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HETEROCYCLES, Vol. , No. , , pp. -,
Received, , Accepted, , Published online, (Please do not delete.)

SYNTHESES OF 4-AMINO-, 4-HYDROXY-, AND 4-NITRO-1,3,4,5-TETRAHYDROBENZ[*cd*]INDOLES AND ITS BROMINATION[1,#]

Kyoko Nakagawa, Naokatsu Aoki, Harunobu Mukaiyama, and Masanori Somei*[2]

Faculty of Pharmaceutical Sciences, Graduate School of Natural Science and Technology, Kanazawa University, Kakuma-machi, Kanazawa, 920-1192, Japan
Corresponding author: e-mail address: somei.home@topaz.plala.or.jp

Abstract – Simple synthetic method for 4-nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (**6**) is established from indole-3-carboxaldehyde (**7**). With **6** in hand, various derivatives of 4-amino-, 4-hydroxy- and 4-amino-4-hydroxymethyl-1,3,4,5-tetrahydrobenz[*cd*]indoles become readily available. Bromination of **6** afforded useful building blocks for further manipulation. Successful optical resolution of **6** by chiral column chromatography is also reported.

INTRODUCTION

In recent years, humanity is facing challenges such as the occurrence of food shortage, outbreak of yellow sand and global warming, increasing number of patients with dementia and osteoporosis in an aging society. Hoping to contribute to solve the challenges, we have recently created novel leads for potent root growth promoters,[3] anti-osteoporosis agents,[4] α_2-blockers,[5] and inhibitors of platelet aggregation.[6]

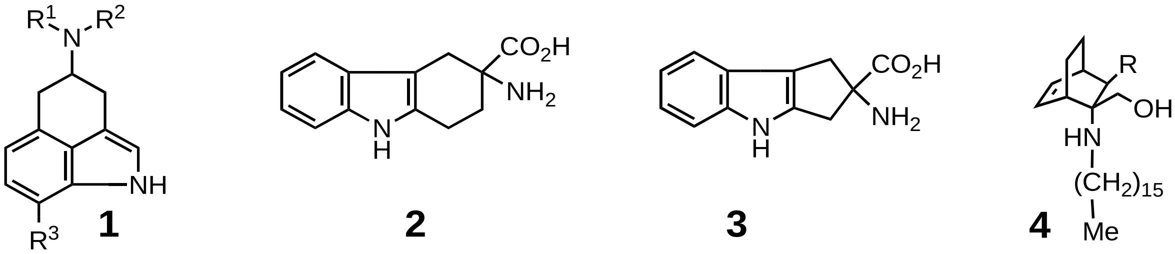


Figure 1 R, R^n = an appropriate substituent

Dedicated to the 77th birthday of Prof. Victor Snieckus.

In our sequence of challenging study, we have also been much interested in developing biologically active substance for Parkinson's disease. Many research groups are working in this field and various dopamine agonists have been developed. Among them, 4-(*N*,*N*-diisopropylamino)-1,3,4,5-tetrahydrobenz[*cd*]indole derivatives[7] **1** seems to be most effective (Figure 1). On the other hand, interesting compounds such as **2**,[8] **3**,[9] and **4**[10] have been reported and they are expected to have characteristic pharmacological effects.

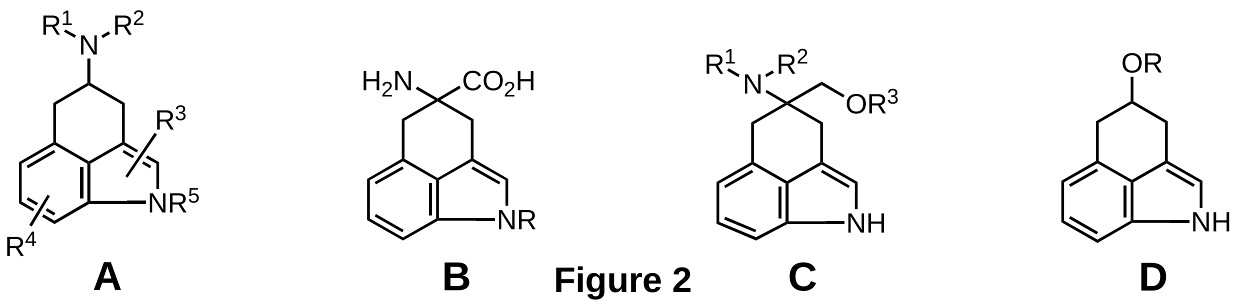


Figure 2

Our Target Compounds R, R^n = an appropriate substituent

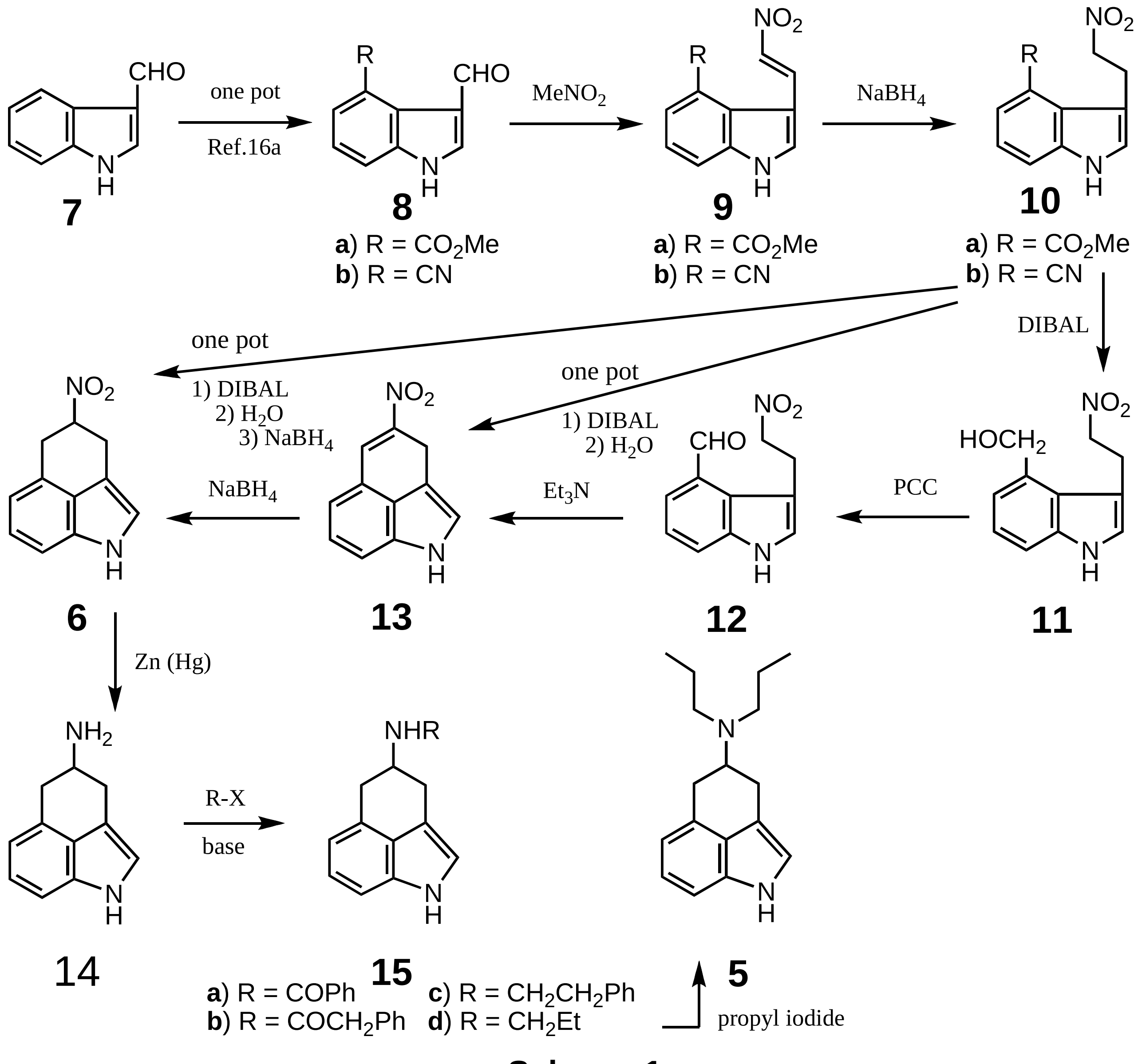
Taking the above compounds into consideration, as possible dopamine agonists and as our targets, we settled 4-amino-1,3,4,5-tetrahydrobenz[*cd*]indoles (type **A**, shown in general formula, Figure 2), 4-amino-1,3,4,5-tetrahydrobenz[*cd*]indole-4-carboxylic acids (type **B**), 4-*N*-substituted-4-hydroxymethyl-1,3,4,5-tetrahydrobenz[*cd*]indoles (type **C**), and 4-alkoxy-1,3,4,5-tetrahydrobenz[*cd*]indoles (type **D**) .
Type **A** has a part of skeleton of ergot alkaloids,[11] whereas type **B** has a conformationally constrained structure[12] of tryptophans. Therefore, we could expect **B** is not only as a dopamine agonist but also as a useful probe to obtain information about the bioactive conformation of a neuropeptide, such as cholecystokinin (CCK),[12] by incorporating **B** into the peptide. Type **C** is an analog of a potent dopamine agonist, 4-*N*,*N*-dipropylamino-1,3,4,5-tetrahydrobenz[*cd*]indole[7,13-15] (**5**, Scheme 1), and type **D** is its oxa-analog. To meet our ends, we needed 4-nitro-1,3,4,5-tetrahydrobenz[*cd*]indole[7,13-15] (**6**) as a common synthetic intermediate.

RESULTS AND DISCUSSION

Many efforts have been devoted on developing a synthetic method for **6**. The shortest synthetic route[7] among thus far known[7,13-15] is the one through indole-4-carboxaldehyde[14] using expensive 2-methyl-3-nitrobenzoic acid as a starting material. Nevertheless it still requires nine steps with low overall yield.[7] On the other hand, we developed a simple four-step synthetic method[15] for **6** from readily available indole-3-carboxaldehyde (**7**). Furthermore, we succeeded in the syntheses of some of typical target compounds. We also succeeded in the optical resolution of both enantiomers of **6** by chiral column chromatography[15] aiming at the syntheses of optically active derivatives. This is the full report of previous communications[15a,b] in addition to newly developed bromine containing 4-nitro-1,3,4,5-tetrahydrobenz[*cd*]indole derivatives, which are useful for further manipulation.

I. A Simple Four-Step Synthesis of 4-Nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (6)

We first prepared 4-methoxycarbonylindole-3-carboxaldehyde[16a] (**8a**) in 53% yield from **7** according to our one pot procedure.[16a] Conversion of **8a** into 4-methoxycarbonyl-3-(2-nitrovinyl)indole (**9a**) in 91% yield was attained by aldol reaction with nitromethane. Subsequent reduction of **9a** with $NaBH_4$ in MeOH afforded 4-methoxycarbonyl-3-(2-nitroethyl)indole (**10a)** in 83% yield. DIBAL reduction of **10a** in THF afforded 4-hydroxymethyl-3-(2-nitroethyl)indole (**11**) in 99% yield, nevertheless attempts to convert **9a** directly into **11** by $LiBH_4$ reduction gave poor results giving **10a** and **11** in 36% and 33% yields, respectively.



Scheme 1

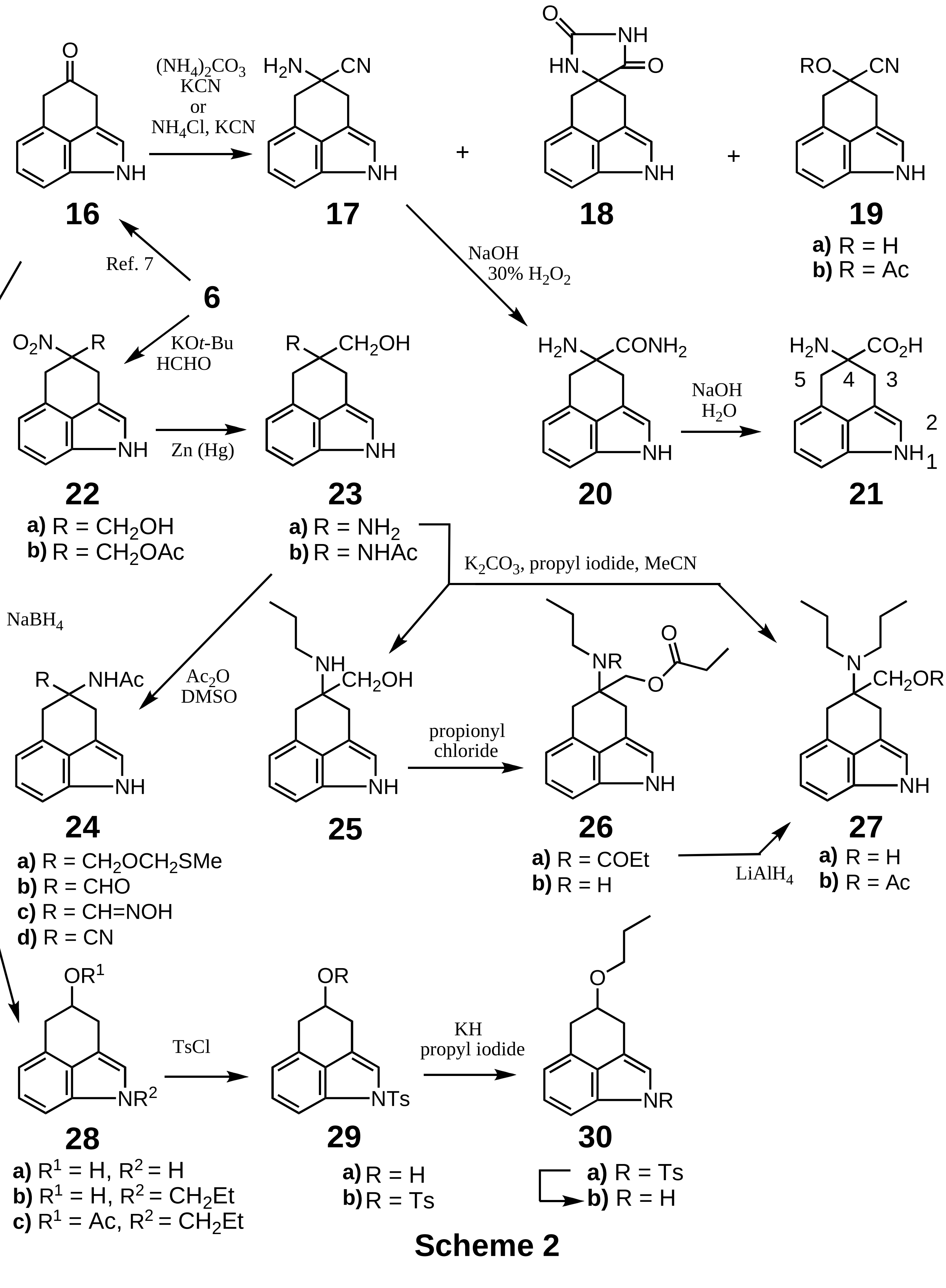
Though oxidation of **11** with either active MnO_2 or dimethyl sulfoxide–acetic anhydride afforded poor results, pyridinium chlorochromate (PCC) in pyridine produced 3-(2-nitroethyl)indole-4-carboxaldehyde (**12**) in 32% yield. Subsequent treatment of **12** with triethylamine in MeOH at reflux for 1 h afforded **13** in 87% yield. Reduction of **13** cleanly proceeded giving **6** in 80% yield with $NaBH_4$ in MeOH.

Based on our previous findings,[16] we realized the following one pot synthesis of 4-cyanoindole-3-carboxaldehyde[16] (**8b**) from **7**. In the first step, by the reaction with thallium tris(trifluoroacetate)[17] in trifluoroacetic acid (TFA), **7** was derived to (3-formylindol-4-yl)thallium bis-trifluoroacetate,[18] which was then treated with iodine and cuprous iodide affording 4-iodoindole-3-carboxaldehyde. It was finally converted to **8b** in 72% overall yield.

Aldol reaction of **8b**[16b] with nitromethane afforded nitrovinyl compound[16b] **9b** in 88% yield. Subsequent reduction of **9b** with $NaBH_4$ in MeOH gave nitroethyl compound[16b] **10b** in 88% yield. Next, sequential treatment of **10b**, initially with diisobutylaluminum hydride (DIBAL) in anhydrous tetrahydrofuran (THF) at reflux for 1 h, then with MeOH–water at reflux for 1 h, was found to produce 1,3-dihydro-4-nitrobenz[*cd*]indole (**13**) in 61% yield. Since **13** was already converted to **6** as described above, the attempt at effecting one pot conversion of **10b** to **6** was readily attained in 55% yield by adding the $NaBH_4$ reduction procedure to the above DIBAL and MeOH–water treatment of **10b**. Consequently, a simple four step synthetic method for **6** from **7** with an overall yield of 31% was established with the originality rate[19] of 60%. However, every attempt to convert **9b** into **6** in one pot operation was unsuccessful. Finally, **6** was reduced to **14** with Zn (Hg)–aq. HCl in MeOH at reflux in 99% yield.

N-Substituted derivatives of **14** were prepared as follows. Treatments of **14** with benzoyl chloride and phenylacetyl chloride in the presence of Et_3N afforded amide compounds, **15a** and **15b**, in 80% and 73% yields, respectively. The reaction of **14** with phenethyl bromide in the presence of KI and K_2CO_3 as a base provided **15c** in 61% yield. Excess amount of propyl iodide converted **14** to *N*-propyl compound **15d** and *N*,*N*-dipropyl compound **5** in 4% and 87% yields, respectively, in the presence of K_2CO_3. In addition, the compound **5** was derived from **15d** in 80% yield by the reaction with propyl iodide in MeCN in the presence of n-Bu_4NBr and K_2CO_3.

Now that **6** is readily available from **7**,[15b] **6** was converted to **16** by the procedure of Kruse and co-worker[6,7] in 81% yield (Scheme 2). Since **16** is known to isomerize to 1,2-dihydro-4-hydroxybenz[*cd*]indole having stabler naphthalene skeleton than indole isomer,[6,7] Bucherer reaction of **16** was investigated under careful control of reaction conditions using $(NH_4)_2CO_3$ and KCN. The results were the formation of α-aminonitrile **17** and spiro-hydantoin derivative **18** in 11% and 59% yields, respectively. While, Strecker type reaction of **16** with NH_4Cl and KCN produced **17** as major product (56%) together with 10% yield of **19a**. Although **19a** was a crystalline solid, it was unstable and gradually changed back to **16**. Isolation of stable 4-acetoxy-4-cyano compound (**19b**) in 43% yield by the treatment of **16** with KCN in AcOH, followed by the reaction of the resulting **19a** with Ac_2O and



Scheme 2

pyridine, clearly established the structure of **19a**. Next, **17** was converted to amide **20** in 84% yield by the reaction with 8% NaOH in the presence of 30% H_2O_2. Subsequent hydrolysis of **20** with 8% NaOH in MeOH produced the desired type **B** amino acid **21** in a quantitative yield.

For the synthesis of the type **C** target compounds, **6** was initially treated with KO*t*-Bu and then with 37% formalin to afford **22a** in 73% yield. Treatment of **22a** with Ac_2O provided **22b** in 98% yield. Reduction of **22a** with Zn (Hg)–aq. HCl gave **23a** in 94% yield.

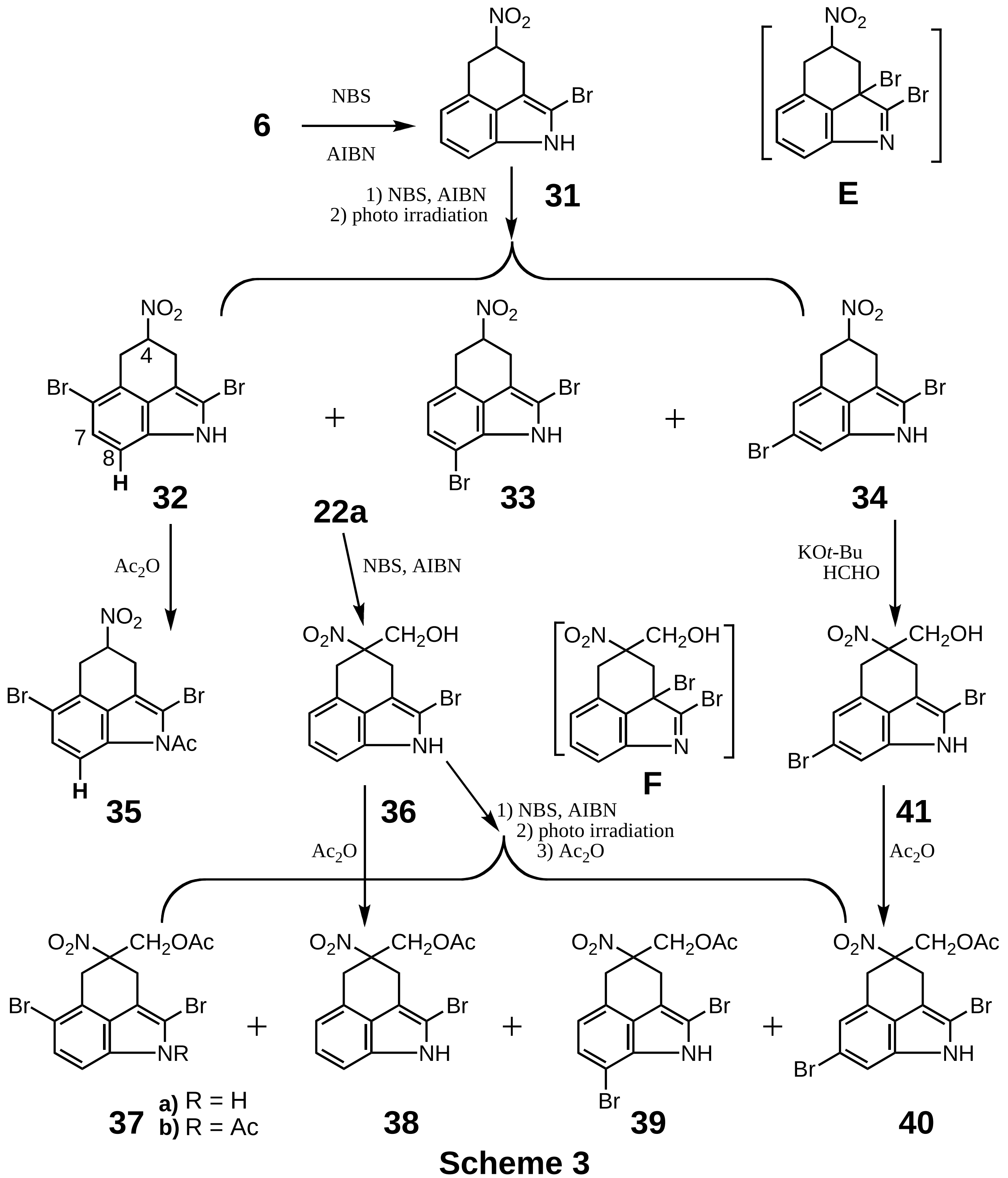
Treatment of **23a** with Ac_2O afforded *N*-acetyl compound **23b** in 98% yield. Subsequent oxidation of **23b** with Ac_2O-DMSO produced **24a** and **24b** in 32% and 56% yields, respectively. The reaction of **24b** with hydroxylamine afforded oxime derivative **24c** as a single isomer in 95% yield. Further treatment of **24c** with Ac_2O at reflux produced 52% yield of 4-acetylamino-4-cyano-1,3,4,5-tetrahydrobenz[*cd*]indole (**24d**), which was alternatively produced by the reaction of **17** with Ac_2O in 61% yield. The reaction of **23a** with propyl iodide (2 equiv.) in the presence of K_2CO_3 produced the mono-propyl **25** and the target compound **27a** in 87 and 6% yields, respectively. Although under similar reaction conditions, the longer reaction time improved the yield of **27a** to 53%, various attempts at realizing exclusive production of **27a** were unsuccessful. While, treatment of **25** with propionyl chloride afforded **26a** and **26b** in 89 and 8% yields, respectively. Subsequent reduction of **26a** with $LiAlH_4$ afforded **27a** in 91% yield. Acetylation of **27a** with Ac_2O afforded 99% yield of **27b**.

The type **D** target compound was produced as follows. Reduction of **16** with $NaBH_4$ afforded 4-hydroxy-1,3,4,5-tetrahydrobenz[*cd*]indole (**28a**) in 99% yield. Treatment of **28a** with NaH in DMF, and then with propyl iodide produced 1-propyl compound **28b** in 96% yield. The structural proof was obtained through conversion of **28b** into **28c** in 75% yield by the reaction with Ac_2O. Thus, comparison of ^{1}H-NMR data of **28b** and **28c** demonstrated that the C(4)-proton attached to 4-hydroxy group of **28b** shifted to lower magnetic field by ca. 1 ppm in the spectrum of **28c**. The fact clearly proved that hydroxy group was acetylated.

Successive treatment of **28a** with NaH in DMF, and then with tosyl chloride produced *N*-tosyl (**29a**) and *N*,*O*-ditosyl compound (**29b**) in 37 and 27% yields, respectively, together with 34% recovery of unreacted starting material. Treatment of **29a** with KH in DMF, and then with propyl iodide afforded 47% yield of the 4-propyloxy compound (**30a**), which was successfully converted to **30b** in 86% yield by hydrolysis with 8% NaOH.

II. Preparation of Bromine Containing Derivatives

It is well known that the introduction of bromine atom into 2 position of ergot alkaloids[11] increases their biological activity. In addition, organometallic chemistry makes it possible to convert C—Br bond to C—C, C—N, C—O bonds, etc., for example by employing Heck reaction,[20] Stille reaction,[21] and so on. Based on the facts, we tried to introduce bromine atom into the 1,3,4,5-tetrahydrobenz[*cd*]indole skeleton.



Scheme 3

The reaction of **6** with NBS in the presence of AIBN proceeded cleanly to afford **31** in 87% yield (Scheme 3). Further treatment of **31** with NBS produced unstable intermediate that is deduced to be 2,2a-dibromo-4-nitro-2a,3,4,5-tetrahydrobenz[*cd*]indole (**E**). Therefore, after bromination of **31** with NBS, the whole was irradiated with 100W mercury lamp in an aim to convert **E** to stable product. As a result, 2,6-

(**32**), 2,8- (**33**), and 2,7-dibromo-4-nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (**34**) were produced in the respective yields of 36%, 2%, and 14% together with unreacted **31** (9%).

Both compounds, **32** and **33**, have a pair of ortho-coupled aromatic protons in their ^{1}H-NMR spectra. Therefore, one of them is a 2,6-dibromo and the other is a 2,8-dibromo compound. The conversion of **32** into 1-acetyl derivative (**35**) in 62% yield by the reaction with Ac_2O proved its structure to be 2,6-dibromo compound. Thus, comparison of ^{1}H-NMR data of **32** and **35** demonstrated that an ortho-coupled C(8)-proton of **32** shifted to lower magnetic field by ca. 1 ppm by the anisotropy effect of the introduced 1-acetyl group of **35**, proving their assigned structures. In addition, the failure to introduce an acetyl group into the 1-position of **33** with Ac_2O even under forced conditions confirmed its assigned structure because steric hindrance between C(8)-bromine atom and 1-acetyl group would explain the results.

Similarly, bromination of **22a** with NBS in the presence of AIBN cleanly afforded **36** in 92% yield. As in the case of **31**, further bromination of **36** with NBS produced unstable intermediate which is deduced to be 2,2a-dibromo-4-hydroxymethyl-4-nitro-2a,3,4,5-tetrahydrobenz[*cd*]indole (**F**). Therefore, after bromination of **36** with NBS, the whole was irradiated with 100W mercury lamp in an aim to convert **F** to stable product. Furthermore the reaction mixture was acetylated by Ac_2O-pyridine for enabling easy separation of products. As a result, 2,6-dibromo- (**37a**) 1-acetyl-2,6-dibromo- (**37b**), 2-bromo- (**38**), 2,8-dibromo- (**39**), and 2,7-dibromo-4-acetoxymethyl-4-nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (**40**) were produced in 14%, 14%, 2%, 5%, and 2% yields, respectively.

Acetylation of **37a** with Ac_2O–pyridine afforded **37b** in 80% yields. As in the case of **32** and **35**, **37a** and **37b** showed the anisotropy effect on their C(8) protons by the introduced 1-acetyl group proving the assigned structures. Proof of the structure of **38** was obtained by its production in 98% yield from **36** by the acetylation with Ac_2O. The structure of **40** was established by alternative synthesis. First, hydroxymethylation of **34** to **41** was carried out in 60% yield by the treatment with 37% formalin in the presence of KO*t*-Bu. Subsequent acetylation of **41** with Ac_2O–pyridine afforded 74% yield of **40** which was identical with the one obtained by the bromination of **36**.

III. Optical Resolution[15a] of 4-Nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (6)

With the desired compound **6** in hand, we next tried its optical resolution on semi-preparative chiral column chromatography, and finally found that optical isomers of **6** were separable as shown in Chart 1 on Chiralpak AS column (Daicel Kagaku) using hexane–isopropanol (18:1, v/v) as an eluent. Syntheses of optically active derivatives of (+)-**6** and (–)-**6** are currently under investigation.

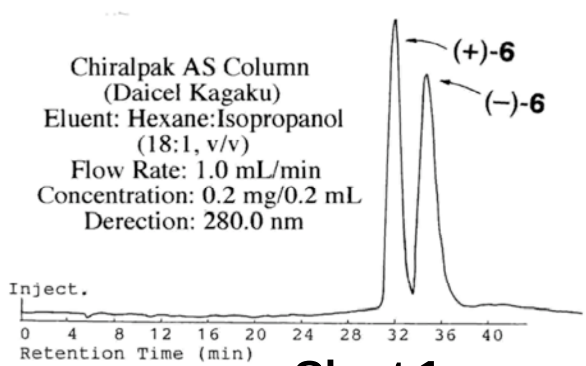


Chart 1

EXPERIMENTAL

Melting points were determined on a Yanagimoto micro melting point apparatus and are uncorrected. Infrared (IR) spectra were determined with a Shimadzu IR-420 spectrophotometer, and proton nuclear magnetic resonance (^{1}H-NMR) spectra with a JEOL JNM-GSX 500 or FX100S spectrometer with tetramethylsilane as an internal standard. Mass spectra (MS) were recorded on a Hitachi M-80 spectrometer. Preparative thin-layer chromatography (p-TLC) was performed on Merck Kiesel-gel GF_{254} (Type 60)(SiO_2). Column chromatography was performed on silica gel (SiO_2, 100-200 mesh, from Kanto Chemical Co. Inc.) throughout the present study.

4-Cyanoindole-3-carboxaldehyde (8b)[16a,b] **from Indole-3-carboxaldehyde (7)** — Compound **7** (101.6 mg, 0.70 mmol) was added to a solution of $Tl(OCOCF_3)_3$ in TFA (1.0 mL, 1.2 mol eq) and stirred at rt for 22.5 h. After evaporation of the solvent, DMF (5.0 mL) was added. To the resultant solution, CuI (335.7 mg, 1.76 mmol) and I_2 (633.0 mg, 2.49 mmol) were added and stirred at rt for 1 h. Then, CuCN (253.8 mg, 2.83 mmol) was added and heated at 64–71 °C for 1 h under ultrasonic bath. Solids were filtered off through thin SiO_2 layer. They were washed with CH_2Cl_2–MeOH (9:1, v/v). To the combined mixture of washings and the filtrate was added H_2O. The whole was extracted with CH_2Cl_2–MeOH (9:1, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was subjected to column-chromatography on SiO_2 with CH_2Cl_2–MeOH (99:1, v/v) as an eluent to give **8b** (85.3 mg, 72%). Spectral data of **8b** are reported in the reference 16b.

Methyl 3-(2-nitrovinyl)indole-4-carboxylate (9a) from Methyl 3-formylindole-4-carboxylate (8a) — Dried NH_4OAc (33.6 mg, 0.44 mmol) was added to a solution of **8a**[16a] (128.2 mg, 0.63 mmol) in CH_3NO_2 (10.0 mL) and heated at 90–95 °C for 4 h with stirring. After evaporation of the solvent under reduced pressure, H_2O was added. The whole was extracted with CH_2Cl_2–MeOH (95:5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave crystalline solid. Recrystallization from MeOH–H_2O afforded **9a** (104.2 mg). Evaporation of the mother liquor leaved an oil, which was subjected to column-chromatography on SiO_2 with CH_2Cl_2–MeOH (95:5, v/v) as an eluent to give additional **9a** (37.3 mg). Total yield of **9a** was 141.5 mg (91%). **9a**: mp 121–122 °C (red prisms, recrystallized from MeOH–H_2O). IR (KBr): 3240, 1718, 1602, 1252 cm^{-1}. ^{1}H-NMR (pyridine-d_5) δ: 3.92 (3H, s), 7.27 (1H, t, J=8.0 Hz), 7.73 (1H, dd, J=8.0, 1.0 Hz), 7.96 (1H, d, J=13.5 Hz), 8.00 (1H, dd, J=8.0, 1.0 Hz), 8.35 (1H, br s), 9.69 (1H, dd, J=13.5, 0.5 Hz). MS *m/z*: 246 (M^+). *Anal.* Calcd for $C_{12}H_{10}N_2O_4$: C, 58.53; H, 4.09; N, 11.38. Found: C, 58.37; H, 3.92; N, 11.29.

4-Cyano-3-(2-nitrovinyl)indole (9b) from (8b) — Dried NH_4OAc (201.3 mg, 2.53 mmol) was added to a solution of **8b** (537.7 mg, 3.16 mmol) in CH_3NO_2 (30.0 mL) and heated at 110–115 °C for 2 h with stirring. After evaporation of the solvent, formed crystals were filtrated. Crystals were washed with MeOH–H_2O (1:1, v/v, 120.0 mL) to give **9b** (569.7 mg). After condensation of mother liquor under reduced pressure, the whole was extracted with CH_2Cl_2–MeOH (95:5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave crystalline solid, which was subjected to column-chromatography on SiO_2 with CH_2Cl_2–MeOH (95:5, v/v) as an eluent to give additional **9b** (20.2 mg). Total yield of **9b** was 589.9 mg (88%). Spectral data of **9b** are reported in the reference 16b.

Methyl 3-(2-Nitroethyl)indole-4-carboxylate (10a) from 9a — $NaBH_4$ (36.8 mg, 0.97 mmol) was added to a solution of **9a** (29.5 mg, 0.12 mmol) in MeOH (10.0 mL) and stirred at rt for 15 min. After addition of H_2O, the mixture was adjusted to pH 1 by adding 3% HCl. The whole was extracted with CH_2Cl_2. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure. The residue was purified by column chromatography on SiO_2 with CH_2Cl_2 as an eluent to give **10a** (24.6 mg, 83%). **10a**: mp 106–107 °C (colorless prisms, recrystallized from CH_2Cl_2–hexane). IR (KBr): 3330, 1697, 1547, 1263, 1205 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 3.65 (2H, t, *J*=7.0 Hz), 3.93 (3H, s), 4.68 (2H, t, *J*=7.0 Hz), 7.14 (1H, br s), 7.17 (1H, t, *J*=7.5 Hz), 7.54 (1H, dd, *J*=7.5, 1.0 Hz), 7.79 (1H, dd, *J*=7.5, 1.0 Hz), 8.28 (1H, br s). MS *m/z*: 248 (M^+). *Anal.* Calcd for $C_{12}H_{12}N_2O_4$: C, 58.06; H, 4.87; N, 11.29. Found: C, 57.86; H, 4.87; N, 11.26.

4-Cyano-3-(2-nitroethyl)indole (10b) from 9b — $NaBH_4$ (20.2 mg, 0.54 mmol) was added to a solution of **9b** (20.5 mg, 0.10 mmol) in MeOH (4.0 mL) and stirred at rt for 0.5 h. After addition of H_2O, the mixture was adjusted to pH 5 by adding 0.6% HCl. The whole was extracted with CH_2Cl_2. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure. The residue was subjected to p-TLC on SiO_2 with EtOAc–hexane (1:1, v/v) as a developing solvent. Extraction of the band having an *Rf* value of 0.67–0.57 with CH_2Cl_2–MeOH (95:5, v/v) gave **10b** (17.3 mg, 88%). Spectral data of **10b** are reported in the reference 16b.

4-Hydroxymethyl-3-(2-nitroethyl)indole (11) from 10a — DIBAL (1.0 M toluene, 1.6 mL, 1.63 mmol) was added to a cooled solution of **10a** (133.9 mg, 0.54 mmol) in dry THF (5.0 mL) under Ar atmosphere and the mixture was stirred at rt for 3 h. After addition of MeOH and 10% aq. solution of Rochelle salt, the whole was adjusted to pH 3 by addition of 0.6% HCl. The whole was extracted with CH_2Cl_2. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was column-chromatographed on SiO_2 with CH_2Cl_2–MeOH (95:5, v/v) as an eluent to give **11** (118.7 mg, 99%). **11**: mp 118–119 °C (colorless prisms, recrystallized from CH_2Cl_2–hexane). IR (KBr): 3560, 3320, 1558, 1378, 990, 747 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 3.69 (2H, t, *J*=7.0 Hz), 4.75 (2H, t, *J*=7.0 Hz), 4.97 (2H, s), 7.03 (1H, dd, *J*=7.0, 2.0 Hz), 7.15 (1H, t, *J*=7.0 Hz), 7.23 (1H, s), 7.36 (1H, dd, *J*=7.0, 2.0 Hz), 8.15 (1H, br s). MS *m/z*: 220 (M^+). *Anal.* Calcd for $C_{11}H_{12}N_2O_3$: C, 59.99; H, 5.49; N, 12.72. Found: C, 59.85; H, 5.46; N, 12.61.

11 from 9a — $LiBH_4$ (29.9 mg, 1.36 mmol) was added to a solution of **9a** (30.8 mg, 0.13 mmol) in THF

(3 mL) and stirred at rt for 30 min, then at reflux for 1 h. After addition of H_2O, the mixture was made acidic by adding 0.6% HCl. The whole was extracted with CH_2Cl_2–MeOH (95:5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure. The residue was subjected to p-TLC on SiO_2 with CH_2Cl_2–MeOH (98:2, v/v) as a developing solvent. Extraction of the bands having an *Rf* value of 0.68–0.36 and 0.34–0.24 with CH_2Cl_2–MeOH (95:5, v/v) gave **10a** (11.1 mg, 36%) and **11** (9.1 mg, 33%), respectively.

3-(2-Nitroethyl)indole-4-carboxaldehyde (12) from 11 — PCC (66.9 mg, 0.31 mmol) was added to a solution of **11** (34.6 mg, 0.16 mmol) in pyridine (2 mL) and stirred at rt for 2.5 h. EtOH (0.2 mL) was then added and stirred for 30 min. After addition of CH_2Cl_2–MeOH (95:5, v/v), the precipitates were filtered off through thin SiO_2 layer. Evaporation of the filtrate under reduced pressure leaves an oil, which was column-chromatographed on SiO_2 with CH_2Cl_2–MeOH (98:2, v/v) as an eluent. The early fractions afforded **12** (11.0 mg, 32%). The middle fractions gave 4.5 mg of unknown product (expected to be a mixture of diastereoisomers of 5-hydroxy-4-nitro-1,3,4,5-tetrahydrobenz[*cd*]indole from MS and ^{1}H-NMR). The later fractions afforded unreacted **11** (4.7 mg, 14%). **12**: mp 159–160 °C (red prisms, recrystallized from MeOH–H_2O). IR (KBr): 3185, 1674, 1538 cm^{-1}. ^{1}H-NMR (10% CD_3OD in $CDCl_3$) δ: 3.73 (2H, t, *J*=6.5 Hz), 4.61 (2H, t, *J*=6.5 Hz), 6.92–7.72 (4H, m), 10.01 (1H, s). MS *m/z*: 218 (M^+). *Anal.* Calcd for $C_{11}H_{10}N_2O_3$: C, 60.54; H, 4.62; N, 12.84. Found: C, 60.30; H, 4.33; N, 12.45.

4-Nitro-1,3-dihydrobenz[*cd*]indole (13) from 12 — A solution of **12** (6.7 mg, 0.03 mmol) in a mixture of Et_3N (0.5 mL) and MeOH (2 mL) was refluxed for 1 h. After evaporation of solvent under reduced pressure, H_2O was added. The mixture was adjusted to pH 4.0 by adding 0.6% HCl. The whole was extracted with CH_2Cl_2–MeOH (95:5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure. The residue was purified by column-chromatography on SiO_2 with CH_2Cl_2 as an eluent to give **13** (5.4 mg, 87%).**13**: mp 190–190.5 °C (red prisms, recrystallized from MeOH–H_2O). IR (KBr): 3356, 1574, 1491, 1290 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 4.33 (2H, br s), 7.01 (1H, dd, *J*=7.0, 2.0 Hz), 7.03 (1H, s), 7.10 (1H, t, *J*=7.0 Hz), 7.19 (1H, dd, *J*=7.0, 2.0 Hz), 8.09 (2H, br s). MS *m/z*: 200 (M^+). *Anal*. Calcd for $C_{11}H_8N_2O_2$: C, 66.00; H, 4.03; N, 13.99. Found: C, 65.94; H, 4.15; N, 13.90.

4-Nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (6) from 13 — $NaBH_4$ (19.1 mg, 0.50 mmol) was added to a solution of **13** (22.0 mg, 0.10 mmol) in MeOH (4 mL) and stirred at rt for 0.5 h. After addition of H_2O, the mixture was made acidic by adding a drop of AcOH–H_2O (1:1, v/v) and extracted with CH_2Cl_2. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure. The residue was purified by column chromatography on SiO_2 with CH_2Cl_2–hexane (2:1, v/v) as an eluent to give **6** (17.8 mg, 80%). **6**: mp 138.5–139 °C (lit.[7] mp 134–135 °C). All spectral data were identical with those of **6** reported by L. I. Kruse et al.[7]

4-Nitro-1,3-dihydrobenz[*cd*]indole (13) from (10b) — DIBAL (1.0 M toluene, 1.6 mL, 1.63 mmol) was added to a cooled solution of **10b** (58.1 mg, 0.27 mmol) in dry THF (1.0 mL) under Ar atmosphere and the mixture was heated at reflux for 1 h. Then, MeOH–H_2O (2:1, v/v, 1.5 mL) was added and the whole was refluxed for 1 h. After addition of MeOH and 10% aq. solution of Rochelle salt, the whole was adjusted to pH 3 by addition of 0.6% HCl. The whole was extracted with CH_2Cl_2–MeOH (95:5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was column-chromatographed on SiO_2 with CH_2Cl_2 to give **13** (33.5 mg, 61%).

4-Nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (6) from (10b) — One Pot Synthesis : DIBAL (1.0 M toluene, 2.90 mL, 2.94 mmol) was added to a cooled solution of **10b** (104.2 mg, 0.49 mmol) in dry THF (3.0 mL) under Ar atmosphere and the mixture was stirred at rt for 1 h. Then, MeOH–H_2O (2:1, v/v, 5.0 mL) was added and the whole was refluxed for 1 h. After cooling, DMF (1.0 mL) and $NaBH_4$ (183.5 mg, 4.83 mmol) were added and the mixture was stirred at rt for 20 min. After addition of MeOH, the whole was adjusted to pH 4 by addition of AcOH–H_2O (1:1, v/v). The whole was extracted with EtOAc. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was column-chromatographed on SiO_2 with CH_2Cl_2–hexane (2:1, v/v) to give **6** (53.7 mg, 55%).

4-Amino-1,3,4,5-tetrahydrobenz[*cd*]indole (14) from 6 — 6% HCl (1 mL) was added to a mixture of Zn powder (472.2 mg, 7.27 mmol) and $HgCl_2$ (43.9 mg, 0.16 mmol) and stirred for 5 min. Liquid was decanted off. To the residue was added a solution of **6** (30.3 mg, 0.15 mmol) in MeOH (3 mL) and then 6% HCl (1.5 mL). The whole was heated at reflux for 3 h with stirring. After filtering off the solid, 8% NaOH was added to make the whole alkaline. The mixture was extracted with CH_2Cl_2. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was subjected to p-TLC on SiO_2 with $CHCl_3$–MeOH–aq. 30% NH_3 (46: 5:0.5, v/v) as a developing solvent. Extraction of the band having an *Rf* value of 0.50–0.21 with $CHCl_3$–MeOH –30% aq. NH_3 (46: 5:0.5, v/v) afforded **14** (25.6 mg, 99%). **14**: mp 129.5–130 °C (lit.[7] mp 119–121 °C) colorless prisms, recrystallized from CH_2Cl_2–hexane). IR (KBr): 3328, 3072, 2912, 1612, 1603, 1582, 1443, 1344, 1261, 1097, 1058, 937, 746 cm^{-1}. ^{1}H-NMR (5% CD_3OD in $CDCl_3$) δ: 2.74 (1H, dd, *J*=15.6, 7.8 Hz), 2.86 (1H, dd, *J*=15.6, 7.8 Hz), 3.12 (1H, dd, *J*=15.6, 3.9 Hz), 3.15 (1H, dd, *J*=15.6, 3.9 Hz), 3.54 (1H, sept, *J*=3.9 Hz), 6.84 (1H, d, *J*=7.5 Hz), 6.89 (1H, s), 7.12 (1H, t, *J*=7.5 Hz), 7.17 (1H, d, *J*=7.5 Hz). MS *m/z*: 172 (M^+). *Anal.* Calcd for $C_{11}H_{12}N_2$: C, 76.71; H, 7.02; N, 16.27. Found: C, 76.61; H, 6.96; N, 15.97.

4-*N*-Benzoylamino-1,3,4,5-tetrahydrobenz[*cd*]indole (15a) from 14 — Benzoyl chloride (41.7 mg, 0.30 mmol) was added to a solution of **14** (41.0 mg, 0.24 mmol) in CH_2Cl_2 (1.5 mL) and Et_3N (0.4 mL). The mixture was stirred at rt for 45 min. After addition of sat. aq. $NaHCO_3$, the whole was extracted with CH_2Cl_2–MeOH (95:5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was subjected to p-TLC on SiO_2 with CH_2Cl_2–MeOH (97:3, v/v) as a developing solvent. Extraction of the band having an *Rf* value of 0.56–0.35 with CH_2Cl_2–MeOH (95:5, v/v) afforded **15a** (44.6 mg, 80%). **15a**: mp 222–222.5 °C (colorless prisms, recrystallized from MeOH). IR (KBr): 3371, 3230, 1623, 1575, 1532, 1486, 1443, 1429, 1401, 757, 715 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 3.05 (1H, dd, *J*=15.5, 5.3 Hz), 3.12 (1H, dd, *J*=16.2, 5.3 Hz), 3.21 (1H, ddd, *J*=15.5, 4.0, 1.3 Hz), 3.32 (1H, dd, *J*=16.2, 4.0 Hz), 4.90–5.03 (1H, m), 6.18 (1H, br d, *J*=6.9 Hz), 6.89 (1H, dd, *J*=6.9, 0.9 Hz), 6.94 (1H, br s), 7.11–7.42 (5H, m), 7.53–7.60 (2H, m), 8.01 (1H, br s). MS *m/z*: 276 (M^+). *Anal.* Calcd for $C_{18}H_{16}N_2O$: C, 78.24; H, 5.84; N, 10.14. Found: C, 78.30; H, 5.61; N, 10.17.

4-(*N*-Phenylacetylamino)-1,3,4,5-tetrahydrobenz[*cd*]indole (15b) from 14 — Phenylacetyl chloride (55.7 mg, 0.36 mmol) was added to a solution of **14** (30.2 mg, 0.18 mmol) in CH_2Cl_2 (5 mL) and Et_3N (0.3 mL). The mixture was stirred at rt for 3 h. After addition of sat. aq. $NaHCO_3$, the whole was extracted with CH_2Cl_2–MeOH (95:5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was subjected to p-TLC on SiO_2 with $CHCl_3$–MeOH–aq. 30% NH_3–hexane (92:10:1:1, v/v) as a developing solvent. Extraction of the band having an *Rf* value of 0.50–0.27 with $CHCl_3$–MeOH–aq. 30%NH_3 (46:5:0.5, v/v) afforded **15b** (36.9 mg, 73%). **15b:** colorless oil. IR (KBr): 3373, 3266, 3053, 2916, 1642, 1511, 1442, 1341, 749, 720, 692 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.82 (1H, dd, *J*=15.2, 5.6 Hz), 2.92 (1H, dd, *J*=15.8, 5.6 Hz), 3.06 (1H, ddd, *J*=15.2, 3.9, 1.3 Hz), 3.15 (1H, dd, *J*=15.8, 3.9 Hz), 3.42 (2H, s), 4.62–4.74 (1H, m), 5.42 (1H, br d, *J*=6.9 Hz), 6.81 (1H, d, *J*=6.6 Hz), 6.85 (1H, br s), 7.01–7.23 (7H, m), 8.00 (1H, br s, D_2O exchange). High resolution MS *m/z*: Calcd for $C_{19}H_{18}N_2O$: 290.1418. Found: 290.1492.

4-*N*-Phenethylamino-1,3,4,5-tetrahydrobenz[*cd*]indole (15c) from 14 — Phenethyl bromide (38.1 mg, 0.21 mmol), KI (20.0 mg, 0.12 mmol), and K_2CO_3 (124.6 mg, 0.90 mmol) were added to a solution of **14** (30.4 mg, 0.18 mmol) in DMF (1.0 mL). The mixture was stirred at reflux for 3 h. After addition of H_2O, the whole was extracted with CH_2Cl_2–MeOH (95:5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was subjected to p-TLC on SiO_2 with $CHCl_3$–MeOH–aq. 30% NH_3 (46:5:0:5, v/v) as a developing solvent. Extraction of the bands having an *Rf* value of 0.32–0.21 and 0.74–0.50 with $CHCl_3$–MeOH–aq. 30% NH_3 (46:5:0.5, v/v) afforded **15c** (29.8 mg, 61%) and unreacted **14** (3.3 mg, 16%), respectively. **15c**: colorless oil. IR (KBr): 3402, 2928, 1603, 1494, 1443, 1342, 1093, 1082, 746, 696 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 1.88 (1H, br s, D_2O exchange), 2.76 (1H, dd, *J*=15.0, 9.0 Hz), 2.85 (2H, t, *J*=7.3 Hz), 2.91 (1H, dd, *J*=15.0, 9.0 Hz), 3.06 (2H, t, *J*=7.3 Hz), 3.10–3.20 (1H, m), 3.28–3.35 (1H, m), 6.83 (1H, d, *J*=6.8 Hz), 6.85 (1H, br s), 7.08–7.17 (2H, m), 7.17–7.23 (3H, m), 7.26–7.31 (2H, m), 7.88 (1H, br s, D_2O exchange). High resolution MS *m/z*: Calcd for $C_{19}H_{20}N_2$: 276.1625. Found: 276.1629.

4-*N*-propylamino- (15d) and 4-(*N*,*N*-Dipropylamino)-1,3,4,5-tetrahydrobenz[*cd*]indole (5) from 14 — *n*-Propyl iodide (124.6 mg, 0.72 mmol) and K_2CO_3 (365.0 mg, 2.65 mmol) were added to a solution of **14** (31.5 mg, 0.18 mmol) in dry MeCN (1.5 mL). The mixture was heated at reflux for 26 h with stirring. After addition of H_2O, the whole was extracted with CH_2Cl_2–MeOH (95:5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was subjected to p-TLC on SiO_2 with $CHCl_3$–MeOH–aq. 30% NH_3 (46:5:0:5, v/v) as a developing solvent. Extraction of the bands having an *Rf* value of 0.93–0.77 and 0.67–0.57 with $CHCl_3$–MeOH–aq. 30% NH_3 (46:5:0.5, v/v) afforded **5** (40.8 mg, 87%) and **15d** (1.7 mg, 4%)**,** respectively. **15d**: pale brown oil. IR (KBr): 3399, 2916, 1605, 1442, 1337, 1941, 743 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 0.94 (3H, t, *J*=7.3 Hz), 1.58 (2H, sex, *J*=7.3 Hz), 1.80 (1H, br s, D_2O exchange), 2.76 (2H, t, *J*=7.3 Hz), 2.80 (1H, dd, *J*=15.6, 8.8 Hz), 2.96 (1H, dd, *J*=15.6, 9.3 Hz), 3.19 (1H, dt, *J*=15.6, 3.9 Hz), 3.27–3.35 (1H, m), 6.85 (1H, d, *J*=6.8 Hz), 6.87 (1H, s), 7.12 (1H, dd, *J*=7.8, 6.8 Hz), 7.17 (1H, d, *J*=7.8 Hz). High resolution MS *m/z*: Calcd for $C_{14}H_{18}N_2$: 214.1469. Found: 214.1479. **5**: pale brown oil. IR (KBr): 3403, 2956, 2935, 1607, 1443, 1339, 1069, 743 cm^{-1}. ^{1}H-NMR (500 MHz, pyridine-d_5) δ: 0.90 (6H, t, *J*=7.3 Hz), 1.44 (4H, sex, *J*=7.3 Hz), 2.50 (4H, t, *J*=7.3 Hz), 2.90 (1H, ddd, *J*=14.8, 11.7, 1.5 Hz), 3.00–3.13 (3H, m), 3.30–3.39 (1H, m), 7.02 (1H, d, *J*=7.3 Hz), 7.20 (1H, br s), 7.28 (1H, dd, *J*=7.8, 7.3 Hz), 7.39 (1H, d, *J*=7.8 Hz). High resolution MS *m/z*: Calcd for $C_{17}H_{24}N_2$: 256.1938. Found: 256.1980.

4-(*N*,*N*-Dipropylamino)-1,3,4,5-tetrahydrobenz[*cd*]indole (5) from 15d — *n*-Propyl iodide (177.0 mg, 1.08 mmol), K_2CO_3 (153.8 mg, 1.11 mmol), and *n*-Bu_4NBr (7.1 mg, 0.02 mmol) were added to a solution of **15d** (23.0 mg, 0.11 mmol) in dry MeCN (2.0 mL). The mixture was heated at reflux for 8 h. The same work-up and purification as described above afforded **5** (22.2 mg, 80%).

1,3,4,5-Tetrahydrobenz[*cd*]indole-4-one (16) from **6** — According to the procedure reported by L. I. Kruse et al.,[7] **16** was prepared from **6** in 81% yield. **16**: mp 150—152 °C (lit.[7] mp 146–147 °C, decomp., colorless needles, recrystallized from EtOAc–hexane). IR (KBr): 3330, 1695, 1446 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 3.81 (2H, s), 3.89 (2H, s), 6.85 (1H, dd, *J*=7.1, 1.2 Hz), 6.95 (1H, d, *J*=1.9 Hz), 7.19 (1H, dd, *J*=8.1, 7.1 Hz), 7.23 (1H, d, *J*=8.1 Hz), 8.06 (1H, br s). MS *m/z*: 171 (M^+). *Anal.* Calcd for $C_{11}H_9NO$: C, 77.17; H, 5.30; N, 8.18. Found: C, 77.37; H, 5.28; N, 7.98.

4-Amino-4-cyano-1,3,4,5-tetrahydrobenz[*cd*]indole (17) and Hydantoin-5-spiro-4-(1,3,4,5-tetrahydrobenz[*cd*]indole) (18) from 16 — A solution of KCN (45.7 mg, 0.71 mmol) and $(NH_4)_2CO_3$ (205.3 mg, 2.14 mmol) in H_2O (3 mL) was added to a solution of **16** (34.7 mg, 0.0.20 mmol) in MeOH (3 mL). The mixture was heated at 60 °C for 2 h with stirring. After addition of H_2O, the whole was extracted with EtOAc. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was column-chromatographed on SiO_2 with CH_2Cl_2–MeOH (98:2, v/v) as an eluent to give unreacted **17** (4.4 mg, 11%) and **18** (28.9 mg, 59%) in the order of elution. **17**: mp 129—132 °C (pale green prisms, recrystallized from CH_2Cl_2–hexane). IR (KBr): 3320, 2220, 1605, 1445, 767, 745 cm^{-1}. ^{1}H-NMR (CD_3OD) δ: 1.74 (2H, br s), 3.14 (1H, d, *J*=15.0 Hz), 3.24 (1H, d, *J*=15.6

Hz), 3.40 (1H, d, J=15.0 Hz), 3.43 (1H, d, J=15.6 Hz), 6.91 (1H, d, J=7.0 Hz), 6.99 (1H, d, J=1.3 Hz), 7.14 (1H, dd, J=8.1, 7.0 Hz), 7.24 (1H, d, J=8.1 Hz), 8.00 (1H, br s). MS *m/z*: 197 (M^+). *Anal.* Calcd for $C_{12}H_{11}N_3$•1/8H_2O: C, 72.25; H, 5.68; N, 21.06. Found: C, 72.31; H, 5.42; N, 21.06. **18**: mp 295—297 °C (colorless prisms, recrystallized from MeOH–H_2O). IR (KBr): 3265, 1773, 1703, 1408, 747 cm^{-1}. ^{1}H-NMR (CD_3OD) δ: 2.96 (1H, dd, J=15.9, 1.9 Hz), 2.98 (1H, ddd, J=15.2, 1.9, 0.7 Hz), 3.30 (1H, dd, J=15.2, 1.5 Hz), 3.41 (1H, dd, J=15.9, 0.7 Hz), 6.83 (1H, br d, J=7.1 Hz), 7.03 (1H, d J=1.5 Hz), 7.08 (1H, dd, J=8.2, 7.1 Hz), 7.20 (1H, d, J=8.2 Hz). MS *m/z*: 241 (M^+). *Anal.* Calcd for $C_{13}H_{11}N_3O_2$: C, 64.72; H, 4.60; N, 17.42. Found: C, 64.83; H, 4.74; N, 17.27.

4-Amino-4-cyano- (17) and 4-Cyano-4-hydroxy-1,3,4,5-tetrahydrobenz[*cd*]indole (19a) from 16 — A solution of KCN (34.8 mg, 0.53 mmol) and NH_4Cl (86.1 mg, 1.61 mmol) in H_2O (3 mL) was added to a solution of **16** (30.1 mg, 0.17 mmol) in MeOH (3 mL). The mixture was heated at 60 °C for 1 h with stirring. After addition of 8% NaOH and H_2O, the whole was extracted with CH_2Cl_2–MeOH (95:5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was column-chromatographed on SiO_2 with EtOAc–hexane (4:3, v/v) as an eluent to give unreacted **16** (6.2 mg, 26%), **19a** (3.0 mg, 10%), and **17** (16.9 mg, 56%) in the order of elution. **19a**: unstable colorless prisms and mp was not determined. IR (KBr): 3360, 2240, 1260, 1062, 798 cm^{-1}. ^{1}H-NMR (5% CD_3OD in $CDCl_3$) δ: 3.24 (1H, dd, J=16.5, 1.3 Hz), 3.36 (1H, d, J=15.8 Hz), 3.46 (1H, d, J=16.5 Hz), 3.49 (1H, d, J=15.8 Hz), 6.89 (1H, d, J=7.0 Hz), 6.98 (1H, s), 7.15 (1H, dd, J=8.2, 7.0 Hz), 7.23 (1H, d, J=8.2 Hz). High resolution MS *m/z*: Calcd for $C_{12}H_{10}N_2O$: 198.0792. Found: 198.0792.

4-Acetoxy-4-Cyano-1,3,4,5-tetrahydrobenz[*cd*]indole (19b) from 16 — A solution of KCN (83.0 mg, 1.28 mmol) in H_2O (1 mL) was added to a solution of **16** (61.0 mg, 0.36 mmol) in MeOH (2 mL) and AcOH (1 mL). The whole was heated at 60 °C for 4 h with stirring. After addition of H_2O, the whole was extracted with CH_2Cl_2. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure. The residue was dissolved in pyridine (0.8 mL) and Ac_2O (0.4 mL) was added. Stirring was continued for 15.5 h at rt and the solvent was evaporated under reduced pressure. The residue was subjected to p-TLC on SiO_2 with EtOAc–hexane (1:1, v/v) as a developing solvent. Extraction of the band having an *Rf* value of 0.75–0.64 with CH_2Cl_2 afforded **19b** (36.5 mg, 43%). **19b**: mp 161—162 °C (colorless needles, recrystallized from MeOH–H_2O). IR (KBr): 3430, 1740, 1225, 1045 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.05 (3H, s), 3.51 (1H, d, J=15.2 Hz), 3.59 (1H, d, J=15.9 Hz), 3.71 (2H, br dd, J=15.9, 15.2 Hz), 6.91 (1H, d, J=7.0 Hz), 6.98 (1H, d, J=1.5 Hz), 7.18 (1H, br dd, J=8.0, 7.0 Hz), 7.24 (1H, d, J=8.0 Hz). MS *m/z*: 240 (M^+). *Anal.* Calcd for $C_{14}H_{12}N_2O_2$: C, 69.99; H, 5.03; N, 11.66. Found: C, 70.17; H, 4.90; N, 11.78.

4-Amino-1,3,4,5-tetrahydrobenz[*cd*]indole-4-carboxamide (20) from 17 — 8% NaOH (2 mL) and 30% H_2O_2 (1 mL) were added to a solution of **17** (90.1 mg, 0.46 mmol) in MeOH (2 mL) and stirred at rt for 1 h. After addition of H_2O, the whole was extracted with CH_2Cl_2–MeOH (95;5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure. The residue was column-chromatographed on SiO_2 with CH_2Cl_2–MeOH (9:1, v/v) to give **20** (83.0 mg, 84%). **20**: mp 81—82 °C (colorless needles, recrystallized from MeOH–H_2O). IR (KBr): 3440, 3200, 1673, 775 cm^{-1}. ^{1}H-NMR (CD_3OD) δ: 2.83 (1H, ddd, *J*=16.1, 1.5, 0.9 Hz), 2.84 (1H, dd, *J*=15.7, 1.3 Hz), 3.32 (1H, dd, *J*=16.1, 1.5 Hz), 3.46 (1H, d, *J*=15.7 Hz), 6.79 (1H, ddd, *J*=7.0, 0.9, 0.9 Hz), 6.99 (1H, d, *J*=1.3 Hz), 7.06 (1H, dd, *J*=8.3, 7.0 Hz), 7.17 (1H, d, *J*=8.3 Hz). *Anal.* Calcd for $C_{12}H_{13}N_3O \cdot H_2O$: C, 61.79; H, 6.48; N, 18.01. Found: C, 62.08; H, 6.44; N, 17.97. High resolution MS *m/z*: Calcd for $C_{12}H_{13}N_3O$: 215.1057. Found: 215.1057.

4-Amino-1,3,4,5-tetrahydrobenz[*cd*]indole-4-carboxylic acid (21) from 20 — 8% NaOH (2 mL) was added to a solution of **20** (20.8 mg, 0.09 mmol) in MeOH (1 mL) and stirred at 55 °C for 24 h. After evaporation of solvent under reduced pressure, the residue was subjected to column-chromatography on ion-exchange resin (IR 120B) with H_2O as an eluent to give **21** (21.2 mg, 100%). **21**: mp 275—278 °C (decomp., pale brown prisms, recrystallized from MeOH-CH_2Cl_2). IR (KBr): 3410, 1605, 1582, 1370 cm^{-1}. ^{1}H-NMR (D_2O) δ: 3.21 (2H, d, *J*=16.5 Hz), 3.46 (1H, d, *J*=16.5 Hz), 3.61 (1H, d, *J*=16.5 Hz), 7.00 (1H, d, *J*=7.1 Hz), 7.21 (1H, s), 7.24 (1H, dd, *J*=7.9, 7.1 Hz), 7.38 (1H, d, *J*=7.1 Hz). MS *m/z*: 216 (M^+). *Anal.* Calcd for $C_{12}H_{12}N_2O_2 \cdot 3/4H_2O$: C, 62.73; H, 5.26; N, 12.19. Found: C, 62.73; H, 5.51; N, 12.11.

4-Nitro-4-hydroxymethyl-1,3,4,5-tetrahydrobenz[*cd*]indole (22a) from 6 — KO*t*-Bu (34.0 mg, 0.30 mmol) was added to a solution of **6** (101.6 mg, 0.50 mmol) in MeOH (6 mL) and stirred for 15 min under ice cooling. After addition of 37% formalin (41.9 mg, 0.52 mmol), the mixture was stirred at rt for 3 h. The pH of the mixture was adjusted to 6 by adding 0.6% HCl and the whole was extracted with CH_2Cl_2. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was column-chromatographed on SiO_2 with CH_2Cl_2 as an eluent to give unreacted **6** (6.6 mg, 2%), **16** (2 mg, 2%), and **22a** (85.7 mg, 73%) in the order of elution. **22a**: mp 154-–155 °C (pale yellow prisms, recrystallized from CH_2Cl_2–hexane). IR (KBr): 3495, 3335, 1537, 1529, 1447, 1414, 1340, 1077, 1042, 1032, 1018, 753 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 3.42 (1H, d, *J*=16.0 Hz), 3.44 (1H, d, *J*=16.0 Hz), 3.67 (1H, d, *J*=16.0 Hz), 3.79 (1H, d, *J*=16.0 Hz), 3.87 (1H, d, *J*=12.3 Hz), 3.93 (1H, d, *J*=12.3 Hz), 6.92 (1H, d, *J*=7.3 Hz), 6.97 (1H, s), 7.16 (1H, dd, *J*=8.3, 7.3 Hz), 7.20 (1H, d, *J*=8.3 Hz), 7.98 (1H, br s). MS *m/z*: 232 (M^+). *Anal.* Calcd for $C_{12}H_{12}N_2O_3$: C, 62.02; H, 5.21; N, 12.06. Found: C, 61.97; H, 5.22; N, 12.02.

4-Acetoxymethyl-4-nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (22b) from 22a — Ac_2O (0.5 mL) was added to a solution of **22a** (45.0 mg, 0.19 mmol) in pyridine (1 mL) and stirred at rt for 2.5 h. After evaporation of the solvent under reduced pressure, H_2O was added. The whole was extracted with CH_2Cl_2–MeOH (95:5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure. The residue was column-chromatographed on SiO_2 with CH_2Cl_2–hexane (4:1, v/v) as an eluent to give **22b** (52.0 mg, 98%). **22b**: mp 136.5-–137 °C (colorless prisms, recrystallized from CH_2Cl_2–hexane). IR (KBr): 3420, 3120, 1758, 1619, 1609, 1525, 1451, 1362, 1237, 1040, 759, 752 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.08 (3H, s), 3.38 (1H, d, *J*=15.6 Hz), 3.45 (1H, d, *J*=16.6 Hz), 3.74 (1H, d, *J*=15.6 Hz), 3.83 (1H, d, *J*=16.6 Hz), 4.42 (1H, d, *J*=12.2 Hz), 4.47 (1H, d, *J*=12.2 Hz), 6.92 (1H, d, *J*=6.8 Hz), 6.97 (1H, br s), 7.16 (1H, dd, *J*=8.3, 6.3 Hz), 7.20 (1H, d, *J*=8.3 Hz), 7.99 (1H, br s). MS *m/z*: 274 (M^+). *Anal.* Calcd for $C_{14}H_{14}N_2O_4$: C, 61.31; H, 5.15; N, 10.21. Found: C, 61.25; H, 5.15; N, 10.15.

4-Amino-4-hydroxymethyl-1,3,4,5-tetrahydrobenz[*cd*]indole (23a) from 22a — 6% HCl (4 mL) was added to a mixture of Zn powder (2.462 g, 37.6 mmol) and $HgCl_2$ (310.8 mg, 1.14 mmol) and stirred for 5 min. Liquid was decanted off. To the residue was added a solution of **22a** (174.0 mg, 0.75 mmol) in MeOH (7 mL) and then 6% HCl (7 mL). The whole was heated at reflux for 5 h with stirring. After filtering off the solid, 8% NaOH was added to make the whole alkaline. The mixture was extracted with CH_2Cl_2–MeOH (95:5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was column-chromatographed on SiO_2 with $CHCl_3$–MeOH–aq. 30% NH_3 (46: 5:0.5, v/v) to give **23a** (142.8 mg, 94%). **23a**: mp 173.5—174.0 °C (colorless prisms, recrystallized from EtOAc–hexane). IR (KBr): 3235, 1609, 1564, 1445, 1344, 1061, 1040, 992, 707 cm^{-1}. ^{1}H-NMR (CD_3OD) δ: 2.73 (1H, d, *J*=15.1 Hz), 2.80 (1H, d, *J*=16.2 Hz), 2.92 (1H, dd, *J*=15.1, 1.0 Hz), 3.00 (1H, d, *J*=16.2 Hz), 3.46 (2H, s), 6.74 (1H, d, *J*=7.3 Hz), 6.91 (1H, s), 7.02 (1H, dd, *J*=8.3, 7.3 Hz), 7.12 (1H, d, *J*=8.3 Hz). MS *m/z*: 202 (M^+). *Anal.* Calcd for $C_{12}H_{14}N_2O$: C, 71.26; H, 6.98; N, 13.85. Found: C, 71.08; H, 6.95; N, 13.72.

4-Acetylamino-4-hydroxymethyl-1,3,4,5-tetrahydrobenz[*cd*]indole (23b) from 23a — Ac_2O (1 mL) was added to a solution of **23a** (90.1 mg, 0.19 mmol) in pyridine (1 mL) and stirred at rt for 2 h. Solvent was evaporated under reduced pressure and the residue was dissolved in MeOH (15 mL). Sat. aq. $NaHCO_3$ (2 mL) was added and the whole was heated at 50 °C for 17 h. The whole was extracted with CH_2Cl_2–MeOH (95:5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was column-chromatographed on SiO_2 with CH_2Cl_2–MeOH (95:5, v/v) to give **23b** (106.6 mg, 98%). **23b**: mp 193—195 °C (colorless prisms, recrystallized from MeOH–H_2O). IR (KBr): 3260, 1622, 1564, 1252, 1063, 747 cm^{-1}. ^{1}H-NMR (CD_3OD) δ: 1.80 (3H, s), 3.03 (1H, dd, *J*=15.7, 1.0 Hz), 3.10 (1H, d, *J*=15.7 Hz), 3.26 (1H, d, *J*=15.7 Hz), 3.37 (1H, d, *J*=15.7 Hz), 3.75 (1H, d, *J*=11.3 Hz), 3.78 (1H, d, *J*=11.3 Hz), 6.74 (1H, dd, *J*=7.3, 0.9 Hz), 6.91 (1H, s), 7.01 (1H, dd, *J*=8.5, 7.3 Hz), 7.12 (1H, d, *J*=8.5 Hz). MS *m/z*: 244 (M^+). *Anal.* Calcd for $C_{14}H_{16}N_2O_2$: C, 68.83; H, 6.60; N, 11.47. Found: C, 68.78; H, 6.54; N, 11.41.

4-Acetylamino-4-methylthiomethoxymethyl- (24a) and 4-Acetylamino-4-formyl-1,3,4,5-tetrahydrobenz[*cd*]indole and (24b) from 23b — Ac_2O (2 mL) was added to dry DMSO (4 mL) and the mixture was stirred at rt for 30 min. To the mixture was added a solution of **23b** (149.4 mg, 0.61 mmol) in dry DMSO (2 mL) and stirring was continued for 12 h. After addition of H_2O, the whole was extracted with EtOAc. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure. The residue was column-chromatographed on SiO_2 with CH_2Cl_2–MeOH (95:5, v/v) as an eluent to give **24a** (60.4 mg, 32%) and **24b** (83.4 mg, 56%) in the order of elution. **24a**: colorless oil. IR (film): 3410, 3300, 1660, 1518, 1447, 1075, 758 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 1.78 (3H, s), 2.15 (3H, s), 2.94 (1H, d, *J*=15.6 Hz), 3.07 (1H, d, *J*=16.1 Hz), 3.56 (2H, dd, *J*=16.1, 15.6 Hz), 3.92 (1H, d, *J*=18.7 Hz), 3.93 (1H, d, *J*=18.7 Hz), 4.66 (2H, s), 5.31 (1H, br s), 6.86 (1H, d, *J*=7.3 Hz), 6.91 (1H, s), 7.13 (1H, dd, *J*=8.0, 7.3 Hz), 7.19 (1H, d, *J*=8.0 Hz), 7.91 (1H, br s). High resolution MS *m/z*: Calcd for $C_{16}H_{20}N_2O_2S$: 304.1244. Found: 304.1292. **24b**: mp 244—246 °C (colorless prisms, recrystallized from MeOH–H_2O). IR (KBr): 3370, 3220, 1735, 1642, 1525, 1374, 747 cm^{-1}. ^{1}H-NMR (pyridine-d_5) δ: 1.83 (3H, s), 3.45 (1H, d, *J*=16.2 Hz), 3.48 (1H, d, *J*=15.7 Hz), 3.52 (1H, d, *J*=16.2 Hz), 3.59 (1H, d, *J*=15.7 Hz), 6.88 (1H, br t, *J*=7.2 Hz), 7.07 (1H, d, *J*=0.9 Hz), 7.15 (1H, dd, *J*=8.0, 7.2 Hz), 7.30 (1H, d, *J*=8.0 Hz), 8.93 (1H, br s), 10.05 (1H, s), 11.58 (1H, br s). MS *m/z*: 242 (M^+). *Anal.* Calcd for $C_{14}H_{14}N_2O_2$: C, 69.40; H, 5.83; N, 11.56. Found: C, 69.29; H, 5.83; N, 11.46.

4-Acetylamino-4-hydroxyiminomethyl-1,3,4,5-tetrahydrobenz[*cd*]indole (24c) from 24b — NH_2OH•HCl (55.9 mg, 0.80 mmol) was added to a solution of **24b** (149.5 mg, 0.62 mmol) in pyridine (5 mL) and stirred at rt for 2.5 h. After addition of H_2O, the whole was extracted with CH_2Cl_2–MeOH (95:5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure. The residue was column-chromatographed on SiO_2 with CH_2Cl_2–MeOH (95:5, v/v) to give **24c** (150.7 mg, 95%). **24c**: mp 119—121 °C (colorless prisms, recrystallized from MeOH–H_2O). IR (KBr): 3400, 1644, 1515, 1445, 747 cm^{-1}. ^{1}H-NMR (CD_3OD) δ: 1.77 (3H, s), 3.19 (1H, dd, *J*=15.4, 1.1 Hz), 3.26 (1H, d, *J*=15.8 Hz), 3.41 (1H, d, *J*=15.4 Hz), 3.51 (1H, d, *J*=15.8 Hz), 6.75 (1H, dd, *J*=8.0, 1.3 Hz), 6.94 (1H, s), 7.03 (1H, dd, *J*=8.3, 8.0 Hz), 7.14 (1H, dd, *J*=8.3, 1.3 Hz), 7.61 (1H, s). MS *m/z*: 257 (M^+). *Anal.* Calcd for $C_{14}H_{15}N_3O_2$: C, 65.35; H, 5.88; N, 16.33. Found: C, 65.12; H, 5.99; N, 16.03.

4-Acetylamino-4-cyano-1,3,4,5-tetrahydrobenz[*cd*]indole (24d) from 24c — A solution of **24c** (117.9 mg, 0.46 mmol) in Ac_2O (5 mL) was heated at reflux for 1.5 h with stirring. After addition of H_2O, 8% NaOH was added and the pH was adjusted to 6. The whole was extracted with CH_2Cl_2–MeOH (95;5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure. The residue was column-chromatographed on SiO_2 with CH_2Cl_2–MeOH (95:5, v/v) to give **24d** (56.5 mg, 52%). **24d**: mp 260—262 °C (colorless needles, recrystallized from MeOH–H_2O). IR (KBr): 3320, 2240, 1661, 1525, 1300, 755 cm^{-1}. ^{1}H-NMR (pyridine-d_5) δ: 1.97 (3H, s), 3.68 (1H, d, *J*=14.3 Hz), 3.74 (1H, d, *J*=15.4 Hz), 4.03 (1H, d, *J*=14.3 Hz), 4.06 (1H, d, *J*=15.4 Hz), 6.90 (1H, d, *J*=7.2 Hz), 7.15 (1H, d, *J*=0.9 Hz), 7.20 (1H, dd, *J*=8.3, 7.2 Hz), 7.38 (1H, d, *J*=8.3 Hz), 9.48 (1H, s), 11.83 (1H, br s). MS *m/z*: 239

(M^+). *Anal.* Calcd for $C_{14}H_{13}N_3O$: C, 70.27; H, 5.48; N, 17.56. Found: C, 70.19; H, 5.50; N, 17.54.

24d from 17 — Ac_2O (0.3 mL) was added to a solution of **17** (6.6 mg, 0.03 mmol) in pyridine (0.6 mL) and the whole was stirred at rt for 38 h. After evaporation of the solvent under reduced pressure, the residue was subjected to p-TLC on SiO_2 with CH_2Cl_2–MeOH (95:5, v/v) as a developing solvent. Extraction of the band having an *Rf* value of 0.47–0.38 with CH_2Cl_2–MeOH (95:5, v/v) afforded **24d** (4.9 mg, 61%).

4-*N*-Propylamino-4-hydroxymethyl- (25) and 4-*N,N*-Dipropylamino-4-hydroxymethyl-1,3,4,5-tetrahydrobenz[*cd*]indole (27a) from 23a — a) General Procedure: K_2CO_3 (909.5 mg, 6.58 mmol) and *n*-propyl iodide (154.5 mg, 0.93 mmol) were added to a solution of **23a** (88.2 mg, 0.44 mmol) in dry MeCN (8 mL) and the mixture was heated at reflux for 18 h. After addition of H_2O, the whole was extracted with CH_2Cl_2–MeOH (95:5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was column-chromatographed on SiO_2 with $CHCl_3$–MeOH–aq. 30% NH_3 (100:3:0.3, v/v) to give **27a** (7.9 mg, 6%) and **25** (93.1 mg, 87%), and unreacted **23** (3.4 mg, 4%) in the order of elution.

b: In the general procedure, K_2CO_3 (2.822 g, 20.4 mmol), *n*-propyl iodide (918.0 mg, 5.40 mmol), **23a** (272.5 mg, 1.35 mmol), and dry MeCN (22 mL) were employed and the refluxing time was 51 h. After the same work-up as described in the general procedure, **27a** (174.9 mg, 53%) and **25** (173.5 mg, 45%) were obtained. **25**: mp 132.0—133.0 °C (colorless prisms, recrystallized from CH_2Cl_2–hexane). IR (KBr): 3240, 2970, 2860, 1620, 1608, 1473, 1443, 1334, 1324, 1087, 1025, 925, 847, 753 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 0.77 (3H, t, *J*=7.3 Hz), 1.23–1.34 (2H, m), 2.36–2.47 (2H, m), 2.75 (1H, dd, *J*=15.6, 1.0 Hz), 3.00 (1H, d, *J*=15.6 Hz), 3.06 (1H, d, *J*=15.6 Hz), 3.47 (1H, d, *J*=10.3 Hz), 3.52 (1H, d, *J*=10.3 Hz), 6.86 (1H, d, *J*=6.9 Hz), 6.90 (1H, s), 7.13 (1H, dd, *J*=7.8, 6.9 Hz), 7.18 (1H, d, *J*=7.8 Hz), 7.91 (1H, br s). MS *m/z*: 244 (M^+). *Anal.* Calcd for $C_{15}H_{20}N_2O$: C, 73.74; H, 8.25; N, 11.46. Found: C, 73.73; H, 8.32; N, 11.45. **27a**: mp 93.5—95.0 °C (colorless prisms, recrystallized from hexane). IR (KBr): 3318, 2970, 1448, 1088, 1052, 1022, 742 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 0.89 (6H, t, *J*=7.3 Hz), 1.50–1.60 (4H, m), 2.63 (4H, m), 2.92–3.02 (3H, m), 3.17 (1H, d, *J*=16.1 Hz), 3.20 (2H, s), 6.84 (1H, d, *J*=6.8 Hz), 6.87 (1H, s), 7.11 (1H, dd, *J*=8.0, 6.8 Hz), 7.15 (1H, d, *J*=8.0 Hz), 7.89 (1H, br s). MS *m/z*: 286 (M^+). *Anal.* Calcd for $C_{18}H_{26}N_2O$: C, 75.48; H, 9.15; N, 9.78. Found: C, 75.64; H, 9.16; N, 9.70.

4-(*N*-Propyl-*N*-propionyl)amino-4-propionyloxymethyl- (26a) and 4-*N*-Propionyloxymethyl-4-*N*-propylamino-1,3,4,5-tetrahydrobenz[*cd*]indole (26b) from 25 — A solution of propionyl chloride (170.8 mg, 1.85 mmol) in CH_2Cl_2 (2 mL) was added to a solution of **25** (149.2 mg, 0.61 mmol) in the mixture of CH_2Cl_2 (8 mL) and Et_3N (0.5 mL). The mixture was stirred at rt for 30 min. After addition of sat. aq. $NaHCO_3$, the whole was heated for 5 min. After addition of H_2O, the whole was extracted with CH_2Cl_2–MeOH (95:5, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was column-chromatographed on SiO_2 with CH_2Cl_2–MeOH (97:3, v/v) to give **26a** (193.9 mg, 89%) and **26b** (13.8 mg, 8%) in the order of elution. **26a**: mp 165—166 °C (colorless prisms, recrystallized from CH_2Cl_2–hexane). IR (KBr): 3230, 2958, 1735, 1640, 1608, 1197, 747 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 0.77 (3H, t, *J*=7.3 Hz), 1.10 (3H, t, *J*=7.3 Hz), 1.16 (3H, t, *J*=7.3 Hz), 1.38–1.57 (2H, m), 2.23 (2H, q, *J*=7.3 Hz), 2.35 (2H, q, *J*=7.3 Hz), 2.92–3.06 (2H, m), 3.09 (1H, d, *J*=16.1 Hz), 3.26 (1H, d, *J*=16.1 Hz), 3.69 (1H, d, *J*=15.6Hz), 3.79 (1H, d, *J*=15.6 Hz), 4.60 (1H, d, *J*=11.2 Hz), 4.69 (1H, d, *J*=11.2 Hz), 6.83 (1H, d, *J*=6.8 Hz), 6.86 (1H, s), 7.12 (1H, dd, *J*=7.8 and 6.8 Hz), 7.14 (1H, d, *J*=7.8 Hz), 7.89 (1H, br s). MS (CI) *m/z*: 357 (M^++1). *Anal.* Calcd for $C_{21}H_{28}N_2O_3$: C, 70.76; H, 7.92; N, 7.86. Found: C, 70.69; H, 7.94; N, 7.77. **26b**: pale yellow oil. IR (film): 3415, 2960, 2950, 1735, 1445, 1185, 748 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 0.80 (3H, t, *J*=7.3 Hz), 1.15 (3H, t, *J*=7.5 Hz), 1.37 (2H, sext, *J*=7.3 Hz), 2.38 (2H, q, *J*=7.5 Hz), 2.51-2.61 (2H, m), 2.94 (1H, d, *J*=15.4 Hz), 2.99 (1H, d, *J*=15.9 Hz), 3.04 (1H, d, *J*=15.4 Hz), 3.10 (1H, d, *J*=15.9 Hz), 4.08 (1H, d, *J*=11.4 Hz), 4.12 (1H, d, *J*=11.4Hz), 6.84 (1H, d, *J*=6.8 Hz), 6.88 (1H, d, *J*=0.9 Hz), 7.12 (1H, dd, *J*=8.0 and 6.8 Hz), 7.17 (1H, d, *J*=8.0 Hz), 7.94 (1H, br s). High resolution MS *m/z*: Calcd for $C_{18}H_{24}N_2O_2$: 300.1836. Found: 300.1836.

27a from 26a — $LiAlH_4$ (428.0 mg, 11.3 mmol) was added to a solution of **26a** (267.0 mg, 0.75 mmol) in dry THF (15 mL) and heated at reflux for 1.5 h. After addition of MeOH and 10% aq. solution of Rochelle salt, the whole was extracted with $CHCl_3$–MeOH–aq. 30% NH_3 (46:3:0.3, v/v). The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was column-chromatographed on SiO_2 with $CHCl_3$–MeOH–aq. 30% NH_3 (100:1:0.1, v/v) to give **27a** (197.2 mg, 91%).

4-Acetoxymethyl-4-*N*,*N*-dipropylamino-1,3,4,5-tetrahydrobenz[*cd*]indole (27b) from 27a — Ac_2O (0.5 mL) was added to a solution of **27a** (20,4 mg, 0.07 mmol) in pyridine (1 mL) and the whole was stirred at rt for 2 h. After evaporation of the solvent under reduced pressure, the residue was column-chromatographed on SiO_2 with $CHCl_3$–MeOH–aq. 30% NH_3 (100:1:0.1, v/v) as an eluent to give **27b** (23.1 mg, 99%). **27b**: pale brown oil. IR (film): 3400, 2980, 2890, 1720, 1445, 1378, 1238, 742 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 0.77 (6H, t, *J*=7.3 Hz), 1.33–1.42 (4H, m), 1.99 (3H, s), 2.64 (4H, t, *J*=7.8 Hz), 2.97 (1H, d, *J*=16.6 Hz), 3.02 (1H, d, *J*=16.6 Hz), 3.09 (1H, d, *J*=16.1 Hz), 3.13 (1H, d, *J*=16.1 Hz), 3.99 (1H, d, *J*=11.7 Hz), 4.02 (1H, d, *J*=11.7 Hz), 6.80 (1H, d, *J*=7.0 Hz), 6.83 (1H, s), 7.08 (1H, dd, *J*=8.3, 7.0 Hz), 7.12 (1H, d, *J*=8.3 Hz), 7.83 (1H, br s). High resolution MS *m/z*: Calcd for $C_{20}H_{28}N_2O_2$: 328.2149. Found: 328.2156.

4-Hydroxy-1,3,4,5-tetrahydrobenz[*cd*]indole (28a) from 16 — $NaBH_4$ (212.8 mg, 5.56 mmol) was added to a solution of **16** (109.2 mg, 0.64 mmol) in MeOH (5 mL) and stirred at rt for 20 min. After addition of H_2O, the whole was extracted with CH_2Cl_2.The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure. The residue was column-chromatographed on SiO_2 with

EtOAc–hexane (1:2, v/v) to give **28a** (110.4 mg, 99%). **28a**: mp 87—88 °C (colorless prisms, recrystallized from ether–hexane). IR (KBr): 3400, 1440, 1043, 755 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.95 (1H, dd, *J*=15.2, 6.7 Hz), 3.06 (1H, dd, *J*=15.8, 6.7 Hz), 3.15 (1H, dd, *J*=15.2, 3.8 Hz), 3.21 (1H, dd, *J*=15.8, 3.8 Hz), 4.45–4.51 (1H, m), 6.87 (1H, dd, *J*=6.8, 0.9 Hz), 6.92 (1H, d, *J*=1.1 Hz), 7.14 (1H, dd, *J*=8.2, 6.8 Hz), 7.19 (1H, dd, *J*=8.2, 0.9 Hz), 7.91 (1H, br s). MS *m/z*: 173 (M^+). *Anal.* Calcd for $C_{11}H_{11}NO$: C, 76.27; H, 6.40; N, 8.09. Found: C, 76.34; H, 6.43; N, 8.02.

4-Hydroxy-1-propyl-1,3,4,5-tetrahydrobenz[*cd*]indole (28b) from 28a — A solution of **28a** (54.3 mg, 0.31 mmol) in abs. DMF (0.5 mL) was added to 60% NaH (14.7 mg, 0.37 mmol) in a flask cooled on an ice bath with stirring. Then propyl iodide (81.0 mg, 0.47 mmol) was added and stirred for 3 h at rt. After addition of sat. aq. NH_4Cl, the whole was extracted with EtOAc. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure. The residue was column-chromatographed on SiO_2 with EtOAc–hexane (1:3, v/v) to give **28b** (64.5 mg, 96%). **28b**: colorless oil. IR (film): 3340, 2930, 1462, 1047, 746 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 0.93 (3H, t, *J*=7.3 Hz), 1.85 (2H, sext, *J*=7.3 Hz), 2.93 (1H, dd, *J*=15.2, 6.8 Hz), 3.04 (1H, dd, *J*=15.7, 3.6 Hz), 3.13 (1H, ddd, *J*=15.2, 3.6, 0.9 Hz), 3.19 (1H, dd, *J*=15.7, 3.6 Hz), 4.03 (2H, t, *J*=7.3 Hz), 4.43–4.49 (1H, m), 6.80 (1H, s), 6.83 (1H, ddd, *J*=6.2, 1.5, 0.9 Hz), 7.12 (1H, d, *J*=8.1 Hz), 7.14 (1H, dd, *J*=8.1, 6.2 Hz). High resolution MS *m/z*: Calcd for $C_{14}H_{17}NO$: 215.1309. Found: 215.1316.

4-Acetoxy-1-propyl-1,3,4,5-tetrahydrobenz[*cd*]indole (28c) from 28b — Ac_2O (0.5 mL) was added to a solution of **28b** (12.0 mg, 0.06 mmol) in pyridine (1 mL) and the whole was stirred at rt for 15 h. After evaporation of the solvent under reduced pressure, the residue was purified by column-chromatography on SiO_2 with CH_2Cl_2–hexane (1:2, v/v) as an eluent to **28c** (10.3 mg, 75%). **28c**: colorless oil. IR (film): 1740, 1460, 1370, 1244, 1038, 1026, 745 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 0.93 (3H, t, *J*=7.3 Hz), 1.85 (2H, sext, *J*=7.3 Hz), 2.04 (3H, s), 2.97 (1H, ddd, *J*=15.0, 7.9, 1.6 Hz), 3.10 (1H, dd, *J*=15.7, 7.9 Hz), 3.21 (2H, ddd, *J*=15.7, 15.0, 4.4 Hz), 4.02 (2H, dt, *J*=7.3, 1.4 Hz), 5.40–5.47 (1H, m), 6.77 (1H, s), 6.80 (1H, ddd, *J*=6.0, 2.6, 1.4 Hz), 7.12 (1H, dd, *J*=8.0, 6.0 Hz), 7.14 (1H, d, *J*=8.0 Hz). High resolution MS *m/z*: Calcd for $C_{16}H_{19}NO_2$: 257.1415. Found: 257.1417.

4-Hydroxy-1-tosyl- (29a) and 1-Tosyl-4-tosyloxy-1,3,4,5-tetrahydrobenz[*cd*]indole (29b) from 28a — A solution of **28a** (111.6 mg, 0.65 mmol) in abs. DMF (2 mL) was added to 60% NaH (31.0 mg, 0.78 mmol) in a flask cooled on an ice bath with stirring. Then tosyl chloride (185.3 mg, 0.96 mmol) was added and stirred at rt for 3 h. After addition of sat. aq. NH_4Cl, the whole was extracted with EtOAc. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure. The residue was column-chromatographed on SiO_2 with CH_2Cl_2–MeOH (99:1, v/v) to give **29b** (84.9 mg, 27%), unreacted **28a** (37.8 mg, 34%), and **29a** (77.6 mg, 37%) in the order of elution. **29a**: pale purple oil. IR (film): 3380, 1438, 1358, 1175, 1110, 1085, 670, 580 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.34 (3H, s), 2.83 (1H, ddd, J=15.7, 7.2, 1.3 Hz), 2.95 (1H, dd, J=16.1, 7.2 Hz), 3.03 (1H, br dd, J=15.7, 3.8 Hz), 3.11 (1H, dd, J=16.1, 3.8 Hz), 4.35–4.41 (1H, m), 6.99 (1H, dd, J=7.3, 0.9 Hz), 7.21 (2H, dd, J=8.5, 0.9 Hz), 7.22 (1H, s), 7.26 (1H, dd, J=8.3, 7.3 Hz), 7.74 (1H, dd, J=8.3, 0.9 Hz), 7.77 (2H, br d, J=8.5 Hz). High resolution MS *m/z*: Calcd for $C_{18}H_{17}NO_3S$: 327.0928. Found: 327.0921. **29b**: colorless oil. IR (film): 1360, 1187, 1178, 1118, 1090, 912, 668 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.34 (3H, s), 2.46 (3H, s), 2.97 (1H, ddd, J=16.0, 7.7, 1.4 Hz), 3.05 (1H, ddd, J=16.0, 4.0, 1.0 Hz), 3.08 (2H, d, J=5.9 Hz), 4.98–5.05 (1H, m), 6.89 (1H, d, J=7.3 Hz), 7.15 (1H, s), 7.22 (1H, dd, J=7.9, 7.3 Hz), 7.22 (2H, dd, J=8.6, 0.9 Hz), 7.31 (2H, dd, J=8.6, 0.9 Hz), 7.72 (1H, d, J=7.9 Hz), 7.74 (4H, t, J=8.6 Hz). High resolution MS *m/z*: Calcd for $C_{25}H_{23}NO_5S_2$: 481.1015. Found: 481.1006.

4-Propyloxy-1-tosyl-1,3,4,5-tetrahydrobenz[*cd*]indole (30a) from 29a — A solution of **29a** (24.0 mg, 0.07 mmol) in abs. DMF (1.5 mL) was added to 35% KH (33.2 mg, 0.29 mmol) in a flask cooled on an ice bath with stirring. Then propyl iodide (52.3 mg, 0.31 mmol) was added and stirred at rt for 22.5 h. After addition of H_2O, the whole was extracted with EtOAc. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure. The residue was subjected to p-TLC on SiO_2 with EtOAc–hexane (1:3, v/v) as a developing solvent. Extraction of the bands having an *Rf* value of 0.14–0.08 and 0.62–0.53 with CH_2Cl_2–MeOH (95:5, v/v) gave unreacted **29a** (4.0 mg, 18%) and **30a** (12.8 mg, 47%), respectively. **30a**: pale purple oil. IR (film): 1363, 1175, 1103, 1085, 670, 583 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 0.89 (3H, t, J=7.3 Hz), 1.57 (2H, sext, J=7.3 Hz), 2.33 (3H, s), 2.72 (1H, ddd, J=15.4, 9.1, 1.8 Hz), 2.89 (1H, dd, J=15.8, 9.1 Hz), 3.11 (1H, dd, J=15.4, 4.0 Hz), 3.15 (1H, dd, J=15.8, 4.0 Hz), 3.51 (2H, t, J=7.3 Hz), 3.81–3.88 (1H, m), 6.97 (1H, d, J=7.1 Hz), 7.17 (1H, s), 7.20 (2H, d, J=8.4 Hz), 7.24 (1H, dd, J=8.2, 7.1 Hz), 7.71 (1H, d, J=8.2 Hz), 7.76 (2H, br d, J=8.4 Hz). High resolution MS *m/z*: Calcd for $C_{21}H_{23}NO_3S$: 369.1397. Found: 369.1400.

4-Propyloxy-1,3,4,5-tetrahydrobenz[*cd*]indole (30b) from 30a — 8% NaOH (1 mL) was added to a solution of **30a** (10.6 mg, 0.03 mmol) and stirred at reflux for 17 h. After adding H_2O, the whole was extracted with CH_2Cl_2. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was column-chromatographed on SiO_2 with EtOAc–hexane (1:4, v/v) to give **30b** (6.0 mg, 86%). **30b**: colorless oil. IR (film): 3420, 2940, 1445, 1080, 748 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 0.95 (3H, t, J=7.3 Hz), 1.64 (2H, sext, J=7.3 Hz), 2.99 (1H, dd, J=15.4, 9.5 Hz), 3.22–3.29 (2H, m), 3.58 (2H, t, J=7.3 Hz), 3.91–3.98 (1H, m), 6.84 (1H, ddd, J=6.8, 1.6, 0.9 Hz), 6.87 (1H, s), 7.12 (1H, dd, J=8.2, 6.8 Hz), 7.16 (1H, d, J=8.2 Hz), 7.26 (1H, br s). High resolution MS *m/z*: Calcd for $C_{14}H_{17}NO$: 215.1309. Found: 215.1314.

2-Bromo-4-nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (31) from 6 — NBS (116.3 mg, 0.65 mmol) and AIBN (20.1 mg, 0.12 mmol) were added to a solution of **6** (121.7 mg, 0.60 mmol) in dry $CHCl_3$ (40 mL) and the mixture was heated at reflux for 30 min with stirring. After cooling, aq. 10% $Na_2S_2O_3$ was added.

The whole was extracted with $CHCl_3$. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was column-chromatographed on SiO_2 with CH_2Cl_2–hexane (1:1, v/v) to give **31** (147.7 mg, 87%). **31:** mp 125—135 °C (decomp., pale yellow needles, recrystallized from CH_2Cl_2–hexane). IR (KBr): 3390, 1535, 1440, 1419, 1375, 1339, 1112, 758 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 3.39 (1H, dd, *J*=15.3, 8.3 Hz), 3.42 (1H, dd, *J*=15.8, 5.5 Hz), 3.52 (1H, dd, *J*=15.6, 4.6 Hz), 3.59 (1H, ddd, *J*=15.8, 8.3, 0.9 Hz), 4.96–5.03 (1H, m), 6.90–6.94 (1H, m), 7.13–7.17 (2H, m), 7.99 (1H, br s). MS *m/z*: 282, 280 (M^+). *Anal.* Calcd for $C_{11}H_9BrN_2O_2$: C, 47.00; H, 3.23; N, 9.97. Found: C, 46.72; H, 3.30; N, 9.73.

2,6-Dibromo- (32), 2,8-Dibromo- (33), 2,7-Dibromo-4-nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (34) from 31 — NBS (1.614 g, 9.07 mmol) and AIBN (270.7 mg, 4.22 mmol) were added to a solution of **31** (2.298 g, 8.18 mmol) in dry $CHCl_3$ (800 mL) and the mixture was heated at reflux for 1 h with stirring. After cooling, the whole was irradiated with 100W mercury lamp in quartz bottle for 30 min under Ar atmosphere. After evaporation of the solvent under reduced pressure, the residue was purified repeatedly by column-chromatography on SiO_2 and HPLC (SiO_2, 15 Kgf/cm^2, 1.5 mL/min). In the order of elution, **33** (58.7 mg, 2%), **34** (403.8 mg, 14%), unreacted **31** (205.8 mg, 9%), and **32** (1.066 g, 36%) were obtained. **32**: mp 164—167 °C (decomp., yellow needles, recrystallized from nitro CH_2Cl_2–hexane). IR (KBr): 3400, 1539, 1440, 1375, 1311, 788 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 3.38 (2H, m), 3.52 (1H, dd, *J*=15.5, 8.6 Hz), 3.58 (1H, dd, *J*=15.5, 4.9 Hz), 4.98–5.04 (1H, m), 7.04 (1H, d, *J*=8.6 Hz), 7.30 (1H, d, *J*=8.6 Hz), 8.04 (1H, br s). MS *m/z*: 362, 360, 358 (M^+). *Anal.* Calcd for $C_{11}H_8Br_2N_2O_2$: C, 36.70; H, 2.24; N, 7.78. Found: C, 36.60; H, 2.08; N, 7.73. **33**: mp 194—196 °C (decomp., pale yellow needles, recrystallized from CH_2Cl_2–hexane). IR (KBr): 3330, 1544, 1433, 1373, 1363, 1323, 800 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 3.38 (1H, dd, *J*=16.1, 5.7 Hz), 3.42 (1H, dd, *J*=15.7, 7.9 Hz), 3.48 (1H, dd, *J*=16.1, 4.3 Hz), 3.56 (1H, dd, *J*=15.7, 8.4 Hz), 4.95–5.04 (1H, m), 6.83 (1H, d, *J*=7.7 Hz), 7.27 (1H, d, *J*=7.7 Hz), 8.10 (1H, br s). MS *m/z*: 362, 360, 358 (M^+). *Anal.* Calcd for $C_{11}H_8Br_2N_2O_2$: C, 36.70; H, 2.24; N, 7.78. Found: C, 36.74; H, 2.11; N, 7.74. **34**: mp 130—134 °C (decomp., pale yellow needles, recrystallized from CH_2Cl_2–hexane). IR (KBr): 3400, 1621, 1542, 1438, 1370, 1320, 1063, 840 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 3.38 (1H, dd, *J*=16.3, 5.5 Hz), 3.42 (1H, dd, *J*=16.1, 8.8 Hz), 3.47 (1H, dd, *J*=16.3, 5.5 Hz), 3.58 (1H, dd, *J*=16.1, 8.8 Hz), 4.95–5.02 (1H, m), 7.08 (1H, d, *J*=1.1 Hz), 7.32 (1H, d, *J*=1.1 Hz), 8.02 (1H, br s). MS *m/z*: 362, 360, 358 (M^+). *Anal.* Calcd for $C_{11}H_8Br_2N_2O_2$: C, 36.70; H, 2.24; N, 7.78. Found: C, 36.70; H, 2.24; N, 7.76.

1-Acetyl-2,6-Dibromo-4-nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (35) from 32 — Ac_2O (0.5 mL) was added to a solution of **32** (122.1 mg, 0.34 mmol) in pyridine (1 mL) and the whole was stirred at rt for 24 h. After addition of sat. aq. NH_4Cl, the whole was extracted with CH_2Cl_2. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was subjected to column-chromatography on SiO_2 with acetone–hexane (1:5, v/v) as an eluent to give **35** (83.9 mg, 62%). **35**: mp 145–147 °C (decomp., pale orange prisms, recrystallized from CH_2Cl_2–hexane). IR (KBr): 1705, 1540, 1435, 1368, 1290 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.85 (3H, s), 3.32 (1H, dd, *J*=16.1, 5.0 Hz), 3.39 (1H, dd, *J*=16.3, 8.1 Hz), 3.54 (1H, dd, *J*=16.1, 5.0 Hz), 3.58 (1H, dd, *J*=16.3, 8.1 Hz), 5.00–5.07 (1H, m), 7.46 (1H, d, *J*=8.8 Hz), 7.96 (1H, d, *J*=8.8 Hz). MS *m/z*: 404, 402, 400 (M^+). *Anal.* Calcd for $C_{13}H_{10}Br_2N_2O_3$: C, 38.84; H, 2.51; N, 6.97. Found: C, 38.62; H, 2.35; N, 6.85.

2-Bromo-4-hydroxymethyl-4-nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (36) from 22a — NBS (126.8 mg, 0.71 mmol) and AIBN (21.9 mg, 0.13 mmol) were added to a solution of **22a** (153.7 mg, 0.66 mmol) in dry $CHCl_3$ (50 mL) and the mixture was heated at reflux for 30 min with stirring. After evaporation of the solvent under reduced pressure, the residue was column-chromatographed on SiO_2 with EtOAc–hexane (1:4, v/v) to give **36** (189.2 mg, 92%). mp 160–163 °C (decomp., yellow prisms, recrystallized from MeOH). IR (KBr): 3485, 3285, 1537, 1441, 1340, 1063, 1022, 858, 763, 745 cm^{-1}. ^{1}H-NMR (CD_3OD) δ: 3.11 (1H, d, *J*=16.1 Hz), 3.31 (1H, d, *J*=16.3 Hz), 3.60 (1H, dd, *J*=16.1, 1.3 Hz), 3.71 (1H, d, *J*=16.3 Hz), 3.91 (1H, d, *J*=11.8 Hz), 3.94 (1H, d, *J*=11.8 Hz), 6.82 (1H, dd, *J*=8.2, 0.9 Hz), 7.04 (1H, br t, *J*=8.2 Hz), 7.08 (1H, dd, *J*=8.2, 0.9 Hz). MS *m/z*: 312, 310 (M^+). *Anal.* Calcd for $C_{12}H_{11}BrN_2O_3$: C, 46.32; H, 3.56; N, 9.00. Found: C, 46.22; H, 3.65; N, 8.91.

4-Acetoxymethyl-2,6-dibromo- (37a) 4-Acetoxymethyl-1-acetyl-2,6-dibromo- (37b), 4-Acetoxymethyl-2-bromo- (38), 4-Acetoxymethyl-2,8-dibromo- (39) and 4-Acetoxymethyl-2,7-dibromo-4-nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (40) from 36 — NBS (43.6 mg, 0.25 mmol) and AIBN (7.5 mg, 0.05 mmol) were added to a solution of **36** (70.9 mg, 0.23 mmol) in dry MeCN (20 mL) and the mixture was heated at reflux for 30 min with stirring. After cooling, the whole was irradiated with 100W mercury lamp in quartz bottle for 10 min under Ar atmosphere. After evaporation of the solvent under reduced pressure, the residue was dissolved in pyridine (2 mL). Ac_2O (1 mL) was then added and stirred at rt for 1 h. After evaporation of the solvent under reduced pressure, the residue was column-chromatographed repeatedly on SiO_2 with acetone–hexane (1:2, v/v) to give **39** (5.2 mg, 5%), **38** (1.7 mg, 2%), **40** (1.7 mg, 2%), **37a** (13.5 mg, 14%), and **37b** (14.9 mg, 14%) in the order of elution. **37a**: mp 170–173 °C (decomp., pale yellow prisms, recrystallized from CH_2Cl_2–hexane). IR (KBr): 3440, 1750, 1550, 1442 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.11 (3H, s), 3.18 (1H, d, *J*=16.2 Hz), 3.39 (1H, d, *J*=16.8 Hz), 3.58 (1H, d, *J*=16.2 Hz), 3.78 (1H, d, *J*=16.8 Hz), 4.44 (1H, d, *J*=12.2 Hz), 4.48 (1H, d, *J*=12.2 Hz), 7.03 (1H, d, *J*=8.6 Hz), 7,29 (1H, d, *J*=8.6 Hz), 8.02 (1H, br s). MS *m/z*: 434, 432, 430 (M^+). *Anal.* Calcd for $C_{14}H_{12}Br_2N_2O_4$•1/4H_2O: C, 38.52; H, 2.89; N, 6.42. Found: C, 38.42; H, 2.83; N, 6.35. **37b**: mp 149–152 °C (decomp., pale yellow prisms, recrystallized from $CHCl_3$). IR (KBr): 1750, 1708, 1543, 1438, 1375, 1300, 1230, 1205, 1040, 812 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.13 (3H, s), 2.85 (3H, s), 3.12 (1H, d, *J*=17.0 Hz), 3.33 (1H, d, *J*=17.0 Hz), 3.60 (1H, dd, *J*=17.0, 1.2 Hz), 3.81 (1H, d, *J*=17.0 Hz), 4.48 (1H, d, J=12.1 Hz), 4.51 (1H, d, J=12.1 Hz), 7.45 (1H, d, J=8.8 Hz), 7.94 (1H, d, J=8.8 Hz). MS *m/z*: 476, 474, 472 (M^+). *Anal.* Calcd for $C_{16}H_{14}Br_2N_2O_5$•1/4H_2O: C, 40.15; H, 3.05; N, 5.85. Found: C, 40.15; H, 2.95; N, 5.77. **38**: mp 141–143 °C (decomp., pale yellow prisms, recrystallized from MeOH–H_2O). IR (KBr): 3430, 1755, 1543, 1443, 1205, 1043 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.09 (3H, s), 3.12 (1H, dd, J=16.1, 0.8 Hz), 3.41 (1H, d, J=16.3 Hz), 3.62 (1H, dd, J=16.1, 0.8 Hz), 3.78 (1H, d, J=16.3 Hz), 4.44 (2H, s), 6.91–6.94 (1H, m), 7.11–7.16 (2H, m), 8.00 (1H, br s). MS *m/z*: 354, 352 (M^+). *Anal.* Calcd for $C_{14}H_{13}BrN_2O_4$: C, 47.61; H, 3.71; N, 7.93. Found: C, 47.52; H, 3.61; N, 7.84. **39**: mp 194–197 °C (decomp., colorless prisms, recrystallized from CH_2Cl_2–hexane). IR (KBr): 3240, 1737, 1545, 1440, 1372, 1260, 1038 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.10 (3H, s), 3.20 (1H, d, J=16.5 Hz), 3.34 (1H, d, J=16.5 Hz), 3.63 (1H, dd, J=16.5, 1.0 Hz), 3.75 (1H, d, J=16.5 Hz), 4.46 (2H, s), 6.83 (1H, dd, J=7.7, 1.0 Hz), 7.26 (1H, d, J=7.7 Hz), 8.14 (1H, br s). MS *m/z*: 434, 432, 430 (M^+). *Anal.* Calcd for $C_{14}H_{12}Br_2N_2O_4$•1/4H_2O: C, 38.52 H, 2.89; N, 6.42. Found: C, 38.60; H, 2.82; N, 6.41. **40**: mp 165–167 °C (decomp., colorless prisms, recrystallized from MeOH–H_2O). IR (KBr): 3290, 1725, 1543, 1443, 1249, 1045 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.10 (3H, s), 3.19 (1H, d, J=16.3 Hz), 3.35 (1H, d, J=16.5 Hz), 3.61 (1H, d, J=16.3 Hz), 3.76 (1H, d, J=16.5 Hz), 4.42 (1H, d, J=12.0 Hz), 4.48 (1H, d, J=12.0 Hz), 7.09 (1H, d, J=0.9 Hz), 7.31 (1H, s), 7.99 (1H, br s). MS *m/z*: 434, 432 (M^+). *Anal.* Calcd for $C_{14}H_{12}Br_2N_2O_4$: C, 38.92; H, 2.80; N, 6.48. Found: C, 38.97; H, 2.83; N, 6.42.

37b from 37a — Ac_2O (1 mL) was added to a solution of **37a** (33.1 mg, 0.08 mmol) in pyridine (2 mL) and the whole was stirred at rt for 1 h. After evaporation of the solvent under reduced pressure, the residue was subjected to p-TLC on SiO_2 with acetone–hexane (2:5, v/v) as a developing solvent. Extraction of the band having an *Rf* value of 0.80–0.71 with EtOAc afforded **37b** (28.8 mg, 80%).

38 from 36 — Ac_2O (0.5 mL) was added to a solution of **36** (50.6 mg, 0.16 mmol) in pyridine (1 mL) and the whole was stirred at rt for 1 h. After evaporation of the solvent under reduced pressure, the residue was column-chromatographed on SiO_2 with CH_2Cl_2–hexane (1:1, v/v) as an eluent to give **38** (56.5 mg, 98%).

2,7-Dibromo-4-hydroxymethyl-4-nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (41) from 34 — KO*t*-Bu (44.5 mg, 0.4 mmol) was added to a solution of **34** (236.5 mg, 0.66 mmol) in MeOH (5 mL) and stirred at rt for 15 min. A solution of 37% HCHO (57.6 mg, 0.71 mmol) was then added and the whole was stirred at rt for 3 h. After addition of sat. aq. NH_4Cl, the whole was extracted with CH_2Cl_2. The extract was washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to leave an oil, which was column-chromatographed on SiO_2 with EtOAc–hexane (1:4, v/v) to give **34** (68.7 mg, 29%) and **41** (153.0 mg, 60%) in the order of elution. **41**: mp 165–168 °C (decomp., pale yellow prisms, recrystallized from MeOH–H_2O). IR (KBr): 3500, 3370, 3220, 1535, 1522, 1443, 1053 cm^{-1}. ^{1}H-NMR ($CDCl_3$) δ: 2.02 (1H, br s), 3.22 (1H, d, J=16.1 Hz), 3.36 (1H, d, J=16.5 Hz), 3.57 (1H, d, J=16.1 Hz), 3.72 (1H, d, *J*=16.5 Hz), 3.92 (1H, d, *J*=12.5 Hz), 3.95 (1H, d, *J*=12.5 Hz), 7.09 (1H, d, *J*=0.9 Hz), 7.31 (1H, d, *J*=0.9 Hz), 7.96 (1H, br s). MS *m/z*: 392, 390, 388 (M^+). *Anal.* Calcd for $C_{12}H_{10}Br_2N_2O_3$: C, 36.95; H, 2.58; N, 7.18. Found: C, 37.02; H, 2.64; N, 7.18.

40 from 41 — Ac_2O (0.5 mL) was added to a solution of **41** (36.1 mg, 0.09 mmol) in pyridine (1 mL) and the whole was stirred at rt for 3 h. After evaporation of the solvent under reduced pressure, the residue was subjected to p-TLC on SiO_2 with EtOAc–hexane (1:2, v/v) as a developing solvent. Extraction of the band having an *Rf* value of 0.72–0.63 with CH_2Cl_2 afforded **40** (29.6 mg, 74%).

Optical Resolution of (±)-4-Nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (6) — Optical resolution of (±)-**6** was carried out by HPLC with semi-preparative Chiralpak AS column (Daicel Kagaku ltd.). Thus, 3.0 mL of a solution of (±)-**6** (141.3 mg, 0.70 mmol) in hexane–isopropanol (18:1, v/v, 123.0 mL) was injected to the column and hexane–isopropanol (18:1, v/v) was used as an eluent employing flow rate 1.0 mL/min. The eluted optical isomer of **6** was detected by UV detector (280.0 nm). Fractions having retention time of 60–67 min gave (+)-**6**. Fractions having retention time of 67–70 min were a mixture of (+)-**6** and (–)-**6**, while (–)-**6** eluted with retention time of 70–78 min. A mixture of (+)-**6** and (–)-**6** were separated by repeating the above procedure. Injections and separation of the mixture were repeated over and over again. Finally, (+)-**6** (61.4 mg, 44%) and (–)-**6** (57.2 mg, 41%) were obtained.

Purity of each optical isomer was confirmed utilizing HPLC with Chiralpak AS column for analysis with hexane–isopropanol (18: 1, v/v) as an eluent (flow rate 1.5 mL/min, UV detection 280.0 nm). (+)-**6**: mp 126.5–127 °C (colorless prisms, recrystallized from MeOH). IR (KBr): 3399, 3117, 2960, 1611, 1604, 1530, 1441, 1418, 1372, 1361, 1345, 1281, 1220, 1080, 987, 872, 840, 812, 774, 753, 560, 517 cm^{-1}. $[\alpha]^{D}_{23}$ +7.12° (c=0.24, 99.5% EtOH). (–)-**6**: mp 125–126 °C (colorless prisms, recrystallized from MeOH). IR (KBr): 3400, 3118, 2965, 1610, 1605, 1531, 1441, 1418, 1372, 1361, 1345, 1281, 1220, 1080, 987, 872, 840, 812, 774, 753, 560, 518 cm^{-1}. $[\alpha]^{D}_{23}$ –7.38° (c=0.25, 99.5% EtOH). ^{1}H-NMR data of (+)-**6** and (–)-**6** were identical with that of (±)-**6**.

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