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A SIMPLE FOUR STEP SYNTHESIS AND OPTICAL RESOLUTION OF
4-NITRO-1, 3, 4, 5-TETRAHYDROBENZ[*cd*]INDOLE, AND THE SYN-
THESES OF 1-HYDROXY DERIVATIVES OF 4-NITRO- AND 4-
AMINO-1, 3, 4, 5-TETRAHYDROBENZ[*cd*]INDOLES¹

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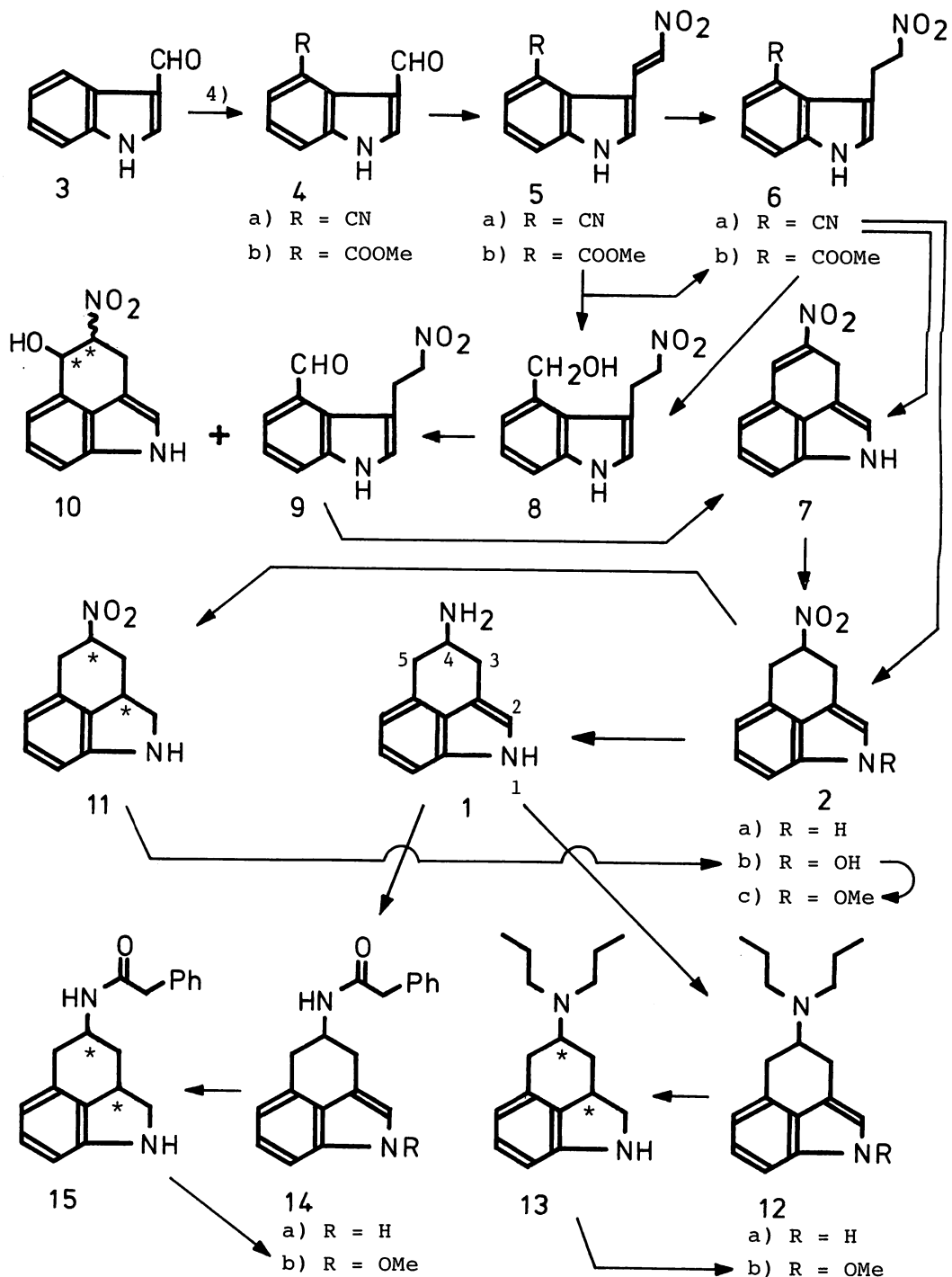
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Abstract ——— 4-Nitro-1, 3, 4, 5-tetrahydrobenz[*cd*]indole
was synthesized from indole-3-carboxaldehyde in four
steps with an overall yield of 30%. Optical resolution
of its enantiomers by chiral column chromatography was
successful. Syntheses of 1-hydroxy derivatives of 4-ni-
tro- and 4-amino-1, 3, 4, 5-tetrahydrobenz[*cd*]indoles are
also reported.

Various biologically active compounds² have been derived from 4-amino-1, 3,
4, 5-tetrahydrobenz[*cd*]indole (1, Scheme 1) as a parent compound, and much
efforts have been devoted on developing a simple synthetic method for 1.²
Its shortest synthetic route among thus far known^{2, 3} is the one through
indole-4-carboxaldehyde³ using 2-methyl-3-nitrobenzoic acid as a starting
material. Nevertheless, it still requires cumbersome nine steps with low
overall yield.²

In this communication, we describe a simple four step synthetic method of
4-nitro-1, 3, 4, 5-tetrahydrobenz[*cd*]indole^{2g} (2a), a synthetic precursor of
1, from indole-3-carboxaldehyde (3). We also succeeded in the optical res-

Scheme 1



olution of both enantiomers of **2a** by chiral column chromatography and in the syntheses of 1-hydroxy derivatives of 4-nitro- and 4-amino-1,3,4,5-tetrahydrobenz[*cd*]indoles.

I. A simple four step synthesis of 4-nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (**2a**)

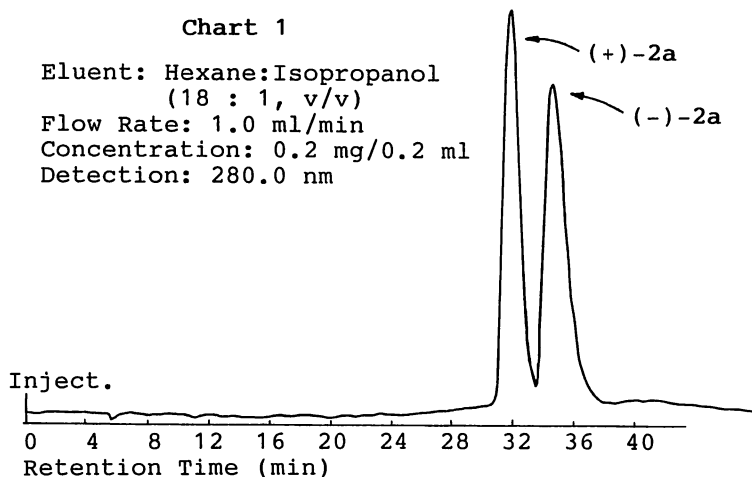
4-Cyano-3-(2-nitroethyl)indole (**6a**) was prepared through **4a** and **5a** in three steps from **3**, according to the reported procedure⁴ in 53% overall yield. Next, sequential treatment of **6a**, initially with diisobutylaluminum hydride (DIBAL) in anhydrous tetrahydrofuran (THF) at room temperature for 30 min, then with methanol (MeOH)-water at reflux for 30 min, was found to produce 1,3-dihydro-4-nitrobenz[*cd*]indole (**7**, mp 190-190.5°C) in 52% yield. Since the compound (**7**) was cleanly reduced to **2a** (mp 138.5-139°C, lit.,²⁹ mp 134-135°C) in 80% yield with sodium borohydride (NaBH₄) in MeOH, the attempt at effecting one pot conversion of **6a** to **2a** was readily attained in 57% yield by adding the NaBH₄ reduction procedure to the above DIBAL and MeOH-water treatment. Consequently, a simple four step synthetic method for **2a** from **3** with an overall yield of 30% was established with the originality rate⁵ of 60%. However, every attempt to convert **5a** into **2a** in one pot operation was unsuccessful at present. Finally, **2a** was reduced to **1** (mp 125-126°C, lit.,²⁹ mp 119-121°C) with amalgamated zinc-aqueous hydrogen chloride at reflux in 99.5% yield.

Alternatively, the compound (**7**) could be prepared by the following route. 4-Methoxycarbonylindole-3-carboxaldehyde (**4b**), obtained in 53% yield from **3** by one pot procedure,⁴ was converted into 4-methoxycarbonyl-3-(2-nitrovinyl)indole (**5b**, mp 121-122°C) in 91% yield by the aldol reaction with nitromethane. Subsequent reduction of **5b** with NaBH₄ in *N,N*-dimethylformamide-MeOH afforded 4-methoxycarbonyl-3-(2-nitroethyl)indole (**6b**, mp 106-107°C) in 83% yield. DIBAL (3 mol eq.) reduction of **6b** in THF afforded 4-hydroxymethyl-3-(2-nitroethyl)indole (**8**, mp 118-119°C) in 99% yield, nevertheless attempts to convert **5b** directly to **8** by DIBAL (3 mol eq.) reduc-

tion were unsuccessful, giving **6b** in 31% yield in addition to 35% yield of starting material. On the other hand, lithium borohydride (LiBH_4) reduction of **5b** in THF at reflux did not realize complete conversion of **5b** into **8**, instead **6b** and **8** were produced in 36 and 33% yields, respectively. Similar behavior was observed on the reduction of **6b** with LiBH_4 (20 mol eq.), resulting in the formation of **8** in 31% yield together with 55% yield of recovery. Though oxidation of **8** with either active manganese dioxide or dimethyl sulfoxide-acetic anhydride afforded poor results, pyridinium chlorochromate (3 mol eq.) in pyridine produced 3-(2-nitroethyl)indole-4-carboxaldehyde (**9**, mp 159-160°C) and 5-hydroxy-4-nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (**10**, as a mixture of diastereoisomers) in 32 and 13% yields, respectively. Subsequent treatment of **9** with triethylamine in MeOH at reflux for 1 h afforded **7** in 87% yield.

II. Optical resolution of 4-nitro-1,3,4,5-tetrahydrobenz[*cd*]indole (**2a**)

With the desired compound (**2a**) in hand, we next tried its optical resolution on chiral column chromatography, and finally found that (+)-**2a** (mp 126.5-127.0°C, $[\alpha]_{\text{D}}^{23} +7.12^\circ$ (99.5% EtOH, $c=0.24$)) and (-)-**2a** (mp 125.0-126.0°C, $[\alpha]_{\text{D}}^{23} -7.38^\circ$ (99.5% EtOH, $c=0.25$)) were separable on Chiralpak AS column (Daicel Kagaku) using isopropanol-hexane (1:18, v/v) as an



eluent, and the results are shown in Chart 1. Determination of their absolute configuration and syntheses of optically active derivatives of **2a** and **1** are currently under investigation.

III. Syntheses of 1-hydroxy derivatives of 4-nitro- and 4-amino-1,3,4,5-tetrahydrobenz[cd]indoles

We suppose that **1**, **2a**, and related indole compounds would be metabolized into the corresponding 1-hydroxyindoles *in vivo*.^{1b,6} Therefore, preparations of the expected compounds are of much interest.

Treatment of **2a** with sodium cyanoborohydride (NaBH_3CN) in trifluoroacetic acid (TFA) and acetic acid (AcOH) (2:3 mixture) produced 95% yield of indoline (**11**), which was an inseparable 2:1 mixture of diastereoisomers. Similarly, 4-dipropylamino-1,3,4,5-tetrahydrobenz[cd]indole (**12a**), readily obtainable from **1** by treatment with propyl iodide,^{2j} was converted to the corresponding indoline (**13**, 6:1 mixture of diastereoisomers) in 86% yield. Subsequent oxidation of **11** with sodium tungstate·dihydrate ($\text{Na}_2\text{WO}_4 \cdot 2\text{H}_2\text{O}$) and urea hydrogen peroxide addition compound^{6c} ($\text{urea} \cdot \text{H}_2\text{O}_2$) afforded 52% yield of the desired 1-hydroxy-4-nitro-1,3,4,5-tetrahydrobenz[cd]indole (**2b**) as prisms (mp 134.0-134.5°C), which could be stored at room temperature for 1 week without any decomposition. The reaction of **2b** with ethereal diazomethane afforded the corresponding 1-methoxy derivative (**2c**) in 64% yield as a stable oil. By carrying out the above two procedures successively, one pot preparation of **2c** was realized in 33% yield. Similar one pot oxidation of the diastereoisomers (**13**) with $\text{Na}_2\text{WO}_4 \cdot 2\text{H}_2\text{O}$ and $\text{urea} \cdot \text{H}_2\text{O}_2$, followed by the methylation of the resultant 1-hydroxyindole with diazomethane afforded 4-dipropylamino-1-methoxy-1,3,4,5-tetrahydrobenz[cd]indole (**12b**) in 46% yield as an unstable oil.

On the other hand, treatment of **1** with phenylacetyl chloride afforded 73% yield of amide compound (**14a**, oil). Reduction of **14a** with NaBH_3CN in TFA and AcOH (1:4, v/v) produced the corresponding diastereoisomers, **15a** (mp 159-160°C) and **15b** (oil), in 41 and 47% yields, respectively. Subsequent

oxidation of the mixture of **15a** and **15b** with $\text{Na}_2\text{WO}_4 \cdot 2\text{H}_2\text{O}$ and $\text{urea} \cdot \text{H}_2\text{O}_2$, followed by the methylation of the resultant unstable 4-dipropylamino-1-hydroxy-1,3,4,5-tetrahydrobenz[cd]indole with dimethyl sulfate and potassium carbonate afforded 40% yield of the desired stable 1-methoxyindole derivative (**14b**, mp 138-139°C).

Reactivity and biological evaluations of the above mentioned 1-hydroxyindole derivatives are in progress.

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