

Synthesis of new pyrrolo[1,2-*a*]quinoxalines: potential non-peptide glucagon receptor antagonists

Jean Guillon^a, Patrick Dallemagne^a, Bruno Pfeiffer^b, Pierre Renard^b,
Dominique Manechez^c, Alain Kervran^d, Sylvain Rault^{a*}

^aCentre d'Etudes et de Recherche sur le Médicament de Normandie, Laboratoire de Pharmacochimie,
UFR des Sciences Pharmaceutiques, 1, rue Vaubénard, 14032 Caen, France

^bADIR, 1, rue Carle Hébert, 92415 Courbevoie cedex, France

^cIRIS, 6, place des Pléiades, 92415 Courbevoie cedex, France

^dINSERM – U 376, Endocrinologie des peptides et régulation génique, CHU Arnaud de Villeneuve,
371, rue du Doyen Gaston Giraud, 34295 Montpellier cedex 5, France

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Abstract – Synthesis of new pyrrolo[1,2-*a*]quinoxaline derivatives was achieved starting from various nitroanilines or orthophenylene-diamines. Their affinity towards glucagon receptors was evaluated. © Elsevier, Paris

pyrrolo[1,2-*a*]quinoxaline derivative / non-peptide antagonist / glucagon receptor / diabetes

1. Introduction

Glucagon is a 29 amino acid single-chain polypeptide hormone, synthesized from proglucagon in the α cells of the pancreatic islet of Langerhans [1]. Glucagon shares some sequence homology with the truncated glucagon-like peptide-1 (7-37) (tGLP-1) which is an other polypeptide hormone synthesized from the same precursor mainly in the L cells of the gastrointestinal tract [2].

The secretion of glucagon is regulated by dietary glucose, amino acids and fatty acids, but also by the autonomic innervation of the pancreatic cells [3, 4]. Glycemia is the primary regulator of glucagon secretion. Glucose, which is the most potent inhibitor of glucagon release by pancreatic α cells, acts both directly and through insulin secretion. Glucose is more effective when taken orally than when administered intravenously. Secretion of glucagon is stimulated by most amino acids and increased by stimulation of adrenergic and cholinergic pancreatic nerves ending. Glucagon plays a crucial role in the regulation of glucose homeostasis by adapting the glucose

production to the glucose requirements. Glucagon stimulates hepatic gluconeogenesis and glycogenolysis leading to a release of glucose into the bloodstream [3, 4]. It also induces lipolysis in the liver and the fat cells [5].

The expression, cloning and signaling properties of the rat glucagon receptor have been published by Jelinek [6]. This receptor belongs to the family of G-protein coupled receptors with seven membrane spanning domains and is positively coupled to adenylyl-cyclase via a Gs protein. Stimulation of cyclic AMP production triggers a succession of reactions leading to the metabolic effects of glucagon.

There are now clear evidences on the implication of glucagon in the pathogenesis of diabetes. In some diabetic states, insulin deficiency is exacerbated despite hyperglycemia by an inappropriate and persistent secretion of glucagon. According to the bihormonal hypothesis of Unger [7–9], overproduction of glucose and ketone bodies could be due to an excess of circulating glucagon whilst insulin deficiency or insensitivity is responsible for the underutilisation of glucose. Considering these biological and physiological data, inhibition of the action of glucagon could be one way to restore normoglycemia. There are clear evidences that glucagon antagonists are able to lower hyperglycemia of diabetic animals without addition of

*Correspondence and reprints

exogenous insulin [10]. If numerous peptidic antagonists of the glucagon receptor have been synthesized, CP-99,711 remains the sole antagonist of this receptor which have been yet described [11]. It was postulated that this compound, discovered by serendipity in a screening program, exerts its activity through the presence of both an aminoalkyl chain and a styryl group linked to a quinoxaline skeleton, in such a manner they are able to mimic the amino terminal region of glucagon.

These structural prerequisites were used by us as the conceptual basis in designing new pyrroloquinoxalines in order to test and to enlarge this first structure–activity relationship.

Thus, taking into account our experience in the field of the synthesis of these type of compounds [12–14], we prepared substituted derivatives bearing aminoalkyl chains and aromatic substituents in various positions (figure 1).

2. Chemistry

Most of the reported structures were obtained from 1-(2-aminophenyl)pyrroles **1a–c**. Preparation of the latter was performed according to the Clauson-Kaas reaction [15, 16] runned under micro-waves irradiation starting from 2-nitroanilines **2a–c** and 2,5-dimethoxytetrahydrofuran in acetic acid. The resulting 1-(2-nitrophenyl)pyrroles **3a–c** intermediates were subsequently reduced using a $\text{BiCl}_3\text{--NaBH}_4$ treatment [17–19] into the attempted 1-(2-aminophenyl)pyrroles **1a–c** (figure 2).

The 5*H*-pyrrolo[1,2-*a*]quinoxalin-4-ones **4a–c** were prepared by reaction of phosgene in toluene solution with **1a–c** according to the previously reported Nagarajan method [20]. Chlorodeshydroxylation of

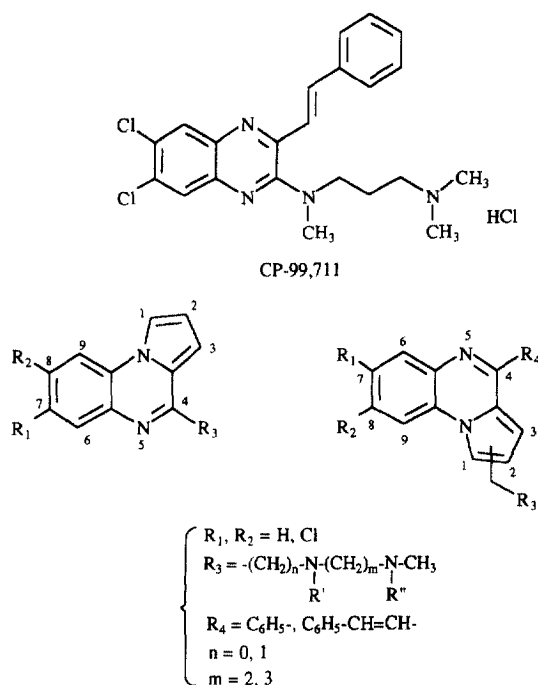


Figure 1. Structures of CP-99,711 and synthesized pyrrolo[1,2-*a*]quinoxalines.

lactames **4a–c** with phosphorus oxychloride according to Cheeseman method [21, 22] led to 4-chloro-pyrrolo[1,2-*a*]quinoxalines **5a–c**. Displacement of the chlorine atom of **5a–c** with *N,N,N'*-trimethyl-1,3-propanediamine or *N*-methylpiperazine was carried on in dimethylformamide in presence of potassium carbonate [23–26] leading to **6a–c** and **7c**, converted

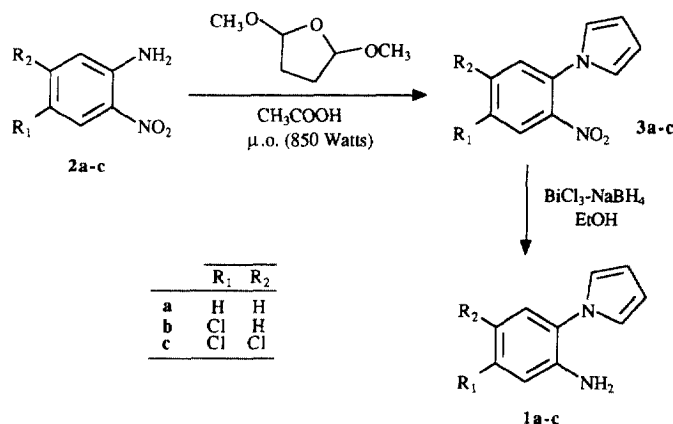


Figure 2. Synthesis of compounds **1a–c**.

into their oxalates **8a–c** and **9c** respectively by treatment with oxalic acid in refluxing isopropanol.

Treatment of **5c** with homopiperazine in a solid–solid fusion yielded the pyrrolo[1,2-*a*]quinoxaline **10c** whose the *N*-methyl derivative **11c** was obtained using dimethylsulfate in acetone [27] (figure 3).

Homologation of the amino side chain in C-4 position of the pyrrolo[1,2-*a*]quinoxaline system was realized by formation of the chloracetamides **12a–c** [28], cyclised into 4-chloromethylpyrrolo[1,2-*a*]quinoxalines **13a–c** by refluxing in phosphorus oxychloride. Displacement of the chlorine atom of **13a–c** with *N,N,N'*-trimethyl-1,3-propanediamine took place in dimethylformamide solution as above to give **14a–c**. Conversion to the oxalates **15a–c** completes the reaction (figure 4).

The 4-phenylpyrrolo[1,2-*a*]quinoxalines **16a–c** and 4-styrylpyrrolo[1,2-*a*]quinoxalines **17a,c** were prepared by cyclisation of the amides **18a–c** and **19a,c** in refluxing phosphorus oxychloride. Under Vilsmeier–Haack reaction conditions [29–31], formylation of **16a–c** and **17a,c** occurs selectively using a POCl₃/DMF complex at 1 position to give the 4-arylpyrrolo[1,2-*a*]quinoxaline-1-carbaldehydes **20a–c** and **21a,c**. Reaction of primary amines [32, 33] with the latter gave the imines **22a–c**, **23a–c** and **24a,c** reduced into the amines **25a–c**, **26a–c** and **27a,c** using sodium borohydride in methanol [34]. The salts **28a–c**, **29a–c** and **30a,c** were obtained as above (figure 5).

In order to obtain 4-phenylpyrrolo[1,2-*a*]quinoxaline-2-carbaldehyde **31a**, we tried to displace the formyl group of **20a** according to the method we

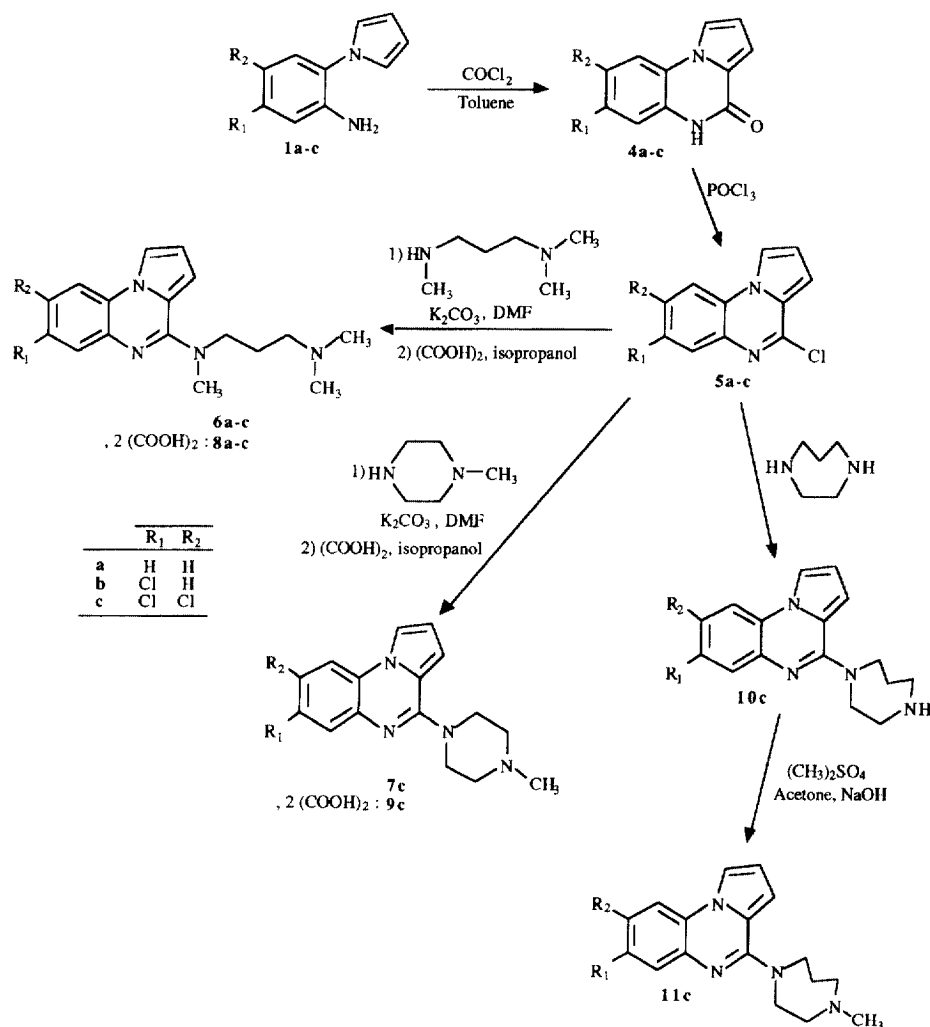


Figure 3. Synthesis of compounds **8a–c**, **9c** and **11c**.

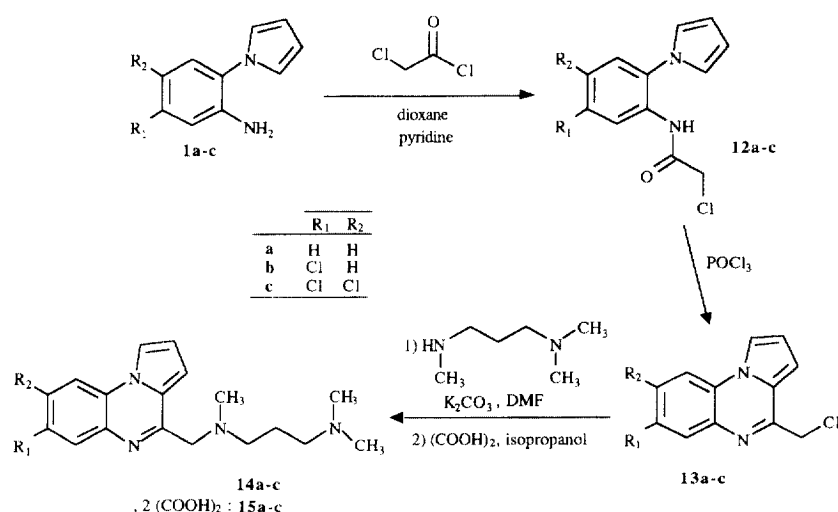


Figure 4. Synthesis of compounds **15a-c**.

previously described in 1-phenylpyrrole series [35]. However, all attempts using trifluoromethanesulfonic acid in various conditions of temperature failed and only furnished the deformylated product **16a** (figure 6).

The aldehydes **31a,b** were finally prepared according to the following sequence. Reaction of commercially available phenylenediamines **32a,b** with 1-phenylpropan-1,2-dione in acetic acid gave the methylphenylquinoxalines **33a,b** according to the von Auwers method [36]. Treatment of **33a,b** with ethyl bromopyruvate in refluxing ethanol [37–39] led to ethyl 4-phenylpyrrolo[1,2-*a*]quinoxaline-2-carboxylates **34a,b**. Reduction of the ester group of **34a,b** with lithium aluminium hydride in anhydrous THF at 0 °C gave the alcohols **35a,b** [40] subsequently oxidized into the attempted aldehydes **31a,b** using manganese dioxide in chloroform [41, 42]. The imines **36a,b**, amines **37a,b** and oxalates **38a,b** were then prepared as above (figure 7).

3. In vitro pharmacology

The binding affinities of the described compounds and reference products (tGLP-1, glucagon, CP-99,711) have been measured at rat tGLP-1 and glucagon receptors [43].

4. Results and discussion

Twenty pyrrolo[1,2-*a*]quinoxaline derivatives were synthesized and evaluated for their affinity to the

glucagon receptor. As glucagon share some sequence homology with tGLP-1 (7-37), all the compounds were also evaluated on the tGLP-1 receptor (table I).

Surprisingly CP-99,711 showed a better affinity for the tGLP-1 receptor than for the glucagon receptor with IC₅₀ of respectively 0.3 μM and 1 μM.

With the exception of **30a** (IC₅₀ = 5 μM and 2.5 μM on glucagon and tGLP-1 receptors respectively) and to a less extend **30c** (IC₅₀ = 10 μM on both receptors) **8c** and **38b** (IC₅₀ = 10 μM on glucagon receptor) none of the synthesized compounds showed any significant affinity for the glucagon receptor.

It is undoubtedly not a hazard if **30a** and **30c** are the only synthesized compounds having a styryl substituent as CP-99,711. Affinities of **30a** and **30c** remain lower than those of CP-99,711 probably because of a wrong relative orientation (too great angulation) between the styryl and the aminoalkylaminomethyl side chains. **38b** which present a lower angulation between the aromatic and amino substituents has a significant affinity for the glucagon receptor though been substituted by a phenyl instead of a styryl.

It would be interesting to enlarge the biological evaluation of these new pyrroloquinoxalines towards other receptors of the same type such as secretine or GRP receptors.

5. Experimental protocols

5.1. Chemistry

Melting points were determined on a Kofler block and are uncorrected. IR spectra were recorded on a Philips PU-9716 spectrophotometer. NMR spectra (¹H, ¹³C, ¹H-COSY) were

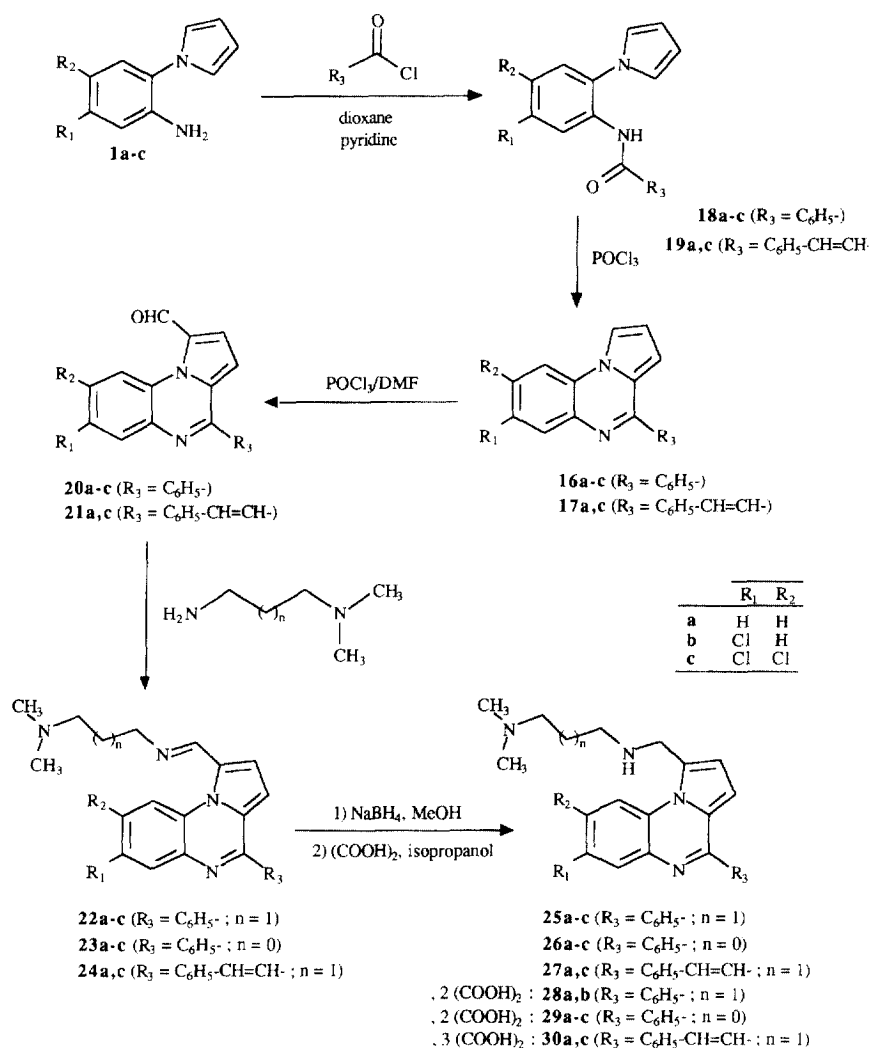


Figure 5. Synthesis of compounds **28a,b**, **29a–c** and **30a,c**.

recorded at 400 MHz or 100 MHz with tetramethylsilane as an internal standard using a JEOL JNM-LA 400 spectrometer. Splitting patterns have been designated as follows: s = singlet; bs = broad singlet; d = doublet; t = triplet; q = quartet; qt = quintuplet; dd = double doublet; m = multiplet. Mass spectra were recorded on a JEOL D 300 instrument using direct inlet system and electron impact ionisation. Analytical TLC was carried out on 0.25 precoated silica gel plates (POLYGRAM SIL G/UV₂₅₄) with visualisation by irradiation with a UV lamp. Silica gel 60 (70–230 mesh) was used for column chromatography. Analyses indicated by the symbols of the elements were within $\pm 0.4\%$ of the theoretical values.

5.1.1. General procedure for the preparation of 1-(2-amino-phenyl)pyrroles **1a–c**

To a solution of 1-(2-nitrophenyl)pyrrole **3** (0.02 mol) in ethanol (130 mL) was added bismuth trichloride (0.03 mol).

Sodium borohydride (0.16 mol) was added portion-wise at 0 °C to the reaction mixture which was then stirred at room temperature for 2 h. The solution was then poured into an aqueous hydrochloric acid solution (1 N, 130 mL) and stirred for an other hour. Ethanol was evaporated under reduced pressure. The residue was made alkaline with concentrated aqueous ammonium hydroxide solution and then extracted with ethyl acetate. The organic layer was dried over magnesium sulfate and evaporated to dryness under reduced pressure. The residue was then recrystallized from hexane to give **1** as yellow crystals.

5.1.2. 1-(2-Aminophenyl)pyrrole **1a**

Yellow crystals (70%); m.p. 96 °C (lit. [22] 98 °C); IR (KBr) 3480, 3310 (NH₂); ¹H-NMR (DMSO-*d*₆) δ : 7.08 (t, 1H, $J_{\text{H-4 H-3}} = J_{\text{H-4 H-5}} = 7.32$ Hz, H-4), 7.02 (dd, 1H, $J_{\text{H-3 H-4}} = 7.32$ Hz, $J_{\text{H-3 H-5}} = 1.46$ Hz, H-3), 6.88 (dd, 2H, $J_{\text{H-6 H-5}} =$

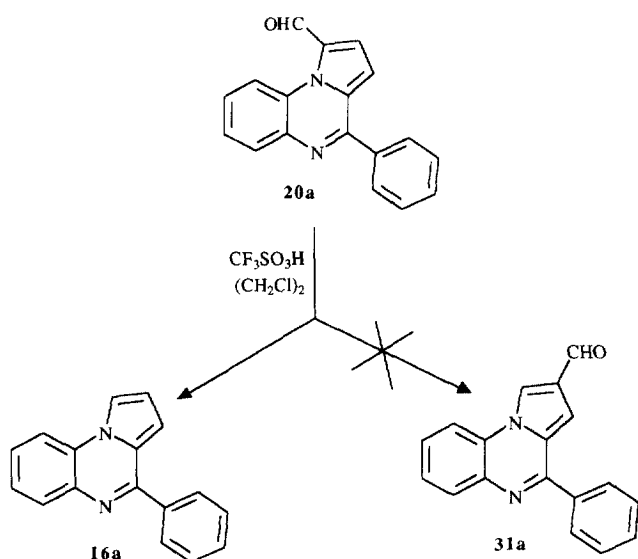


Figure 6. Attempt to rearrange compound 20a.

1.96 Hz, 2H- α), 6.84 (dd, 1H, $J_{H-6\ H-5} = 7.32$ Hz, $J_{H-6\ H-4} = 1.46$ Hz, H-6), 6.63 (t, 1H, $J_{H-5\ H-6} = J_{H-5\ H-4} = 7.32$ Hz, H-5), 6.23 (dd, 2H, $J_{H-\beta\ H-\alpha} = 1.96$ Hz, 2H- β); $^{13}\text{C-NMR}$ (DMSO- d_6) δ : 142.8 (C-1), 127.8 (C-2), 126.2 (C-4), 126.1 (C-6), 121.2 (2C- α), 116.3 (C-5), 115.6 (C-3), 108.7 (2C- β).

5.1.3. 1-(2-Amino-4-chlorophenyl)pyrrole 1b

Yellow crystals (74%): m.p. 89 °C (lit. [44] 89 °C); IR (KBr) 3380, 3210 (NH $_2$); $^1\text{H-NMR}$ (DMSO- d_6) δ : 7.01 (d, 1H, $J_{H-6\ H-5} = 8.30$ Hz, H-6), 6.89 (d, 1H, $J_{H-3\ H-5} = 2.44$ Hz, H-3), 6.87 (dd, 2H, $J_{H-\alpha\ H-\beta} = 1.95$ Hz, 2H- α), 6.61 (dd, 1H, $J_{H-5\ H-6} = 8.30$ Hz, $J_{H-5\ H-3} = 2.44$ Hz, H-5), 6.24 (dd, 2H, $J_{H-\beta\ H-\alpha} = 1.95$ Hz, 2H- β), 5.11 (s, 2H, NH $_2$); $^{13}\text{C-NMR}$ (DMSO- d_6) δ : 144.5 (C-2), 132.2 (C-4), 127.9 (C-1), 125.0 (C-6), 121.4 (2C- α), 115.8 (C-5), 114.8 (C-3), 109.2 (2C- β).

5.1.4. 1-(2-Amino-4,5-dichlorophenyl)pyrrole 1c

Yellow crystals (63%): m.p. 60 °C (lit. [44] 58 °C); IR (KBr) 3410, 3320 (NH $_2$); $^1\text{H-NMR}$ (DMSO- d_6) δ : 7.23 (s, 1H, H-3), 7.07 (s, 1H, H-6), 6.91 (dd, 2H, $J_{H-\alpha\ H-\beta} = 1.96$ Hz, 2H- α), 6.29 (dd, 2H, $J_{H-\beta\ H-\alpha} = 1.96$ Hz, 2H- β), 5.20 (s, 2H, NH $_2$); $^{13}\text{C-NMR}$ (DMSO- d_6) δ : 143.5 (C-2), 130.1 (C-4), 127.7 (C-1), 125.9 (C-5), 121.4 (2C- α), 116.8 (C-6), 116.2 (C-3), 109.4 (2C- β); MS (EI) m/z : 227 (M $^+$, 61), 226 (62), 225 (100), 224 (83), 198 (35), 156 (19), 78 (15).

5.1.5. General procedure for the preparation of 1-(2-nitrophenyl)pyrroles 3a-c

A mixture of nitroaniline 2 (0.07 mol) and 2,5-dimethoxytetrahydrofuran (0.07 mol) in acetic acid (100 mL) was refluxed for 8 min with vigorous stirring under microwaves (850 Watts) irradiations. After cooling, the reaction mixture was poured into water (300 mL). The precipitate was filtered, washed with water and dissolved in ethyl ether (150 mL). The organic layer was washed with water (100 mL), dried over magnesium sulfate and evaporated to dryness under reduced pressure to give red crystals which were recrystallized from petroleum ether.

5.1.6. 1-(2-Nitrophenyl)pyrrole 3a

Red crystals (82%): m.p. 56 °C (lit. [22] 55 °C); $^1\text{H-NMR}$ (DMSO- d_6) δ : 7.23 (dd, 1H, $J_{H-3\ H-4} = 7.32$ Hz, $J_{H-3\ H-5} = 1.46$ Hz, H-3), 6.98 (dd, 1H, $J_{H-6\ H-5} = 7.32$ Hz, $J_{H-6\ H-4} = 1.46$ Hz, H-6), 6.82 (m, 2H, H-4 et H-5), 6.12 (dd, 2H, $J_{H-\alpha\ H-\beta} = 1.96$ Hz, 2H- α), 5.45 (dd, 2H, $J_{H-\beta\ H-\alpha} = 1.96$ Hz, 2H- β).

5.1.7. 1-(4-Chloro-2-nitrophenyl)pyrrole 3b

Red crystals (84%): m.p. 57 °C (lit. [44] 56 °C); $^1\text{H-NMR}$ (DMSO- d_6) δ : 8.18 (d, 1H, $J_{H-3\ H-5} = 2.44$ Hz, H-3), 7.83 (dd, 1H, $J_{H-5\ H-6} = 8.78$ Hz, $J_{H-5\ H-3} = 2.44$ Hz, H-5), 7.65 (d, 1H, $J_{H-6\ H-5} = 8.78$ Hz, H-6), 6.93 (dd, 2H, $J_{H-\alpha\ H-\beta} = 1.96$ Hz, 2H- α), 6.29 (dd, 2H, $J_{H-\beta\ H-\alpha} = 1.96$ Hz, 2H- β).

5.1.8. 1-(4,5-Dichloro-2-nitrophenyl)pyrrole 3c

Red crystals (86%): m.p. 69 °C (lit. [44] 70 °C); $^1\text{H-NMR}$ (DMSO- d_6) δ : 8.43 (s, 1H, H-3), 8.01 (s, 1H, H-6), 6.97 (dd, 2H, $J_{H-\alpha\ H-\beta} = 1.95$ Hz, 2H- α), 6.28 (dd, 2H, $J_{H-\beta\ H-\alpha} = 1.95$ Hz, 2H- β); $^{13}\text{C-NMR}$ (DMSO- d_6) δ : 143.0 (C-5), 138.2 (C-2), 136.2 (C-1), 132.7 (C-4), 129.2 (C-3), 126.4 (C-6), 121.3 (2C- α), 111.0 (2C- β); MS (EI) m/z : 258 (M $^+$ + 1, 23), 256 (37), 241 (67), 239 (100), 211 (59), 186 (45), 140 (35).

5.1.9. General procedure for the preparation of 5H-pyrrolo[1,2-a]quinoxalin-4-ones 4a-c

A solution of phosgene in toluene (20%, 0.0375 mol) was added to a solution of 1-(2-aminophenyl)pyrrole 1 (0.03 mol) in toluene (80 mL), then heated under reflux for 4 h. The solution was then allowed to come to room temperature. The crystalline precipitate was filtered off, washed with ethyl ether and recrystallized from ethyl acetate to give 4 as white crystals.

5.1.10. 7-Chloro-5H-pyrrolo[1,2-a]quinoxalin-4-one 4b

White crystals (84%): m.p. > 260 °C; IR (KBr) 3200-2700 (NH), 1650 (CO); $^1\text{H-NMR}$ (DMSO- d_6) δ : 11.25 (s, 1H, NH), 8.13 (dd, 1H, $J_{H-1\ H-2} = 2.60$ Hz, $J_{H-1\ H-3} = 0.91$ Hz, H-1), 8.03 (d, 1H, $J_{H-9\ H-8} = 8.75$ Hz, H-9), 7.33 (d, 1H, $J_{H-6\ H-8} = 1.83$ Hz, H-6), 7.21 (dd, 1H, $J_{H-8\ H-9} = 8.75$ Hz, $J_{H-8\ H-6} = 1.83$ Hz, H-8), 7.06 (dd, 1H, $J_{H-3\ H-2} = 3.70$ Hz, $J_{H-3\ H-1} = 0.91$ Hz, H-3), 6.69 (dd, 1H, $J_{H-2\ H-3} = 3.70$ Hz, $J_{H-2\ H-1} = 2.60$ Hz, 1H, H-2); $^{13}\text{C-NMR}$ (DMSO- d_6) δ : 154.8 (CO), 129.9 (C-5a), 129.3 (C-3a), 123.0 (C-7), 122.0 (C-9a), 121.6 (C-1), 118.3 (C-8), 116.6 (C-3), 115.7 (C-9), 112.9 (C-6), 111.7 (C-2). Anal. C $_{11}$ H $_7$ ClN $_2$ O (C, H, N).

5.1.11. 7,8-Dichloro-5H-pyrrolo[1,2-a]quinoxalin-4-one 4c

White crystals (91%): m.p. > 260 °C; IR (KBr) 3200-2700 (NH), 1645 (CO); $^1\text{H-NMR}$ (DMSO- d_6) δ : 11.09 (s, 1H, NH), 8.27 (s, 1H, H-9), 8.12 (dd, 1H, $J_{H-1\ H-2} = 2.70$ Hz, $J_{H-1\ H-3} = 0.92$ Hz, H-1), 7.45 (s, 1H, H-6), 7.05 (dd, 1H, $J_{H-3\ H-2} = 3.64$ Hz, $J_{H-3\ H-1} = 0.92$ Hz, H-3), 6.66 (dd, 1H, $J_{H-2\ H-3} = 3.64$ Hz, $J_{H-2\ H-1} = 2.70$ Hz, H-2); $^{13}\text{C-NMR}$ (DMSO- d_6) δ : 154.7 (CO), 128.9 (C-3a), 127.4 (C-5a), 124.4 (C-9a), 123.3 (C-7), 122.7 (C-8), 118.9 (C-1), 117.4 (C-3), 116.8 (C-6), 113.2 (C-9), 112.3 (C-2); MS (EI) m/z : 254 (M $^+$ + 1, 67), 253 (M $^+$, 15), 252 (100), 223 (10), 197 (13), 189 (23). Anal. C $_{11}$ H $_6$ Cl $_2$ N $_2$ O (C, H, N).

5.1.12. General procedure for the preparation of 4-chloropyrrolo[1,2-a]quinoxalines 5a-c

A solution of 5H-pyrrolo[1,2-a]quinoxalin-4-one 4 (0.03 mol) in POCl $_3$ (60 mL) was refluxed for 4 h. After removing excess of reactive under vacuum, the residue was carefully dissolved in water at 0 °C and the resulting solution was alkalized with 30% aqueous ammonium hydroxide solution. The precipitate was filtered and recrystallized from ethyl acetate to give 5.

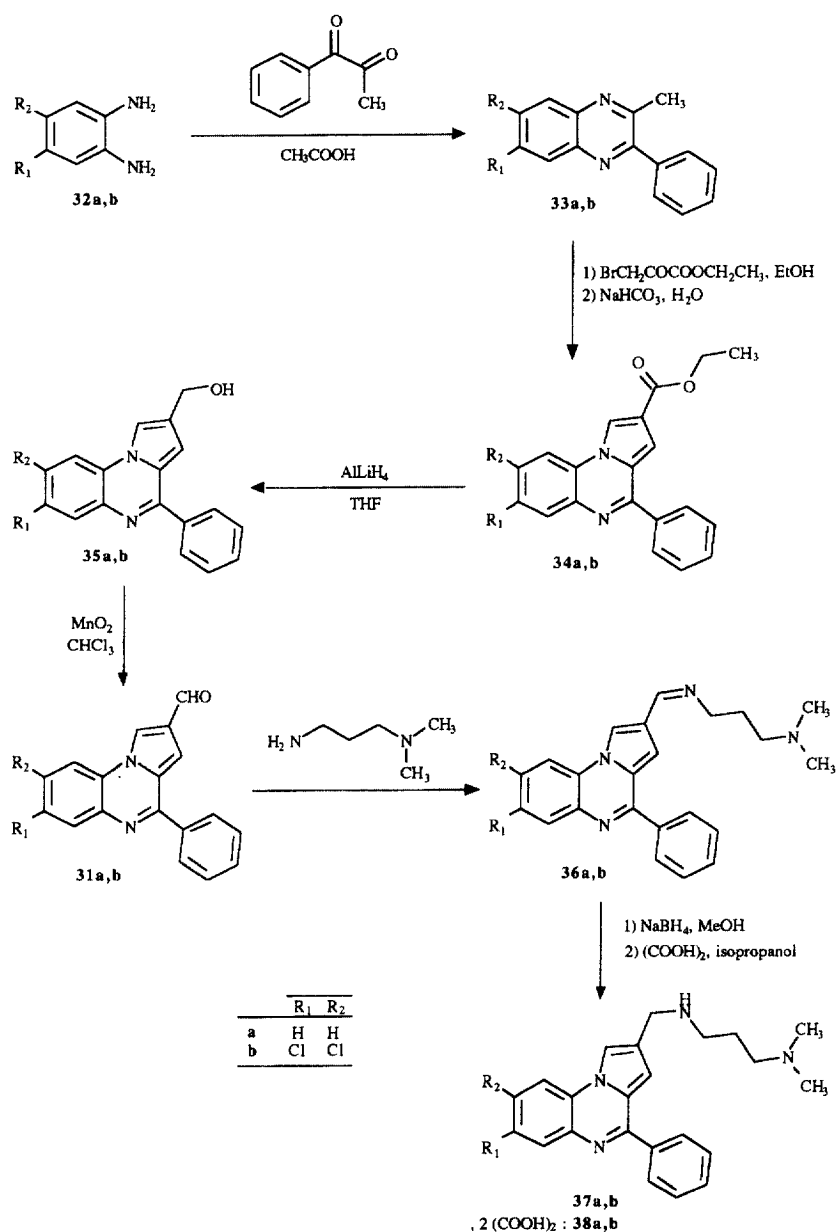


Figure 7. Synthesis of compounds **38a,b**.

5.1.13. 4,7-Dichloropyrrolo[1,2-a]quinoxaline **5b**

White crystals (79%): m.p. 198 °C; $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 8.52 (dd, 1H, $J_{\text{H-1 H-2}} = 2.68$ Hz, $J_{\text{H-1 H-3}} = 0.98$ Hz, H-1), 8.28 (d, 1H, $J_{\text{H-9 H-8}} = 8.79$ Hz, H-9), 7.83 (d, 1H, $J_{\text{H-6 H-8}} = 2.44$ Hz,

H-6), 7.62 (dd, 1H, $J_{\text{H-8 H-9}} = 8.79$ Hz, $J_{\text{H-8 H-6}} = 2.44$ Hz, H-8), 7.06 (dd, 1H, $J_{\text{H-3 H-2}} = 3.91$ Hz, $J_{\text{H-3 H-1}} = 0.98$ Hz, H-3), 6.98 (dd, 1H, $J_{\text{H-2 H-3}} = 3.91$ Hz, $J_{\text{H-2 H-1}} = 2.68$ Hz, H-2). Anal. $\text{C}_{11}\text{H}_6\text{Cl}_2\text{N}_2$ (C, H, N).

Table I. Binding of new pyrrolo[1,2-*a*]quinoxalines to tGLP-1 and glucagon receptors.

Compound	tGLP-1 receptor IC ₅₀ (μM)	Glucagon receptor IC ₅₀ (μM)
tGLP-1	16 × 10 ⁻⁵	> 10
Glucagon	> 10	5 × 10 ⁻⁴
CP-99,711	0.3	0.1
8a	> 10	> 10
8b	> 10	> 10
8c	> 10	10
9c	> 10	> 10
11c	> 10	> 10
15a	> 10	> 10
15b	> 10	> 10
15c	> 10	> 10
22c	> 10	> 10
23a	> 10	> 10
25c	> 10	> 10
28a	> 10	> 10
28b	> 10	> 10
29a	> 10	> 10
29b	> 10	> 10
29c	> 10	> 10
30a	2.5	5
30c	10	10
38a	> 10	> 10
38b	> 10	10

5.1.14. 4,7,8-Trichloropyrrolo[1,2-*a*]quinoxaline 5c

White crystals (95%): m.p. 230 °C; ¹H-NMR (DMSO-*d*₆) δ: 8.57 (s, 1H, H-9), 8.54 (m, 1H, H-1), 7.95 (s, 1H, H-6), 7.06 (m, 1H, H-3), 6.97 (m, 1H, H-2); MS (EI) *m/z*: 272 (M⁺ + 1, 94), 271 (M⁺, 14), 270 (100), 235 (24), 208 (11), 200 (15), 135 (10). Anal. C₁₁H₅Cl₃N₂ (C, H, N).

5.1.15. General procedure for the preparation of *N*-(pyrrolo[1,2-*a*]quinoxalin-4-yl)-*N,N,N'*-trimethylpropane-1,3-diamines **6a–c, 7,8-Dichloro-4-(4-methylpiperazin-1-yl)pyrrolo[1,2-*a*]quinoxaline **7c** and *N*-(pyrrolo[1,2-*a*]quinoxalin-4-ylmethyl)-*N,N,N'*-trimethylpropane-1,3-diamines **14a–c****

To a solution of 4-chloropyrrolo[1,2-*a*]quinoxaline **5** or 4-chloromethylpyrrolo[1,2-*a*]quinoxaline **13** (0.01 mol) in dimethylformamide (35 mL) were added K₂CO₃ (0.012 mol) then *N,N,N'*-trimethyl-1,3-propanediamine or *N*-methylpiperazine (0.011 mol). The reaction mixture was heated at 120–130 °C for 4 h and, after cooling, was poured into water (100 mL). The suspension was extracted with ethyl ether (2 × 100 mL). The

organic layers were collected, washed with water (150 mL), dried over magnesium sulfate and evaporated to dryness under reduced pressure to give **6a–c**, **7c** or **14a–c**. Oils were used without other purification; **7c** was recrystallized from hexane.

5.1.16. *N*-(pyrrolo[1,2-*a*]quinoxalin-4-yl)-*N,N,N'*-trimethylpropane-1,3-diamine **6a**

Yellow oil (84%): ¹H-NMR (DMSO-*d*₆) δ: 8.26 (dd, 1H, *J*_{H-1 H-2} = 2.78 Hz, *J*_{H-1 H-3} = 1.20 Hz, H-1), 8.00 (d, 1H, *J*_{H-9 H-8} = 7.73 Hz, H-9), 7.45 (d, 1H, *J*_{H-6 H-7} = 7.73 Hz, H-6), 7.26 (t, 1H, *J*_{H-8 H-9} = *J*_{H-8 H-7} = 7.73 Hz, H-8), 7.17 (t, 1H, *J*_{H-7 H-8} = *J*_{H-7 H-6} = 7.73 Hz, H-7), 7.01 (dd, 1H, *J*_{H-3 H-2} = 4.03 Hz, *J*_{H-3 H-1} = 1.20 Hz, H-3), 6.76 (dd, 1H, *J*_{H-2 H-3} = 4.03 Hz, *J*_{H-2 H-1} = 2.78 Hz, H-2), 3.74 (t, 2H, *J*_{CH₂ CH₂} = 7.10 Hz, CH₂), 3.34 (s, 3H, CH₃), 2.26 (t, 2H, *J*_{CH₂ CH₂} = 7.10 Hz, CH₂), 2.14 (s, 6H, 2CH₃), 1.81 (qt, 2H, *J*_{CH₂ CH₂} = 7.10 Hz, CH₂); ¹³C-NMR (DMSO-*d*₆) δ: 150.6 (C-4), 136.3 (C-5a), 125.7 (C-6), 125.0 (C-7), 124.5 (C-9a), 122.2 (C-8), 118.7 (C-3a), 115.6 (C-9), 113.8 (C-1), 112.3 (C-3), 108.1 (C-2), 56.4 (CH₂), 49.3 (CH₂), 45.2 (2CH₃), 38.2 (CH₃), 25.4 (CH₂). Anal. C₁₇H₂₂N₄ (C, H, N).

5.1.17. *N*-(7-Chloropyrrolo[1,2-*a*]quinoxalin-4-yl)-*N,N,N'*-trimethylpropane-1,3-diamine **6b**

Yellow oil (84%): ¹H-NMR (DMSO-*d*₆) δ: 8.19 (m, 1H, H-1), 7.95 (d, 1H, *J*_{H-9 H-8} = 8.79 Hz, H-9), 7.36 (d, 1H, *J*_{H-6 H-8} = 2.47 Hz, H-6), 7.11 (dd, 1H, *J*_{H-8 H-9} = 8.79 Hz, *J*_{H-8 H-6} = 2.47 Hz, H-8), 6.98 (m, 1H, H-3), 6.74 (m, 1H, H-2), 3.69 (t, 2H, *J*_{CH₂ CH₂} = 7.0 Hz, CH₂), 3.32 (s, 3H, CH₃), 2.27 (t, 2H, *J*_{CH₂ CH₂} = 7.0 Hz, CH₂), 2.14 (s, 6H, 2CH₃), 1.77 (qt, 2H, *J*_{CH₂ CH₂} = 7.0 Hz, CH₂). Anal. C₁₇H₂₁ClN₄ (C, H, N).

5.1.18. *N*-(7,8-Dichloropyrrolo[1,2-*a*]quinoxalin-4-yl)-*N,N,N'*-trimethylpropane-1,3-diamine **6c**

Yellow oil (93%): ¹H-NMR (DMSO-*d*₆) δ: 8.30 (dd, 1H, *J*_{H-1 H-2} = 2.93 Hz, *J*_{H-1 H-3} = 0.98 Hz, H-1), 8.28 (s, 1H, H-9), 7.42 (s, 1H, H-6), 7.02 (dd, 1H, *J*_{H-3 H-2} = 3.91 Hz, *J*_{H-3 H-1} = 0.98 Hz, H-3), 6.76 (dd, 1H, *J*_{H-2 H-3} = 3.91 Hz, *J*_{H-2 H-1} = 2.93 Hz, H-2), 3.71 (t, 2H, *J*_{CH₂ CH₂} = 7.32 Hz, CH₂), 3.33 (s, 3H, CH₃), 2.26 (t, 2H, *J*_{CH₂ CH₂} = 7.32 Hz, CH₂), 2.15 (s, 6H, 2CH₃), 1.80 (qt, 2H, *J*_{CH₂ CH₂} = 7.32 Hz, CH₂); ¹³C-NMR (DMSO-*d*₆) δ: 150.8 (C-4), 136.5 (C-5a), 126.7 (C-9), 125.6 (C-9a), 124.0 (C-8), 122.9 (C-7), 118.0 (C-3a), 116.7 (C-1), 115.3 (C-6), 112.7 (C-2), 109.2 (C-3), 56.4 (CH₂), 49.3 (CH₂), 45.1 (2CH₃), 38.2 (CH₃), 25.3 (CH₂); MS (EI) *m/z*: 352 (M⁺ + 1, 17), 351 (M⁺, 32), 292 (36), 279 (80), 250 (73), 236 (20), 85 (63), 58 (100). Anal. C₁₇H₂₀Cl₂N₄ (C, H, N).

5.1.19. 7,8-Dichloro-4-(4-methylpiperazin-1-yl)pyrrolo[1,2-*a*]quinoxaline **7c**

Yellow crystals (80%): m.p. 144 °C; ¹H-NMR (DMSO-*d*₆) δ: 8.33 (s, 1H, H-9), 8.28 (dd, 1H, *J*_{H-1 H-2} = 3.11 Hz, *J*_{H-1 H-3} = 0.92 Hz, H-1), 7.59 (s, 1H, H-6), 6.96 (dd, 1H, *J*_{H-3 H-2} = 4.07 Hz, *J*_{H-3 H-1} = 0.92 Hz, H-3), 6.79 (dd, 1H, *J*_{H-2 H-3} = 4.07 Hz, *J*_{H-2 H-1} = 3.11 Hz, H-2), 3.79 (t, 4H, *J*_{CH₂ CH₂} = 4.76 Hz, 2CH₂), 2.48 (t, 4H, *J*_{CH₂ CH₂} = 4.76 Hz, 2CH₂), 2.24 (s, 3H, CH₃); ¹³C-NMR (DMSO-*d*₆) δ: 152.1 (C-4), 135.9 (C-5a), 126.9 (C-9a), 126.7 (C-8), 124.7 (C-7), 124.6 (C-6), 118.6 (C-9), 117.0 (C-1), 115.6 (C-3a), 113.1 (C-3), 108.6 (C-2), 54.5 (2CH₂), 46.9 (2CH₂), 45.4 (CH₃). Anal. C₁₆H₁₆Cl₂N₄ (C, H, N).

5.1.20. *N*-(Pyrrolo[1,2-*a*]quinoxalin-4-ylmethyl)-*N,N,N'*-trimethylpropane-1,3-diamine **14a**

Orange oil (66%): ¹H-NMR (DMSO-*d*₆) δ: 8.37 (m, 1H, H-1), 8.23 (d, 1H, *J*_{H-9 H-8} = 7.82 Hz, H-9), 7.86 (d, 1H, *J*_{H-6 H-7} = 7.82 Hz, H-6), 7.58 (m, 1H, H-8), 7.46 (m, 1H, H-7), 7.18 (m, 1H, H-3), 6.89 (m, 1H, H-2), 3.78 (s, 2H, CH₂), 2.46 (t, 2H,

$J_{\text{CH}_2\text{CH}_2} = 6.84$ Hz, CH_2), 2.22 (s, 3H, CH_3), 2.16 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 6.84$ Hz, CH_2), 2.05 (s, 6H, 2CH_3), 1.54 (qt, 2H, $J_{\text{CH}_2\text{CH}_2} = 6.84$ Hz, CH_2). Anal. $\text{C}_{18}\text{H}_{24}\text{N}_4$ (C, H, N).

5.1.21. *N*-(7-Chloropyrrolo[1,2-*a*]quinoxalin-4-ylmethyl)-*N,N',N'*-trimethylpropane-1,3-diamine **14b**

Orange oil (78%): $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 8.39 (m, 1H, H-1), 8.29 (d, 1H, $J_{\text{H-9 H-8}} = 8.79$ Hz, H-9), 7.84 (d, 1H, $J_{\text{H-6 H-8}} = 2.44$ Hz, H-6), 7.56 (dd, 1H, $J_{\text{H-8 H-9}} = 8.79$ Hz, $J_{\text{H-8 H-6}} = 2.44$ Hz, H-8), 7.19 (m, 1H, H-3), 6.89 (m, 1H, H-2), 3.75 (s, 2H, CH_2), 2.43 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 6.83$ Hz, CH_2), 2.21 (s, 3H, CH_3), 2.16 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 6.83$ Hz, CH_2), 2.05 (s, 6H, 2CH_3), 1.59 (qt, 2H, $J_{\text{CH}_2\text{CH}_2} = 6.83$ Hz, CH_2). Anal. $\text{C}_{18}\text{H}_{23}\text{ClN}_4$ (C, H, N).

5.1.22. *N*-(7,8-Dichloropyrrolo[1,2-*a*]quinoxalin-4-ylmethyl)-*N,N',N'*-trimethylpropane-1,3-diamine **14c**

Orange oil (67%): $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 8.55 (s, 1H, H-9), 8.43 (dd, 1H, $J_{\text{H-1 H-2}} = 2.26$ Hz, $J_{\text{H-1 H-3}} = 0.96$ Hz, H-1), 7.93 (s, 1H, H-6), 7.18 (dd, 1H, $J_{\text{H-3 H-2}} = 3.50$ Hz, $J_{\text{H-3 H-1}} = 0.96$ Hz, H-3), 6.89 (dd, 1H, $J_{\text{H-2 H-3}} = 3.50$ Hz, $J_{\text{H-2 H-1}} = 2.26$ Hz, H-2), 3.72 (s, 2H, CH_2), 2.47 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 6.92$ Hz, CH_2), 2.25 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 6.92$ Hz, CH_2), 2.21 (s, 3H, CH_3), 2.12 (s, 6H, 2CH_3), 1.62 (qt, 2H, $J_{\text{CH}_2\text{CH}_2} = 6.92$ Hz, CH_2); $^{13}\text{C-NMR}$ ($\text{DMSO-}d_6$) δ : 155.8 (C-4), 134.7 (C-5a), 129.7 (C-9a), 129.4 (C-8), 126.9 (C-7), 126.6 (C-6), 124.8 (C-9), 116.7 (C-3a), 116.4 (C-1), 114.0 (C-3), 108.5 (C-2), 62.2 (CH_2), 56.8 (CH_2), 55.4 (CH_2), 44.7 (2CH_3), 42.2 (CH_3), 24.6 (CH_2). Anal. $\text{C}_{18}\text{H}_{22}\text{Cl}_2\text{N}_4$ (C, H, N).

5.1.23. 7,8-Dichloro-4-([1,4]diazepan-1-yl)-pyrrolo[1,2-*a*]quinoxaline **10c**

To a solution of homopiperazine (0.026 mol) at 40–50 °C was added portion-wise 4,7,8-trichloropyrrolo[1,2-*a*]quinoxaline **5c** (0.0037 mol). The reaction mixture was heated at 140 °C for 3 h and then, after cooling, was poured into water (50 mL). The precipitate was collected, washed with water, dried and recrystallized from ethanol. Yellow crystals (70%): m.p. 110 °C; IR (KBr) 3420 (NH); $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 8.25 (dd, 1H, $J_{\text{H-1 H-2}} = 2.98$ Hz, $J_{\text{H-1 H-3}} = 0.97$ Hz, H-1), 8.23 (s, 1H, H-9), 7.44 (s, 1H, H-6), 6.94 (dd, 1H, $J_{\text{H-3 H-2}} = 4.08$ Hz, $J_{\text{H-3 H-1}} = 0.97$ Hz, H-3), 6.74 (dd, 1H, $J_{\text{H-2 H-3}} = 4.08$ Hz, $J_{\text{H-2 H-1}} = 2.98$ Hz, H-2), 3.96 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 5.52$ Hz, CH_2), 3.92 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 5.52$ Hz, CH_2), 3.00 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 5.52$ Hz, CH_2), 2.76 (m, 3H, NH and CH_2), 1.87 (qt, 2H, $J_{\text{CH}_2\text{CH}_2} = 5.52$ Hz, CH_2). Anal. $\text{C}_{16}\text{H}_{16}\text{Cl}_2\text{N}_4$ (C, H, N).

5.1.24. 7,8-Dichloro-4-(4-methyl[1,4]diazepan-1-yl)-pyrrolo[1,2-*a*]quinoxaline **11c**

To a solution of 7,8-dichloro-4-([1,4]diazepan-1-yl)-pyrrolo[1,2-*a*]quinoxaline **10c** (0.002 mol) in acetone (35 mL) was added aqueous sodium hydroxide solution (5%, 5 mL) then dimethyl sulfate (0.003 mol). The mixture was refluxed for 3 h and evaporated to dryness. The residue was triturated in water to give **10c** as white crystals which were filtered, washed with water, dried and recrystallized from propan-2-ol. White crystals (91%): m.p. > 260 °C; $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 8.39 (dd, 1H, $J_{\text{H-1 H-2}} = 2.90$ Hz, $J_{\text{H-1 H-3}} = 0.80$ Hz, H-1), 8.38 (s, 1H, H-9), 7.54 (s, 1H, H-6), 7.05 (dd, 1H, $J_{\text{H-3 H-2}} = 3.40$ Hz, $J_{\text{H-3 H-1}} = 0.80$ Hz, H-3), 6.84 (dd, 1H, $J_{\text{H-2 H-3}} = 3.40$ Hz, $J_{\text{H-2 H-1}} = 2.90$ Hz, H-2), 4.23 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 5.30$ Hz, CH_2), 4.10 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 5.30$ Hz, CH_2), 3.77 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 5.30$ Hz, CH_2), 3.60 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 5.30$ Hz, CH_2), 3.41 (s, 3H, CH_3), 2.36 (qt, 2H, $J_{\text{CH}_2\text{CH}_2} = 5.30$ Hz, CH_2); $^{13}\text{C-NMR}$ ($\text{DMSO-}d_6$) δ : 155.2 (C-4), 135.9 (C-5a), 126.9 (C-9a), 126.3 (C-7), 124.4 (C-8), 124.1 (C-6), 118.0 (C-9), 117.4 (C-1), 115.7

(C-3a), 113.2 (C-3), 109.9 (C-2), 64.9 (CH_2), 64.0 (CH_2), 52.7 (CH_2), 52.0 (CH_2), 40.8 (CH_3), 22.2 (CH_2). Anal. $\text{C}_{17}\text{H}_{18}\text{Cl}_2\text{N}_4$ (C, H, N).

5.1.25. General procedure for the preparation of *N*-(pyrrolo[1,2-*a*]quinoxalinyldi- or -trimethylalkyldiamine oxalates **8a–c, **9c**, **15a–c**, **28a,b**, **29a–c**, **30a,c** and **38a,b****

To a solution of *N*-(pyrrolo[1,2-*a*]quinoxalinyldi- or -trimethylalkyldiamines **6**, **7c**, **14**, **25**, **26**, **27** or **37** (0.006 mol) in isopropanol (35 mL) was added oxalic acid (0.018 mol). The reaction mixture was heated under reflux for 30 min. The precipitate was filtered, washed with ethyl ether and recrystallized from a mixture of propan-2-ol/water (60:40).

5.1.26. *N*-(pyrrolo[1,2-*a*]quinoxalin-4-yl)-*N,N',N'*-trimethylpropane-1,3-diamine (oxalate) **8a**

White crystals (76%): m.p. 198 °C; IR (KBr) 2760–2630 (NH^+) 1690 (CO); $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 8.57 (bs, 4H, NH^+ and OH), 8.31 (dd, 1H, $J_{\text{H-1 H-2}} = 2.93$ Hz, $J_{\text{H-1 H-3}} = 0.97$ Hz, H-1), 8.04 (d, 1H, $J_{\text{H-9 H-8}} = 7.81$ Hz, H-9), 7.46 (d, 1H, $J_{\text{H-6 H-7}} = 7.81$ Hz, H-6), 7.28 (t, 1H, $J_{\text{H-8 H-9}} = J_{\text{H-8 H-7}} = 7.81$ Hz, H-8), 7.19 (t, 1H, $J_{\text{H-7 H-8}} = J_{\text{H-7 H-6}} = 7.81$ Hz, H-7), 7.09 (dd, 1H, $J_{\text{H-3 H-2}} = 4.15$ Hz, $J_{\text{H-3 H-1}} = 0.97$ Hz, H-3), 6.80 (dd, 1H, $J_{\text{H-2 H-3}} = 4.15$ Hz, $J_{\text{H-2 H-1}} = 2.93$ Hz, H-2), 3.80 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 7.10$ Hz, CH_2), 3.40 (s, 3H, CH_3), 3.13 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 7.10$ Hz, CH_2), 2.79 (s, 6H, 2CH_3), 2.09 (qt, 2H, $J_{\text{CH}_2\text{CH}_2} = 7.10$ Hz, CH_2). Anal. $\text{C}_{21}\text{H}_{26}\text{N}_4\text{O}_8$ (C, H, N).

5.1.27. *N*-(7-Chloropyrrolo[1,2-*a*]quinoxalin-4-yl)-*N,N',N'*-trimethylpropane-1,3-diamine (oxalate) **8b**

Yellow crystals (82%): m.p. 200 °C; IR (KBr) 3100–2400 (NH^+) 1710 (CO); $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 9.94 (bs, 4H, NH^+ and OH), 8.22 (m, 1H, H-1), 7.99 (d, 1H, $J_{\text{H-9 H-8}} = 8.78$ Hz, H-9), 7.42 (d, 1H, $J_{\text{H-6 H-8}} = 1.50$ Hz, H-6), 7.15 (dd, 1H, $J_{\text{H-8 H-9}} = 8.78$ Hz, $J_{\text{H-8 H-6}} = 1.50$ Hz, H-8), 7.07 (m, 1H, H-3), 6.78 (m, 1H, H-2), 3.81 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 7.16$ Hz, CH_2), 3.43 (s, 3H, CH_3), 3.14 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 7.16$ Hz, CH_2), 2.79 (s, 6H, 2CH_3), 2.09 (qt, 2H, $J_{\text{CH}_2\text{CH}_2} = 7.16$ Hz, CH_2). Anal. $\text{C}_{21}\text{H}_{25}\text{ClN}_4\text{O}_8$ (C, H, N).

5.1.28. *N*-(7,8-Dichloropyrrolo[1,2-*a*]quinoxalin-4-yl)-*N,N',N'*-trimethylpropane-1,3-diamine (oxalate) **8c**

White crystals (84%): m.p. 198 °C; IR (KBr) 3200–2300 (NH^+) 1710 (CO); $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 9.83 (bs, 4H, NH^+ and OH), 8.27 (dd, 1H, $J_{\text{H-1 H-2}} = 2.91$ Hz, $J_{\text{H-1 H-3}} = 1.03$ Hz, H-1), 8.25 (s, 1H, H-9), 7.54 (s, 1H, H-6), 7.08 (dd, 1H, $J_{\text{H-3 H-2}} = 4.05$ Hz, $J_{\text{H-3 H-1}} = 1.03$ Hz, H-3), 6.78 (dd, 1H, $J_{\text{H-2 H-3}} = 4.05$ Hz, $J_{\text{H-2 H-1}} = 2.91$ Hz, H-2), 3.82 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 7.40$ Hz, CH_2), 3.42 (s, 3H, CH_3), 3.15 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 7.40$ Hz, CH_2), 2.79 (s, 6H, 2CH_3), 2.10 (qt, $J_{\text{CH}_2\text{CH}_2} = 7.40$ Hz, CH_2). Anal. $\text{C}_{21}\text{H}_{24}\text{Cl}_2\text{N}_4\text{O}_8$ (C, H, N).

5.1.29. 7,8-Dichloro-4-(4-methylpiperazin-1-yl)pyrrolo[1,2-*a*]quinoxaline (oxalate) **9c**

White crystals (82%): m.p. > 260 °C; IR (KBr) 3100–2400 (NH^+) 1710 (CO); $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 9.05 (bs, 4H, NH^+ and OH), 8.35 (s, 1H, H-9), 8.30 (dd, 1H, $J_{\text{H-1 H-2}} = 3.28$ Hz, $J_{\text{H-1 H-3}} = 0.92$ Hz, H-1), 7.64 (s, 1H, H-6), 7.02 (dd, 1H, $J_{\text{H-3 H-2}} = 3.98$ Hz, $J_{\text{H-3 H-1}} = 0.92$ Hz, H-3), 6.82 (dd, 1H, $J_{\text{H-2 H-3}} = 3.98$ Hz, $J_{\text{H-2 H-1}} = 3.28$ Hz, H-2), 3.96 (t, 4H, $J_{\text{CH}_2\text{CH}_2} = 4.83$ Hz, 2CH_2), 3.06 (t, 4H, $J_{\text{CH}_2\text{CH}_2} = 4.83$ Hz, 2CH_2), 2.64 (s, 3H, CH_3). Anal. $\text{C}_{20}\text{H}_{20}\text{Cl}_2\text{N}_4\text{O}_8$ (C, H, N).

5.1.30. *N*-(Pyrrolo[1,2-*a*]quinoxalin-4-ylmethyl)-*N,N',N'*-trimethylpropane-1,3-diamine (oxalate) **15a**

Yellow crystals (66%): m.p. 228 °C; IR (KBr) 2850–2350 (NH^+) 1705 (CO); $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 8.39 (dd, 1H,

$J_{H-1\ H-2} = 2.44$ Hz, $J_{H-1\ H-3} = 1.46$ Hz, H-1), 8.23 (d, 1H, $J_{H-9\ H-8} = 7.81$ Hz, H-9), 7.88 (d, 1H, $J_{H-6\ H-7} = 7.81$ Hz, H-6), 7.55 (t, 1H, $J_{H-8\ H-9} = J_{H-8\ H-7} = 7.81$ Hz, H-8), 7.48 (t, 1H, $J_{H-7\ H-8} = J_{H-7\ H-6} = 7.81$ Hz, H-7), 7.15 (dd, 1H, $J_{H-3\ H-2} = 3.90$ Hz, $J_{H-3\ H-1} = 1.46$ Hz, H-3), 7.03 (bs, 4H, NH^+ and OH), 6.92 (dd, 1H, $J_{H-2\ H-3} = 3.90$ Hz, $J_{H-2\ H-1} = 2.44$ Hz, H-2), 4.07 (s, 2H, CH_2), 3.09 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 7.33$ Hz, CH_2), 2.80 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 7.33$ Hz, CH_2), 2.75 (s, 6H, 2CH_3), 2.46 (s, 3H, CH_3), 1.95 (qt, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 7.33$ Hz, CH_2). Anal. $\text{C}_{22}\text{H}_{28}\text{N}_4\text{O}_8$ (C, H, N).

5.1.31. *N*-(7-Chloropyrrolo[1,2-*a*]quinoxalin-4-ylmethyl)-*N,N'*-trimethylpropane-1,3-diamine (oxalate) **15b**

Yellow crystals (72%): m.p. 254 °C; IR (KBr) 3150-2500 (NH^+) 1700 (CO); $^1\text{H-NMR}$ (DMSO- d_6) δ : 8.41 (m, 1H, H-1), 8.27 (d, 1H, $J_{H-9\ H-8} = 8.79$ Hz, H-9), 7.87 (d, 1H, $J_{H-6\ H-8} = 1.95$ Hz, H-6), 7.60 (dd, 1H, $J_{H-8\ H-9} = 8.79$ Hz, $J_{H-8\ H-6} = 1.95$ Hz, H-8), 7.19 (bs, 5H, H-3, NH^+ and OH), 6.94 (m, 1H, H-2), 4.06 (s, 2H, CH_2), 3.08 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 7.33$ Hz, CH_2), 2.78 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 7.33$ Hz, CH_2), 2.75 (s, 6H, 2CH_3), 2.44 (s, 3H, CH_3), 1.94 (qt, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 7.33$ Hz, CH_2). Anal. $\text{C}_{22}\text{H}_{27}\text{ClN}_4\text{O}_8$ (C, H, N).

5.1.32. *N*-(7,8-Dichloropyrrolo[1,2-*a*]quinoxalin-4-ylmethyl)-*N,N'*-trimethylpropane-1,3-diamine (oxalate) **15c**

Beige crystals (51%): m.p. 261 °C; IR (KBr) 2850-2300 (NH^+) 1710 (CO); $^1\text{H-NMR}$ (DMSO- d_6) δ : 8.61 (s, 1H, H-9), 8.49 (m, 1H, H-1), 8.03 (s, 1H, H-6), 7.21 (bs, 5H, H-3, NH^+ and OH), 6.95 (m, 1H, H-2), 4.04 (s, 2H, CH_2), 3.08 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 7.33$ Hz, CH_2), 2.77 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 7.33$ Hz, CH_2), 2.75 (s, 6H, 2CH_3), 2.43 (s, 3H, CH_3), 1.94 (qt, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 7.33$ Hz, CH_2). Anal. $\text{C}_{22}\text{H}_{26}\text{Cl}_2\text{N}_4\text{O}_8$ (C, H, N).

5.1.33. *N'*-(4-Phenylpyrrolo[1,2-*a*]quinoxalin-1-ylmethyl)-*N,N*-dimethylpropane-1,3-diamine (oxalate) **28a**

Orange crystals (68%): m.p. 218 °C; IR (KBr) 2900-2300 (NH_2^+ and NH^+) 1700 (CO); $^1\text{H-NMR}$ (DMSO- d_6) δ : 8.37 (d, 1H, $J_{H-9\ H-8} = 7.81$ Hz, H-9), 7.93 (m, 3H, H-2', H-6' and H-6), 7.54 (m, 5H, H-3', H-4', H-5', H-7 and H-8), 7.01 (d, 1H, $J_{H-2\ H-3} = 3.91$ Hz, H-2), 6.95 (d, 1H, $J_{H-3\ H-2} = 3.91$ Hz, H-3), 6.89 (bs, 5H, NH_2^+ , NH^+ and OH), 4.64 (s, 2H, CH_2), 3.10 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 6.84$ Hz, CH_2), 3.00 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 6.84$ Hz, CH_2), 2.71 (s, 6H, 2CH_3), 2.00 (qt, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 6.84$ Hz, CH_2). Anal. $\text{C}_{27}\text{H}_{30}\text{N}_4\text{O}_8$ (C, H, N).

5.1.34. *N'*-(7-Chloro-4-phenylpyrrolo[1,2-*a*]quinoxalin-1-ylmethyl)-*N,N*-dimethylpropane-1,3-diamine (oxalate) **28b**

Yellow crystals (67%): m.p. 239 °C; IR (KBr) 2900-2500 (NH_2^+ and NH^+) 1715 (CO); $^1\text{H-NMR}$ (DMSO- d_6) δ : 8.57 (bs, 5H, NH_2^+ , NH^+ and OH), 8.44 (d, 1H, $J_{H-9\ H-8} = 8.80$ Hz, H-9), 7.92 (m, 3H, H-2', H-6' and H-6), 7.55 (m, 4H, H-3', H-4', H-5' and H-8), 7.00 (2d, 2H, $J_{H-2\ H-3} = J_{H-3\ H-2} = 4.39$ Hz, H-2 and H-3), 4.50 (s, 2H, CH_2), 3.08 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 6.84$ Hz, CH_2), 2.92 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 6.84$ Hz, CH_2), 2.71 (s, 6H, 2CH_3), 1.94 (qt, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 6.84$ Hz, CH_2). Anal. $\text{C}_{27}\text{H}_{29}\text{ClN}_4\text{O}_8$ (C, H, N).

5.1.35. *N'*-(4-Phenylpyrrolo[1,2-*a*]quinoxalin-1-ylmethyl)-*N,N*-dimethylethane-1,2-diamine (oxalate) **29a**

Yellow crystals (72%): m.p. 236 °C; IR (KBr) 2900-2550 (NH_2^+ and NH^+) 1715 (CO); $^1\text{H-NMR}$ (DMSO- d_6) δ : 8.88 (bs, 5H, NH_2^+ , NH^+ and OH), 8.39 (d, 1H, $J_{H-9\ H-8} = 7.82$ Hz, H-9), 7.91 (m, 3H, H-2', H-6' and H-6), 7.54 (m, 5H, H-3', H-4', H-5', H-7 and H-8), 6.95 (d, 1H, $J_{H-2\ H-3} = 4.14$ Hz, H-2), 6.91 (d, 1H, $J_{H-3\ H-2} = 4.14$ Hz, H-3), 4.46 (s, 2H, CH_2), 3.17 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 6.84$ Hz, CH_2), 3.13 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 6.84$ Hz, CH_2), 2.73 (s, 6H, 2CH_3). Anal. $\text{C}_{26}\text{H}_{28}\text{N}_4\text{O}_8$ (C, H, N).

5.1.36. *N'*-(7-Chloro-4-phenylpyrrolo[1,2-*a*]quinoxalin-1-ylmethyl)-*N,N*-dimethylethane-1,2-diamine (oxalate) **29b**

Yellow crystals (66%): m.p. 232 °C; IR (KBr) 2880-2400 (NH_2^+ and NH^+) 1710 (CO); $^1\text{H-NMR}$ (DMSO- d_6) δ : 8.46 (d, 1H, $J_{H-9\ H-8} = 8.80$ Hz, H-9), 7.93 (m, 3H, H-2', H-6' and H-6), 7.69 (bs, 5H, NH_2^+ , NH^+ and OH), 7.57 (m, 4H, H-3', H-4', H-5' and H-8), 6.98 (2d, 2H, $J_{H-2\ H-3} = J_{H-3\ H-2} = 4.40$ Hz, H-2 and H-3), 4.42 (s, 2H, CH_2), 3.20 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 6.84$ Hz, CH_2), 3.12 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 6.84$ Hz, CH_2), 2.76 (s, 6H, 2CH_3). Anal. $\text{C}_{26}\text{H}_{27}\text{ClN}_4\text{O}_8$ (C, H, N).

5.1.37. *N'*-(7,8-Dichloro-4-phenylpyrrolo[1,2-*a*]quinoxalin-1-ylmethyl)-*N,N*-dimethylethane-1,2-diamine (oxalate) **29c**

Yellow crystals (71%): m.p. 236 °C; IR (KBr) 2930-2400 (NH_2^+ and NH^+) 1710 (CO); $^1\text{H-NMR}$ (DMSO- d_6) δ : 8.68 (s, 1H, H-9), 8.04 (s, 1H, H-6), 7.92 (m, 2H, H-2' and H-6'), 7.80 (bs, 5H, NH_2^+ , NH^+ and OH), 7.60 (m, 3H, H-3', H-4' and H-5'), 6.99 (m, 2H, H-2 and H-3), 4.36 (s, 2H, CH_2), 3.22 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 5.70$ Hz, CH_2), 3.09 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 5.70$ Hz, CH_2), 2.79 (s, 6H, 2CH_3). Anal. $\text{C}_{26}\text{H}_{26}\text{Cl}_2\text{N}_4\text{O}_8$ (C, H, N).

5.1.38. *N'*-(4-Styrylpyrrolo[1,2-*a*]quinoxalin-1-ylmethyl)-*N,N*-dimethylpropane-1,3-diamine (oxalate) **30a**

Brown crystals (52%): m.p. 167 °C; IR (KBr) 2900-2600 (NH_2^+ and NH^+) 1710 (CO); $^1\text{H-NMR}$ (DMSO- d_6) δ : 8.28 (m, 1H, H-9), 8.02 (d, 1H, $J_{H\text{-trans}\ H\text{-trans}} = 15.70$ Hz, $\text{CH}=\text{CH}$), 7.95 (m, 1H, H-6), 7.89 (d, 1H, $J_{H\text{-trans}\ H\text{-trans}} = 15.70$ Hz, $\text{CH}=\text{CH}$), 7.69 (m, 11H, H-7, H-8, H-2', H-6', NH^+ , NH_2^+ and OH), 7.55 (m, 3H, H-3', H-4' and H-5'), 7.08 (d, 1H, $J_{H-2\ H-3} = 4.10$ Hz, H-2), 7.05 (d, 1H, $J_{H-3\ H-2} = 4.10$ Hz, H-3), 4.28 (s, 2H, CH_2), 3.06 (m, 4H, 2CH_2), 2.71 (s, 6H, 2CH_3), 1.98 (m, 2H, CH_2). Anal. $\text{C}_{31}\text{H}_{34}\text{N}_4\text{O}_{12}$ (C, H, N).

5.1.39. *N'*-(7,8-Dichloro-4-styrylpyrrolo[1,2-*a*]quinoxalin-1-ylmethyl)-*N,N*-dimethylpropane-1,3-diamine (oxalate) **30c**

Orange crystals (57%): m.p. 203 °C; IR (KBr) 3100-2300 (NH_2^+ and NH^+) 1700 (CO); $^1\text{H-NMR}$ (DMSO- d_6) δ : 8.73 (s, 1H, H-9), 7.99 (s, 1H, H-6), 7.98 (d, 1H, $J_{H\text{-trans}\ H\text{-trans}} = 15.75$ Hz, $\text{CH}=\text{CH}$), 7.77 (m, 2H, H-2' and H-6'), 7.63 (d, 1H, $J_{H\text{-trans}\ H\text{-trans}} = 15.75$ Hz, $\text{CH}=\text{CH}$), 7.42 (m, 4H, H-2, H-3', H-4' and H-5'), 6.98 (d, 1H, $J_{H-3\ H-2} = 3.60$ Hz, H-3), 6.56 (bs, 7H, NH_2^+ , NH^+ and OH), 4.34 (s, 2H, CH_2), 3.08 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 7.0$ Hz, CH_2), 2.84 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 7.0$ Hz, CH_2), 2.71 (s, 6H, 2CH_3), 1.93 (qt, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 7.0$ Hz, 2H, CH_2). Anal. $\text{C}_{31}\text{H}_{32}\text{N}_4\text{Cl}_2\text{O}_{12}$ (C, H, N).

5.1.40. *N'*-(4-Phenylpyrrolo[1,2-*a*]quinoxalin-2-ylmethyl)-*N,N*-dimethylpropane-1,3-diamine (oxalate) **38a**

Yellow crystals (76%): m.p. 234 °C; IR (KBr) 3100-2400 (NH_2^+ and NH^+) 1710 (CO); $^1\text{H-NMR}$ (DMSO- d_6) δ : 8.59 (d, 1H, $J_{H-1\ H-3} = 0.90$ Hz, H-1), 8.19 (dd, 1H, $J_{H-9\ H-8} = 8.20$ Hz, $J_{H-9\ H-7} = 1.20$ Hz, H-9), 8.01 (m, 2H, H-2' and H-6'), 7.95 (dd, 1H, $J_{H-6\ H-7} = 8.20$ Hz, $J_{H-6\ H-8} = 1.20$ Hz, H-6), 7.63 (t, 1H, $J_{H-8\ H-7} = J_{H-8\ H-9} = 8.20$ Hz, H-8), 7.59 (m, 3H, H-3', H-4' and H-5'), 7.53 (t, 1H, $J_{H-7\ H-8} = J_{H-7\ H-6} = 8.20$ Hz, H-7), 7.45 (bs, 5H, NH_2^+ , NH^+ and OH), 7.20 (d, 1H, $J_{H-3\ H-1} = 0.90$ Hz, H-3), 4.29 (s, 2H, CH_2), 3.01 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 7.30$ Hz, CH_2), 3.01 (t, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 7.30$ Hz, CH_2), 2.64 (s, 6H, 2CH_3), 2.04 (qt, 2H, $J_{\text{CH}_2\ \text{CH}_2} = 7.30$ Hz, CH_2). Anal. $\text{C}_{27}\text{H}_{30}\text{N}_4\text{O}_8$ (C, H, N).

5.1.41. *N'*-(7,8-Dichloro-4-phenylpyrrolo[1,2-*a*]quinoxalin-2-ylmethyl)-*N,N*-dimethylpropane-1,3-diamine (oxalate) **38b**

Yellow crystals (64%): m.p. 245 °C; IR (KBr) 3070-2740 (NH_2^+ and NH^+) 1720 (CO); $^1\text{H-NMR}$ (DMSO- d_6) δ : 8.64 (s, 1H, H-1), 8.44 (s, 1H, H-9), 8.26 (bs, 5H, NH_2^+ , NH^+ and OH), 8.04 (s, 1H, H-6), 7.98 (m, 2H, H-2' and H-6'), 7.57 (m, 3H, H-3', H-4' and H-5'), 7.26 (s, 1H, H-3), 4.26 (s, 2H, CH_2), 3.04

(t, 2H, $J_{\text{CH}_2\text{CH}_2} = 6.93$ Hz, CH_2), 3.01 (t, 2H, $J_{\text{CH}_2\text{CH}_2} = 6.93$ Hz, CH_2), 2.64 (s, 6H, 2CH_3), 2.06 (qt, 2H, $J_{\text{CH}_2\text{CH}_2} = 6.93$ Hz, CH_2). Anal. $\text{C}_{27}\text{H}_{28}\text{Cl}_2\text{N}_4\text{O}_8$ (C, H, N).

5.1.42. General procedure for the preparation of 2-chloro-N-(2-pyrrol-1-yl-phenyl)acetamides 12a-c

To a solution of 1-(2-aminophenyl)pyrrole **1** (0.02 mol) in dioxane (80 mL) was added pyridine (0.022 mol) then chloroacetyl chloride (0.02 mol). The reaction mixture was refluxed for 4 h and the solvent then removed under reduced pressure. The residue was triturated with water and extracted with ethyl ether (2 x 80 mL). The organic layers were collected, washed with an aqueous sodium hydrogen carbonate solution (100 mL) then with water (100 mL), dried over magnesium sulfate and evaporated to dryness. The precipitate was recrystallized from ethanol.

5.1.43. 2-Chloro-N-(4-chloro-2-pyrrol-1-yl-phenyl)acetamide 12b

Beige crystals (84%): m.p. 103 °C; IR (KBr) 3340 (NH), 1700 (CO); $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 9.75 (s, 1H, NH), 7.80 (s, 1H, H-3), 7.38 (m, 2H, H-5 and H-6), 6.98 (dd, 2H, $J_{\text{H-}\alpha\text{H-}\beta} = 1.95$ Hz, 2H- α), 6.27 (dd, 2H, $J_{\text{H-}\beta\text{H-}\alpha} = 1.95$ Hz, 2H- β), 4.24 (s, 2H, CH_2). Anal. $\text{C}_{12}\text{H}_{10}\text{N}_2\text{Cl}_2$ (C, H, N).

5.1.44. 2-Chloro-N-(4,5-dichloro-2-pyrrol-1-yl-phenyl)acetamide 12c

Yellow crystals (71%): m.p. 149 °C; IR (KBr) 3290 (NH), 1665 (CO); $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 9.87 (s, 1H, NH), 7.96 (s, 1H, H-3), 7.68 (s, 1H, H-6), 7.04 (dd, 2H, $J_{\text{H-}\alpha\text{H-}\beta} = 1.95$ Hz, 2H- α), 6.28 (dd, 2H, $J_{\text{H-}\beta\text{H-}\alpha} = 1.95$ Hz, 2H- β), 4.24 (s, 2H, CH_2). Anal. $\text{C}_{12}\text{H}_8\text{N}_2\text{Cl}_3$ (C, H, N).

5.1.45. General procedure for the preparation of 4-chloromethylpyrrolo[1,2-a]quinoxalines 13a-c

A solution of chloroacetyl derivative **12** (0.02 mol) and POCl_3 (0.1 mol) in toluene (100 mL) was heated under reflux for 4 h. After cooling, the precipitate was filtered and dissolved in water (100 mL). The solution was then made alkaline with sodium hydrogen carbonate and extracted with ethyl acetate (150 mL). The organic layer was washed with water (120 mL), dried over magnesium sulfate and evaporated to dryness under reduced pressure. The precipitate was collected and recrystallized from hexane.

5.1.46. 7-Chloro-4-chloromethylpyrrolo[1,2-a]quinoxaline 13b

Yellow crystals (52%): m.p. 152 °C; $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 8.55 (dd, 1H, $J_{\text{H-1H-2}} = 2.93$ Hz, $J_{\text{H-1H-3}} = 1.46$ Hz, H-1), 8.35 (d, 1H, $J_{\text{H-9H-8}} = 8.79$ Hz, H-9), 7.92 (d, 1H, $J_{\text{H-6H-8}} = 2.44$ Hz, H-6), 7.68 (dd, 1H, $J_{\text{H-8H-9}} = 8.79$ Hz, $J_{\text{H-8H-6}} = 2.44$ Hz, H-8), 7.24 (dd, 1H, $J_{\text{H-3H-2}} = 3.91$ Hz, $J_{\text{H-3H-1}} = 1.46$ Hz, H-3), 7.01 (dd, 1H, $J_{\text{H-2H-3}} = 3.91$ Hz, $J_{\text{H-2H-1}} = 2.93$ Hz, H-2), 5.02 (s, 2H, CH_2). Anal. $\text{C}_{12}\text{H}_8\text{N}_2\text{Cl}_2$ (C, H, N).

5.1.47. 7,8-Dichloro-4-chloromethylpyrrolo[1,2-a]quinoxaline 13c

Yellow crystals (67%): m.p. 180 °C; $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 8.56 (s, 1H, H-9), 8.48 (dd, 1H, $J_{\text{H-1H-2}} = 3.10$ Hz, $J_{\text{H-1H-3}} = 1.20$ Hz, H-1), 7.99 (s, 1H, H-6), 7.19 (dd, 1H, $J_{\text{H-3H-2}} = 4.30$ Hz, $J_{\text{H-3H-1}} = 1.20$ Hz, H-3), 6.96 (dd, 1H, $J_{\text{H-2H-3}} = 4.30$ Hz, $J_{\text{H-2H-1}} = 3.10$ Hz, H-2), 4.94 (s, 2H, CH_2). Anal. $\text{C}_{12}\text{H}_7\text{N}_2\text{Cl}_3$ (C, H, N).

5.1.48. General procedure for the preparation of 4-phenylpyrrolo[1,2-a]quinoxalines 16a-c and 4-styrylpyrrolo[1,2-a]quinoxalines 17a,c

A solution of derivative **18** or **19** (0.03 mol) and pyridine (0.03 mol) in phosphorus oxychloride (70 mL) was heated

under reflux for 4 h then evaporated to dryness. After cooling, the precipitate was filtered and slowly dissolved in water (100 mL). The solution was then made alkaline with sodium carbonate and extracted with methylene chloride (150 mL). The organic layer was washed with water (120 mL), dried over calcium chloride and evaporated to dryness under reduced pressure. The precipitate was collected, washed with hexane and recrystallized from toluene.

5.1.49. 4,5-Dichloro-4-phenylpyrrolo[1,2-a]quinoxaline 16c

White crystals (93%): m.p. 180 °C; $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 8.55 (s, 1H, H-9), 8.49 (dd, 1H, $J_{\text{H-1H-2}} = 2.48$ Hz, $J_{\text{H-1H-3}} = 1.28$ Hz, H-1), 8.02 (s, 1H, H-6), 7.96 (m, 2H, H-2' and H-6'), 7.56 (m, 3H, H-3', H-4' and H-5'), 7.02 (dd, 1H, $J_{\text{H-3H-2}} = 3.84$ Hz, $J_{\text{H-3H-1}} = 1.28$ Hz, H-3), 6.95 (dd, 1H, $J_{\text{H-2H-3}} = 3.84$ Hz, $J_{\text{H-2H-1}} = 2.48$ Hz, H-2); $^{13}\text{C-NMR}$ ($\text{DMSO-}d_6$) δ : 154.0 (C-4), 136.9 (C-5a), 134.9 (C-1'), 129.6 (C-9a), 129.5 (C-8), 129.2 (C-7), 128.0 (C-4'), 127.6 (C-2' and C-6'), 126.9 (C-3' and C-5'), 125.8 (C-6), 123.7 (C-9), 117.0 (C-1), 116.0 (C-3a), 114.1 (C-3), 108.9 (C-2); MS (EI) m/z : 314 ($\text{M}^+ + 1$, 19); 313 (M^+ , 64); 311 (100); 285 (21); 250 (6); 156 (14); 105 (21); 80 (22). Anal. $\text{C}_{17}\text{H}_{10}\text{N}_2\text{Cl}_2$ (C, H, N).

5.1.50. 4-Styrylpyrrolo[1,2-a]quinoxaline 17a

Yellow crystals (74%): m.p. 118 °C; $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 8.40 (m, 1H, H-1), 8.20 (d, 1H, $J_{\text{H-9H-8}} = 7.83$ Hz, H-9), 8.05 (d, 1H, $J_{\text{H-trans H-trans}} = 15.80$ Hz, CH=), 7.93 (d, 1H, $J_{\text{H-6H-7}} = 7.83$ Hz, H-6), 7.84 (m, 2H, H-2' and H-6'), 7.73 (d, 1H, $J_{\text{H-trans H-trans}} = 15.80$ Hz, CH=), 7.49 (m, 6H, H-3', H-4', H-5', H-7, H-8 and H-3), 6.97 (dd, 1H, $J_{\text{H-2H-3}} = 3.65$ Hz, $J_{\text{H-2H-1}} = 2.80$ Hz, H-2); $^{13}\text{C-NMR}$ ($\text{DMSO-}d_6$) δ : 149.0 (C-4), 136.0 (CH=), 135.7 (C-9a), 135.6 (CH=), 129.1 (C-5a), 129.0 (C-4'), 128.7 (C-3' and C-5'), 127.7 (C-2' and C-6'), 127.1 (C-6), 126.9 (C-8), 125.5 (C-3a), 125.3 (C-7), 123.3 (C-1'), 116.0 (C-1), 114.5 (C-9), 113.8 (C-3), 106.5 (C-2). Anal. $\text{C}_{19}\text{H}_{14}\text{N}_2$ (C, H, N).

5.1.51. 7,8-Dichloro-4-styrylpyrrolo[1,2-a]quinoxaline 17c

Yellow crystals (84%): m.p. 182 °C; $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 8.51 (s, 1H, H-9), 8.45 (dd, 1H, $J_{\text{H-1H-2}} = 2.74$ Hz, $J_{\text{H-1H-3}} = 0.91$ Hz, H-1), 8.00 (d, 1H, $J_{\text{H-trans H-trans}} = 15.83$ Hz, CH=), 7.99 (s, 1H, H-6), 7.79 (m, 2H, H-2' and H-6'), 7.63 (d, 1H, $J_{\text{H-trans H-trans}} = 15.83$ Hz, CH=), 7.42 (m, 4H, H-3', H-4', H-5' and H-3), 6.97 (dd, 1H, $J_{\text{H-2H-3}} = 3.70$ Hz, $J_{\text{H-2H-1}} = 2.74$ Hz, H-2); $^{13}\text{C-NMR}$ ($\text{DMSO-}d_6$) δ : 150.3 (C-4), 136.7 (CH=), 135.7 (C-5a), 135.4 (C-1'), 129.5 (C-9a), 129.3 (C-8), 128.8 (C-3' and C-5'), 128.4 (C-7), 127.9 (C-2' and C-6'), 127.2 (CH=), 126.4 (C-4'), 125.3 (C-6), 122.4 (C-9), 117.5 (C-1), 116.5 (C-3a), 114.5 (C-3), 107.8 (C-2). Anal. $\text{C}_{19}\text{H}_{12}\text{N}_2\text{Cl}_2$ (C, H, N).

5.1.52. General procedure for the preparation of N-(2-pyrrol-1-yl-phenyl)benzamides 18a-c and N-(2-pyrrol-1-yl-phenyl)-3-phenylacrylamides 19a,c

To a solution of 1-(2-aminophenyl)pyrrole **1** (0.02 mol) in dioxane (80 mL) was added pyridine (0.022 mol) then benzoyl chloride or cinnamoyl chloride (0.022 mol). The reaction mixture was refluxed for 4 h and the solvent then removed under reduced pressure. The residue was triturated with water and extracted with ethyl ether (2 x 80 mL). The organic layers were collected, washed with an aqueous sodium hydrogen carbonate solution (100 mL) then with water (100 mL), dried over magnesium sulfate and evaporated to dryness. The precipitate was recrystallized from ethanol.

5.1.53. N-(4,5-Dichloro-2-pyrrol-1-yl-phenyl)benzamide 18c

White crystals (89%): m.p. 135 °C; IR (KBr) 3390 (NH), 1670 (CO); $^1\text{H-NMR}$ ($\text{DMSO-}d_6$) δ : 9.97 (s, 1H, NH), 7.95 (s,

1H, H-3), 7.84 (d, 2H, $J_{H-2', H-3'} = J_{H-6', H-5'} = 7.51$ Hz, H-2' and H-6'), 7.73 (s, 1H, H-6), 7.58 (t, 1H, $J_{H-4', H-3'} = J_{H-4', H-5'} = 7.51$ Hz, H-4'), 7.49 (t, 2H, $J_{H-3', H-4'} = J_{H-3', H-2'} = J_{H-5', H-4'} = J_{H-5', H-6'} = 7.51$ Hz, H-3' and H-5'), 7.08 (dd, 2H, $J_{H-\alpha, H-\beta} = 1.95$ Hz, 2H- α), 6.22 (dd, 2H, $J_{H-\beta, H-\alpha} = 1.95$ Hz, 2H- β); ^{13}C -NMR (DMSO- d_6) δ : 165.7 (CO), 135.9 (C-1'), 133.5 (C-2), 131.7 (C-4'), 131.4 (C-1), 129.5 (C-4), 128.8 (C-5), 128.6 (C-3), 128.3 (C-3' and C-5'), 127.5 (C-2' and C-6'), 127.0 (C-6), 121.3 (2C- α), 109.8 (2C- β); MS (EI) m/z : 332 ($M^+ + 1$, 13), 330 (20), 315 (9), 123 (42), 122 (100), 106 (64). Anal. $\text{C}_{17}\text{H}_{12}\text{N}_2\text{Cl}_2\text{O}$ (C, H, N).

5.1.54. *N*-(2-pyrrol-1-yl-phenyl)-3-phenylacrylamide **19a**

White crystals (30%): m.p. 128 °C; IR (KBr) 3200 (NH), 1650 (CO); ^1H -NMR (DMSO- d_6) δ : 9.58 (s, 1H, NH), 7.71 (d, 1H, $J_{H\text{-trans } H\text{-trans}} = 15.60$ Hz, CH=), 7.61 (m, 3H, H-arom), 7.40 (m, 6H, H-arom), 6.99 (dd, 2H, $J_{H-\alpha, H-\beta} = 1.96$ Hz, 2H- α), 6.83 (d, 1H, $J_{H\text{-trans } H\text{-trans}} = 15.60$ Hz, CH=), 6.25 (dd, 2H, $J_{H-\beta, H-\alpha} = 1.96$ Hz, 2H- β). Anal. $\text{C}_{19}\text{H}_{16}\text{N}_2\text{O}$ (C, H, N).

5.1.55. *N*-(4,5-Dichloro-2-pyrrol-1-yl-phenyl)-3-phenylacrylamide **19c**

White crystals (41%): m.p. 158 °C; IR (KBr) 3240 (NH), 1650 (CO); ^1H -NMR (DMSO- d_6) δ : 9.65 (s, 1H, NH), 8.10 (s, 1H, H-3), 7.62 (s, 1H, H-6), 7.59 (m, 2H, H-2' and H-6'), 7.58 (d, 1H, $J_{H\text{-trans } H\text{-trans}} = 15.60$ Hz, CH=), 7.42 (m, 3H, H-3', H-4' and H-5'), 7.04 (dd, 2H, $J_{H-\alpha, H-\beta} = 1.85$ Hz, 2H- α), 6.85 (d, 1H, $J_{H\text{-trans } H\text{-trans}} = 15.60$ Hz, CH=), 6.27 (dd, 2H, $J_{H-\beta, H-\alpha} = 1.85$ Hz, 2H- β); ^{13}C -NMR (DMSO- d_6) δ : 164.4 (CO), 141.0 (CH=), 134.5 (C-1'), 134.0 (C-2), 131.5 (C-1), 129.9 (C-4), 128.9 (C-5), 127.8 (C-3' and C-5'), 127.7 (C-4'), 127.5 (C-2' and C-6'), 127.4 (C-3), 121.6 (C-6), 121.5 (CH=), 121.2 (2C- α), 110.2 (2C- β). Anal. $\text{C}_{19}\text{H}_{14}\text{N}_2\text{OCl}_2$ (C, H, N).

5.1.56. General procedure for the preparation of 4-arylpyrrolo[1,2-*a*]quinoxaline-1-carbaldehydes **20a-c** and **21a,c**

To cold (0 °C) *N,N*-dimethylformamide (0.09 mol) was added dropwise phosphorus oxychloride (0.09 mol). The mixture was allowed to stir at 0–5 °C for 10 min, then a solution of 4-arylpyrrolo[1,2-*a*]quinoxaline **16** or **17** in *N,N*-dimethylformamide (70 mL) was slowly added. The reaction mixture was then stirred at 130 °C for 3 h, cooled, poured into ice water (100 mL) and treated with an aqueous sodium hydroxide solution (6 N) until pH = 8–9. The solid product was isolated by filtration and dissolved in methylene chloride (100 mL). The organic layer was washed with water (80 mL), dried over calcium chloride and evaporated to dryness. The precipitate was collected, washed with hexane, dried and recrystallized from ethanol (A silica-gel column was used to purify the product **21c** with methylene chloride. The desired fractions were combined and evaporated to dryness).

5.1.57. 4-Phenylpyrrolo[1,2-*a*]quinoxaline-1-carbaldehyde **20a**

Beige crystals (71%): m.p. 153 °C; IR (KBr) 1665 (CO); ^1H -NMR (DMSO- d_6) δ : 10.03 (s, 1H, CHO), 9.16 (dd, 1H, $J_{H-9, H-8} = 7.80$ Hz, $J_{H-9, H-7} = 1.28$ Hz, H-9), 8.03 (dd, 1H, $J_{H-6, H-7} = 7.80$ Hz, $J_{H-6, H-8} = 1.28$ Hz, H-6), 7.92 (m, 2H, H-2' and H-6'), 7.80 (d, 1H, $J_{H-2, H-3} = 4.44$ Hz, H-2), 7.62 (m, 5H, H-3', H-4', H-5', H-7 and H-8), 7.07 (d, 1H, $J_{H-3, H-2} = 4.44$ Hz, H-3); ^{13}C -NMR (DMSO- d_6) δ : 179.0 (CO), 153.6 (C-4), 137.2 (C-5a), 131.8 (C-1'), 131.1 (C-9a), 130.0 (C-1), 129.8 (C-4'), 129.7 (C-3a), 128.6 (C-2' and C-6'), 128.5 (C-3' and C-5'), 128.0 (C-8), 127.4 (C-7), 126.7 (C-2), 119.3 (C-6), 119.2 (C-9), 109.2 (C-3). Anal. $\text{C}_{18}\text{H}_{12}\text{N}_2\text{O}$ (C, H, N).

5.1.58. 7-Chloro-4-phenylpyrrolo[1,2-*a*]quinoxaline-1-carbaldehyde **20b**

Beige crystals (54%): m.p. 197 °C; IR (KBr) 1675 (CO); ^1H -NMR (DMSO- d_6) δ : 10.02 (s, 1H, CHO), 9.20 (d, 1H,

$J_{H-9, H-8} = 8.80$ Hz, H-9), 7.98 (d, 1H, $J_{H-6, H-8} = 2.20$ Hz, H-6), 7.92 (m, 2H, H-2' and H-6'), 7.84 (d, 1H, $J_{H-2, H-3} = 4.40$ Hz, H-2), 7.61 (m, 4H, H-3', H-4', H-5' and H-8), 7.11 (d, $J_{H-3, H-2} = 4.40$ Hz, H-3). Anal. $\text{C}_{18}\text{H}_{11}\text{N}_2\text{ClO}$ (C, H, N).

5.1.59. 7,8-Dichloro-4-phenylpyrrolo[1,2-*a*]quinoxaline-1-carbaldehyde **20c**

Orange crystals (41%): m.p. 229 °C; IR (KBr) 1660 (CO); ^1H -NMR (DMSO- d_6) δ : 9.93 (s, 1H, CHO), 9.60 (s, 1H, H-9), 8.10 (s, 1H, H-6), 7.90 (m, 2H, H-2' and H-6'), 7.86 (d, 1H, $J_{H-2, H-3} = 4.35$ Hz, H-2), 7.57 (m, 3H, H-3', H-4' and H-5'), 7.12 (d, 1H, $J_{H-3, H-2} = 4.35$ Hz, H-3); ^{13}C -NMR (DMSO- d_6) δ : 179.3 (CO), 155.2 (C-4), 136.9 (C-5a), 136.6 (C-1'), 132.0 (C-9a), 131.4 (C-1), 131.1 (C-8), 130.4 (C-7), 129.8 (C-4'), 129.1 (C-3a), 128.6 (C-2' and C-6'), 128.5 (C-3' and C-5'), 126.8 (C-6), 121.2 (C-2), 120.9 (C-9), 110.3 (C-3); MS (EI) m/z : 342 ($M^+ + 1$, 70), 340 (100), 316 (52), 286 (77), 276 (26), 241 (30), 152 (43). Anal. $\text{C}_{18}\text{H}_{10}\text{N}_2\text{Cl}_2\text{O}$ (C, H, N).

5.1.60. 4-Styrylpyrrolo[1,2-*a*]quinoxaline-1-carbaldehyde **21a**

Brown crystals (35%): m.p. 80 °C; IR (KBr) 1675 (CO); ^1H -NMR (DMSO- d_6) δ : 9.96 (s, 1H, CHO), 9.21 (m, 1H, H-9), 8.04 (d, 1H, $J_{H\text{-trans } H\text{-trans}} = 16.60$ Hz, CH=), 7.96 (m, 1H, H-6), 7.88 (m, 2H, CH= and H-2), 7.69 (d, 1H, $J_{H-3, H-2} = 4.20$ Hz, H-3), 7.58 (m, 2H, H-2' and H-6'), 7.46 (m, 5H, H-7, H-8, H-3', H-4' and H-5'). Anal. $\text{C}_{20}\text{H}_{14}\text{N}_2\text{O}$ (C, H, N).

5.1.61. 7,8-Dichloro-4-styrylpyrrolo[1,2-*a*]quinoxaline-1-carbaldehyde **21c**

Yellow crystals (9%): m.p. 228 °C; IR (KBr) 1660 (CO); ^1H -NMR (DMSO- d_6) δ : 9.88 (s, 1H, CHO), 9.55 (s, 1H, H-9), 7.99 (s, 1H, H-6), 7.96 (d, 1H, $J_{H\text{-trans } H\text{-trans}} = 16.0$ Hz, CH=), 7.85 (d, 1H, $J_{H-2, H-3} = 4.30$ Hz, H-2), 7.75 (d, 2H, $J_{H-2', H-3'} = J_{H-6', H-5'} = 7.40$ Hz, H-2' and H-6'), 7.63 (d, 1H, $J_{H\text{-trans } H\text{-trans}} = 16.0$ Hz, CH=), 7.55 (d, 1H, $J_{H-3, H-2} = 4.30$ Hz, H-2), 7.41 (m, 3H, H-3', H-4' and H-5'); ^{13}C -NMR (DMSO- d_6) δ : 179.1 (CO), 151.0 (C-4), 138.1 (CH=), 137.1 (C-5a), 135.7 (C-1'), 132.0 (C-9a), 131.9 (C-1), 131.4 (C-8), 129.7 (C-7), 129.4 (CH=), 129.1 (C-3a), 129.0 (C-4'), 128.7 (C-3' and C-5'), 128.0 (C-2' and C-6'), 126.9 (C-6), 121.9 (C-2), 121.1 (C-9), 108.5 (C-3). Anal. $\text{C}_{20}\text{H}_{12}\text{N}_2\text{Cl}_2\text{O}$ (C, H, N).

5.1.62. General procedure for the preparation of *N'*-(4-arylpyrrolo[1,2-*a*]quinoxalin-1- or -2-ylmethylene)-*N,N*-dimethylalkylidiamines **22a-c**, **23a-c**, **24a,c** and **36a,b**

A solution of 4-arylpyrrolo[1,2-*a*]quinoxaline-1- or -2-carbaldehyde **20**, **21** or **31** (0.008 mol) in 3-dimethylaminopropylamine or 2-dimethylaminoethylamine (20 mL) was refluxed for 4 h. The excess of diamine was evaporated to dryness under reduced pressure. After cooling, the residue was extracted with methylene chloride (100 mL). The organic layer was washed with water (90 mL), dried over calcium chloride and evaporated to dryness. Solids were recrystallized from methanol; oils were used without further purification.

5.1.63. *N'*-(4-Phenylpyrrolo[1,2-*a*]quinoxalin-1-ylmethylene)-*N,N*-dimethylpropane-1,3-diamine **22a**

Orange oil (96%): IR (KBr) 1620 (C=N); ^1H -NMR (DMSO- d_6) δ : 8.92 (s, 1H, CH=N), 8.57 (dd, 1H, $J_{H-9, H-8} = 7.81$ Hz, $J_{H-9, H-7} = 1.95$ Hz, H-9), 7.95 (m, 3H, H-2', H-6' and H-6), 7.57 (m, 5H, H-3', H-4', H-5', H-7 and H-8), 7.31 (d, 1H, $J_{H-2, H-3} = 4.40$ Hz, H-2), 7.00 (d, 1H, $J_{H-3, H-2} = 4.40$ Hz, H-3), 3.72 (t, 2H, $J_{\text{CH}_2 \text{CH}_2} = 6.84$ Hz, CH_2), 2.33 (t, 2H, $J_{\text{CH}_2 \text{CH}_2} = 6.84$ Hz, CH_2), 2.16 (s, 6H, 2 CH_3), 1.83 (qt, 2H, $J_{\text{CH}_2 \text{CH}_2} = 6.84$ Hz, CH_2). Anal. $\text{C}_{23}\text{H}_{24}\text{N}_4$ (C, H, N).

5.1.64. *N'*-(7-Chloro-4-phenylpyrrolo[1,2-*a*]quinoxalin-1-ylmethylene)-*N,N*-dimethylpropane-1,3-diamine 22b

Orange crystals (98%): m.p. 90 °C; IR (KBr) 1620 (C=N); ¹H-NMR (DMSO-*d*₆) δ: 8.80 (d, 1H, *J*_{H-9 H-8} = 8.80 Hz, H-9), 8.78 (s, 1H, CH=N), 7.89 (m, 3H, H-2', H-6' and H-6), 7.56 (m, 3H, H-3', H-4' and H-5'), 7.47 (dd, 1H, *J*_{H-8 H-9} = 8.80 Hz, *J*_{H-8 H-6} = 2.44 Hz, H-8), 7.28 (d, 1H, *J*_{H-2 H-3} = 4.30 Hz, H-2), 6.98 (d, 1H, *J*_{H-3 H-2} = 4.30 Hz, H-3), 3.70 (t, 2H, *J*_{CH₂ CH₂} = 6.84 Hz, CH₂), 2.36 (t, 2H, *J*_{CH₂ CH₂} = 6.84 Hz, CH₂), 2.17 (s, 6H, 2CH₃), 1.83 (qt, 2H, *J*_{CH₂ CH₂} = 6.84 Hz, CH₂). Anal. C₂₃H₂₃N₄Cl (C, H, N).

5.1.65. *N'*-(7,8-Dichloro-4-phenylpyrrolo[1,2-*a*]quinoxalin-1-ylmethylene)-*N,N*-dimethylpropane-1,3-diamine 22c

Beige crystals (93%): m.p. 119 °C; IR (KBr) 1615 (C=N); ¹H-NMR (DMSO-*d*₆) δ: 9.92 (s, 1H, H-9), 8.65 (s, 1H, CH=N), 8.00 (s, 1H, H-6), 7.87 (m, 2H, H-2' and H-6'), 7.56 (m, 3H, H-3', H-4' and H-5'), 7.32 (d, 1H, *J*_{H-2 H-3} = 4.40 Hz, H-2), 7.02 (d, 1H, *J*_{H-3 H-2} = 4.40 Hz, H-3), 3.71 (t, 2H, *J*_{CH₂ CH₂} = 6.84 Hz, CH₂), 2.40 (t, 2H, *J*_{CH₂ CH₂} = 6.84 Hz, CH₂), 2.18 (s, 6H, 2CH₃), 1.87 (qt, 2H, *J*_{CH₂ CH₂} = 6.84 Hz, CH₂); MS (EI) *m/z*: 426 (M⁺ + 1, 20), 356 (60), 312 (100), 207 (51), 149 (65). Anal. C₂₃H₂₂N₄Cl₂ (C, H, N).

5.1.66. *N'*-(4-Phenylpyrrolo[1,2-*a*]quinoxalin-1-ylmethylene)-*N,N*-dimethylethane-1,2-diamine 23a

Beige crystals (88%): m.p. 74 °C; IR (KBr) 1635 (C=N); ¹H-NMR (DMSO-*d*₆) δ: 8.88 (s, 1H, CH=N), 8.57 (dd, 1H, *J*_{H-9 H-8} = 7.80 Hz, *J*_{H-9 H-7} = 1.96 Hz, H-9), 7.94 (m, 3H, H-2', H-6' and H-6), 7.54 (m, 5H, H-3', H-4', H-5', H-7 and H-8), 7.26 (d, 1H, *J*_{H-2 H-3} = 4.40 Hz, H-2), 6.99 (d, 1H, *J*_{H-3 H-2} = 4.40 Hz, H-3), 3.78 (t, 2H, *J*_{CH₂ CH₂} = 6.84 Hz, CH₂), 2.61 (t, 2H, *J*_{CH₂ CH₂} = 6.84 Hz, CH₂), 2.28 (s, 6H, 2CH₃). Anal. C₂₂H₂₂N₄ (C, H, N).

5.1.67. *N'*-(7-Chloro-4-phenylpyrrolo[1,2-*a*]quinoxalin-1-ylmethylene)-*N,N*-dimethylethane-1,2-diamine 23b

Orange crystals (98%): m.p. 93 °C; IR (KBr) 1615 (C=N); ¹H-NMR (DMSO-*d*₆) δ: 8.79 (s, 1H, CH=N), 8.77 (d, 1H, *J*_{H-9 H-8} = 8.80 Hz, H-9), 7.89 (m, 3H, H-2', H-6' and H-6), 7.57 (m, 3H, H-3', H-4' and H-5'), 7.50 (dd, 1H, *J*_{H-8 H-9} = 8.80 Hz, *J*_{H-8 H-6} = 2.44 Hz, H-8), 7.27 (d, 1H, *J*_{H-2 H-3} = 4.40 Hz, H-2), 7.00 (d, 1H, *J*_{H-3 H-2} = 4.40 Hz, H-3), 3.77 (t, 2H, *J*_{CH₂ CH₂} = 6.35 Hz, CH₂), 2.60 (t, 2H, *J*_{CH₂ CH₂} = 6.35 Hz, CH₂), 2.26 (s, 6H, 2CH₃). Anal. C₂₂H₂₁ClN₄ (C, H, N).

5.1.68. *N'*-(7,8-Dichloro-4-phenylpyrrolo[1,2-*a*]quinoxalin-1-ylmethylene)-*N,N*-dimethyl-ethane-1,2-diamine 23c

Orange crystals (94%): m.p. 95 °C; IR (KBr) 1635 (C=N); ¹H-NMR (DMSO-*d*₆) δ: 9.79 (s, 1H, CH=N), 8.73 (s, 1H, H-9), 8.07 (s, 1H, H-6), 7.90 (m, 2H, H-2' and H-6'), 7.58 (m, 3H, H-3', H-4' and H-5'), 7.36 (d, 1H, *J*_{H-2 H-3} = 4.0 Hz, H-2), 7.07 (d, 1H, *J*_{H-3 H-2} = 4.0 Hz, H-3), 3.80 (t, 2H, *J*_{CH₂ CH₂} = 6.1 Hz, CH₂), 2.68 (t, 2H, *J*_{CH₂ CH₂} = 6.1 Hz, CH₂), 2.27 (s, 6H, 2CH₃). Anal. C₂₂H₂₀Cl₂N₄ (C, H, N).

5.1.69. *N'*-(4-Styrylpyrrolo[1,2-*a*]quinoxalin-1-ylmethylene)-*N,N*-dimethylpropane-1,3-diamine 24a

Brown oil (85%): IR (KBr) 1625 (C=N); ¹H-NMR (DMSO-*d*₆) δ: 8.91 (s, 1H, CH=N), 8.62 (m, 1H, H-9), 8.07 (d, 1H, *J*_{H-trans H-trans} = 15.70 Hz, CH=), 7.91 (m, 1H, H-6), 7.84 (d, 1H, *J*_{H-trans H-trans} = 15.70 Hz, CH=), 7.45 (m, 4H, H-7, H-8, H-2' and H-6'), 7.27 (m, 4H, H-2, H-3', H-4' and H-5'), 7.11 (d, 1H, *J*_{H-3 H-2} = 4.15 Hz, H-3), 3.25 (t, 2H, *J*_{CH₂ CH₂} = 6.85 Hz, CH₂), 2.31 (t, 2H, *J*_{CH₂ CH₂} = 6.85 Hz, CH₂), 2.15 (s, 6H, 2CH₃), 1.81 (qt, 2H, *J*_{CH₂ CH₂} = 6.85 Hz, CH₂). Anal. C₂₅H₂₆N₄ (C, H, N).

5.1.70. *N'*-(7,8-Dichloro-4-styrylpyrrolo[1,2-*a*]quinoxalin-1-ylmethylene)-*N,N*-dimethylpropane-1,3-diamine 24c

Orange oil (85%): IR (KBr) 1630 (C=N); ¹H-NMR (DMSO-*d*₆) δ: 9.05 (s, 1H, CH=N), 8.52 (s, 1H, H-9), 7.90 (d, 1H, *J*_{H-trans H-trans} = 15.65 Hz, CH=), 7.86 (s, 1H, H-6), 7.78 (m, 2H, H-2' and H-6'), 7.61 (d, 1H, *J*_{H-trans H-trans} = 15.65 Hz, CH=), 7.43 (m, 3H, H-3', H-4' and H-5'), 7.17 (d, 1H, *J*_{H-2 H-3} = 4.0 Hz, H-2), 7.06 (d, 1H, *J*_{H-3 H-2} = 4.0 Hz, H-3), 3.66 (t, 2H, *J*_{CH₂ CH₂} = 6.90 Hz, CH₂), 2.43 (t, 2H, *J*_{CH₂ CH₂} = 6.90 Hz, CH₂), 2.20 (s, 6H, 2CH₃), 1.86 (qt, 2H, *J*_{CH₂ CH₂} = 6.90 Hz, CH₂). Anal. C₂₅H₂₄Cl₂N₄ (C, H, N).

5.1.71. *N'*-(4-Phenylpyrrolo[1,2-*a*]quinoxalin-2-ylmethylene)-*N,N*-dimethylpropane-1,3-diamine 36a

Orange oil (95%): IR (KBr) 1640 (C=N); ¹H-NMR (DMSO-*d*₆) δ: 8.80 (s, 1H, H-1), 8.39 (s, 1H, CH=N), 8.30 (d, 1H, *J*_{H-9 H-8} = 7.86 Hz, H-9), 7.95 (m, 2H, H-2' and H-6'), 7.89 (d, 1H, *J*_{H-6 H-7} = 7.86 Hz, H-6), 7.56 (m, 4H, H-3', H-4', H-5' and H-8), 7.48 (m, 1H, H-7), 7.18 (s, 1H, H-3), 3.52 (t, 2H, *J*_{CH₂ CH₂} = 7.03 Hz, CH₂), 2.20 (t, 2H, *J*_{CH₂ CH₂} = 7.03 Hz, CH₂), 2.08 (s, 6H, 3CH₃), 1.69 (qt, 2H, *J*_{CH₂ CH₂} = 7.03 Hz, CH₂); ¹³C-NMR (DMSO-*d*₆) δ: 154.7 (C-4), 153.3 (CH=N), 137.4 (C-5a), 135.5 (C-1'), 130.0 (C-9a), 129.5 (C-4'), 128.4 (C-2' and C-6'), 128.2 (C-3' and C-5'), 128.1 (C-8), 127.0 (C-7), 126.3 (C-6), 125.9 (C-9), 124.7 (C-1), 117.0 (C-3a), 114.8 (C-2), 106.5 (C-3), 58.8 (CH₂), 56.8 (CH₂), 45.1 (2CH₃), 28.5 (CH₂). Anal. C₂₃H₂₄N₄ (C, H, N).

5.1.72. *N'*-(7,8-Dichloro-4-phenylpyrrolo[1,2-*a*]quinoxalin-2-ylmethylene)-*N,N*-dimethylpropane-1,3-diamine 36b

Orange oil (96%): IR (KBr) 1630 (C=N); ¹H-NMR (DMSO-*d*₆) δ: 8.77 (d, 1H, *J*_{H-1 H-3} = 1.0 Hz, H-1), 8.59 (s, 1H, H-9), 8.30 (s, 1H, CH=N), 7.95 (s, 1H, H-6), 7.91 (dd, 2H, *J*_{H-2' H-3'} = *J*_{H-6' H-5'} = 7.70 Hz, *J*_{H-2' H-4'} = *J*_{H-5' H-4'} = 1.40 Hz, H-2' and H-6'), 7.58 (m, 3H, H-3', H-4' and H-5'), 7.13 (d, 1H, *J*_{H-3 H-1} = 1.0 Hz, H-3), 3.53 (t, 2H, *J*_{CH₂ CH₂} = 7.0 Hz, CH₂), 2.26 (t, 2H, *J*_{CH₂ CH₂} = 7.0 Hz, CH₂), 2.14 (s, 6H, 2CH₃), 1.73 (qt, 2H, *J*_{CH₂ CH₂} = 7.0 Hz, CH₂); ¹³C-NMR (DMSO-*d*₆) δ: 154.6 (C-4), 154.2 (CH=N), 136.8 (C-5a), 135.1 (C-1'), 130.3 (C-9a), 130.0 (C-8), 129.8 (C-7), 128.5 (C-2' and C-6'), 128.4 (C-3' and C-5'), 127.8 (C-4'), 127.4 (C-6), 125.8 (C-9), 124.3 (C-1), 118.1 (C-3a), 116.7 (C-2), 107.5 (C-3), 58.8 (CH₂), 56.9 (CH₂), 45.1 (2CH₃), 28.4 (CH₂). Anal. C₂₃H₂₂N₄Cl₂ (C, H, N).

5.1.73. General procedure for the preparation of *N'*-(4-arylpyrrolo[1,2-*a*]quinoxalin-1- or -2-ylmethyl)-*N,N*-dimethylalkyldiamines 25a-c, 26a-c, 27a-c and 37a-b

To a solution of *N'*-(4-arylpyrrolo[1,2-*a*]quinoxalin-1- or -2-ylmethylene)-*N,N*-dimethylalkyldiamines **22**, **23**, **24** or **36** (0.008 mol) in methanol (50 mL) was added portion-wise at 0 °C sodium borohydride (0.016 mol). The reaction mixture was then heated under reflux for 4 h and then evaporated to dryness under reduced pressure. After cooling, the residue was triturated in water and extracted with methylene chloride (100 mL). The organic layer was washed with water (80 mL), dried over calcium chloride and evaporated to dryness. Solids were recrystallized from hexane; oils were used without further purification.

5.1.74. *N'*-(4-Phenylpyrrolo[1,2-*a*]quinoxalin-1-ylmethyl)-*N,N*-dimethylpropane-1,3-diamine 25a

Orange oil (81%): IR (KBr) 3230 (NH); ¹H-NMR (DMSO-*d*₆) δ: 8.60 (m, 1H, H-9), 7.93 (m, 3H, H-2', H-6' and H-6), 7.54 (m, 5H, H-3', H-4', H-5', H-7 and H-8), 6.89 (d, 1H, *J*_{H-2 H-3} = 4.40 Hz, H-2), 6.83 (d, 1H, *J*_{H-3 H-2} = 4.40 Hz, H-3), 4.20 (s, 2H, CH₂), 2.82 (bs, 1H, NH), 2.68 (t, 2H, *J*_{CH₂ CH₂} =

6.84 Hz, CH₂), 2.25 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.84 Hz, CH₂), 2.09 (s, 6H, 2CH₃), 1.59 (qt, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.84 Hz, CH₂). Anal. C₂₃H₂₆N₄ (C, H, N).

5.1.75. *N'-(7-Chloro-4-phenylpyrrolo[1,2-a]quinoxalin-1-ylmethyl)-N,N-dimethylpropane-1,3-diamine 25b*

Yellow oil (97%): IR (KBr) 3285 (NH); ¹H-NMR (DMSO-*d*₆) δ: 8.56 (d, 1H, $J_{\text{H-9 H-8}}$ = 8.79 Hz, H-9), 7.90 (m, 2H, H-2' and H-6'), 7.84 (d, 1H, $J_{\text{H-6 H-8}}$ = 2.44 Hz, H-6), 7.56 (m, 3H, H-3', H-4' and H-5'), 7.47 (dd, 1H, $J_{\text{H-8 H-9}}$ = 8.79 Hz, $J_{\text{H-8 H-6}}$ = 2.44 Hz, H-8), 6.90 (d, 1H, $J_{\text{H-2 H-3}}$ = 3.91 Hz, H-2), 6.83 (d, 1H, $J_{\text{H-3 H-2}}$ = 3.91 Hz, H-3), 4.12 (s, 2H, CH₂), 3.06 (s, 1H, NH), 2.64 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.84 Hz, CH₂), 2.23 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.84 Hz, CH₂), 2.08 (s, 6H, 2CH₃), 1.57 (qt, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.84 Hz, CH₂); ¹³C-NMR (DMSO-*d*₆) δ: 154.3 (C-4), 137.8 (C-5a), 137.5 (C-1'), 132.7 (C-9a), 129.9 (C-7), 128.8 (C-1), 128.4 (C-3' and C-5'), 128.0 (C-2' and C-6'), 127.1 (C-4'), 126.6 (C-8), 126.2 (C-6), 125.7 (C-9), 119.7 (C-3a), 116.5 (C-2), 108.2 (C-3), 57.3 (CH₂), 54.8 (CH₂), 47.0 (CH₂), 45.1 (2CH₃), 27.2 (CH₂). Anal. C₂₃H₂₅ClN₄ (C, H, N).

5.1.76. *N'-(7,8-Dichloro-4-phenylpyrrolo[1,2-a]quinoxalin-1-ylmethyl)-N,N-dimethylpropane-1,3-diamine 25c*

Yellow crystals (89%): m.p. 120 °C; IR (KBr) 3240 (NH); ¹H-NMR (DMSO-*d*₆) δ: 8.89 (s, 1H, H-9), 7.95 (s, 1H, H-6), 7.87 (m, 2H, H-2' and H-6'), 7.54 (m, 3H, H-3', H-4' and H-5'), 6.91 (d, 1H, $J_{\text{H-2 H-3}}$ = 4.05 Hz, H-2), 6.85 (d, 1H, $J_{\text{H-3 H-2}}$ = 4.05 Hz, H-3), 4.03 (s, 2H, CH₂), 3.32 (s, 1H, NH), 2.62 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 7.01 Hz, CH₂), 2.32 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 7.01 Hz, CH₂), 2.11 (s, 6H, 2CH₃), 1.59 (qt, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 7.01 Hz, CH₂); ¹³C-NMR (DMSO-*d*₆) δ: 154.5 (C-4), 137.1 (C-5a), 136.3 (C-1'), 132.6 (C-9a), 129.8 (C-8), 129.1 (C-7), 128.4 (C-2' and C-6'), 128.2 (C-3' and C-5'), 126.9 (C-1), 126.8 (C-4'), 125.5 (C-9), 120.1 (C-6), 119.8 (C-3a), 117.1 (C-2), 108.6 (C-3), 56.9 (CH₂), 46.7 (CH₂), 46.6 (CH₂), 44.4 (2CH₃), 26.5 (CH₂); MS (EI) *m/z*: 427 (M⁺, 12), 326 (23), 281 (15), 207 (31), 149 (16), 85 (35), 58 (100). Anal. C₂₃H₂₄Cl₂N₄ (C, H, N).

5.1.77. *N'-(4-Phenylpyrrolo[1,2-a]quinoxalin-1-ylmethyl)-N,N-dimethylethane-1,2-diamine 26a*

Orange oil (95%): IR (KBr) 3290 (NH); ¹H-NMR (DMSO-*d*₆) δ: 8.59 (d, 1H, $J_{\text{H-9 H-8}}$ = 7.81 Hz, H-9), 7.93 (m, 3H, H-2', H-6' and H-6), 7.51 (m, 5H, H-3', H-4', H-5', H-7 and H-8), 6.89 (d, 1H, $J_{\text{H-2 H-3}}$ = 4.20 Hz, H-2), 6.85 (d, 1H, $J_{\text{H-3 H-2}}$ = 4.20 Hz, H-3), 4.26 (s, 2H, CH₂), 2.88 (bs, 1H, NH), 2.75 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.35 Hz, CH₂), 2.39 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.35 Hz, CH₂), 2.16 (s, 6H, 2CH₃). Anal. C₂₂H₂₄N₄ (C, H, N).

5.1.78. *N'-(7-Chloro-4-phenylpyrrolo[1,2-a]quinoxalin-1-ylmethyl)-N,N-dimethylethane-1,2-diamine 26b*

Orange oil (95%): IR (KBr) 3290 (NH); ¹H-NMR (DMSO-*d*₆) δ: 8.58 (d, 1H, $J_{\text{H-9 H-8}}$ = 8.79 Hz, H-9), 7.90 (m, 2H, H-2' and H-6'), 7.85 (d, 1H, $J_{\text{H-6 H-8}}$ = 2.44 Hz, H-6), 7.56 (m, 3H, H-3', H-4' and H-5'), 7.47 (dd, 1H, $J_{\text{H-8 H-9}}$ = 8.79 Hz, $J_{\text{H-8 H-6}}$ = 2.44 Hz, H-8), 6.90 (d, 1H, $J_{\text{H-2 H-3}}$ = 4.40 Hz, H-2), 6.83 (d, 1H, $J_{\text{H-3 H-2}}$ = 4.40 Hz, H-3), 4.18 (s, 2H, CH₂), 2.71 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.34 Hz, CH₂), 2.35 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.34 Hz, CH₂), 2.20 (bs, 1H, NH), 2.14 (s, 6H, 2CH₃). Anal. C₂₂H₂₃ClN₄ (C, H, N).

5.1.79. *N'-(7,8-Dichloro-4-phenylpyrrolo[1,2-a]quinoxalin-1-ylmethyl)-N,N-dimethylethane-1,2-diamine 26c*

Yellow crystals (97%): m.p. 81 °C; IR (KBr) 3280 (NH); ¹H-NMR (DMSO-*d*₆) δ: 8.88 (s, 1H, H-9), 7.94 (s, 1H, H-6), 7.88 (m, 2H, H-2' and H-6'), 7.54 (m, 3H, H-3', H-4' and H-5'), 6.90 (d, 1H, $J_{\text{H-2 H-3}}$ = 3.98 Hz, H-2), 6.83 (d, 1H, $J_{\text{H-3 H-2}}$ =

3.98 Hz, H-3), 4.13 (s, 2H, CH₂), 3.15 (s, 1H, NH), 2.75 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.40 Hz, CH₂), 2.41 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.40 Hz, CH₂), 2.16 (s, 6H, 2CH₃); ¹³C-NMR (DMSO-*d*₆) δ: 154.8 (C-4), 137.4 (C-5a), 136.7 (C-1'), 132.9 (C-9a), 130.0 (C-8), 129.4 (C-7), 128.7 (C-4'), 128.5 (C-2' and C-6'), 128.3 (C-3' and C-5'), 127.2 (C-6), 127.1 (C-9), 125.9 (C-1), 120.0 (C-3a), 117.2 (C-3), 108.8 (C-2), 58.8 (CH₂), 46.9 (CH₂), 46.5 (CH₂), 45.2 (2CH₃). Anal. C₂₂H₂₂Cl₂N₄ (C, H, N).

5.1.80. *N'-(4-Styrylpyrrolo[1,2-a]quinoxalin-1-ylmethyl)-N,N-dimethylpropane-1,3-diamine 27a*

Brown oil (87%): IR (KBr) 3280 (NH); ¹H-NMR (DMSO-*d*₆) δ: 8.49 (m, 1H, H-9), 7.93 (d, 1H, $J_{\text{H-trans H-trans}}$ = 15.75 Hz, CH=), 7.84 (m, 1H, H-6), 7.77 (d, 1H, $J_{\text{H-trans H-trans}}$ = 15.75 Hz, CH=), 7.43 (m, 4H, H-7, H-8, H-2' and H-6'), 7.28 (m, 3H, H-3', H-4' and H-5'), 6.95 (d, 1H, $J_{\text{H-2 H-3}}$ = 4.10 Hz, H-2), 6.77 (d, 1H, $J_{\text{H-3 H-2}}$ = 4.10 Hz, H-3), 4.23 (s, 2H, CH₂), 3.16 (bs, 1H, NH), 2.60 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.85 Hz, CH₂), 2.24 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.85 Hz, CH₂), 2.06 (s, 6H, 2CH₃), 1.90 (qt, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.85 Hz, 2H, CH₂). Anal. C₂₅H₂₈N₄ (C, H, N).

5.1.81. *N'-(7,8-Dichloro-4-styrylpyrrolo[1,2-a]quinoxalin-1-ylmethyl)-N,N-dimethylpropane-1,3-diamine 27c*

Orange oil (76%): IR (KBr) 3290 (NH); ¹H-NMR (CDCl₃) δ: 8.78 (s, 1H, H-9), 7.95 (s, 1H, H-6), 7.93 (d, 1H, $J_{\text{H-trans H-trans}}$ = 15.80 Hz, CH=), 7.46 (m, 2H, H-2' and H-6'), 7.40 (d, 1H, $J_{\text{H-trans H-trans}}$ = 15.80 Hz, CH=), 7.32 (m, 3H, H-3', H-4' and H-5'), 6.78 (d, 1H, $J_{\text{H-2 H-3}}$ = 3.90 Hz, H-2), 6.67 (d, 1H, $J_{\text{H-3 H-2}}$ = 3.90 Hz, H-3), 4.14 (s, 2H, CH₂), 2.85 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.60 Hz, CH₂), 2.45 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.60 Hz, CH₂), 2.21 (s, 6H, 2CH₃), 1.76 (qt, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.60 Hz, CH₂). MS (EI) *m/z*: 454 (M⁺ + 1, 22), 453 (M⁺, 35), 352 (55), 265 (24), 202 (54), 140 (35), 91 (51), 85 (100), 59 (93). Anal. C₂₅H₂₆Cl₂N₄ (C, H, N).

5.1.82. *N'-(4-Phenylpyrrolo[1,2-a]quinoxalin-2-ylmethyl)-N,N-dimethylpropane-1,3-diamine 37a*

Yellow oil (92%): IR (KBr) 3260 (NH); ¹H-NMR (DMSO-*d*₆) δ: 8.45 (s, 1H, H-1), 8.21 (d, 1H, $J_{\text{H-9 H-8}}$ = 7.76 Hz, H-9), 7.98 (m, 2H, H-2' and H-6'), 7.91 (d, 1H, $J_{\text{H-6 H-7}}$ = 7.76 Hz, H-6), 7.58 (m, 4H, H-3', H-4', H-5' and H-8), 7.47 (t, 1H, $J_{\text{H-7 H-8}}$ = $J_{\text{H-7 H-6}}$ = 7.76 Hz, H-7), 7.02 (s, 1H, H-3), 3.88 (s, 2H, CH₂), 3.70 (bs, 1H, NH), 2.62 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.96 Hz, CH₂), 2.25 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.96 Hz, CH₂), 2.09 (s, 6H, 2CH₃), 1.59 (qt, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 6.96 Hz, CH₂); ¹³C-NMR (DMSO-*d*₆) δ: 152.7 (C-4), 137.9 (C-5a), 135.4 (C-1'), 129.9 (C-9a), 129.5 (C-4'), 128.5 (C-2' and C-6'), 128.3 (C-3' and C-5'), 128.2 (C-8), 127.8 (C-7), 126.5 (C-6), 125.2 (C-9), 124.1 (C-2), 115.0 (C-3a), 114.4 (C-1), 108.2 (C-3), 57.2 (CH₂), 46.8 (CH₂), 45.5 (CH₂), 45.0 (2CH₃), 26.7 (CH₂). Anal. C₂₃H₂₆N₄ (C, H, N).

5.1.83. *N'-(7,8-Dichloro-4-phenylpyrrolo[1,2-a]quinoxalin-2-ylmethyl)-N,N-dimethylpropane-1,3-diamine 37b*

Yellow crystals (81%): m.p. 56 °C; IR (KBr) 3440 (NH); ¹H-NMR (DMSO-*d*₆) δ: 8.52 (s, 1H, H-9), 8.48 (s, 1H, H-1), 8.03 (s, 1H, H-6), 7.97 (m, 2H, H-2' and H-6'), 7.57 (m, 3H, H-3', H-4' and H-5'), 7.07 (s, 1H, H-3), 3.89 (s, 2H, CH₂), 3.21 (s, 1H, NH), 2.67 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 7.10 Hz, CH₂), 2.32 (t, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 7.10 Hz, CH₂), 2.15 (s, 6H, 2CH₃), 1.64 (qt, 2H, $J_{\text{CH}_2\text{CH}_2}$ = 7.10 Hz, CH₂); ¹³C-NMR (DMSO-*d*₆) δ: 154.0 (C-4), 137.1 (C-5a), 135.0 (C-1'), 130.2 (C-9a), 129.9 (C-8), 129.5 (C-7), 128.5 (C-2' and C-6'), 128.4 (C-3' and C-5'), 127.1 (C-4'), 126.7 (C-6), 125.8 (C-9), 123.8 (C-2), 116.7 (C-3a), 116.2 (C-1), 109.6 (C-3), 56.7 (CH₂), 46.2 (CH₂), 44.7 (2CH₃), 44.6 (CH₂), 25.5 (CH₂); MS (EI) *m/z*: 429 (M⁺ + 2, 16), 428 (M⁺ + 1, 27), 427 (M⁺, 73), 380 (22), 354 (30), 325 (100), 285 (66), 250 (24), 101 (58). Anal. C₂₃H₂₄Cl₂N₄ (C, H, N).

5.1.84. General procedure for the preparation of 4-phenylpyrrolo[1,2-a]quinoxaline-2-carbaldehydes **31a,b**

To a solution of (4-phenylpyrrolo[1,2-a]quinoxalin-2-yl)-methanol **35** (0.008 mol) in chloroform (180 mL), was added manganese dioxide (0.08 mol). The reaction mixture was then refluxed for 12 h. The black solid was removed and washed with chloroform (2 x 50 mL). The filtrate and washings were combined, dried and evaporated to dryness under reduced pressure. The residue was chromatographed on a silica-gel column eluting with ethyl acetate/petroleum ether (50:50).

5.1.85. 4-Phenylpyrrolo[1,2-a]quinoxaline-2-carbaldehyde **31a**

White crystals (38%): m.p. 181 °C; IR (KBr) 1670 (CO); ¹H-NMR (DMSO-*d*₆) δ: 10.08 (s, 1H, CHO), 9.16 (d, 1H, *J*_{H-1 H-3} = 1.20 Hz, H-1), 8.38 (dd, 1H, *J*_{H-9 H-8} = 8.17 Hz, *J*_{H-9 H-7} = 1.37 Hz, H-9), 7.97 (m, 2H, H-2' and H-6'), 7.93 (dd, 1H, *J*_{H-6 H-7} = 8.17 Hz, *J*_{H-6 H-8} = 1.37 Hz, H-6), 7.63 (m, 1H, H-8), 7.59 (m, 3H, H-3', H-4' and H-5'), 7.56 (m, 1H, H-7), 7.33 (d, 1H, *J*_{H-3 H-1} = 1.20 Hz, H-3); ¹³C-NMR (DMSO-*d*₆) δ: 187.1 (CO), 154.2 (C-4), 137.1 (C-5a), 135.9 (C-1'), 130.3 (C-9a), 129.8 (C-4'), 128.6 (C-2' and C-6'), 128.5 (C-8), 128.4 (C-3' and C-5'), 128.3 (C-7), 126.9 (C-6), 126.2 (C-9), 125.3 (C-1), 120.9 (C-3a), 115.2 (C-2), 107.4 (C-3). Anal. C₁₈H₁₂N₂O (C, H, N).

5.1.86. 7,8-Dichloro-4-phenylpyrrolo[1,2-a]quinoxaline-2-carbaldehyde **31b**

White crystals (62%): m.p. > 260 °C; IR (KBr) 1690 (CO); ¹H-NMR (DMSO-*d*₆) δ: 10.10 (s, 1H, CHO), 9.09 (d, 1H, *J*_{H-1 H-3} = 1.40 Hz, H-1), 8.65 (s, 1H, H-9), 8.04 (s, 1H, H-6), 7.96 (m, 2H, H-2' and H-6'), 7.57 (m, 3H, H-3', H-4' and H-5'), 7.34 (d, 1H, *J*_{H-3 H-1} = 1.40 Hz, H-3); MS (EI) *m/z*: 343 (M⁺ + 2, 14), 342 (M⁺ + 1, 50), 341 (M⁺, 31), 340 (75), 311 (55), 213 (52), 207 (60), 133 (100), 96 (18). Anal. C₁₈H₁₀Cl₂N₂O (C, H, N).

5.1.87. General procedure for the preparation of 2-methyl-3-phenylquinoxalines **33a,b**

To a solution of 1-phenyl-1,2-propanedione (0.08 mol) in acetic acid (80 mL) cooled at 0 °C, was added 1,2-phenylenediamine **32** (0.08 mol). The reaction mixture was then refluxed for 1 h, then cooled and poured into water (150 mL). The precipitate was filtered, washed with water and dissolved in methylene chloride (100 mL). The organic layer was washed with water (85 mL), dried over calcium chloride and evaporated to dryness under reduced pressure. The precipitate was then recrystallized from ethanol.

5.1.88. 6,7-Dichloro-2-methyl-3-phenylquinoxaline **33b**

Beige crystals (75%): m.p. 161 °C; ¹H-NMR (DMSO-*d*₆) δ: 8.19 (s, 1H, H-8), 8.16 (s, 1H, H-5), 7.68 (m, 2H, H-2' and H-6'), 7.52 (m, 3H, H-3', H-4' and H-5'), 2.67 (s, 3H, CH₃); ¹³C-NMR (DMSO-*d*₆) δ: 155.7 (C-3), 154.2 (C-2), 139.5 (C-4a), 139.3 (C-8a), 138.1 (C-1'), 132.5 (C-7), 132.1 (C-6), 129.6 (C-5), 129.5 (C-8), 129.1 (C-4'), 128.9 (C-3' and C-5'), 128.2 (C-2' and C-6'), 24.0 (CH₃); MS (EI) *m/z*: 291 (M⁺ + 2, 8), 290 (M⁺ + 1, 18), 289 (M⁺, 43), 288 (75), 286 (100), 185 (16), 144 (29), 109 (13). Anal. C₁₅H₁₀Cl₂N₂ (C, H, N).

5.1.89. General procedure for the preparation of ethyl 4-phenylpyrrolo[1,2-a]quinoxaline-2-carboxylates **34a,b**

To a solution of 2-methyl-3-phenylquinoxaline **33** (0.03 mol) in dry ethanol (100 mL), was added ethyl bromopyruvate (0.0405 mol). The mixture was refluxed for 20 h. After filtration the solid was suspended in water, made alkaline with sodium hydrogen carbonate and extracted with methylene chlo-

ride. After drying, the organic layers were evaporated to give **34a,b** which were recrystallized from ethyl acetate.

5.1.90. Ethyl 4-phenylpyrrolo[1,2-a]quinoxaline-2-carboxylate **34a**

White crystals (36%): m.p. 210 °C; IR (KBr) 1700 (CO); ¹H-NMR (DMSO-*d*₆) δ: 8.91 (d, 1H, *J*_{H-1 H-3} = 1.50 Hz, H-1), 8.38 (dd, 1H, *J*_{H-9 H-8} = 7.74 Hz, *J*_{H-9 H-7} = 1.47 Hz, H-9), 7.96 (m, 2H, H-2' and H-6'), 7.93 (dd, 1H, *J*_{H-6 H-7} = 7.74 Hz, *J*_{H-6 H-8} = 1.47 Hz, H-6), 7.57 (m, 5H, H-3', H-4', H-5', H-7 and H-8), 7.22 (d, 1H, *J*_{H-3 H-1} = 1.50 Hz, H-3), 4.34 (q, 2H, *J*_{CH₂ CH₃} = 7.04 Hz, CH₂), 1.35 (t, 3H, *J*_{CH₃ CH₂} = 7.04 Hz, CH₃); ¹³C-NMR (DMSO-*d*₆) δ: 162.8 (CO), 153.3 (C-4), 136.9 (C-5a), 135.5 (C-1'), 129.5 (C-9a), 129.2 (C-4'), 128.0 (C-2' and C-6'), 127.8 (C-3' and C-5'), 127.7 (C-8), 126.0 (C-7), 125.7 (C-6), 124.3 (C-9), 119.7 (C-1), 118.6 (C-3a), 114.6 (C-2), 108.0 (C-3), 59.5 (CH₂), 13.7 (CH₃). Anal. C₂₀H₁₆N₂O₂ (C, H, N).

5.1.91. Ethyl 7,8-dichloro-4-phenylpyrrolo[1,2-a]quinoxaline-2-carboxylate **34b**

White crystals (19%): m.p. 232 °C; IR (KBr) 1710 (CO); ¹H-NMR (DMSO-*d*₆) δ: 9.04 (d, 1H, *J*_{H-1 H-3} = 1.30 Hz, H-1), 8.79 (s, 1H, H-9), 8.06 (s, 1H, H-6), 7.95 (m, 2H, H-2' and H-6'), 7.58 (m, 3H, H-3', H-4' and H-5'), 7.23 (d, 1H, *J*_{H-3 H-1} = 1.30 Hz, H-3), 4.33 (q, 2H, *J*_{CH₂ CH₃} = 7.10 Hz, CH₂), 1.34 (t, 3H, *J*_{CH₃ CH₂} = 7.10 Hz, CH₃); MS (EI) *m/z*: 387 (M⁺ + 2, 15), 386 (M⁺ + 1, 21), 385 (M⁺, 71), 383 (100), 354 (34), 310 (45), 286 (31), 213 (50), 133 (71). Anal. C₂₀H₁₄Cl₂N₂O₂ (C, H, N).

5.1.92. General procedure for the preparation of (4-phenylpyrrolo[1,2-a]quinoxalin-2-yl)-methanols **35a,b**

To a suspension of lithium aluminium hydride (0.018 mol) in tetrahydrofuran (130 mL) cooled at 0 °C, was added under nitrogen ethyl 4-phenylpyrrolo[1,2-a]quinoxaline-2-carboxylate **34** (0.006 mol). The reaction mixture was then stirred at 0–5 °C during 2 h, then water was added dropwise and cautiously for decomposition of excess hydride. The precipitate was filtered and washed with tetrahydrofuran. The filtrate was then dried over calcium chloride and evaporated to dryness. The residue was triturated in ethyl acetate and the precipitate was filtered and recrystallized from chloroform.

5.1.93. (4-Phenylpyrrolo[1,2-a]quinoxalin-2-yl)methanol **35a**

Yellow crystals (43%): m.p. 146 °C; IR (KBr) 3260 (OH); ¹H-NMR (DMSO-*d*₆) δ: 8.43 (s, 1H, H-1), 8.25 (d, 1H, *J*_{H-9 H-8} = 7.72 Hz, H-9), 7.97 (m, 2H, H-2' and H-6'), 7.91 (d, 1H, *J*_{H-6 H-7} = 7.72 Hz, H-6), 7.57 (m, 4H, H-3', H-4', H-5' and H-8), 7.47 (t, 1H, *J*_{H-7 H-8} = *J*_{H-7 H-6} = 7.72 Hz, H-7), 6.96 (s, 1H, H-3), 5.13 (t, 1H, *J*_{OH CH₂} = 5.53 Hz, OH), 4.65 (d, 2H, *J*_{CH₂ OH} = 5.53 Hz, CH₂); ¹³C-NMR (DMSO-*d*₆) δ: 152.9 (C-4), 137.9 (C-5a), 135.4 (C-1'), 131.3 (C-9a), 129.9 (C-4'), 129.5 (C-8), 128.5 (C-2' and C-6'), 128.3 (C-3' and C-5'), 127.8 (C-7), 126.6 (C-6), 125.2 (C-9), 124.1 (C-2), 114.5 (C-3a), 114.1 (C-1), 107.2 (C-3), 56.8 (CH₂). Anal. C₁₈H₁₄N₂O (C, H, N).

5.1.94. (7,8-Dichloro-4-phenylpyrrolo[1,2-a]quinoxalin-2-yl)-methanol **35b**

Yellow crystals (70%): m.p. 188 °C; IR (KBr) 3390 (OH); ¹H-NMR (DMSO-*d*₆) δ: 8.64 (s, 1H, H-9), 8.50 (d, 1H, *J*_{H-1 H-3} = 1.0 Hz, H-1), 8.05 (s, 1H, H-6), 7.93 (m, 2H, H-2' and H-6'), 7.56 (m, 3H, H-3', H-4' and H-5'), 6.98 (d, 1H, *J*_{H-3 H-1} = 1.0 Hz, H-3), 5.19 (t, 1H, *J*_{OH CH₂} = 5.50 Hz, OH), 4.61 (d, 2H, *J*_{CH₂ OH} = 5.50 Hz, CH₂); ¹³C-NMR (DMSO-*d*₆) δ: 154.2 (C-4), 137.2 (C-5a), 135.2 (C-1'), 132.1 (C-9a), 130.3 (C-8), 130.0 (C-7), 129.6 (C-4'), 128.6 (C-2' and C-6'), 128.4 (C-3' and C-5'), 127.1 (C-6), 126.2 (C-9), 123.9 (C-2), 116.5 (C-3a), 115.6

(C-1), 108.4 (C-3), 56.7 (CH₂); MS (EI) *m/z*: 345 (M⁺ + 2, 12), 344 (M⁺ + 1, 18), 343 (M⁺, 65), 341 (100), 324 (30), 310 (57), 287 (17), 144 (25). Anal. C₁₈H₁₂Cl₂N₂O (C, H, N).

5.2. *In vitro* pharmacology

5.2.1. Cell cultures

The rat beta cell line subcloned RIN T3 was cultured in DMEM-glucose 1 g/l medium with 10% foetal calf serum, 100 U/mL penicillin and 100 µg/mL streptomycin [45].

5.2.2. Membrane preparations

The RIN T3 cells membranes were prepared on sucrose gradient according to the method previously described [43].

The membranes of rat liver were prepared on sucrose gradient according to the method of Neville Jr up to step eleven [46].

5.2.3. Radioligand preparations

tGLP-1 (Peninsula, USA) and glucagon (Novo Nordisk, Denmark) were labelled with 125 iodine according to the method using the chloramine T and purified on HPLC column (µBondapak C 18).

5.2.4. Binding studies

Competition experiments with labelled tGLP-1 or glucagon were performed according to the method previously described [43].

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