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Studies of the reactions between indole-2,3-diones (isatins) and 2-aminobenzylamine

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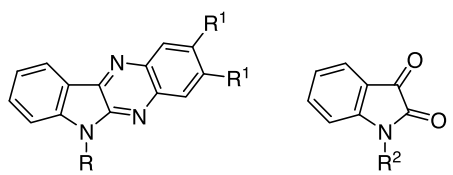
Abstract—Reflux of equimolecular amounts 2-aminobenzylamine and isatins in acetic acid produced indolo[3,2-*c*]quinolin-6-ones in good yields. A proposed mechanism involving initial formation of a spiro compound is given. This isolable intermediate subsequently rearranges via a sequential isocyanate ring opening and a cyclisation process to a urea derivative which finally cyclized to the indolo[3,2-*c*]quinolin-6-ones. The urea derivative could be prepared separately and cyclized selectively to indolo[3,2-*c*]quinolin-6-one. Reaction of N-acetylisatin with 2-aminobenzylamine at room temperature yielded the 1,4-benzodiazepinone 3-(2-acetamidophenyl)-1,5-dihydro-1,4-benzodiazepin-2-one whereas its isomer 2(2-acetamidophenyl)-4,5-dihydro-1,4-benzodiazepin-3-one was obtained from 2-(2-acetylaminophenyl)-*N*-(2-aminobenzyl)-2-oxoacetamide in acetic acid at room temperature.The previously unknown linear isomer of indolo[3,2-*c*]quinolin-6-one, i.e. indolo[2,3-*b*]quinolin-11-one, has been prepared by thermal (260°C) cyclization of methyl 2-phenylamino indole-3-carboxylate, which in turn was prepared in two steps from methyl indole-3-carboxylate.

1. Introduction

Several members of the tetracyclic ring system 6*H*-indolo-[2,3-*b*]quinoxaline (**1a**) (Fig. 1), first synthesized[1] in 1895 by Schunck and Marchlewski from isatin (indole-2,3-diones, **2a**) and *o*-phenylenediamine, have been intensely studied[2] because some derivatives with basic side-chains in the 6-position, such as 2,3-dimethyl-6-(2-dimethylaminoethyl)-6*H*-indolo[2,3-*b*]quinoxaline (**1b**), exhibit potent antiviral activity,[3] against e.g. HSV-1, CMV and VZV. Compound **1b** and its congeners have no effects on virus polymerases. It is believed rather to act via inhibition of the decapsidation process of the virus.[4] In this context the propensity of **1b** to reversibly intercalate with DNA might play a role.[5,6]



1a R=R^1=H
1b R=2-dimethylaminoethyl
R^1=CH$_3$

2a R^2=H
2b R^2=Ac

Figure 1.

In connection with efforts to synthesize analogues of **1b**, the interactions of various diamines with isatin and N-acetylisatin (**2b**) have been studied.[7] In this paper we report the outcome of reactions between 2-aminobenzylamine and isatin as well as between N-acetylisatin.

2. Results and discussion

The condensation between isatin and *o*-phenylenediamine can, depending on the solvent, give rise to three different products (**1a**, **3** or **4**).[8–10] In acidic solvents, like acetic acid, the linear product **1a** is the dominating product. The spiro compound **3** (Fig. 2) reportedly has been obtained in a high yield when the reaction was performed in *N*-methyl-2-pyrrolidone, whereas the ring-opened quinoxalinone **4** was the major product when THF or benzene was used as solvent. In some papers[8,9] compound **4**, with a carbonyl absorption at 1670 cm^{-1} in the IR spectrum,[10] incorrectly has been assigned the structure of **5a**, with a carbonyl band

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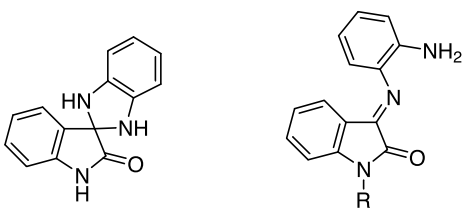


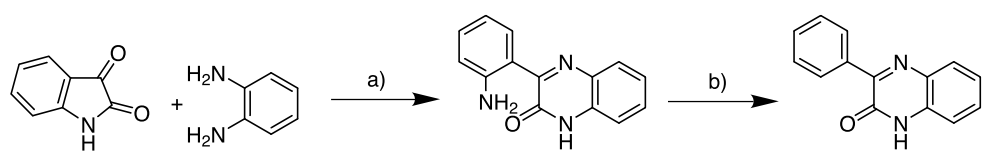
3 **5a** R=H **5b** R=Me

Figure 2.

expected around 1715 cm^{-1}. It is uncertain if **5a** has ever been described, although its *N*-methyl derivative (**5b**) seems to have been correctly assigned (ν_{CO}=1720 cm^{-1}).[10]

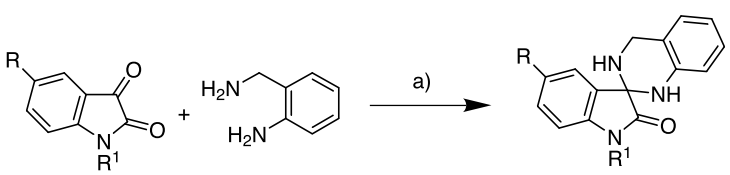
The literature methods for the synthesis of **4** are relatively complicated but it has now been found that treatment of an alkaline water solution of isatin with *o*-phenylenediamine at 60°C for 1 h followed by adjustment of the pH to ca. 5 gave **4** in high yield and purity. The quinoxalinone **4** could be diazotized and reduced with H_3PO_2 giving the known[11] parent quinoxalinone **6**, thereby unequivocally establishing the structure of **4** (Scheme 1).

The condensation of isatin with *o*-phenylenediamine in refluxing methanol has been reported[8] to produce a mixture of **1a** (39%), **4** (30%) and only traces of the spiro compound **3**. Now, in a similar experiment using 2-aminobenzylamine as partner to isatin, the spiro compound **7a** (which can be considered as a higher homologue of **3**) was obtained as the sole product, whilst none of the possible 2,3-condensation products (**8a**–**b**) nor the ring-opened products **9** and **10** were observed (Fig. 3). Not surprisingly, the formation of the 6-membered ring in **7a** is more favored compared to that of the seven-membered ring in the other at least theoretically possible products (**8a**,**b**, **9** and **10**). When the reaction was performed at ambient temperature instead of refluxing methanol the yield of **7a** increased from 53 to 67%. The IR spectrum of **7a** exhibits a characteristic carbonyl at 1706 cm^{-1} and the ^{1}H NMR spectrum features signals at 4.36 and 3.78 ppm from the methylene group and a signal at 3.15 ppm from the N*H* in the 3-position in the tetrahydroquinazoline ring, which all couple with each other. The ^{13}C NMR spectrum includes a quaternary signal at 68.7 ppm from the carbon atom in the spiro center (Scheme 2). A disubstituted derivative of **7a**, compound **11**, obtained from isatin and 2-amino-5-chloro-α-phenyl-benzylamine, has been briefly described previously in the literature.[12]



4 (80%) **6** (47%)

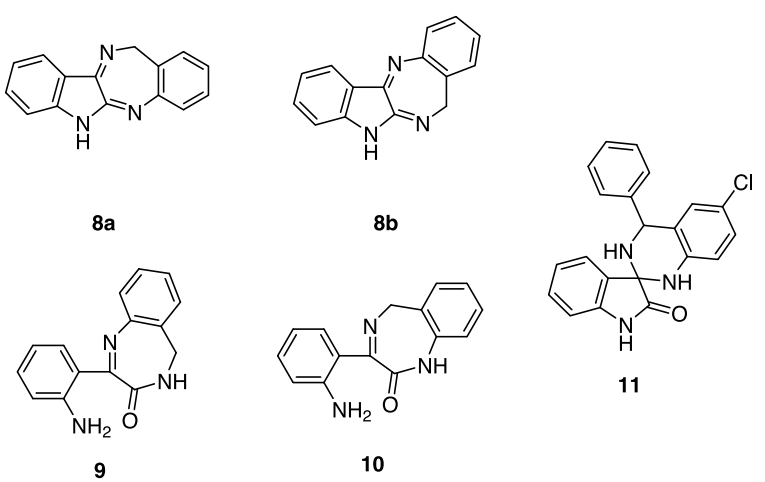
Scheme 1. (a) (i) NaOH, 60°C, 2 h, (ii) pH 5.5, room temperature, 48 h. (b) (i) aq. 20% HCl, $NaNO_2$, 3°C, 5 min, (ii) H_3PO_2, reflux, 2–3 min.



2a R=R^1=H
2c R=CH_3, R^1=H
2f R=H, R^1=CH_3

7a R=R^1=H (67%)
7b R=CH_3, R^1=H (65%)
7c R=H, R^1=CH_3 (68%)

Scheme 2. (a) Methanol, room temperature, 48 h.



8a **8b** **11**

9 **10**

Figure 3.

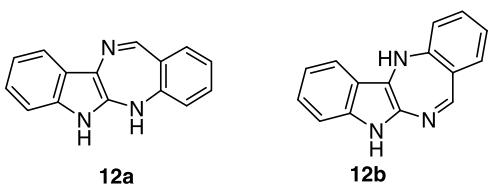
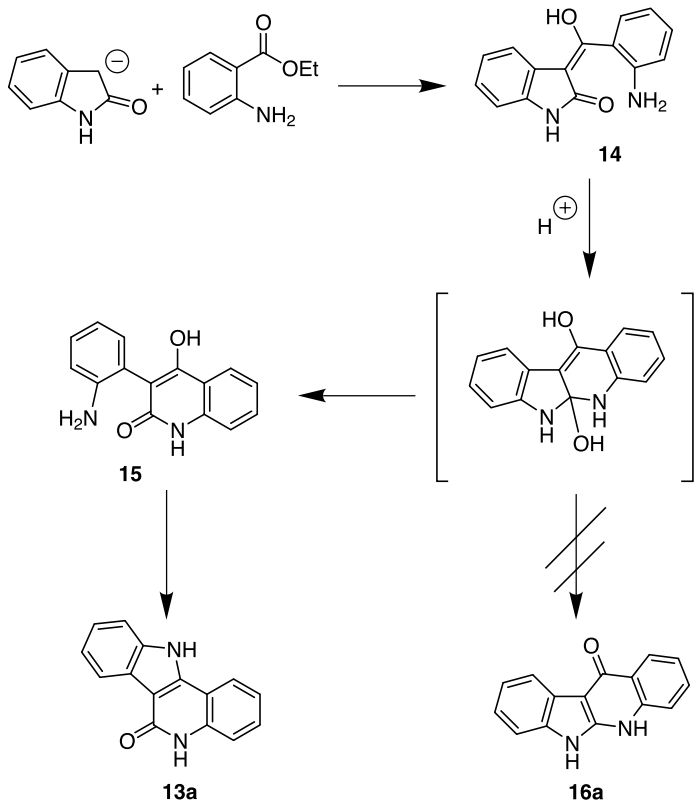


Figure 4.

When 2-aminobenzylamine was refluxed with isatin in acetic acid (rather than methanol), neither of the two possible 2,3-condensation products **8a** and **8b** (Fig. 3) nor the two possible tautomers **12a** and **12b** were observed. (Fig. 4) Instead a product, **A** ($C_{15}H_{10}N_2O$), was formed easily in a good yield together with traces of the spiro compound **7a**. Product **A** was initially assigned structure **16a** because repetition of a literature method involving condensation of the anion of oxindole and methyl 2-aminobenzoate gave an identical product.[13] Further studies however revealed that both products are in fact the angular molecule **13a** rather than the linear, i.e. **16a** (Scheme 4). The angular products obtained now are also identical with products obtained by other established procedures published by us and others.[14–16]

As indicated in Scheme 3 ring opening of the intermediate, probably after protonation of the anilinic nitrogen atom in the tetrahedral intermediate, takes preference over elimination of water. The known molecule **15**[17] could be independently synthesized and cyclized (exclusively) to the angular isomer **13a**. In this context there are several precedents in the literature of related ring-openings that should be noted. Thus Fryer et al. found in 1968 that compound **17** gave the angular salt **18** when heated under acidic conditions (HCl),[18] and Abramovitch and Hey reported in 1954 that the nitro compound **19** upon reduction with tin in hydrochloric acid gave, after ring-opening, the quinolone derivative **20**.[19] (Fig. 5).

Hydrogenation of the condensation product from oxindole (2-indolinone) and pyridine-2-carboxaldehyde (**21**) gave a product that was at first believed to be **22**, but was later shown to be **23** (with the ortho amidine **24** as a likely intermediate).[20] (Fig. 6)



Scheme 3. Plausible mechanism for the reaction of oxindole and ethyl anthranilate.

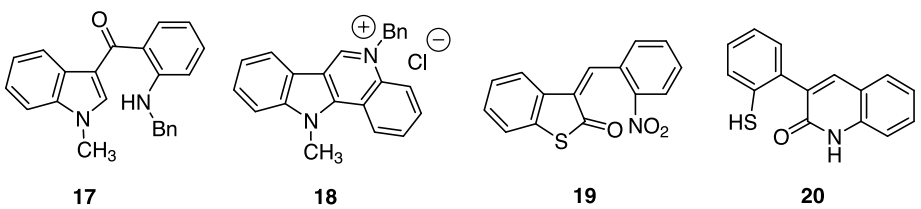
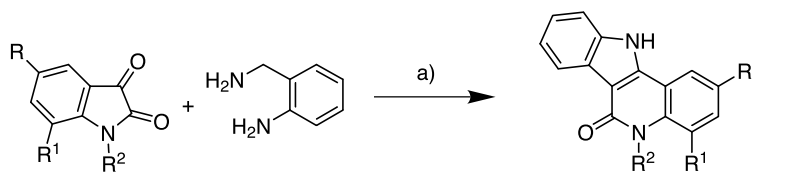


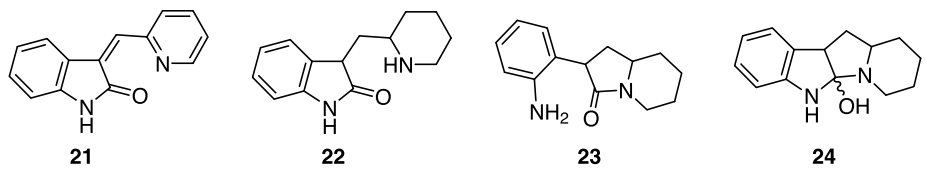
Figure 5.



2a R=R^1=R^2=H
2c R=CH$_3$, R^1=R^2=H
2d R=Cl, R^1=R^2=H
2e R=R^1=Cl, R^2=H
2f R=R^1=H, R^2=CH$_3$

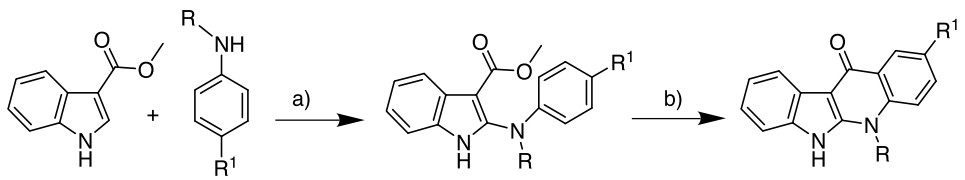
13a R=R^1=R^2=H (60-95%)
13b R=CH$_3$, R^1=R^2=H (61%)
13c R=Cl, R^1=R^2=H (51%)
13d R=R^1=Cl, R^2=H (66%)
13e R=R^1=H, R^2=CH$_3$ (81%)

Scheme 4. (a) Acetic acid, reflux, 15 min–2 h.



21 **22** **23** **24**

Figure 6.



25

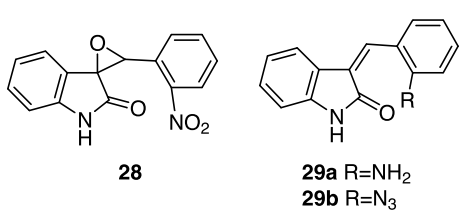
26a R=R^1=H
26b R=Me, R^1=H
26c R=H, R^1=Me

27a R=R^1=H (58%)
27b R=Me, R^1=H (64%)
27c R=H, R^1=Me (74%)

16a R=R^1=H (93%)
16b R=Me, R^1=H (88%)
16c R=H, R^1=Me (86%)

Scheme 5. (a) (i) NCS, 1,4-dimethylpiperazine, CH_2Cl_2, 0°C, 2 h, (ii) trichloroacetic acid, **26a**–**c**, room temperature, 2 h. (b) Diphenyl ether, reflux, 30 min–3 h 30 min.

Now it became of interest to synthesize and study the true linear isomer **16a** (in fact all literature reports describing its purported synthesis deal with the angular isomer). After several unsuccessful attempts the desired compound could be prepared as outlined in Scheme 5. By reaction of the ester **25** with *N*-chlorosuccinimide (NCS) a reactive chloroindolenine could be prepared and subsequently reacted with an aniline in the 2-position of the indole and final cyclization. This methodology originally developed by Booker-Milburn et al.[21] for introduction of allyloxy functions in the 2-position of indoles worked very well also for introduction of anilino functions. By subsequent treatment with refluxing diphenyl ether the linear analogues **16a**–**c** could be obtained in reasonable yields. No undesired rearrangements to angular isomers were observed under these conditions. Attempts to rearrange **16a** under basic as well as acidic conditions failed, thus showing that it is the intermediates (in e.g. Scheme 3) that are critical for the outcome and not the linear indoloquinolinones themselves.



28 **29a** R=NH$_2$ **29b** R=N$_3$

Figure 7.

It should be added that Kikumoto and Kobayashi, who reduced the epoxide **28** with tin dichloride in a mixture of concentrated hydrochloric acid and ethanol, obtained a product with composition $C_{15}H_{12}N_2O$.[22] The IR spectrum of this material, claimed to be the linear isomer **16a**, featured a carbonyl band at 1700 cm^{-1}, which is not in consonance with the structure of **16a**, which absorbs at 1639 cm^{-1}. The product obtained by the Japanese workers could now be identified as **29a**, a known compound that is obtained when **29b** is reduced with zinc in a mixture of concentrated hydrochloric acid and ethanol.[23] (Fig. 7)

More recently other workers have suggested the formation of structures like **30** upon reduction of e.g. **28**.[24] These results could not be confirmed in our laboratory. Attempts to cyclize **31a**, prepared from **31b**, to **30** failed. De Diesbach described in 1951 the reduction of **32** and its subsequent facile cyclization to yield a purported mixture of **13a** and **16a**.[17] The reported individual components were however never separated and characterized. We have repeated this experiment and conclude that the angular isomer **13a** is the sole product. More recently (1980)[25] derivatives of **16a**

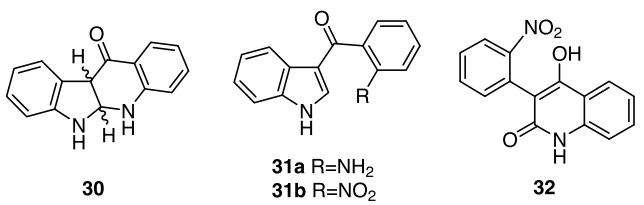
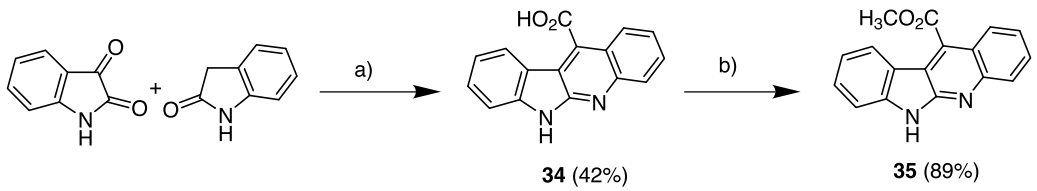


Figure 8.

were claimed as the products when derivatives of isatoic anhydride and 3-mercaptomethyloxindole was condensed with NaH as the base. However all these products were later demonstrated to be angular (Fig. 8).[26]

In spite of the fact that the parent compound of **16a** (i.e. **33**) has been known since at least 1897, very few established derivatives substituted in the 6-membered heterocyclic moiety have been described.[27–29] However, Seidel described a long time ago, the preparation of **34** by condensing isatin with oxindole under alkaline conditions.[30] This reaction has now been confirmed (Scheme 6). Treatment of this acid with diazomethane gave the corresponding methyl ester (**35**), which gave NMR-data in agreement with a product previously reported via a complex procedure involving treatment of the precursor **36** with $AlCl_3$ in methylene chloride.[31] Seidel has also reported the interesting *N*-methylated derivative **37**, which was obtained as a side-product in a complex industrial process (not repeated by us).[30] (Fig. 9).



Scheme 6. (a) (i) Aq. KOH (20%), reflux, 4 h, (ii) acetic acid, (iii) aq. HCl.[30] (b) CH_2N_2, Et_2O, room temperature, 5 min.

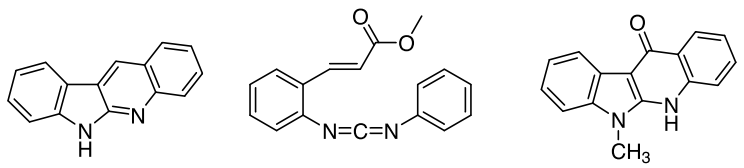
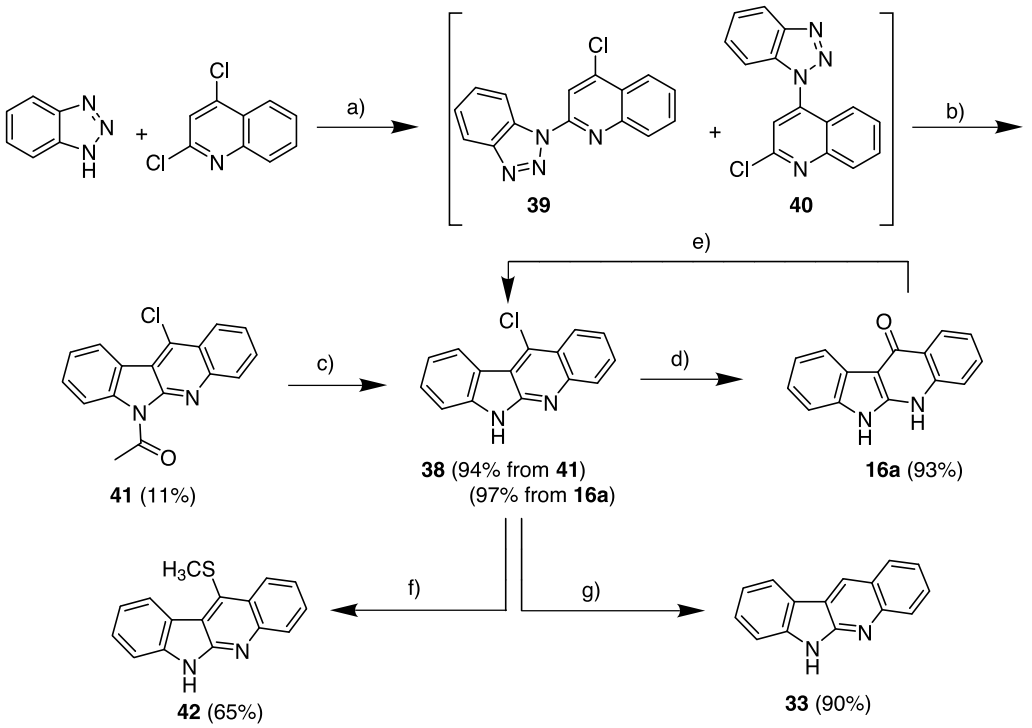


Figure 9.



Scheme 7. (a) 110°C (b) (i) polyphosphoric acid, 130–180°C, (ii) NH_4OH, 100°C, 5 min, (iii) acetic anhydride, reflux. (c) aq. 2 M HCl, reflux, 30 h. (d) DMSO, H_2O, 110°C, 48 h. (e) $POCl_3$, reflux, 3 h. (f) NaOAc, DMSO, 140°C, 2 h. (g) Raney nickel, dioxane, reflux.

The monochloro derivative **38** could be prepared starting from 2,4-dichloroquinoline and benzotriazole which gave, when heated at 110°C until the exothermic reaction had ceased, a 3:1 mixture of the regioisomers **39** and **40** that subsequently was treated with hot polyphosphoric acid (PPA). The linear analogue was separated by crystallization as its *N*-acetyl derivative (**41**) after treatment with hot acetic anhydride. The acetyl group could be removed easily with dilute hydrochloric acid. The chloro derivative **38** could be correlated with its parent compound **33** by treatment with Raney nickel in hot dioxane. The chloro substituent was reluctant to participate in nucleophilic substitutions and treatment with sodium hydroxide in DMSO somewhat surprisingly gave the thiomethyl derivative **42**. On the other hand compound **16a** could also be converted to **38** by treatment with $POCl_3$. The desired product **16a** was finally obtained by treatment of **38** with water in hot DMSO (Scheme 7).

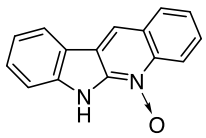


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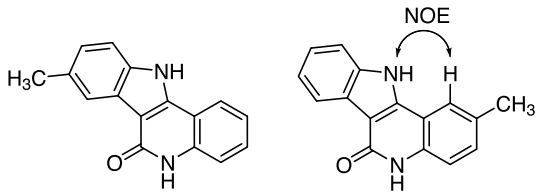
Figure 10.



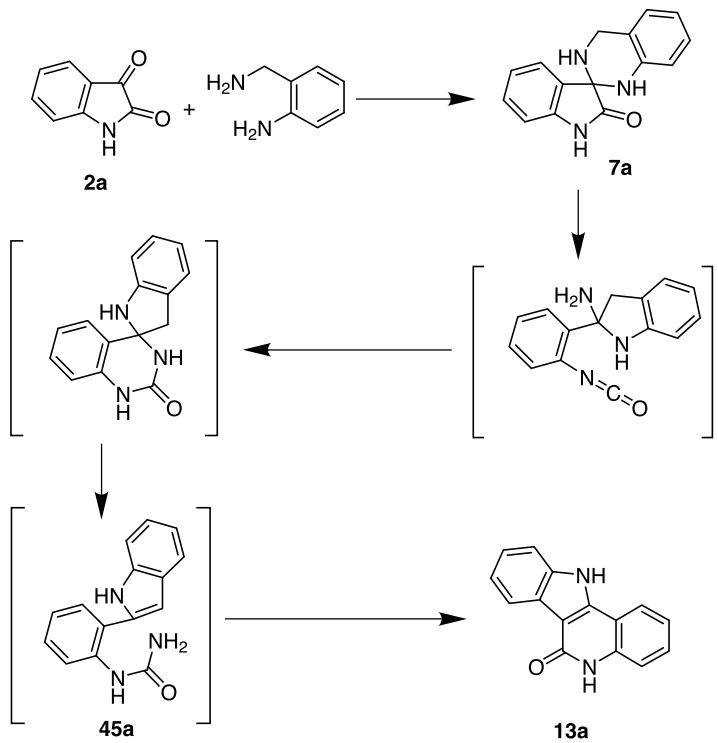
44 **13b**

Figure 11.

At this point it was argued that **16a** under acidic conditions might yield the intermediate outlined in Scheme 1 and hence rearrange to **13a**. This was however found not to be the case. The well-known parent compound of **16a** (i.e. **33**) has been oxidized to the corresponding *N*-oxide **43** (Fig. 10) by Kikumoto.[22] We have repeated this experiment and conclude that the structure assigned is correct. Deoxygenation of **43** with zinc in acetic acid gave **33** back.

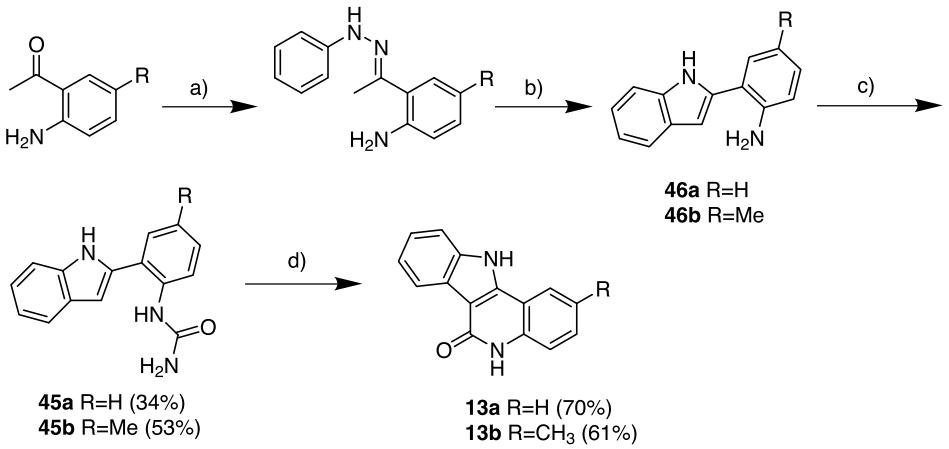
The indoloquinolin-6-one **13a** can also be obtained by refluxing the spiro compound **7a** in acetic acid or, in higher yield, when **7a** was refluxed in acetic acid with an additional equivalent of 2-aminobenzylamine. These results indicate that **7a** is a precursor of **13a**. As a synthetic route to the tetracyclic ring system **13a** our new method has considerable advantages over the previously known procedures[14–16,32] because the fast one-step procedure is operationally simple. Reactions of 2-aminobenzylamine with some substituted isatins gave similar results (**13b–d**). The product from 5-methylisatin and 2-aminobenzylamine was initially considered to have structure **44** (Fig. 11) (i.e. with the isatin as the source of the indole moiety of the ring system). However a strong NOE between the protons indicated in structure **13b** strongly suggested that in fact the indole moiety is formed from 2-aminobenzylamine.

A mechanistic rationalization of the ready formation of **13a** from isatin and 2-aminobenzylamine is given in Scheme 8, starting with the formation of the 6-membered spiro compound **7a** followed by a isocyanate ring opening. Such ring openings are known in the literature.[34] Subsequently a cyclisation between the amine formed and the

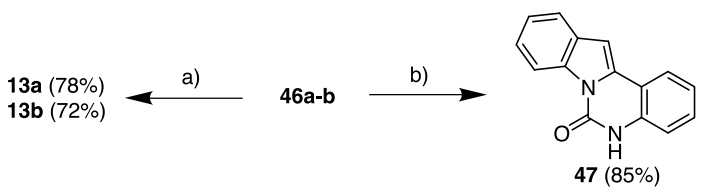


2a **7a** **45a** **13a**

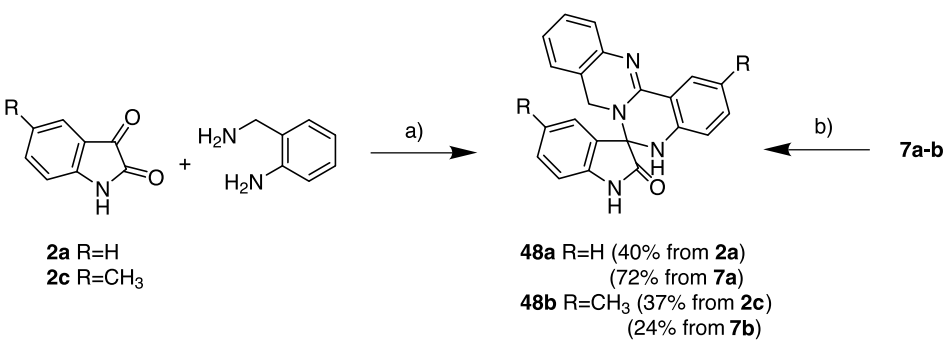
Scheme 8. Mechanistic rationalization of the formation of indolo[3,2-*c*]quinolin-6-one from isatin and 2-aminobenzylamine.



Scheme 9. (a) Phenylhydrazine, acetic acid, ethanol, reflux, 6 h.[33] (b) methanesulfonic acid, P_2O_5, 80°C, 30 min.[33] (c) sodium cyanate, aq. 1 M HCl, methanol, room temperature, 25 h (d) acetic acid, reflux, 1–2 h.



Scheme 10. (a) Acetic acid, sodium cyanate, reflux, 2 h (b) $COCl_2$, dioxane, reflux, 20 min.[14]



Scheme 11. (a) Acetic acid, room temperature, 20 h. (b) 2-aminobenzylamine, acetic acid, room temperature, 20 h.

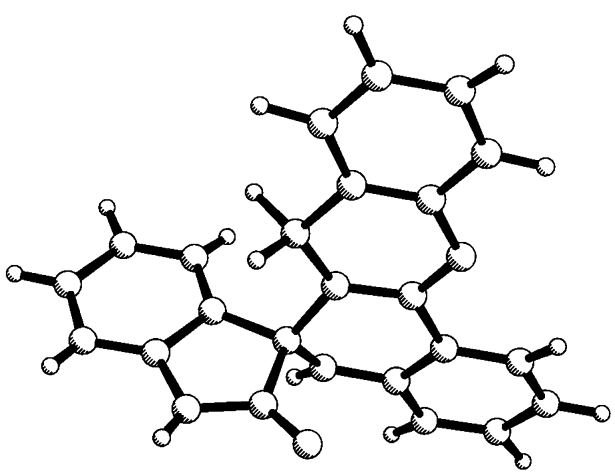


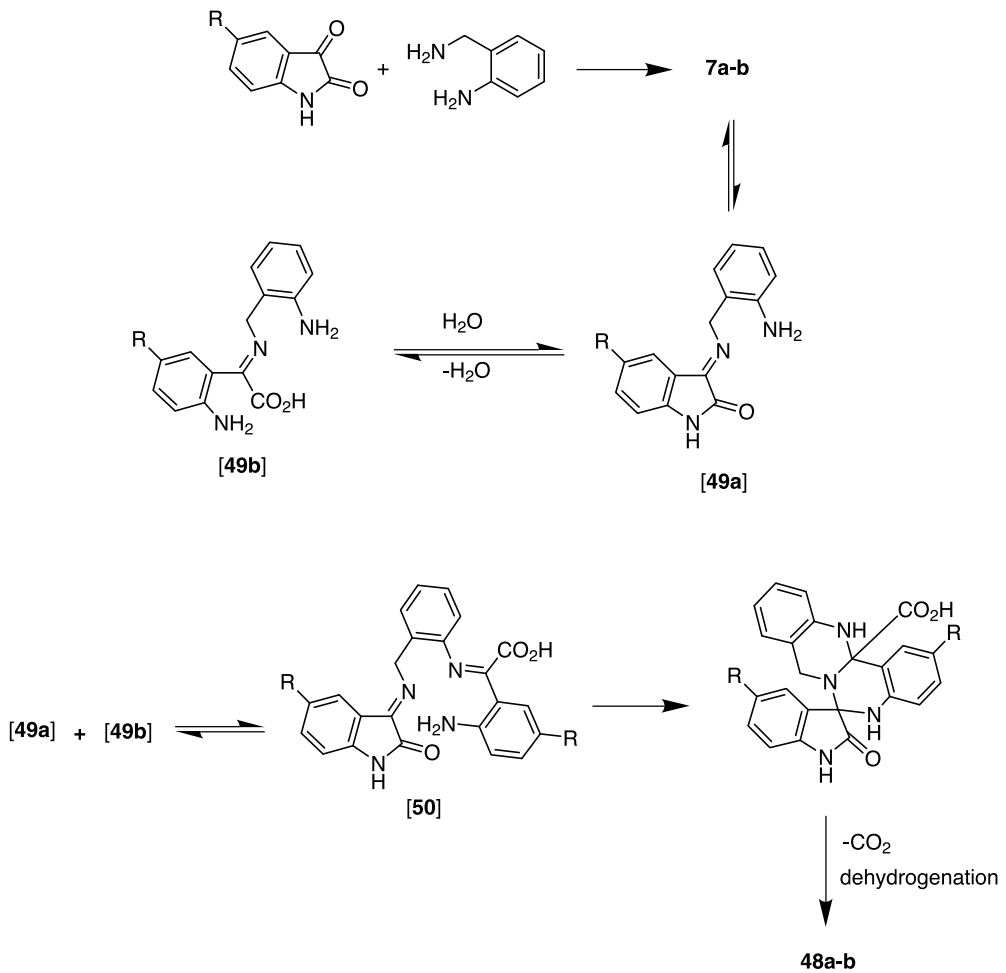
Figure 12. Pluto drawing of compound **48a**.

isocyanate group will occur, followed by a ring opening of the spiro intermediate leading to the 2-substituted indole derivative **45a**, finally followed by a regioselective cyclization to the indolo[3,2-*c*]quinoline-6-one **13a**.

The correctness of this assignment was eventually confirmed by an independent synthesis from **46a** and **46b**, which in turn were obtained by Fischer indolizations of the phenylhydrazones of the corresponding 2-amino-acetophenones (Scheme 9).[33]

Compounds **45a** and **45b** could be independently synthesized from **46a** and **46b** and sodium cyanate under acidic conditions and then smoothly selectively cyclized to **13a** and **13b**, respectively. On the other hand cyclization of **46a**, in dioxane, gave the known compound **47** (Scheme 10).[14]

Reaction of 2-aminobenzylamine with isatin in acetic acid at room temperature (as distinct from reactions at reflux)



Scheme 12. A plausible mechanism for the formation of **48a**,**b**.

gave a quite different product, namely the 2:1 product **48a**, the structure of which has been determined with X-ray crystallography (Scheme 11 and Fig. 12). Compound **13a** could not be isolated when **48a** was heated to reflux in acetic acid, while addition of 1 equivalent of 2-aminobenzylamine to the reaction mixture gave traces of **13a**. A plausible mechanism for the formation of **48a**,**b** is given in Scheme 12. Thus it is assumed that the spiro compound **7a** is in equilibrium with its chain tautomer **49a**, which after ring opening will yield **49b**. These two compounds will subsequently condense (giving **50**) which after cyclization and decarboxylation will yield the observed product **48a**,**b**. A somewhat analogous series of transformations has been invoked by Wassermann to explain the formation of the alkaloid vasicine (**51**), when 2-aminobenzylamine was reacted with the vinyl vicinal tricarbonyl reagent (**52**).[35] A molecule, **53a**, structurally related to **48a** could readily be prepared in high yields by condensation of 2-aminobenzamide and isatin in acetic acid. The spiro carbon atoms in **53a** and **53b** resonated at 70.9 and 71.6 ppm, respectively, in their ^{13}C NMR spectra. Interestingly **53a**, is related with the classic, and during several decades controversial compound,[36] isamic acid **54** (Fig. 13).

It is well known that the relative reactivity of the two carbonyl groups in isatin and N-acetylisatin differ considerably and hence it was also of interest to study the reactions between N-acetylisatin and 2-aminobenzylamine. It is also well known that N-acetylisatin is readily ring opened by ammonia,[37] amines[38] and alcohols.[39] For example when N-acetylisatin is refluxed in ethanol for 3 h, nucleophilic ring opening produces the ester **55**, which readily reacts with ethylenediamine or *o*-phenylenediamine giving **56** or **57** in high yields.[7,40] When the ester **55** was

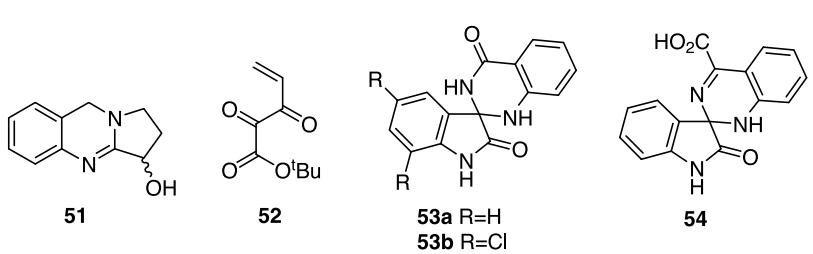


Figure 13.

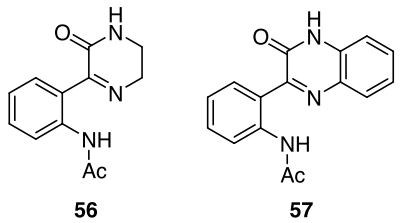
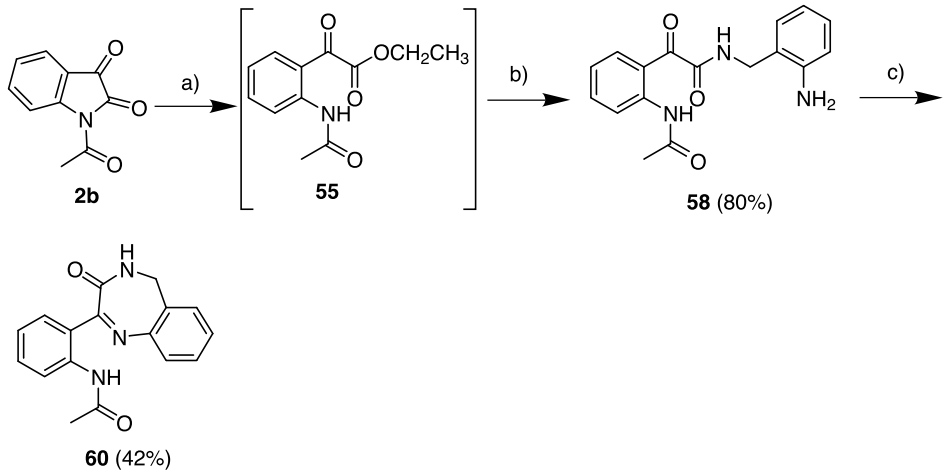


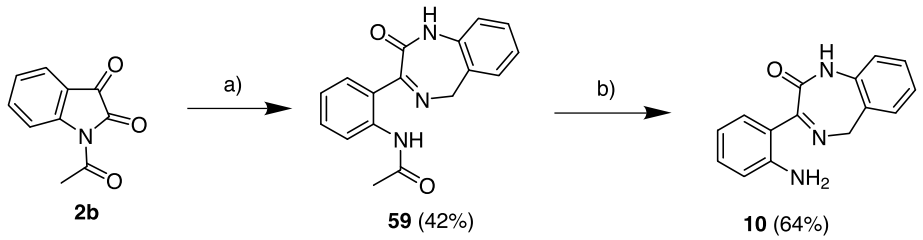
Figure 14.

reacted with 2-aminobenzylamine in ethanol the aliphatic amine function reacted exclusively with the ester carbonyl group giving compound **58** in high yield. The ^{1}H NMR spectrum of **58** includes a methylene at 4.24 ppm, which couples to an N*H* at 9.09 ppm. The ^{1}H NMR spectrum also includes an N*H* signal at 10.52 ppm and an NH_2 signal at 5.10 ppm (Fig. 14, Schemes 13 and 14).

When 2-aminobenzylamine was stirred at room temperature with N-acetylisatin in acetic acid, the 3-(2′-acetamido-phenyl)-1,5-dihydro-1,4-benzodiazepin-2-one **59** could be collected by filtration when the pH of the reaction mixture was increased to 9–10. The isomeric benzodiazepine **60** could be collected by filtration directly from the reaction mixture, when **58** was stirred at room temperature in acetic acid. When the pH of the filtrate was increased to 9–10, a mixture of **59** and **60** was obtained. In none of these experiments the quinazolines **61** or **62** have been observed. The formation of the six-membered ring in the quinazolines might have been expected to be competitive to that of the seven-membered ring in **59** and **60**, which indeed has been the case for some related compounds.[41] The ^{1}H NMR spectrum of **60** included a broadened signal at 4.2 and 4.0 ppm from the methylene group and a signal at 9.01 ppm from the N*H*, which show a coupling that disappeared when the signal from the methylene group was irradiated. The ^{1}H NMR spectrum of **60** also included a singlet at 11.13 ppm from the N*H* in the acetamido group. The ^{1}H NMR spectrum of **59** included a singlet from the two methylene protons (4.66 ppm) and two 1H singlets (11.12 and 10.86 ppm) from the two N*H* functions. Particularly compound **59** deserves interest as an analogue to the pharmacologically highly active 5-aryl-1,3-dihydro-1,4-benzodiazepin-2-one, e.g. diazepam **63**. Deacetylation of **59** gave the amine **10**, however attempts to generate the fused indoles **8a** and/or **12a** failed. No ring contractions (**59**–**61** or **60**–**62**) were observed during these deacetylations (Fig. 15).



Scheme 13. (a) Ethanol, reflux, 3 h. (b) 2-Aminobenzylamine, ethanol, 5–25°C. (c) Acetic acid, room temperature, 168 h.



Scheme 14. (a) Acetic acid, room temperature, 168 h. (b) KOH, ethanol, H_2O, reflux.

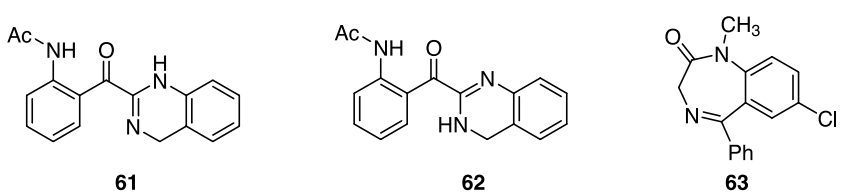


Figure 15.

3. Conclusions

In this paper we have shown that simple indole-2,3-diones can, when reacted with 2-aminobenzylamine in acetic acid be quickly and conveniently converted to indolo[3,2-*c*]-quinolin-6-ones **13a** or, depending upon the conditions (choice of reactants) highly functionalized 1,4-benzodiazepin-2(2*H*)-one **59** and 1,4-benzodiazepin-3(3*H*)-one **60**. The choice of solvent is of paramount importance, as demonstrated by the reaction of 2-aminobenzylamine and isatin in methanol, which yields the spirocyclic quinazoline derivative **7a** that is believed to be an intermediate in the formation of **13a**. We have also shown two alternative ways to form indolo[2,3-*b*]quinolin-11-one (**16a**) which to this day has been unknown.

4. Experimental

4.1. General

NMR spectra were recorded in DMSO-d_6 solutions at room temperature, unless otherwise stated, on a Bruker DPX 300 (300 MHz) spectrometer. J values are given in Hz and δ values are given in ppm. IR spectra are recorded on a Perkin–Elmer 1600 FTIR. Melting points were taken on a Büchi Melting Point B-545 apparatus and are uncorrected. Chromatography was performed on Merck silica gel 60, TLC analyses were run on Merck silica gel F_{254} plates. The elemental analysis was performed by H. Kolbe Mikroanalytisches Laboratorium, Mülheim an der Ruhr, Germany. HRMS analyses were performed by E. Nilsson, University of Lund, Sweden. Solvents were of analytical grade and were used as received.

4.1.1. 3-(2′-Aminophenyl)-quinoxaline-2(1*H*)-one (4). Isatin (7.35 g, 50 mmol) was dissolved in potassium hydroxide (aq., 8%, 80 mL), *o*-phenylenediamine (5.40 g, 50 mmol) was added and the mixture was heated (60°C) for 2 h (or until a clear solution was obtained). The pH was then adjusted to ca. 5.5 by addition of acetic acid. After 2 days at ambient temperature the yellow-orange solid formed was collected. Yield: 9.50 g (80%); mp: 248–250°C (lit.,[42] 260–262°C); IR (KBr) ν_{max}: 3385, 2899, 2851, 1682, 1567, 1528, 1438, 744, 597 cm^{-1}; ^{1}H NMR δ: 12.40 (1H, br s, N*H*), 8.08 (1H, dd, J=1.5, 8.0 Hz, Ph), 7.78 (1H, dd, J=1.0, 8.0 Hz, Ph), 7.48 (1H, dt, J=1.3, 7.7 Hz, Ph), 7.32–7.25 (2H, m, Ph), 7.13 (1H, dt, J=1.5, 7.6 Hz, Ph), 6.80 (1H, d, J=1.0, 8.2 Hz, Ph), 6.57 (1H, dt, J=1.1, 7.6 Hz, Ph), 6.43 (2H, s, NH_2); ^{13}C NMR δ: 155.8 (s), 154.8 (s), 148.6 (s), 131.6 (s), 131.3 (d), 131.2 (s), 130.6 (d), 129.5 (d), 127.9 (d), 123.1 (d), 117.5 (s), 116.1 (d), 114.9 (d), 114.5 (d).

4.1.2. 3-Phenylquinoxaline-2(1*H*)-one (6). Compound **4** (1.18 g, 10 mmol) was dissolved in hydrochloric acid (20%, 10 mL) by stirring at 3°C. Solid sodium nitrite (0.69 g, 10 mmol) was added keeping the temperature at 3°C. After 5 min at this temperature the solid material was removed and the filtrate added to hot hypophosphorus acid (aq., 50%, 10 mL). After a short period (2–3 min) of boiling the mixture was cooled and the product collected by filtration. Yield: 0.52 g (47%); mp: 245–247°C; This product was identical with a sample of 3-phenylquinoxaline-2(1*H*)-one prepared by condensation of ethyl phenylglyoxylate according to the literature method.[11]

4.1.3. 1,2,3,4-Tetrahydroquinazoline-2-spiro-3′-1*H*-indolin-2-one (7a). A mixture of isatin (2.94 g, 20 mmol) and 2-aminobenzylamine (2.44 g, 20 mmol) in MeOH (125 mL) was stirred at room temperature for 48 h, whereupon the reaction mixture was concentrated to 50 mL. The solid formed was collected by filtration. Yield: 3.39 g (67%); mp: 166–167°C (dec.); IR (KBr) ν_{max}: 3379, 3316, 3189, 1706, 1623, 1476, 746 cm^{-1}; ^{1}H NMR δ: 10.29 (1H, s, N*H*), 7.4–7.2 (2H, m, Ph), 7.1–6.8 (4H, m, Ph), 6.6–6.4 (3H, m, Ph), 4.36 (1H, dd, J=8.8, 16.4 Hz, CH_2), 3.78 (1H, dd, J=6.0, 16.4 Hz, CH_2), 3.15 (1H, dd, NH, J=6.0, 8.8 Hz, CH_2); ^{13}C NMR δ: 177.2 (s), 142.6 (s), 141.5 (s), 131.4 (s), 129.4 (d), 126.5 (d), 125.4 (d), 123.9 (d), 121.5 (d), 119.7 (s), 115.9 (d), 113.7 (d), 109.4 (d), 68.7 (s), 40.7 (t). Anal. calcd for $C_{15}H_{13}N_3O$: C, 71.70; H, 5.21; N, 16.72. Found: C, 71.78; H, 5.14; N, 16.64.

4.1.4. 1,2,3,4-Tetrahydroquinazoline-5-methyl-2-spiro-3′-1*H*-indolin-2-one (7b). A mixture of 5-methylisatin (3.22 g, 20 mmol) and 2-aminobenzylamine (2.44 g, 20 mmol) in MeOH (125 mL) was stirred at room temperature for 48 h, whereupon the reaction mixture was concentrated to 50 mL. The solid formed was collected by filtration. Yield: 3.45 g (65%); mp: 174–175°C; IR (KBr) ν_{max}: 3369, 3329, 3173, 3042, 1699, 1628, 1605, 1496, 802, 747 cm^{-1}; ^{1}H NMR δ: 10.14 (1H, s, N*H*), 7.09 (1H, s, Ph), 7.05 (1H, d, J=7.9 Hz, Ph), 6.94–6.84 (2H, m, Ph), 6.70 (1H, d, J=7.9 Hz, Ph), 6.55–6.47 (2H, m, Ph), 6.43 (1H, s, Ph), 4.32 (1H, dd, J=16.4, 8.8 Hz, CH_2), 3.76 (1H, dd, J=16.4, 6.0 Hz, CH_2), 3.04 (dd, J=8.5, 6.0 Hz, N*H*), 2.23 (3H, s, CH_3); ^{13}C NMR δ: 177.3 (s), 142.7 (s), 139.1 (s), 131.5 (s), 130.4 (s), 129.5 (d), 126.6 (d), 125.5 (d), 124.7 (d), 119.8 (s), 115.8 (d), 113.7 (d), 109.3 (d), 68.9 (s), 40.8 (t), 20.7 (q). Anal. calcd for $C_{16}H_{15}N_3O$: C, 72.43; H, 5.70; N, 15.84. Found: C, 72.49; H, 5.83; N, 15.77.

4.1.5. 1,2,3,4-Tetrahydroquinazoline-1-methyl-2-spiro-3′-1*H*-indolin-2-one (7c). *Method A*. A mixture of N-methylisatin (1.61 g, 10 mmol) and 2-aminobenzylamine (1.22 g, 10 mmol) in MeOH (60 mL) was stirred at room temperature for 48 h, whereupon the reaction mixture was concentrated to 30 mL. The solid formed was collected by filtration, washed with cold ethanol and dried. Yield: 1.82 g (68%).

Method B. A mixture of N-methylisatin (1.61 g, 10 mmol) and 2-aminobenzylamine (2.44 g, 20 mmol) in acetic acid (100 mL) was stirred at room temperature for 20 h, whereupon the mixture was poured into water and basified with NaOH (2 M). The solid thus formed was isolated by filtration and washed with water. Yield: 2.13 g (80%).

Mp: 155–156°C (dec.); IR (KBr) ν_{max}: 3374, 3302, 3050, 3009, 2925, 1692, 1612, 1493, 1030, 754, 736 cm^{-1}; ^{1}H NMR δ: 7.40–7.31 (2H, m, Ph), 7.08–7.00 (2H, m, Ph), 6.95–6.86 (2H, m, Ph), 6.57–6.48 (2H, m, Ph), 6.44 (1H, s, N*H*), 4.35 (1H, dd, J=16.4, 8.9 Hz, CH_2), 3.77 (1H, dd, J=16.4, 5.9 Hz, CH_2), 3.23 (1H, dd, J=8.9, 5.9 Hz, N*H*), 3.10 (3H, s, CH_3); ^{13}C NMR δ: 175.3 (s), 143.1 (s), 142.5 (s),

130.7 (s), 129.6 (d), 126.6 (d), 125.5 (d), 123.6 (d), 122.3 (d), 119.7 (s), 116.0 (d), 113.8 (d), 108.4 (d), 68.6 (s), 40.8 (t), 25.6 (q). Anal. calcd for $C_{16}H_{15}N_3O$: C, 72.43; H, 5.70; N, 15.84. Found: C, 72.53; H, 5.77; N, 15.79.

4.1.6. 3-(2′-Aminophenyl)-4,5-dihydro-1,4-benzodiazepin-3(3*H*)-one (10). Compound **59** (2.93 g, 10 mmol) was added to 20% KOH (1:1, EtOH/H_2O, 25 mL). The solution was refluxed for 2 h and thereafter cooled in an ice-bath. Slow addition of acetic acid produced a yellow solid, which was collected by filtration. Yield: 1.60 g (64%); mp: 188–190°C; IR (KBr) ν_{max}: 3394, 3272, 2839, 1655, 1613, 1490, 1252, 764, 742 cm^{-1}; ^1H NMR δ: 11.04 (1H, s, N*H*), 7.41 (1H, d, J=7.5 Hz, Ph), 7.4–7.2 (2H, m, Ph), 7.2–7.0 (5H, m, Ph), 6.68 (1H, dd, J=8.3, 1.1 Hz, Ph), 6.45 (1H, m, Ph), 4.6 (2H, br s, CH_2); ^{13}C NMR δ: 165.8 (s), 165.3 (s), 149.7 (s), 136.9 (s), 133.4 (s), 131.1 (d), 130.7 (d), 128.5 (d), 128.2 (d), 124.3 (d), 120.9 (d), 116.0 (d), 114.2 (s), 114.0 (d), 53.1 (t). Anal. calcd for $C_{15}H_{13}N_3O$: C, 71.70; H, 5.21; N, 16.72. Found: C, 71.62; H, 5.16; N, 16.57.

4.1.7. 5,11-Dihydro-indolo[3,2-*c*]quinolin-6-one (13a). *Method A*. A mixture of isatin (2.94 g, 20 mmol) and 2-aminobenzylamine (2.44 g, 20 mmol) was heated to reflux in acetic acid (100 mL) for 2 h, whereupon the reaction mixture was poured into water. The solid formed was collected by filtration. The crude product was flash chromatographed (MeOH/CH_2Cl_2, 1/9), to give **13a** as a beige solid. Yield: 2.81 g (60%). When 2 equiv. of 2-aminobenzylamine were used, the yield calculated on isatin increased to 95%.

Method B. A solution of **7a** (503 mg, 2 mmol) in acetic acid (10 mL) was heated to reflux for 2 h, whereupon the reaction mixture was poured into water. The solid formed was collected by filtration. The crude product was flash chromatographed (MeOH/CH_2Cl_2, 1/9), to give **14a** as a beige solid. Yield: 319 mg (68%). When an extra equivalent of 2-aminobenzylamine was added, the yield based on **7a** increased to 96%.

Method C. To a solution of **46a** (0.620 g, 3.0 mmol) and acetic acid (5 mL) was sodium cyanate (0.210 g, 3.2 mmol) added and refluxed for 2 h. The solution was poured into ice-water and the formed solid was filtrated by suction and washed with water. The solid was recrystallized from 2-propanol/methanol to give **13a**. Yield: 0.540 g (78%).

Method D. Acetic acid (1 mL) and **45a** (0.100 g, 0.4 mmol) was heated to reflux for 1 h, whereupon the reaction mixture was poured into water. The solid formed was collected by filtration and washed with water. The crude product was flash chromatographed (MeOH/$CHCl_3$, 3/97), to give **13a** as a beige solid. Yield: 0.065 g (70%).

Mp: >360°C (lit.,[16] 340°C); IR (KBr) ν_{max}: 3204, 2995, 2886, 1636, 1612, 1585, 1553, 1454, 1396, 748 cm^{-1}; ^1H NMR δ: 12.69 (1H, s, N*H*), 11.61 (1H, s, N*H*), 8.25–8.20 (2H, m, Ph), 7.63 (1H, d, J=8.0 Hz, Ph), 7.54–7.45 (2H, m, Ph), 7.40–7.24 (3H, m, Ph); ^{13}C NMR δ: 160.1 (s), 140.9 (s), 138.0 (s), 138.8 (s), 129.1 (d), 124.4 (s), 124.0 (d), 122.2 (d), 121.5 (d), 121.1 (d), 120.8 (d), 116.1 (d), 112.1 (s), 111.7 (d), 106.5 (s).

4.1.8. 2-Methyl-5,11-dihydro-indolo[3,2-*c*]quinolin-6-one (13b). *Method A*. A mixture of 5-methylisatin (1.61 g, 10 mmol) and 2-aminobenzylamine (2.44 g, 20 mmol) was heated to reflux in acetic acid (100 mL) for 2 h. The reaction mixture was allowed to attain room temperature. The solid formed was collected and thereafter stirred for 30 min in a solution of $NaHCO_3$ and collected by filtration. Yield: 1.51 g (61%).

Method B. A solution of **7b** (1.32 g, 5 mmol) in acetic acid (15 mL) was heated to reflux for 2 h. The reaction mixture was allowed to attain room temperature and the solid formed was collected by filtration. The crude product was treated in $NaHCO_3$ (10%) for 30 min and then filtered and washed with water, which gave 0.72 g of **13b**. The filtrate was poured into water and a second corp of **13b** was collected by filtration (0.25 g). Yield: 0.97 g (78%).

Method C. To a solution of **46b** (0.650 g, 3.0 mmol) and acetic acid (5 mL) sodium cyanate (0.210 g, 3.2 mmol) was added and refluxed for 2 h. The solution was poured into ice-water and the formed solid was filtered by suction and washed with water. The solid was recrystallized from ethanol to give 0.370 g of **13b**. A second crop was obtained by concentration of the mother liquor and purified by chromatography using methanol in chloroform giving 0.150 g of **13b**. Yield: 0.520 g (72%).

Method D. Acetic acid (1.3 mL) and **45a** (0.140 g, 0.53 mmol) was heated to reflux for 2 h, whereupon the reaction mixture was poured into water. The solid formed was collected by filtration and washed with water. The crude product was treated with ethyl acetate and filtered to give 0.060 g of **13b**. A second crop was obtained by concentration of the mother liquor and purified by chromatography using methanol in chloroform giving 0.020 g of **13b**. Yield: 0.080 g (61%).

Mp: 342–343°C; IR (KBr) ν_{max}: 3216, 1630, 1617, 1590, 1555, 1456, 1390, 812, 788, 748 cm^{-1}; ^1H NMR δ: 12.50 (1H, s, N*H*), 11.36 (1H, s, N*H*), 8.19 (1H, d, J=8.0 Hz), 8.00 (1H, s, Ph), 7.60 (1H, d, J=8.0 Hz, Ph), 7.35–7.22 (4H, m, Ph), 2.41 (3H, s, CH_3); ^{13}C NMR δ: 159.7 (s), 140.5 (s), 137.6 (s), 135.9 (s), 130.3 (s), 130.2 (d), 124.3 (s), 123.8 (d), 121.6 (d), 120.8 (d), 120.6 (d), 115.9 (d), 111.7 (s), 111.6 (d), 106.4 (s), 20.6 (q). Anal. calcd for $C_{16}H_{12}N_2O$: C, 77.40; H, 4.87; N, 11.28. Found: C, 77.26; H, 4.94; N, 11.20.

4.1.9. 2-Chloro-5,11-dihydro-indolo[3,2-*c*]quinolin-6-one (13c). A mixture of 5-chloroisatin (0.345 g, 1.9 mmol) and 2-aminobenzylamine (0.464 g, 3.8 mmol) was refluxed in concentrated acetic acid (10 mL) for 2 h, whereupon the reaction mixture was poured into water. The solid formed was collected by filtration. The crude product was heated in ethanol and filtered to give **13c** as a pinkish solid. Yield: 0.261 g (51%); mp>360°C; IR (KBr) ν_{max}: 3272, 1630, 1613, 1452, 1392, 812, 732 cm^{-1}; ^1H NMR δ: 12.60 (1H, s, N*H*), 11.57 (1H, s, N*H*), 8.31 (1H, d, J=1.4 Hz, Ph), 8.20 (1H, d, J=4.8 Hz, Ph), 7.63 (1H, d, J=4.8 Hz, Ph), 7.54 (1H, dd, J=1.4, 5.2 Hz, Ph), 7.47 (1H, d, J=5.2 Hz, Ph), 7.39 (1H, t, J=4.5 Hz, Ph), 7.28 (1H, t, J=4.5 Hz, Ph); ^{13}C NMR δ: 159.6 (s), 139.4 (s), 137.7 (s), 136.6 (s), 128.9 (d), 125.4 (s), 124.4 (d), 124.1 (s), 121.4 (d),

121.2 (s), 120.8 (d), 117.8 (d), 113.2 (s), 111.8 (d), 107.0 (s). Anal. calcd for $C_{15}H_9ClN_2O$: C, 67.05; H, 3.38; N, 10.43. Found: C, 67.16; H, 3.45; N, 10.37.

4.1.10. 2,4-Dichloro-5,11-dihydro-indolo[3,2-*c*]quinolin-6-one (13d). A mixture of 5,7-dichloroisatin (2.16 g, 10 mmol) and 2-aminobenzylamine (2.44 g, 20 mmol) was heated to reflux in acetic acid (100 mL) for 15 min. The reaction mixture was allowed to attain room temperature. The solid formed was collected by filtration. Yield: 2.00 g (66%); mp: >360°C; IR (KBr) ν_{max}: 3398, 3082, 1644, 1608, 1419, 1367, 1330, 739 cm^{-1}; ^1H NMR δ: 12.69 (1H, s, N*H*), 10.64 (1H, s, N*H*), 8.31 (1H, d, *J*=1.8 Hz, Ph), 8.20 (1H, d, *J*=7.9 Hz, Ph), 7.77 (1H, d, *J*=1.8 Hz, Ph), 7.63 (1H, d, *J*=7.9 Hz, Ph), 7.41 (1H, t, *J*=7.2 Hz, Ph), 7.29 (1H, t, *J*=7.2 Hz, Ph); ^{13}C NMR δ: 159.1 (s), 138.9 (s), 137.8 (s), 132.9 (s), 128.4 (d), 125.4 (s), 124.8 (d), 123.8 (s), 121.4 (d), 120.9 (d), 120.7 (d), 120.1 (s), 114.5 (s), 111.9 (d), 107.3 (s). Anal. calcd for $C_{15}H_8Cl_2N_2O$: C, 59.43; H, 2.66; N, 9.24. Found: C, 59.35; H, 2.57; N, 9.18.

4.1.11. 5-Methyl-5,11-dihydro-indolo[3,2-*c*]quinolin-6-one (13e). *Method A*. A mixture of N-methylisatin (1.61 g, 10 mmol) and 2-aminobenzylamine (2.44 g, 20 mmol) was heated to reflux in acetic acid (25 mL) for 2 h. The reaction mixture was allowed to attain room temperature and poured into water. The solid thus formed was collected by filtration. Yield: 2.02 g (81%).

Method B. A solution of **7c** (0.53 g, 2 mmol) in acetic acid (10 mL) was heated to reflux for 2 h. The reaction mixture was allowed to attain room temperature and poured into water. The solid thus formed was collected by filtration, washed with water and purified by column chromatography (2/98 MeOH/$CHCl_3$). Yield: 0.36 g (73%).

Mp: 265–266°C (dec.) (lit.,[16] 265°C); IR (KBr) ν_{max}: 3155, 1614, 1568, 1327, 742 cm^{-1}; ^1H NMR δ: 12.55 (1H, s, N*H*), 8.30–8.23 (2H, m, Ph), 7.64–7.60 (3H, m, Ph), 7.41–7.34 (2H, m, Ph), 7.27 (1H, t, *J*=7.0 Hz, Ph), 3.74 (3H, s, CH_3); ^{13}C NMR δ: 159.0 (s), 139.6 (s), 138.7 (s), 137.8 (s), 129.6 (d), 124.6 (s), 124.1 (d), 122.6 (d), 121.6 (d), 121.1 (d), 120.8 (d), 115.7 (d), 112.9 (s), 111.7 (d), 105.9 (s), 28.5 (q).

4.1.12. 5,6-Dihydro-indolo[2,3-*b*]quinolin-11-one (16a). *Method A*. The ester (**27a**) (1.0 g, 3.76 mmol) in diphenyl ether (5 mL) was heated at reflux for 3 h 30 min, whereupon the reaction mixture was allowed to attain room temperature. The solid thus formed was isolated by filtration and washed with a large quantity of diethyl ether. Yield: 0.570 g (65%).

Method B. 11-Chloro-5*H*-indolo[2,3-*b*]quinoline (**38**) (0.100 g, 0.4 mmol) was dissolved in DMSO (4 mL). Water (0.5 mL) was added to the solution and heated at 24 h at 110°C. An additional portion of water (0.5 mL) was added and the solution was heated for another 24 h whereby it was poured out on water (80 mL). The solid thus formed was isolated by filtration, washed with water and dried. Yield: 0.086 g (93%).

Mp: >360°C; IR (KBr) ν_{max}: 3289, 2947, 1668, 1555, 1441, 1211, 790, 756, 746, 714, 694 cm^{-1}; ^1H NMR δ: 12.30 (1H, s, N*H*), 11.68 (1H, s, N*H*), 8.31 (1H, d, *J*=7.9 Hz, Ph), 8.19 (1H, m, Ph), 7.65 (2H, m, Ph), 7.48 (1H, dd, *J*=1.5, 6.8 Hz, Ph), 7.3–7.2 (3H, m, Ph); ^{13}C NMR δ: 172.3 (s), 145.3 (s), 138.3 (s), 135.0 (s), 130.8 (d), 125.3 (d), 123.8 (s), 123.6 (s), 122.6 (d), 121.4 (d), 120.8 (d), 120.0 (d), 117.4 (d), 110.9 (d), 101.8 (s). Anal. calcd for $C_{15}H_{10}N_2O$: C, 76.91; H, 4.30; N, 11.96. Found: C, 77.18; H, 4.41; N, 11.84.

4.1.13. 5,6-Dihydro-6-methylindolo[2,3-*b*]quinolin-11-one (16b). *Method A*. Diphenyl ether (6 mL) and **27b** (1.20 g, 4.29 mmol) were heated at reflux for 2 h 30 min, whereupon the reaction mixture was allowed to attain room temperature. The solid thus formed was isolated by filtration and washed with a large quantity of diethyl ether. Yield: 0.93 g (88%); mp: >360°C; IR (KBr) ν_{max}: 3055, 1611, 1578, 1540, 1515, 1458, 742, 677 cm^{-1}; ^1H NMR δ: 12.07 (1H, s, N*H*), 8.39 (1H, d, *J*=7.0 Hz, Ph), 8.20 (1H, d, *J*=7.0 Hz, Ph), 7.76 (2H, m, Ph), 7.48 (1H, d, *J*=7.0 Hz, Ph), 7.41 (1H, d, *J*=7.9 Hz, Ph), 7.30–7.20 (2H, m, Ph), 3.99 (3H, s, CH_3); ^{13}C NMR δ: 171.5 (s), 146.9 (s), 139.2 (s), 134.7 (s), 131.2 (d), 125.8 (d), 124.7 (s), 124.1 (s), 122.8 (d), 121.6 (d), 121.2 (d), 120.1 (d), 115.2 (d), 110.8 (d), 102.3 (s), 33.2 (q). Anal. calcd for $C_{16}H_{12}N_2O$: C, 77.40; H, 4.87; N, 11.28. Found: C, 77.48; H, 4.79; N, 11.21.

4.1.14. 5,6-Dihydro-2-methylindolo[2,3-*b*]quinolin-11-one (16c). *Method A*. Diphenyl ether (6 mL) and **27c** (1.20 g, 4.29 mmol) were heated at reflux for 30 min, whereupon the reaction mixture was allowed to attain room temperature. The solid thus formed was isolated by filtration and washed with a large quantity of diethyl ether. Yield: 0.91 g (86%); mp: >360°C; IR (KBr) ν_{max}: 3090, 1638, 1632, 1578, 1514, 1479, 810, 797, 739 cm^{-1}; ^1H NMR δ: 12.19 (1H, s, N*H*), 11.61 (1H, s, N*H*), 8.18 (1H, d, *J*=6.8 Hz, Ph), 8.09 (1H, s, Ph), 7.54 (1H, d, *J*=8.4 Hz, Ph), 7.46 (2H, m, Ph), 7.26–7.15 (2H, m, Ph), 2.44 (3H, s, CH_3); ^{13}C NMR δ: 172.2 (s), 145.3 (s), 136.3 (s), 135.0 (s), 132.0 (d), 130.4 (s), 124.8 (d), 123.9 (s), 123.5 (s), 122.5 (d), 120.7 (d), 120.0 (d), 117.3 (d), 110.8 (d), 101.8 (s), 20.7 (q). Anal. calcd for $C_{16}H_{12}N_2O$: C, 77.40; H, 4.87; N, 11.28. Found: C, 77.54; H, 4.75; N, 11.33.

4.2. General procedure for synthesis of 27a–c

To a solution of methyl indole-3-carboxylate (2.08 g, 11.9 mmol) and dichloromethane (50 mL) at 0°C under argon *N*,*N*′-dimethylpiperazine (0.75 g, 6.56 mmol) and NCS (1.75 g, 13.1 mmol) were added. The reaction mixture was allowed to stand at 0°C for 2 h. Whereupon a solution of trichloroacetic acid (0.5 g, 3 mmol) and the appropriate aniline **26a–c** (23.4 mmol) in dichloromethane (50 mL) was added and the reaction mixture was allowed to attain room temperature. After 2 h the reaction mixture was washed with 10% aqueous sodium bicarbonate solution and then with 1 M aqueous hydrochloric acid and finally with water. The resulting solution was dried, filtered and evaporated. The residue was chromatographed using hexane/ethyl acetate 8:2 as eluent.

4.2.1. 2-Phenylamino-1*H*-indole-3-carboxylic acid methyl ester (27a). Yield: 1.84 g (58%); mp: 121–122°C; IR (KBr) ν_{max}: 3258, 3044, 2948, 1655, 1636, 1569, 1481,

1205, 1096, 785, 750, 688 cm^{-1}; ^1H NMR δ: 11.43 (1H, s, N*H*), 9.11 (1H, s, N*H*), 7.70 (1H, d, *J*=7.6 Hz, Ph), 7.50–7.35 (4H, m, Ph), 7.27 (1H, d, *J*=7.6 Hz, Ph), 7.15 (1H, t, *J*=6.8 Hz, Ph), 7.10–7.00 (2H, m, Ph), 3.85 (3H, s, CH_3); ^{13}C NMR δ: 166.4 (s), 148.4 (s), 139.1 (s), 132.8 (s), 129.6 (d), 125.8 (s), 123.5 (d), 121.1 (d), 120.3 (d), 120.2 (d), 118.5 (d), 110.8 (d), 86.1 (s), 50.3 (q). Anal. calcd for $C_{16}H_{14}N_2O_2$: C, 72.16; H, 5.30; 10.52. Found: C, 72.25; H, 5.29; N, 10.45.

4.2.2. 2-(Methylphenylamino)-1*H*-indole-3-carboxylic acid methyl ester (27b). Yield: 2.13 g (64%); mp: 146–147°C; IR (KBr) ν_{max}: 3289, 2947, 1668, 1555, 1441, 1211, 790, 756, 746, 714, 694 cm^{-1}; ^1H NMR δ: 11.97 (1H, s, N*H*), 7.95 (1H, m, Ph), 7.33 (1H, m, Ph), 7.30–7.15 (4H, m, Ph), 6.82 (1H, t, *J*=7.3 Hz, Ph), 6.8–6.7 (2H, m, Ph), 3.65 (3H, s, OCH_3), 3.35 (3H, s, CH_3); ^{13}C NMR δ: 163.6 (s), 147.6 (s), 147.3 (s), 132.5 (s), 128.9 (d), 126.1 (s), 122.1 (d), 121.1 (d), 120.5 (d), 119.0 (d), 114.6 (d), 111.4 (d), 96.9 (s), 50.3 (q), 39.4 (q). Anal. calcd for $C_{17}H_{16}N_2O_2$: C, 72.84; H, 5.75; N, 9.99. Found: C, 73.02; H, 5.63; N, 9.83.

4.2.3. 2-(*p*-Tolylamino)-1*H*-indole-3-carboxylic acid methyl ester (27c). Yield: 1.45 g (74%); mp: 139–140°C; IR (KBr) ν_{max}: 3338, 3290, 2953, 1660, 1633, 1588, 1569, 1441, 1204, 1091, 783, 748, 737 cm^{-1}; ^1H NMR δ: 11.26 (1H, s, N*H*), 8.98 (1H, s, N*H*), 7.64 (1H, d, *J*=7.5 Hz, Ph), 7.29–7.20 (5H, m, Ph), 7.05–6.95 (2H, m, Ph), 3.83 (3H, s, OCH_3), 2.32 (3H, s, CH_3); ^{13}C NMR δ: 166.4 (s), 149.1 (s), 136.3 (s), 133.1 (s), 132.8 (s), 130.1 (d), 125.9 (s), 121.1 (d), 121.0 (d), 120.1 (d), 118.3 (d), 110.7 (d), 85.4 (s), 50.3 (q), 20.5 (q). Anal. calcd for $C_{17}H_{16}N_2O_2$: C, 72.84; H, 5.75; N, 9.99. Found: C, 72.88; H, 5.76; N, 10.06.

4.2.4. 2-Nitrobenzyl-oxireno[α,3]oxindole (28). Sodium (1.52 g, 65 mmol) was dissolved in ethanol (75 mL) under N_2, whereupon isatin (4.41 g, 30 mmol) was added, which gave a red-violet solution. 2-Nitrobenzyl chloride (5.16 g, 30 mmol) in EtOH was then added at 15°C to the stirred solution. After 3 h at room temperature, water (300 mL) and acetic acid (10 mL) was added and the solid formed was collected after 2 h and recrystallized from EtOH. Yield: 6.60 g (78%); mp: 174–176°C (lit.,[23] 174–176.5°C); IR (KBr) ν_{max}: 3300, 1737, 1702, 1622, 1528, 1470, 1342 cm^{-1}; ^1H NMR δ: 10.94 (1H, s, N*H*), 8.18 (1H, dd, *J*=8.2, 0.9 Hz, Ph), 8.00–7.93 (2H, m, Ph), 7.78–7.72 (1H, m, Ph), 7.20 (1H, dt, *J*=7.7, 1.1 Hz, Ph), 6.90 (1H, d, *J*=7.7 Hz, Ph), 6.64 (1H, dt, *J*=7.5, 1.1 Hz, Ph), 5.97 (1H, td, *J*=7.5, 0.6 Hz, Ph), 5.06 (1H, s, C*H*); ^{13}C NMR δ: 171.6 (s), 146.6 (s), 143.6 (s), 134.8 (d), 130.5 (d), 130.1 (d), 130.0 (s), 129.0 (d), 124.7 (d), 122.0 (d), 121.5 (d), 120.1 (s), 110.7 (d), 63.6 (d), 61.5 (s).

4.2.5. 3-(2-Aminobenzoyl)-1*H*-indole (29a). An EtOH (4 mL) suspension of **28** (2.8 g, 10 mmol) was treated with $SnCl_2$ (8 g, 112.8 mmol) in concentrated HCl (7.5 mL). The mixture was heated for 1 h on a water bath. After cooling the mixture, now containing yellow crystals, was poured into NaOH (2 M, aq) and the solid thus formed was isolated by filtration.

Yield: 1.20 g (50%); mp: 228–230°C (lit.,[24] 228–230°C); IR (KBr) ν_{max}: 3405, 3340, 3131, 1700, 1601, 1458, 1337, 1232, 742 cm^{-1}; ^1H NMR δ: 10.51 (1H, s, N*H*), 7.55 (1H, s, C*H*), 7.46 (1H, d, *J*=7.7 Hz, Ph), 7.41 (1H, dd, *J*=7.7, 1.2 Hz, Ph), 7.2–7.1 (2H, m, Ph), 6.9–6.7 (3H, m, Ph), 6.61 (1H, d, *J*=7.7 Hz, Ph), 5.52 (2H, s, NH_2); ^{13}C NMR δ: 168.8 (s), 147.9 (s), 142.2 (s), 133.2 (d), 131.0 (d), 129.2 (d), 129.2 (d), 125.9 (s), 122.2 (d), 121.5 (s), 120.7 (d), 117.9 (s), 115.5 (d), 115.4 (d), 109.6 (d).

4.2.6. 11-Chloro 6*H*-indolo[2,3-*b*]quinoline (38). *Method A*. 11-Chloro N-acetylindolo[2,3-*b*]quinoline (0.295 g, 1.0 mmol) was refluxed in hydrochloric acid (2 M, 10 mL) for 30 h. The solution was allowed to attain room temperature and then basified with saturated sodium bicarbonate and thereafter filtered by suction, washed with water and dried. Yield: 0.238 g (94%).

Method B. **16a** (0.046 g, 0.2 mmol) was refluxed in $POCl_3$ (1 mL) for 3 h. The reaction mixture was poured into water and basified with saturated sodium bicarbonate. The solid thus formed was isolated by filtration, washed with water and dried.

Yield: 0.048 g (97%); mp: 314–316°C; IR (KBr) ν_{max}: 3426, 3144, 1613, 1572, 1405, 1256, 1230, 736 cm^{-1}; ^1H NMR δ: 12.02 (1H, s, N*H*), 8.54 (1H, d, *J*=7.7 Hz, Ph), 8.37 (1H, dd, *J*=8.5, 0.9 Hz, Ph), 8.05 (1H, d, *J*=8.5 Hz, Ph), 7.82 (1H, m, Ph), 7.65–7.53 (3H, m, Ph), 7.31 (1H, m, Ph); ^{13}C NMR δ: 152.5 (s), 146.6 (s), 141.6 (s), 134.0 (s), 129.6 (d), 129.0 (d), 127.5 (d), 124.0 (d), 123.6 (d), 123.4 (d), 121.3 (s), 120.1 (d), 119.2 (s), 115.1 (s), 111.1 (d).

4.3. Dechlorination of 11-chloro 6*H*-indolo[2,3-*b*]-quinoline (38) with Raney nickel

Compound **38** (0.253 g, 1.0 mmol) was refluxed with Raney nickel (2.0 g) in dioxane (15 mL) for 3 h. The mixture was filtered while hot and evaporated and treated with ethanol to give 6*H*-indolo[2,3-*b*]quinoline (**33**). Yield: 0.202 g (92%); mp: 347–348°C (lit.,[29] 346°C); A sample prepared using a literature method [29] was identical with our product.

4.4. Synthesis of the ester 35

The acid **34**[30] (0.262 g, 1.0 mmol) was added in portions at room temperature to diazomethane (1.2 mmol) dissolved in ether (40 mL) plus methanol (0.5 mL). The acid dissolved within 5 min and upon concentration and addition of petroleum ether the ester **35** was obtained as white crystals. Yield: 0.245 g (89%); mp: 258–259°C (lit.,[31] >240°C); The spectral data were in agreement with those published.[31]

4.4.1. 11-Chloro-5-acetylindolo[2,3-*b*]quinoline (41). Benzotriazole (5.95 g, 50 mmol) and 2,4-dichloroquinoline (9.90 g, 50 mmol) were heated at 110°C until the exothermic reaction finished. The solid formed was allowed to attain room temperature and PPA (70 g) was added and the mixture was heated at 130°C until the formation of N_2 had ceased whereupon the mixture was heated at 180°C for 5 min. The dark solution was allowed to attain room temperature whereupon it was poured into water. The solid thus formed was separated by filtration and was thoroughly washed with water. The crude solid was heated in NH_4OH at 100°C for 5 min and then cooled to room temperature.

A white solid was isolated by filtration, washed with water and heated to reflux in acetic anhydride (100 mL), filtrated hot and **41** was isolated by filtration after cooling to room temperature.

Yield: 1.65 g (11%); mp: 203–204°C; IR (KBr) ν_{max}: 1703, 1565, 1452, 1382, 1337, 1249, 1188, 764, 758, 750 cm^{-1}; ^1H NMR (75°C) δ: 8.67 (1H, d, J=8.4 Hz, Ph), 8.65 (1H, d, J=7.2 Hz, Ph), 8.42 (1H, d, J=8.4 Hz, Ph), 8.17 (1H, d, J=7.5 Hz, Ph), 7.93 (1H, t, J=7.5 Hz, Ph), 7.79 (1H, t, J=7.2 Hz, Ph), 7.71 (1H, t, J=7.2 Hz, Ph), 7.57 (1H, t, J=7.5 Hz, Ph), 3.22 (3H, s, CH_3); ^{13}C NMR (75°C) δ: 170.4 (s), 150.6 (s), 145.0 (s), 139.5 (s), 134.5 (s), 130.1 (d), 129.5 (d), 128.2 (d), 126.2 (d), 124.0 (d), 123.0 (d), 122.9 (d), 122.8 (s), 120.9 (s), 116.4 (d), 116.1 (s), 27.3 (t). Anal. calcd for $C_{17}H_{11}ClN_2O$: C, 69.28; H, 3.76; N, 9.50. Found: C, 69.18; H, 3.66; N, 9.46.

4.4.2. 11-Thiomethyl-6*H*-indolo[2,3-*b*]quinoline (42). Compound **38** (1.47 g, 5.0 mmol) and sodium acetate (2.0 g) were heated in DMSO at 165°C for 4 h. After cooling the mixture was poured into water and the solid obtained was recrystallized from acetonitrile to give **42**. Yield: 0.80 g (63%); mp: 210–212°C; IR (KBr) ν_{max}: 3145, 1607, 1485, 1457, 1398, 1373, 1256, 1226, 746 cm^{-1}; ^1H NMR δ: 11.90 (1H, s, NH), 8.76 (1H, d, J=7.8 Hz, Ph), 8.65 (1H, d, J=8.5 Hz, Ph), 8.01 (1H, d, J=8.5 Hz, Ph), 7.75 (1H, m, Ph), 7.53 (2H, m, Ph), 7.29 (1H, m, Ph), 2.07 (3H, s, SCH_3); ^{13}C NMR δ: 152.0 (s), 146.2 (s), 141.8 (s), 137.4 (s), 128.8 (d), 128.5 (d), 127.6 (d), 125.3 (d), 124.7 (d), 124.4 (d), 123.3 (d), 120.0 (d), 110.8 (d), 18.5 (t). Anal. calcd for $C_{16}H_{12}N_2S$: C, 72.65; H, 4.54; N, 10.58. Found: C, 72.91; H, 4.52; N, 10.36.

4.4.3. [2-(1*H*-Indol-2-yl)phenyl]-urea (45a). To a solution of **46a** (0.620 g, 3.0 mmol), methanol (30 mL) and hydrochloric acid (1 M (aq.), 5 mL) sodium cyanate (0.220 g, 3.3 mmol) was added at room temperature. After 22 h more sodium cyanate (0.220 g, 3.3 mmol) was added to the reaction mixture and the reaction was stirred at room temperature for 3 h. The solvent was concentrated to 5 mL and poured on water. The solid thus formed was filtered, washed with water, dried and purified by chromatography using hexane/ethyl acetate 6:4 as eluent to give **45a** as a white solid. Yield: 0.250 g (34%); mp: >174°C (dec.); IR (KBr) ν_{max}: 3488, 3334, 3190, 3054, 1726, 1656, 1579, 1442, 1253, 1043, 763, 744, 694 cm^{-1}; ^1H NMR δ: 11.35 (1H, s, NH), 7.98 (1H, d, J=8.3 Hz, Ph), 7.78 (1H, s, CH), 7.58 (1H, d, J=7.8 Hz, Ph), 7.43 (2H, m, Ph), 7.28 (1H, t, J=7.8 Hz, Ph), 7.05 (3H, m, Ph), 6.61 (1H, s, NH), 6.16 (2H, s, NH_2); ^{13}C NMR δ: 170.3 (s), 156.1 (s), 137.2 (s), 136.6 (s), 134.7 (s), 129.3 (d), 127.9 (s), 123.2 (d), 122.2 (d), 122.0 (d), 121.3 (d), 120.0 (d), 119.1 (d), 111.3 (d), 101.4 (d). HRMS (FAB): [M], found 251.1060. $C_{15}H_{13}N_3O$ requires 251.1059.

4.4.4. [2-(1*H*-Indol-2-yl)-4-methylphenyl]-urea (45b). To a solution of **46b** (0.660 g, 3.0 mmol), methanol (50 mL) and hydrochloric acid (1 M (aq.), 7 mL) was sodium cyanate (0.220 g, 3.3 mmol) added at room temperature. After 22 h more sodium cyanate (0.220 g, 3.3 mmol) was added to the reaction mixture and the reaction was stirred in room temperature for 3 h. The solvent was concentrated to 5 mL and poured on water. The solid thus formed was filtered, washed with water, dried and purified by chromatography, using hexane/ethyl acetate 5:5, to give **45b** as a white solid. Yield: 0.420 g (53%); mp: >180°C (dec.); IR (KBr) ν_{max}: 3440, 3283, 3194, 1681, 1602, 1453, 1415, 1232, 772, 742 cm^{-1}; ^1H NMR δ: 11.33 (1H, s, NH), 7.80 (1H, d, J=8.3 Hz, Ph), 7.77 (1H, s, CH), 7.55 (1H, d, J=7.8 Hz, Ph), 7.40 (1H, d, J=8.3 Hz, Ph), 7.30 (d, 1H, J=1.4 Hz, Ph), 7.10 (m, 2H, Ph), 7.01 (1H, t, J=7.0 Hz, Ph), 6.60 (d, 1H, J=1.4 Hz, NH), 6.08 (1H, s, NH_2), 2.30 (3H, s, CH_3); ^{13}C NMR δ: 156.4 (s), 136.6 (s), 134.9 (s), 134.6 (s), 131.3 (s), 129.5 (d), 128.5 (s), 128.5 (d), 123.6 (s), 122.8 (d), 121.3 (d), 120.1 (d), 119.2 (d), 111.4 (d), 101.4 (d), 20.4 (q). Anal. calcd for $C_{16}H_{15}N_3O$: C, 72.43; H, 5.70; N, 15.84. Found: C, 72.58; H, 5.69; N, 15.73.

4.4.5. Compound 48a. *Method A*. A mixture of isatin (1.47 g, 10 mmol) and 2-aminobenzylamine (2.44 g, 20 mmol) was stirred at room temperature in acetic acid (100 mL) for 20 h. The reaction mixture was poured into water and basified (NaOH). The solid formed was collected by filtration, to give **48a** as a yellow solid. Yield: 1.41 g (40%).

Method B. A mixture of **7a** (0.503 g, 2 mmol) and 2-aminobenzylamine (0.244 g, 2 mmol) was stirred at room temperature in acetic acid (10 mL) for 20 h. The reaction mixture was poured into water and basified (NaOH). The solid formed was collected by filtration, to give **48a** as a yellow solid. Yield: 0.255 g (72%).

Mp: 244–246°C; IR (KBr) ν_{max}: 3166, 3097, 1729, 1610, 1552, 1490, 1474, 1333, 1193, 754 cm^{-1}; ^1H NMR δ: 10.70 (1H, s, NH), 7.99 (1H, d, J=7.5 Hz, Ph), 7.5–7.3 (3H, m, Ph), 7.3–7.0 (3H, m, Ph), 7.04 (1H, d, J=7.5 Hz, Ph), 6.95–6.84 (3H, m, Ph), 6.73 (1H, t, J=7.5 Hz, Ph), 6.63 (1H, d, J=8.0 Hz, Ph), 3.98 (1H, d, J=13.2 Hz, CH_2), 3.87 (1H, d, J=13.2 Hz, CH_2); ^{13}C NMR δ: 174.4 (s), 150.2 (s), 143.8 (s), 142.4 (s), 142.0 (s), 131.7 (d), 131.2 (d), 128.2 (d), 126.5 (s), 125.9 (d), 125.4 (d), 124.9 (d), 124.3 (d), 123.6 (d), 122.7 (d), 121.0 (s), 117.9 (d), 116.1 (s), 114.2 (d), 110.6 (d), 74.7 (s), 43.6 (t). Anal. calcd for $C_{22}H_{16}N_4O$: C, 74.98; H, 4.58; N, 15.90. Found: C, 75.11; H, 4.43; N, 15.76.

4.4.6. Compound 48b. *Method A*. A mixture of 5-methylisatin (1.61 g, 10 mmol) and 2-aminobenzylamine (2.44 g, 20 mmol) was stirred at room temperature in acetic acid (50 mL) for 20 h. The reaction mixture was poured into water and basified with NaOH (2 M). The solid thus formed was isolated by filtration, washed with water and treated with ethyl acetate. Yield: 0.7 g (37%).

Method B. A mixture of **7b** (0.530 g, 2 mmol) and 2-aminobenzylamine (244 mg, 2 mmol) was stirred at room temperature in acetic acid (10 mL) for 20 h. The reaction mixture was poured into water and basified with NaOH (2 M). The solid formed was collected by filtration and treated with ethyl acetate, to give **48b** as a yellow solid. Yield: 0.090 g (24%).

Mp: 288–289°C (dec.); IR (KBr) ν_{max}: 3399, 3148, 3079, 2910, 1725, 1627, 1548, 1497, 1490, 1332, 1203, 1161, 813, 762 cm^{-1}; ^1H NMR δ: 10.63 (1H, br s, NH), 7.81 (1H, s, Ph), 7.54 (1H, s, Ph), 7.26–6.73 (8H, m, Ph), 6.55 (1H, d, J=8.0 Hz, Ph), 3.97 (1H, d, 13.2, CH_2), 3.88 (1H, d, 13.2,

CH_2), 2.27 (3H, s, CH_3), 2.24 (3H, s, CH_3); ^{13}C NMR δ: 174.6 (s), 150.5 (s), 142.3 (s), 141.6 (s), 140.1 (s), 132.5 (d), 131.7 (s), 131.4 (d), 128.2 (d), 126.7 (s), 126.4 (s), 126.0 (d), 125.5 (d), 125.4 (d), 124.3 (d), 123.6 (d), 121.1 (s), 116.2 (s), 114.3 (d), 110.4 (d), 75.1 (s), 43.7 (t), 20.5 (q), 20.3 (q). HRMS (FAB): $[M+H]^+$, found 381.1707. $C_{24}H_{21}N_4O$ requires 381.1715.

4.4.7. 1,2,3,4-Tetrahydroquinazolin-4-one-2-spiro-3′-1*H*-indolin-2-one (53a). Isatin (7.35 g, 50 mmol) and 2-aminobenzamide (6.80 g, 50 mmol) were dissolved in hot acetic acid (70 mL) and then heated at reflux for 3 h, whereupon the clear solution was evaporated. The residue treated with 2-propanol gave a whitish solid. The analytical sample was recrystallized from EtOH. Yield: 10.70 g (81%); mp: 247–249°C; IR (KBr) ν_{max}: 3490, 3233, 1712, 1649, 1622, 1474, 759 cm^{-1}; ^1H NMR δ: 10.28 (1H, s, N*H*), 8.33 (1H, s, N*H*), 7.59 (1H, d, *J*=7.3 Hz, Ph), 7.47 (1H, d, *J*=7.3 Hz, Ph), 7.32 (1H, t, *J*=7.7 Hz, Ph), 7.27 (1H, s, N*H*), 7.21 (1H, t, *J*=8.1 Hz, Ph), 7.05 (1H, t, *J*=7.4 Hz, Ph), 6.84 (1H, d, *J*=7.7 Hz, Ph), 6.67 (1H, t, *J*=7.4 Hz, Ph), 6.60 (1H, d, *J*=8.1 Hz, Ph); ^{13}C NMR δ: 175.9 (s), 163.8 (s), 146.7 (s), 142.0 (s), 133.2 (d), 130.7 (d), 129.4 (s), 126.8 (d), 125.3 (d), 122.2 (d), 117.0 (d), 114.2 (s), 113.8 (d), 110.0 (d). 70.9 (s). HRMS (FAB): $[M+H]^+$, found 266.0938. $C_{15}H_{12}N_3O_2$ requires 266.0929.

4.4.8. 1,2,3,4-Tetrahydroquinazolin-4-one-2-spiro-3′-5,7-dichloro-1*H*-indolin-2-one (53b). 5,7-Dichloroisatin (10.80 g, 50 mmol) and 2-aminobenzamide (6.80 g, 50 mmol) were dissolved in hot acetic acid (70 mL) and then heated at reflux for 3 h, whereupon the clear solution was evaporated. The residue treated with 2-propanol gave a whitish solid. Yield: 12.4 g (74%); mp: 277–278°C; IR (KBr) ν_{max}: 3248, 1736, 1636, 1614, 1460, 1167, 748 cm^{-1}; ^1H NMR δ: 10.95 (1H, s, N*H*), 8.41 (1H, s, N*H*), 7.7–7.6 (2H, m, Ph), 7.52 (1H, d, *J*=1.9 Hz, Ph), 7.39 (1H, s, N*H*), 7.25 (1H, t, *J*=7.6 Hz, Ph), 6.71 (1H, t, *J*=7.6 Hz, Ph), 6.59 (1H, d, *J*=8.0 Hz, Ph); ^{13}C NMR δ: 175.7 (s), 163.4 (s), 146.2 (s), 139.0 (s), 133.5 (d), 132.5 (s), 129.9 (d), 126.8 (d), 126.7 (s), 124.2 (d), 117.5 (d), 114.9 (s), 114.0 (s), 113.8 (d). 71.6 (s). Anal. calcd for $C_{15}H_9Cl_2N_3O_2$: C, 53.92; H, 2.71; N, 12.58. Found: C, 54.08; H, 2.77; N, 12.42.

4.4.9. 2-(2-Acetylaminophenyl)-*N*-(2-aminobenzyl)-2-oxoacetamide (58). N-Acetylisatin (9.46 g, 50 mmol) was heated to reflux in ethanol (200 mL) for 3 h, whereupon 2-aminobenzylamine (6.11 g, 50 mmol) was added to the solution at 5°C. After completed addition the temperature was slowly allowed to increase to room temperature. The solid formed was collected by filtration. Yield: 12.4 g (80%); mp: 150–151°C; IR (KBr) ν_{max}: 3462, 3356, 3284, 3230, 1697, 1681, 1660, 1633, 1606, 1543, 1480, 752 cm^{-1}; ^1H NMR δ: 10.52 (1H, s, N*H*), 9.09 (1H, t, *J*=6.2 Hz, N*H*), 7.77 (1H, d, *J*=7.5 Hz, Ph), 7.7–7.5 (2H, m, Ph), 7.22 (1H, dd, *J*=7.6,1.1 Hz, Ph), 7.07 (1H, dd, *J*=7.5, 1.4 Hz, Ph), 6.97 (1H, dd, *J*=7.6, 1.4 Hz, Ph), 6.64 (1H, dd, *J*=8.0, 1.1 Hz, Ph), 6.52 (1H, dd, *J*=7.3, 1.1 Hz, Ph), 5.10 (2H, s, NH_2), 4.24 (2H, d, *J*=6.2 Hz, CH_2), 1.97 (3H, s, CH_3); ^{13}C NMR δ: 190.9 (s), 168.8 (s), 163.6 (s), 146.1 (s), 138.2 (s), 133.8 (d), 131.3 (d), 129.2 (d), 128.0 (d), 124.3 (s), 123.4 (d), 121.4 (d), 121.2 (s), 115.8 (d), 114.7 (d), 39.1 (t), 23.7 (q). Anal. calcd for $C_{17}H_{17}N_3O_3$: C, 65.58; H, 5.50; N, 13.50. Found: C, 65.50; H, 5.58; N, 13.39.

4.4.10. 3-(2′-Acetamidophenyl)-1,5-dihydro-1,4-benzodiazepin-2(2*H*)-one (59). A mixture of N-acetylisatin (9.46 g, 50 mmol) and 2-aminobenzylamine (6.11 g, 50 mmol) was stirred at room temperature in acetic acid (250 mL) for 7 days. The reaction mixture was basified with NaOH (2 M). The solid formed was collected by filtration and recrystallized from CH_2Cl_2. Yield: 6.18 g (42%); mp: 233–234°C; IR (KBr) ν_{max}: 3179, 3074, 2968, 2900, 1676, 1660, 1603, 1577, 1538, 1445, 1315, 752 cm^{-1}; ^1H NMR δ: 11.12 (1H, s, N*H*), 10.86 (1H, s, N*H*), 7.88 (1H, d, *J*=7.8 Hz, Ph), 7.50–7.30 (4H, m, Ph), 7.20–7.10 (3H, m, Ph), 4.66 (2H, s, CH_2), 1.97 (3H, s, CH_3); ^{13}C NMR δ: 168.1 (s), 164.6 (s), 164.2 (s), 137.7 (s), 137.0 (s), 132.0 (s), 130.5 (d), 130.4 (d), 128.6 (d), 128.5 (d), 126.0 (s), 124.3 (d), 123.3 (d), 122.2 (d), 120.8 (d), 53.2 (t), 23.9 (q). HRMS (FAB): $[M+H]^+$, found 294.1252. $C_{17}H_{16}N_3O_2$ requires 294.1242.

4.4.11. 2-(2′-Acetamidophenyl)-4,5-dihydro-1,4-benzodiazepin-3(3*H*)-one (60). A solution of **55** (3.11 g, 10 mmol) in acetic acid (50 mL) was stirred at room temperature for 7 days. The solid formed was collected by filtration. Yield: 1.23 g (42%); mp: 250–255°C (dec.); IR (KBr) ν_{max}: 3169, 3068, 2909, 2870, 1692, 1667, 1588, 1567, 1530, 1446, 1310, 1194, 778, 758, 744 cm^{-1}; ^1H NMR δ: 11.13 (1H, s, N*H*), 9.01 (1H, t, 6.2, N*H*), 7.84 (1H, d, *J*=8.1 Hz, Ph), 7.80 (1H, d, *J*=7.7 Hz, Ph), 7.6–7.4 (3H, m, Ph), 7.39 (1H, d, *J*=7.4 Hz, Ph), 7.3–7.2 (2H, m, Ph), 4.20 (1H, br s, CH_2), 4.00 (1H, br s, CH_2), 2.11 (3H, s, CH_3); ^{13}C NMR δ: 168.6 (s), 163.6 (s), 162.4 (s), 145.5 (s), 138.1 (s), 131.3 (d), 131.1 (s), 131.1 (d), 128.8 (d), 127.5 (s), 127.4 (d), 126.7 (d), 126.3 (d), 123.9 (d), 122.9 (d), 41.4 (t), 23.9 (q). HRMS (FAB): $[M+H]^+$, found 294.1234. $C_{17}H_{16}N_3O_2$ requires 294.1242.

4.5. Collection and refinement of X-ray diffraction data

The data collections for the compound **48a** was performed with a Nicolet diffractometer equipped with Cu K_α radiation and an Enraf-Nonius CAD4 diffractometer with Mo Kα radiation. The data sets were corrected for absorption and the structures were solved by direct methods and refined by full-matrix least-squares including an extinction parameter for compound **48a**. Only crystals of poor quality could be obtained from compound **48a** and as the refinements gave rather high *R*-values and large standard deviations only crystal data is given below. The connectivity is, however, undoubtedly that shown for the compound.

*Compound **48a***. A crystal of dimensions 0.25×0.25×0.40 mm^3 was used for the data collection. Of the measured 2314 independent reflections, 1375 with $I>2\sigma(I)$ were used in the refinements and gave R=0.065 and R_w=0.082 with 309 parameters. $C_{22}H_{16}N_4O$, M=352.40: Compound **48a**, space group $P2_1/c$, a=10.332(9), b=14.938(4), c=11.654(8) Å, β=109.83(6)°, V=1692(2) $Å^3$, Z=4, D_c=1.383 g cm^{-3}, $2\theta_{max}$=45° (Mo Kα), T=150 K.

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