isolate by purification on chromatotron from the filtrate (47 %). Mp > 300ºC. HRMS found for M°C⁺ 398.1367; C₂₁H₁₆N₇O₂ requires 398.11365. \(\nu\)max (KBr) (cm⁻¹) 1691 (CO), 1320, 745. \(\lambda\)max (nm) (log ε) (EtOH) 290(3.95), 377.5(3.74). \(^{13}\)C NMR δ 187.01 (CO), 152.31 (C), 139.37 (CH), 134.72 (C), 134.01 (C), 131.94 (C), 127.82 (CH), 123.06 (CH), 120.05 (CH), 119.11 (CH), 10.80 (CH₃). MS m/z (%) 398(0.1), 370(11), 369(42), 341(67), 341(67), 340(100), 301(30), 104(41), 77(22). A secondary compound was also obtained, identified as \((1Z, 3Z)-1-(3\text{-methyl-[1,2,3]}\text{-triazolo[1,5-\(a\)]pyridine-7-yl})-4-(5\text{-methyl-2-}[1,2,3]\text{-triazol-4-yl})-1,3\text{-butadiene} (8)\) (14%). Mp 190-192ºC (ethyl acetate/hexane). HRMS found for M⁺ 398.1367; C₁₄H₁₅N₆ requires 398.1279. \(\nu\)max (KBr) (cm⁻¹) 3478 (broad, NH), 3150, 3042, 2965, 2901, 1623, 1540, 1437, 1145, 962, 796, 769. \(\lambda\)max (nm) (log ε) (EtOH) 317(4.14), 360.5(4.22). \(^1\)H NMR δ 7.84 (dd, J₁=11.8, J₂=11.7Hz, Hb), 7.52 (d, J=8.7Hz, H4), 7.28 (d, J=11.9Hz, Ha), 7.17 (dd, J₁=8.7, J₂=6.8Hz, H5), 7.0 (d, J=6.8Hz, H6), 6.75 (ddd, J₁=11.5, J₂=11.5, J₃=1.1Hz, Hc), 6.37 (ddd, J₁=11.5, J₂=1.3, J₃=1.1Hz, Hd), 2.6 (s, CH₃(1)), 2.3 (s, CH₃(2)). \(^{13}\)C NMR δ 135.03 (C), 134.08 (C), 132.88 (CH), 132.13 (C), 129.10 (C), 126.17 (CH), 123.65 (CH), 121.38 (CH), 120.17 (CH), 116.41 (CH), 116.13 (CH), 10.48 (CH₃ (1)), 9.62(CH₃ (2)). MS m/z (%) 266 (100), 238 (42), 237 (52), 209 (57), 195 (35), 168 (52), 154 (58), 142 (44), 77 (23).

6-[1,2,3]Triazolo[1,5-\(a\)]pyridin-3-yl-2-pyridyl-6-(6-[1,2,3]triazolo[1,5-\(a\)]pyridin-3-yl-2-pyridylcarbonyl)-2-pyridylmethanone (7c'). \(1c\) (1.0 g, 5.1 mmol), toluene (40 mL), \(n\)-BuLi
(2.7 mL), diethyl 2,6-pyridincarboxylate (0.65 g, 2.5 mmol). The precipitate was purified by recrystallization from ethyl acetate, giving 7c' (0.60 g). The filtrate was purified by chromatotron, elution with ethyl acetate/hexane with increasing amount of ethyl acetate gave first starting material 1c (0.100 g, 10 %), then a white solid identified as 3-(2-pyridyl-7-(6-[1,2,3]triazolo[1,5-a]pyridine-3-yl-2-pyridyl)-4,7-dihydro[1,2,3]triazolo[1,5-a]pyridine (9) (10 % yield). Mp 252-254ºC (AcOEt). HRMS found for M+ 392.1526; C22H16N8 requires 392.1497. νmax (KBr) (cm-1) 1624, 1599, 1569, 1533, 1493, 799, 738. λmax (nm) (log ε) (EtOH) 298.5(4.35), 329(4.10). 1H NMR δ 8.63 (ddd, J 1=7.0, J2=J3=0.9Hz, 1H, H7), 8.57 (ddd, J 1=4.9, J2=J3=1.0Hz, 1H, H6'''), 8.31 (ddd, J 1=8.8, J2=J3=0.9Hz, 1H, H4), 8.21 (m, 2H, H3''', H3'), 7.73 (dd, J 1=7.7, J2=7.7Hz, 1H, H4'''), 7.65 (dd, J 1=J2=J3=1.0Hz, 1H, H4'''), 7.43 (m, 1H, H6'''), 7.17 (ddd, J1=7.5, J2=4.9, J3=1.1Hz, 1H, H5'''), 7.03 (ddd, J 1=8.8, J 2=6.6, J 3=0.9, 1H, H5'), 6.69 (ddd, J 1=7.0, J 2=6.8, J 3=1.3Hz, 1H, H6), 6.68 (dd, J 1=7.7Hz, 1H, H5'), 6.07 (m, 2H, H5'', H7'''), 3.24 (m, 2H, H4''). 13C NMR δ 157.12 (C), 151.69 (C), 149.44 (CH), 141.60 (C), 137.64 (CH), 136.90 (C), 136.68 (CH), 131.99 (C), 131.04 (C), 126.43 (2CH), 125.15 (CH), 122.39 (CH), 121.13 (CH), 120.85 (CH), 119.58 (CH), 118.62 (CH), 118.03 (CH), 115.86 (CH), 59.01 (CH), 30.79 (CH2). MS m/z (%) 392(96), 364(30), 336(43), 335(100), 308(23), 258 (42), 231(50), 229(12), 197(59), 168(25), 142(16), 78(13). Further elution gave 12 (8 % yield). Mp > 350ºC, lit. > 350ºC. The last compound eluted was an additional amount of 7c' (0.1 g) as a yellow solid (50% total yield). Mp > 350ºC (AcOEt). HRMS found for M-+N2 493.1542; C31H19N5O2 requires 493.1539. νmax (KBr) (cm-1) 3065, 1684(CO), 1594, 1528, 1323, 1238, 1158, 1043, 993, 748. λmax (nm) (log ε ) (EtOH) 297.5(4.90), 326(4.87). 13C NMR δ 186.77 (CO), 151.71 (C), 138.99(C), 137.54 (C), 134.43 (C), 131.03 (C), 129.93 (C), 128.27 (CH), 127.32 (CH), 126.56 (CH), 124.87 (CH), 120.42 (CH), 116.03 (CH). MS m/z (%) 495 (26), 467 (50), 566 (100), 438 (8), 389 (17), 333 (8), 243 (6), 167 (15), 78 (3).

3-Phenyl-[1,2,3]triazolo[1,5-a]pyridin-7-yl-6-(3-phenyl-[1,2,3]triazolo[1,5-a]pyridin-7-yl-carbonyl)-2-pyridylmetanone (7d). 1d (0.5 g, 2.56 mmol), toluene (30 mL), n-BuLi (1.4 mL), diethyl 2,6-pyridinedicarboxylate (0.28 g, 1.28 mmol). The precipitate was purified by recrystallization from ethyl acetate giving 7d (0.50 g), (75 %). Mp 235-237ºC. HRMS found for M+-N2 493.1542; C31H19N5O2 requires 493.1539. νmax (KBr) (cm-1) 3125, 1684(CO), 1594, 1528, 1323, 1238, 1158, 1043, 993, 748. λmax (nm) (log ε ) (EtOH) 297.5(4.90), 326(4.87). 13C NMR δ 192.36 (CO), 154.69 (C), 152.65 (C), 151.43 (C), 137.71 (CH), 137.29 (CH), 132.21 (C), 126.88 (CH), 125.18 (CH), 123.53 (CH), 123.42 (CH), 120.42 (CH), 116.03 (CH). MS m/z (%) 523(10), 495 (26), 467 (50), 566 (100), 438 (8), 389 (17), 333 (8), 243 (6), 167 (15), 78 (3).

General procedures for triazolo ring opening reactions of triazolopyridines (7).

Procedure A:
A suspension of the corresponding triazolopyridine 7a–d and selenium dioxide (3 equivalents) in aqueous sulfuric acid was heated at reflux for 24 h. Then was cooled, neutralized with aqueous saturated solution of sodium bicarbonate, and extracted with dichloromethane. The organic layers were dried, and the solvent evaporated. The yield and conditions of purification are given for each compound.
Procedure B:
A suspension of the corresponding triazolopyridine 7a–d in aqueous sulfuric acid (10 mL, 1 M) was heated to reflux for 24 h. The solution was neutralized with a saturated aqueous solution of sodium bicarbonate and extracted with dichloromethane. The organic solvent was dried, and evaporated. The residue was almost pure compounds in quantitative yield.

6-Hydroxymethyl-2-pyridyl-6-(6-hydroxymethyl-2-pyridylcarbonyl)-2-pyridylmethanone (13a). The title compound was obtained by procedure A from 7a (50 mg, 0.13 mmol), SeO₂ (45 mg, 0.4 mmol), H₂SO₄ (10 mL, 2.5 M) almost pure. (100%). Recrystallization from dichloromethane/hexane. Mp 92-94°C. HRMS found for M⁺ 349.1096; C₁₀H₁₅N₃O₄ requires 349.1062. ν max (KBr) (cm⁻¹) 3426(OH), 1681(CO), 1587, 1450, 1331, 1070, 992, 754. ¹H NMR δ 8.14(d, J=8.4Hz, 2H, H₃', H₅'), 8.00(dd, J₁=J₂=8.4Hz, 1H, H₄'), 7.89(d, J=7.5Hz, 2H, H₃), 7.69(dd, J₁=7.8, J₂=7.5Hz, 2H, H₄), 7.36(d, J=7.8Hz, 2H, H₅), 4.66(s, 4H, CH₂), 3.89(brs, 2H, OH). ¹³C NMR δ 191.73 (CO), 159.18 (C), 153.47 (C), 152.37 (C), 137.62 (C H), 137.16 (CH), 127.09 (CH), 124.21 (CH), 123.50 (CH), 64.21 (CH₂). m/z (%) 349 (3), 289 (51), 271 (27), 243 (18), 211 (10), 182 (100), 167 (63), 128 (11), 105 (78), 77 (91).

6-Hydroxyethyl-2-pyridyl-6-[6-(1-hydroxyethyl)-2-pyridylcarbonyl]-2-pyridylmethanone (13b). The title compound was obtained by procedure A from 7b (50 mg, 0.12 mmol), SeO₂ (45 mg, 0.37 mmol), H₂SO₄ (10 mL, 2.5 M) almost pure in quantitative yield as a yellow oil. HRMS found for M⁺ 377.1323; C₂₁H₁₉N₃O₄ requires 377.1375. ν max (KBr) (cm⁻¹) 3387(OH), 2974, 1681(CO), 1586, 1448, 1393, 1118, 992, 753. ¹H NMR δ 8.14(d, J=8.4Hz, 2H, H₃', H₅'), 8.01(dd, J₁=J₂=8.4Hz, 1H, H₄'), 7.92(d, J=7.5Hz, 2H, H₃), 7.74(dd, J₁=7.8, J₂=7.5Hz, 2H, H₄), 7.39 (d, J=7.8Hz, 2H, H₅), 4.81 (q, J=6.6Hz, 1H, CH), 4.80 (q, J=6.6Hz, 1H, CH), 4.14 (brs, 2H, OH), 1.37 (d, J=6.6Hz, 3H, CH₃), 1.35 (d, J=6.6Hz, 3H, CH₃). ¹³C NMR δ 191.76(CO), 162.91(C), 153.68(C), 152.02(C), 137.40(CH), 137.37(CH), 126.99(CH), 123.85(CH), 122.84(CH), 68.97(CH-CH₂), 23.92(CH₃). m/z (%) 377 (100), 362 (43), 344 (31), 316 (27), 288 (7), 227 (68), 122 (13), 104 (38), 78 (30).

6-(2-Pyridylcarbonyl)-2-pyridyl-6-[6-(2-pyridylcarbonyl)-2-pyridylcarbonyl]-2-pyridylmethanone (14c). The title compound was obtained by procedures A and B from 7c’ (50 mg, 0.095 mmol), SeO₂ (32 mg, 0.29 mmol), H₂SO₄ (10 mL, 2.5 M) almost pure in quantitative yield. Recrystallization from dichloromethane/cyclohexane. Mp 112-114°C. HRMS found for M⁺ 499.1359; C₂₉H₁₇N₅O₄ requires 499.1280. ν max (KBr) (cm⁻¹) 1687(CO), 988, 738. ¹H NMR δ 8.61 (ddd, J₁=4.7, J₂=1.7, J₃=0.7Hz, 2H, H₆), 8.20 (d, J=7.9Hz, 4H, H₃', H₃'', H₅''), 8.2 (dd, J₁=7.9, J₂=1.1Hz, 2H, H₅'), 8.03 (ddd, J₁=7.7, J₂=1.9, J₃=0.7Hz, 2H, H₃), 7.95 (dd, J₁=J₂=7.9Hz, 2H, H₄), 7.86 (dd, J₁=J₂=7.9Hz, 1H, H₄''), 7.68 (ddd, J₁=J₂=7.7, J₃=1.7Hz, 2H, H₄), 7.33 (ddd, J₁=7.7, J₂=4.7, J₃=1.1Hz, 2H, H₅). ¹³C NMR δ 191.72 (CO), 191.22 (CO), 153.47 (C), 153.26 (C), 153.07 (C), 149.17 (CH), 137.61 (CH), 137.25 (CH), 136.59 (CH), 127.74 (CH), 127.71 (CH), 127.56 (CH), 126.52 (CH), 125.96 (CH). m/z (%) 499 (27), 366 (26), 365 (30), 337 (9), 288 (16), 231 (8), 155 (17), 78 (100).

6-Hydroxyphenylmethyl-2-pyridyl-6-[6-(hydroxyphenyl)-2-pyridylcarbonyl]-2-pyridylmethanone (13d). The title compound was obtained by procedure A from 7d (50 mg, 0.096
mmol), SeO₂ (33 mg, 0.29 mmol), H₂SO₄ (10 mL, 3 M). A residue was obtained which was purified by chromatotron using hexane/ethyl acetate as eluent. The first isolated compound was a yellow oil identified as 14d (17 % yield). Recrystallization from ether/hexane. Mp 42-44° C. HRMS found for M⁺ 497.1302; C₃₁H₁₉N₃O₄ requires 497.1375. νmax (KBr) (cm⁻¹) 2924, 1666(CO), 1325, 1261, 1020, 738, 692, 633. ¹H NMR δ 8.17 (d, J=7.9Hz, 2H, H3’, H5’), 7.97-7.89 (m, 7H, Ho, H4, H4’), 7.42-7.36 (m, 2H, Hp), 7.24-7.19 (m, 4H, Hm). ¹³C NMR δ 192.13 (CO), 191.87 (CO), 153.99 (C), 153.42 (C), 152.56 (C), 137.95 (CH), 137.58 (CH), 135.45 (C), 133.11 (CH), 131.25 (CH), 127.94 (CH), 127.28 (CH), 127.22 (CH), 127.14 (CH). m/z (%) 497 (57), 469 (3), 364 (3), 287 (10), 231 (3), 182 (100), 154 (6), 77 (49).

Then a yellow oil was eluted and identified as 13d (14 % yield). HRMS found for M⁺ 501.1670; C₃₁H₂₃N₃O₄ requires 501.1688. νmax (KBr) (cm⁻¹) 3426 (OH), 2923, 1681 (CO), 1584, 1450, 1310, 1056, 992, 753, 700. ¹H NMR δ 8.12 (dd, J₁=7.8, J₂=3.6Hz, 2H, H3’, H5’), 8.01 (dd, J₁=J₂=7.8Hz, 1H, H4’), 7.93 (dd, J₁=7.8, J₂=3.6Hz, 2H, H5), 7.64 (dd, J₁=J₂=7.8Hz, 2H, H4), 7.23-7.16 (m, 12H, H3, Ho, Hm, Hp), 5.65 (d, J=4.2Hz, 2H, CH-OH), 4.93 (brs, 2H, OH). ¹³C NMR δ 191.54 (CO), 191.50 (CO), 160.80 (C), 160.75 (C), 153.79 (C), 153.73(C), 151.66(C), 142.49(C), 137.57 (CH), 137.55(CH), 137.40 (CH), 137.38 (CH), 128.55 (CH), 127.91 (CH), 127.11 (CH), 127.07 (CH), 127.02 (CH), 126.99 (CH), 124.40 (CH), 124.36 (CH), 123.99 (CH), 75.06 (CH), 75.02 (CH-OH). m/z (%) 501(4), 497(54), 422(5), 316(6), 271(16), 231(4), 182(100), 154(8), 77(46).

Compound 13d was obtained by procedure B from 7d (40 mg, 0.076 mmol) and H₂SO₄ (10 mL, 4 M), almost pure, in quantitative yield.

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References