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Studies on Aromatic Nitro Compounds. IV.[1] Reactions of 2-Nitronaphthalenes with Active Methylene Compounds in the Presence of Bases

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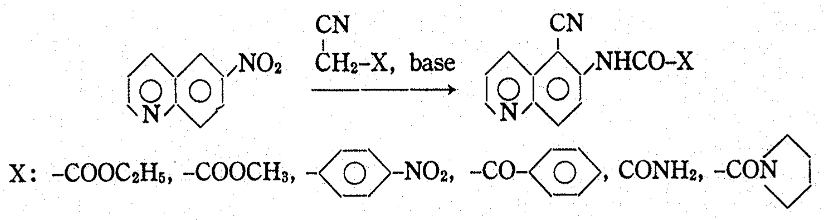
The reactions of 2-nitronaphthalenes with active methylene compounds in the presence of a base were investigated. 2-Nitronaphthalene (I) reacted with ethyl cyanoacetate in the presence of potassium hydroxide to produce ethyl *N*-(1-cyano-2-naphthyl)oxamate (IIa) in 64% yield. Similarly, the reactions of I with methyl cyanoacetate, *p*-nitrophenylacetonitrile, ω-cyanoacetophenone, α-cyanoacetamide and 1-cyanoacetylpyrrolidine in the presence of a base gave the 2-aminonaphthalene-1-carbonitriles (IIb—f) as major products corresponding to IIa.

On the other hand, the reaction of 2,3-dinitronaphthalene (VII) with ethyl cyanoacetate in the presence of potassium hydroxide gave ethyl 2-cyano-2-(3-nitro-1-naphthyl)acetate (VIIIa). In the reaction of 2-nitronaphthalene-1-carbonitrile (IX) with ethyl cyanoacetate, ethyl 2-cyano-2-(1-cyano-2-naphthyl)acetate (Xa) was obtained.

Keywords——2-nitronaphthalene; base; active methylene compounds; *N*-(1-cyano-2-naphthyl)oxamates; hydrolysis; 2,3-dinitronaphthalene; ethyl 2-cyano-2-(3-nitro-1-naphthyl)acetate; 2-nitronaphthalene-1-carbonitrile; ethyl 2-cyano-2-(1-cyano-2-naphthyl)acetate

In the first paper of this series,[2] we showed that 6-nitroquinoline reacts with some cyanomethylene compounds in the presence of a base to give 6-aminoquinoline-5-carbonitrile derivatives as the main products.



In order to investigate further the scope of this reaction, we examined the reactions of 2-nitronaphthalenes with cyanomethylene compounds.

When 2-nitronaphthalene (I) was treated with ethyl cyanoacetate and potassium hydroxide in dimethylformamide (DMF) at room temperature, the expected ethyl *N*-(1-cyano-2-

TABLE I. Reaction[a] of 2-Nitronaphthalene with Ethyl Cyanoacetate in Various Solvents

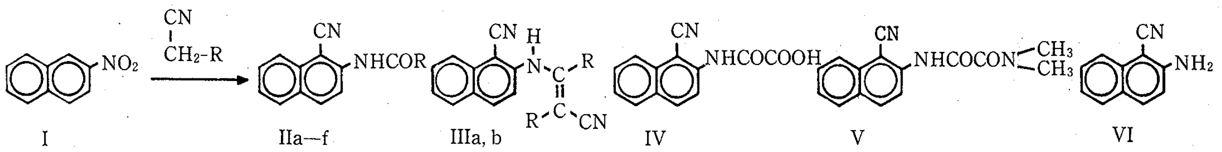
Exp. No.	Reaction solvent	Yield of IIa (%)	Recovery of I
1	DMF	64	—
2	99% aq. DMF	40	11
3	95% aq. DMF	11	59
4	90% aq. DMF	7	82
5	80% aq. DMF	—	95
6	DMSO	61	—
7	HMPA	31	—

[a] All reactions were carried out in a solution of Ia (0.01 mol), ethyl cyanoacetate (0.03 mol), and potassium hydroxide (0.03 mol) in the solvent (30 ml) for 24 h at room temperature.

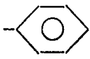
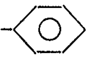
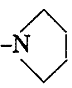
naphthyl)oxamate (IIa) was obtained in 64% yield. Various conditions for this reaction were examined, and Tables I and II summarize the results.

When DMF, dimethyl sulfoxide (DMSO), or hexamethylphosphoric triamide (HMPA) was used as a solvent, IIa was obtained. However, no reaction occurred in ethanol or acetonitrile, and I was recovered unchanged. DMF was shown to be the most suitable solvent. It was found that the yield of IIa decreased with increase in the amount of water, and that IIa was no longer formed in 80% aqueous DMF. Therefore, anhydrous DMF was also used as a solvent in the reaction of other cyanomethylene compounds.

Table II. Reaction[a] of 2-Nitronaphthalene with Some Cyanomethylene Compounds



I IIa—f IIIa, b IV V VI

Exp. No.	R	Reaction conditions		Products, % yield					
		Base	Time (h)	II	III	IV	V	VI	I
8	a: $-COOC_2H_5$	KCN	24	30	13				
9	a: $-COOC_2H_5$	NaOH	24	Trace	4	28			58
10	a: $-COOC_2H_5$	LiOH	24	3	3	21			41
11	a: $-COOC_2H_5$	*tert*-BuOK	24	23	7		23		
12	a: $-COOC_2H_5$	*tert*-BuOK	48		7		40	10	
13	b: $-COOCH_3$	KOH	24	65	1				
14	b: $-COOCH_3$	KCN	24	33	18				
15	b: $-COOCH_3$	*tert*-BuOK	48		10		41	17	
16	c: -  $-NO_2$	KOH	24	31					
17	d: -CO- 	KOH	160	38					41
18	e: $-CONH_2$	KOH	24	59					
19	f: -CO-N 	KOH	24	44					

a) All reactions were carried out with the use of I, the cyanomethylene compound and potassium hydroxide in a 1: 3: 3 molar ratio, except for Exp. Nos. 16 and 17 in which a 1: 1.5: 1.5 molar ratio of I to the cyanomethylene compound and potassium hydroxide was used.

When potassium cyanide was used in place of potassium hydroxide, the yield of IIa decreased to 30%, and diethyl 2-cyano-3-(1-cyano-2-naphthylamino)fumarate (IIIa) was additionally formed in 13% yield. With sodium hydroxide or lithium hydroxide, IIa and IIIa were both obtained in less than 5% yields, and the major product was *N*-(1-cyano-2-naphthyl)oxamic acid (IV). Interestingly, with potassium *tert*-butoxide, *N*-(1-cyano-2-naphthyl)-*N'*,*N'*-dimethyloxamide (V) was obtained in 23% yield together with IIa and IIIa. When the reaction time was prolonged (48 h), the yield of V increased to 40%, and no formation of IIa was noted. On treatment with potassium *tert*-butoxide in DMF, IIa was converted to V. On the basis of the results presented above, V seems to be formed by the reaction of IIa with DMF in the presence of potassium *tert*-butoxide.

Subsequently, the reaction of I with methyl cyanoacetate and potassium hydroxide in DMF at room temperature for 24 h gave methyl *N*-(1-cyano-2-naphthyl)oxamate (IIb) in 65% yield. In a similar manner, I reacted with *p*-nitrophenylacetonitrile, ω-cyanoacetophenone, α-cyanoacetamide, and 1-cyanoacetylpyrrolidine to produce the 2-aminonaphthalene-1-carbonitrile derivatives (IIc, d, e and f) corresponding to IIa (Table II).

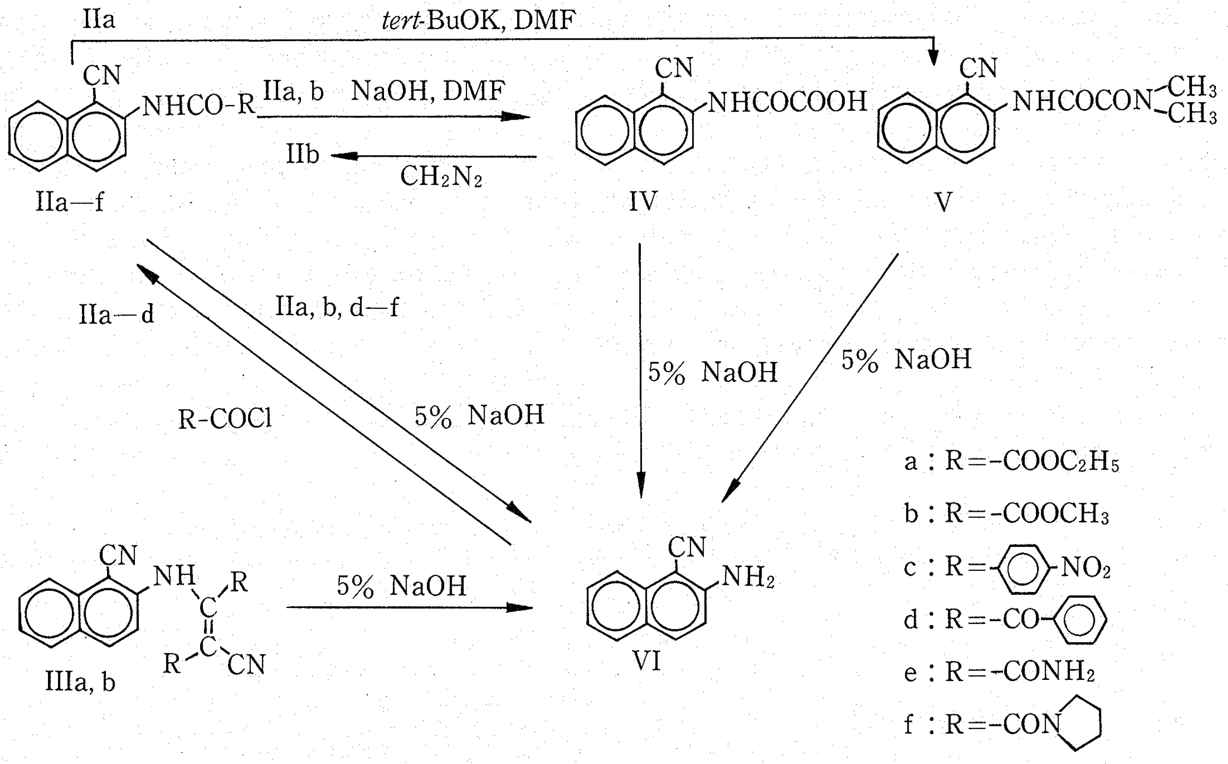


Chart 1

Chart 1 illustrates the reactions carried out in connection with the structural elucidation of II—VI. On hydrolysis with 5% sodium hydroxide, II, III, IV and V gave the same compound, 2-aminonaphthalene-1-carbonitrile (VI), which was identical with an authentic sample.[3] The reaction of IV with diazomethane resulted in the formation of IIb (22%) and VI (13%). On treatment with sodium hydroxide in DMF at room temperature, IIa and b were hydrolyzed to IV. The infrared (IR) spectra of IIIa and b exhibited an amine band

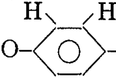
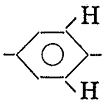
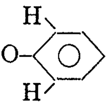
Table III. Physical and Analytical Data for 2-Substituted Naphthalene-1-carbonitriles

Compd. No.	mp (°C) (Recrystn. solvent)	Appearance	Formula	Analysis (%) Calcd (Found)		
				C	H	N
IIa	173 (EtOH)	Colorless needles	$C_{15}H_{12}N_2O_3$	67.15 (67.14	4.51 4.44	10.44 10.39)
IIb	196 (MeOH)	Colorless prisms	$C_{14}H_{10}N_2O_3$	66.13 (66.11	3.96 3.98	11.02 11.07)
IIc	274 (MeOH)	Pale yellow plates	$C_{18}H_{11}N_3O_3$	68.14 (68.15	3.49 3.52	13.24 13.17)
IId	169—170 (Acetone-Petr. ether)	Colorless needles	$C_{19}H_{12}N_2O_2$	75.99 (75.92	4.03 4.03	9.33 9.34)
IIe	250—252 (MeOH)	Colorless needles	$C_{13}H_9N_3O_2$	65.26 (65.20	3.79 3.83	17.57 17.50)
IIf	190—192 (MeOH)	Colorless needles	$C_{17}H_{15}N_3O_2$	69.61 (69.12	5.15 5.06	14.33 14.37)
IIIa	167—169 (EtOH)	Yellow plates	$C_{20}H_{17}N_3O_4$	66.11 (65.84	4.72 4.54	11.57 11.47)
IIIb	197 (MeOH)	Pale yellow columns	$C_{18}H_{13}N_3O_4$	64.47 (64.53	3.91 3.72	12.53 12.44)
IV	204 (dec.) (Acetone)	Colorless needles	$C_{13}H_8N_2O_3$	65.00 (65.15	3.36 2.98	11.66 11.75)
V	172—173 (Acetone)	Colorless scales	$C_{15}H_{13}N_3O_2$	67.40 (67.41	4.90 4.74	15.72 15.79)

at near 3200 cm^{-1}, a characteristic conjugated nitrile band at 2203 cm^{-1}, and two strong bands at near 1745 cm^{-1} and near 1675 cm^{-1} indicative of a carbonyl group and a chelated carbonyl group. The absorption band at near 1675 cm^{-1} suggested the presence of hydrogen bonding between the ester carbonyl and an amino group. The proton magnetic resonance (PMR) spectra showed a broad signal at near δ 11.7 (1H) due to a chelated amino proton, in addition to signals due to six aromatic protons and the protons of two alkoxycarbonyl groups. On the basis of these data, IIIa and b were assigned as the fumarate derivatives. The structures of IIa—d were confirmed by direct comparison with the corresponding authentic samples prepared from VI and ethoxalyl, methoxalyl, *p*-nitrobenzoyl, and phenyloxalyl chlorides, respectively. These structures were also supported by the analytical (Table III) and spectral data (Table IV).

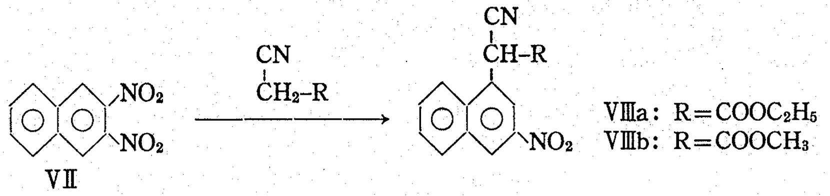
In contrast with 2-nitronaphthalene, different reactions took place in the cases of 2,3-dinitronaphthalene (VII) and 2-nitronaphthalene-1-carbonitrile under the same conditions.

TABLE IV. Spectral Data for 2-Substituted Naphthalene-1-carbonitriles

Compd. No.	IR $\nu_{\max}^{\text{KBr}}$ cm^{-1}			Proton NMR spectra ppm (J in Hz)			MS m/e (M$^+$)
	NH	CN	CO	C$_3$–H	C$_4$–H	Others	
IIa	3256 3130	2198	1734	8.06 (d, $J_{3,4}=9$)$^{a)}$	8.54	1.45 (–OCH$_2$–C$\underline{H}_3$), 4.47 (–OC$\underline{H}_2$–CH$_3$), 7.44—7.76 (2H, m, C$_{6,7}$–H),7.86 and 8.10 (2H, m, C$_{5,8}$–H), 9.64 (1H, br s, $\rangle$NH)	268
IIb	3250	2196	1709	8.07 (d, $J_{3,4}=9$)$^{a)}$	8.55	4.06 (–OC$\underline{H}_3$), 7.44—7.78 (2H, m, C$_{6,7}$–H), 7.88 and 8.11 (2H, m, C$_{5,8}$–H), 9.60 (1H, br. s, $\rangle$NH)	254
IIc	3302 3110	2202	1662	7.76 (d, $J_{3,4}=9$)$^{b)}$		7.58—7.90 (2H, m, C$_{6,7}$–H), 8.04—8.48 (7H, m, –CO––NO$_2$ and C$_{4,5,8}$–H), 11.15 (1H, br s, $\rangle$NH)	317
IId	3310	2200	1697 1659	8.07 (d, $J_{3,4}=9.2$)	8.59	7.38—7.69 (5H, m, C$_{6,7}$—H and –CO-–H), 7.71—8.22 (2H, m, C$_{5,8}$—H), 8.43 (2H, m, –CO–), 9.71 (1H, br s, $\rangle$NH)	300
IIe	3370 3300 3235 3180	2201	1697 1645	7.90 (d, $J_{3,4}=9$)$^{b)}$	8.28	7.53—7.80 (2H, m, C$_{6,7}$—H), 7.96—8.18 (2H, m, C$_{5,8}$–H), 8.41 (2H, br s, –CO-NH$_2$), 10.87 (1H, br s, $\rangle$NH)	239
IIf	3275	2190	1711	7.85 (d, $J_{3,4}=9$)$^{b)}$	8.29	1.8—2.1 (4H, m), 3.50 (2H, m) and 3.82 (2H, m), 7.56—7.92 (2H, m, C$_{6,7}$–H), 8.07 (2H, m, C$_{5,8}$–H), 11.02 (1H, br s, $\rangle$NH)	293
IIIa	3200	2203	1738 1671	7.44 (d, $J_{3,4}=9$)$^{c)}$	8.57	1.06 and 1.13 (–OCH$_2$–C$\underline{H}_3\times2$), 4.17 (–OC$\underline{H}_2$–CH$_3\times2$), 7.60—8.38 (4H, m), 11.84 (1H, br s, $\rangle$NH)	363
IIIb	3195	2203	1750 1681	7.83 (d, $J_{3,4}=9$)$^{b)}$	8.37	3.73 and 3.78 (–OCH$_3\times2$), 7.45—8.23 (4H, m), 11.56 (1H, br s, $\rangle$NH)	335
IV	3335	2210	1753 1708	7.85 (d, $J_{3,4}=9$)$^{b)}$	8.30	7.56—7.90 (2H, m, C$_{6,7}$–H), 8.09 (2H, d.d, $J=7.7$ and 1.5, C$_{5,8}$–H), 11.12 and 12.0—12.8 (2H, br s)	240
V	3270	2200	1706 1647	7.77 (d, $J_{3,4}=9$)$^{b)}$	8.30	3.01 and 3.21 (6H, s, –N(C$\underline{H}_3$)$\times2$), 7.56—7.90 (2H, m, C$_{6,7}$–H), 8.10 (2H, d.d, $J=$ 8 and 2, C$_{5,8}$–H), 11.28 (1H, br s, $\rangle$NH)	267

Abbreviations: br s, broad singlet; d, doublet; d.d, doublet of doublets; m, multiplet; s, singlet.
a) In CDCl$_3$.
b) In DMSO-d_6.
c) In HMPA-d_{18}.

When VII was treated with ethyl cyanoacetate and potassium hydroxide in DMF at room temperature for 5 h, ethyl 2-cyano-2-(3-nitro-1-naphthyl)acetate (VIIIa) was obtained in 51% yield. Compound VIIIa was converted to (3-nitro-1-naphthyl)acetonitrile when VIIIa was chromatographed on alumina (see "Experimental"). Similarly, the reaction of VII with methyl cyanoacetate gave methyl 2-cyano-2-(3-nitro-1-naphthyl)acetate (VIIIb) in 54% yield.

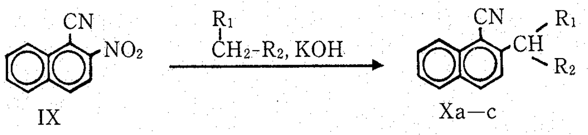


VIIIa: $R=COOC_2H_5$
VIIIb: $R=COOCH_3$

Similarly, Morrison[4] reported that treatment of VII with ethyl cyanoacetate and sodium methoxide in methanol affords VIIIb, although no experimental details were provided.

On the other hand, treatment of 2-nitronaphthalene-1-carbonitrile (IX)[5] with ethyl cyanoacetate, α-cyanoacetamide and diethyl malonate in DMF resulted in ordinary nucleophilic displacement of the nitro group, and ethyl 2-cyano-2-(1-cyano-2-naphthyl)acetate (Xa), 2-cyano-2-(1-cyano-2-naphthyl)acetamide (Xb) and diethyl 2-(1-cyano-2-naphthyl)malonate (Xc) were obtained in 88, 63 and 94% yields, respectively (Table V). The structural assignments of Xa—c were made on the basis of elemental analysis and spectral data (see "Experimental").

Table V. Reaction of 2-Nitronaphthalene-1-carbonitrile with Active Methylene Compounds in the Presence of Potassium Hydroxide



Exp. No.		R_1	R_2	Reaction conditions Time (h)	Temp. (°C)	Yield of Xa—c (%)
20	a	CN	$COOC_2H_5$	5	RT	88
21	b	CN	$CONH_2$	5	RT	63
22	c	$COOC_2H_5$	$COOC_2H_5$	24	RT	94

It is well known that the nitro group of aromatic compounds in which electron-withdrawing groups occupy the positions *ortho* and/or *para* to a nitro group undergoes nucleophilic displacement by a variety of nucleophiles.[6]

The mechanism for the reaction of 2-nitronaphthalene (I) with cyanomethylene compounds has not been established; this is now under investigation.

Experimental

DMF was prepared by distillation from calcium hydride and was stored over molecular sieve 4A. All melting points are uncorrected. IR spectra were recorded on an IRA-2 spectrophotometer. PMR spectra were taken on a Hitachi R-22 spectrometer at 90 MHz or a JNM-MH-100 spectrometer at 100 MHz using tetramethylsilane as an internal standard. Mass spectra were measured with a JEOL model JMS-01SG spectrometer.

Reaction of 2-Nitronaphthalene (I) with Cyanomethylene Compounds (a—f). General Procedure for the Preparation of IIa—f (Exp. Nos. 1, 6, 7, 13 and 16—19 in Tables I and II)——The nitro compound (I) (1.73 g, 0.01 mol) was added to a solution (or suspension) of the cyanomethylene compound (0.03 mol) and a base (0.03 mol) in a solvent (30 ml), and the mixture was stirred for the specified time (Tables I and II) at room temperature. The reaction solution was poured into ice water. The resulting mixture was neutralized with 10% HCl, and the deposited crystals were collected, washed with water, dried and recrystallized from the solvent indicated in Table III. In the case of IIc and d, the precipitate was washed with ether to remove the unchanged cyanomethylene compounds, dried and recrystallized from MeOH. The yields, the elemental analyses and the spectral data of II are shown in Tables I—IV.

Reaction of I with Ethyl or Methyl Cyanoacetate in the Presence of KCN (Exp. Nos. 8 and 14 in Table II)——The compound (I) (0.01 mol) was added to a solution of ethyl or methyl cyanoacetate (0.03 mol) and KCN (0.03 mol) in DMF (30 ml), and the mixture was stirred for 24 h at room temperature. The reaction solution was poured into ice water. The resulting mixture was neutralized with 10% HCl, and the deposited crystals were collected. The filtrate was extracted with $CHCl_3$. The $CHCl_3$ extract was dried over Na_2SO_4 and concentrated to dryness. The residue and the above deposited crystals were combined and chromatographed on silica gel. The first fraction eluted with $CHCl_3$ gave III. The second fraction eluted with $CHCl_3$ gave II. The yields of II and III, the elemental analysis and spectral data of III are shown in Tables II—IV.

Reaction of I with Ethyl Cyanoacetate in the Presence of Lithium Hydroxide (Exp. No. 10 in Table II)——The compound (I) (0.01 mol) was added to a solution of ethyl cyanoacetate (0.03 mol) and LiOH (0.03 mol) in DMF (30 ml), and the mixture was stirred for 24 h at room temperature. The mixture was poured into ice water, and the precipitate was collected. The filtrate was acidified with dil. AcOH, and extracted with $CHCl_3$. The $CHCl_3$ extract was dried over Na_2SO_4 and evaporated to dryness. The residue and the above precipitate were combined and chromatographed on silica gel with $CHCl_3$ as the eluent. The first fraction gave I (712 mg, 41%). The second fraction gave IIIa (113 mg, 3%), which was recrystallized from EtOH. The third fraction gave IIa (74 mg, 3%). The mother liquor from $CHCl_3$ extraction was salted out with NaCl, and cooled. The precipitate was collected, washed with small amounts of cold water, and recrystallized from acetone to give *N*-(1-cyano-2-naphthyl)oxamic acid (IV) as colorless needles, 494 mg (21%).

Reaction of I with Ethyl or Methyl Cyanoacetate in the Presence of *tert*-BuOK (Exp. Nos. 12 and 15 in Table II)——The compound (I) (0.01 mol) was added to a solution of ethyl or methyl cyanoacetate (0.03 mol) and *tert*-BuOK (0.03 mol) in DMF (30 ml), and the mixture was stirred for 48 h at room temperature. The reaction solution was poured into ice water, and the deposited crystals were collected, washed with water, dried and recrystallized from MeOH to give V. The filtrate was acidified with dil. AcOH, and extracted with $CHCl_3$. The $CHCl_3$ extract was dried over Na_2SO_4 and evaporated to dryness. The residue was chromatographed on silica gel with $CHCl_3$ as the eluent. The first product to appear was IIIa or b. The second product to appear was 2-aminonaphthalene-1-carbonitrile (VI). The third fraction gave V.

Hydrolysis of II——A solution of IIa, b, d, e or f (100 mg) in 5% NaOH (3 ml) was refluxed for 0.5 h at 120°C on an oil bath, and cooled. The precipitate was collected, washed with water, dried and recrystallized from $CHCl_3$ to yield colorless scales (VI), mp 131.5°C, which were identical with an authentic sample.[3] Yields were 100, 87, 71, 85 and 82%, respectively.

Hydrolysis of III——A solution of IIIa or b (200 mg) in 5% NaOH (6 ml) was refluxed for 0.5 h at 120°C on an oil bath and cooled. The precipitate was collected, washed with water and dried to yield VI. Yields were 54 and 50%, respectively.

Hydrolysis of IV——A solution of IV (300 mg) in 5% NaOH (8 ml) was refluxed for 1 h and cooled. After work-up as described for the hydrolysis of II, VI (177 mg) was obtained in 84% yield.

Hydrolysis of V——A solution of V (300 mg) in 5% NaOH (8 ml) was refluxed for 1 h and cooled. After work-up as described for the hydrolysis of II, VI (157 mg) was obtained in 83% yield.

Preparation of *N*-(1-Cyano-2-naphthyl)-*N'*,*N'*-dimethyloxamide (V) from IIa——(i) Compound IIa (268 mg, 1 mmol) was added to a solution of ethyl cyanoacetate (226 mg, 2 mmol) and *tert*-BuOK (224 mg, 2 mmol) in DMF (3 ml), and the mixture was stirred for 24 h at room temperature. The mixture was poured into ice water. The precipitate was collected, washed with water, dried, and recrystallized from EtOH to give V, 202 mg (76%).

(ii) Compound IIa (0.804 g) was added to a solution of *tert*-BuOK (1.344 g) in DMF (9 ml), and the mixture was stirred for 7 h at room temperature. The mixture was poured into ice water. The precipitate was collected, washed with a small amount of ice water, and dried to yield the potassium salt of IV (160 mg), which was converted to IV by treatment with 10% HCl. The filtrate was extracted with $CHCl_3$. The $CHCl_3$ extract was dried over Na_2SO_4 and evaporated to dryness. The residue was recrystallized from EtOH to give V, 0.605 g (76%).

Preparation of *N*-(1-Cyano-2-naphthyl)oxamic Acid (IV) from IIa——Powdered NaOH (160 mg) was added to a solution of IIa (536 mg, 2 mmol) in DMF (5 ml). The reaction mixture was stirred for 1 h at room temperature. The mixture was added to ice water (10 ml), and neutralized with 10% HCl. The precipitate was collected, dried and recrystallized from acetone–ether to give IV, 326 mg (68%), colorless needles, mp 204°C (dec.).

Reaction of IV with Diazomethane——A suspension of IV (240 mg) in ethereal diazomethane (20 ml) was stirred for 3 h at 0—5°C. After removal of the ether by evaporation, the residue was chromatographed on silica gel. The first fraction eluted with $CHCl_3$ gave IIb, 56 mg (22%). The second fraction eluted with

$CHCl_3$ gave 2-aminonaphthalene-1-carbonitrile (VI), 15 mg (13%).

Preparation of IIa, b, c and d from VI——A solution of VI (1 mmol) and ethoxalyl, methoxalyl, *p*-nitrobenzoyl, or phenyloxalyl chloride (1.5 mmol) in pyridine (3 ml) was kept at room temperature overnight. The reactants were poured into ice water (20—30 ml), and the deposited crystals were collected, washed with water, dried and recrystallized from the solvent listed in Table III. Yields were 100, 91, 87 and 82%, respectively.

Reaction of 2,3-Dinitronaphthalene with Ethyl or Methyl Cyanoacetate in the Presence of KOH——2,3-Dinitronaphthalene (VII) (1.09 g, 5 mmol) was added to a solution of ethyl or methyl cyanoacetate (15 mmol) and KOH (15 mmol) in DMF (15 ml), and the mixture was stirred for 5 h at room temperature. The reaction solution was poured into ice water, and extracted with $CHCl_3$. The $CHCl_3$ layer was washed with water, dried over Na_2SO_4, and then concentrated *in vacuo*. (ia) For ethyl cyanoacetate: The residue was chromatographed on silica gel. The first fraction eluted with petr. ether gave VII (30 mg). The second fraction eluted with ether gave ethyl 2-cyano-2-(3-nitro-1-naphthyl)acetate (VIIIa: 723 mg, 51%), which was recrystallized from ether to yield colorless needles, mp 125—126.5°C. *Anal.* Calcd for $C_{15}H_{12}N_2O_4$: C, 63.38; H, 4.26; N, 9.86. Found: C, 63.40; H, 4.10; N, 9.52. IR ν_{max}^{KBr} cm^{-1}: 2245 (CN), 1744 (>C=O), 1531, 1338 (NO_2). PMR (in DMSO-d_6) δ: 1.17 (3H, t, J=7 Hz, $-O-CH_2C\underline{H}_3$), 4.27 (2H, q, J=7 Hz, $-O-C\underline{H}_2CH_3$), 6.64 (1H, s, $-CH<$), 7.72—8.07 (2H, m, $C_{6,7}$-H), 8.09—8.24 (1H, m, C_5-H), 8.36—8.51 (1H, m, C_8-H), 8.46 (1H, d, J=2 Hz, C_2-H), 9.13 (1H, d, J=2 Hz, C_4-H).

(ib) The residue was chromatographed on alumina. The first fraction eluted with petr. ether gave VII (45 mg). The second fraction eluted with $CHCl_3$ gave (3-nitro-1-naphthyl)acetonitrile (561 mg, 53%), which was recrystallized from EtOH to yield pale yellow prisms, mp 187—187.5°C. *Anal.* Calcd for $C_{12}H_8N_2O_2$: C, 67.92; H, 3.80; N, 13.20. Found: C, 67.97; H, 3.58; N, 12.98. MS *m/e*: 212 (M^+). IR ν_{max}^{KBr} cm^{-1}: 2230 (CN), 1520, 1335 (NO_2). PMR (in DMSO-d_6) δ: 4.67 (2H, s, $-C\underline{H}_2-CN$), 7.76—8.15 (2H, m, $C_{6,7}$-H), 8.22 (1H, m, C_5-H), 8.35—8.44 (1H, m, C_8-H), 8.38 (1H, d, J=2 Hz, C_2-H), 9.05 (1H, d, J=2 Hz, C_4-H).

(ii) For methyl cyanoacetate: The crude deposited crystals were collected and dried (1.035 g). Recrystallization from MeOH gave methyl 2-cyano-2-(3-nitro-1-naphthyl)acetate (VIIIb: 734 mg, 54%), pale yellow columns, mp 173—174°C. *Anal.* Calcd for $C_{14}H_{10}N_2O_4$: C, 62.22; H, 3.73; N, 10.37, Found: C, 62.14; H, 3.55; N, 10.19. MS *m/e*: 270 (M^+). IR ν_{max}^{KBr} cm^{-1}: 2240 (CN), 1738 (>C=O), 1531, 1342 (NO_2). PMR (in DMSO-d_6) δ: 3.78 (3H, s, $-COOC\underline{H}_3$), 6.67 (1H, s, $-CH<$), 7.80—8.08 (2H, m, $C_{6,7}$-H), 8.20 (1H, m, C_5-H), 8.45—8.53 (1H, m, C_8-H), 8.50 (1H, d, J=2 Hz, C_2-H), 9.17 (1H, d, J=2 Hz, C_4-H).

Preparation of 2-Nitronaphthalene-1-carbonitrile (IX)——A mixture of 1-chloro-2-nitronaphthalene[7] (2 g) and copper(I) cyanide (2.9 g) in DMF (5 ml) was refluxed for 3 h. After removal of the solvent under reduced pressure, the residue was poured into 5 N aq. NH_4OH (400 ml). The resulting suspension was stirred for 2.5 h and the brown solid was collected, washed with water and dried. The solid was chromatographed on silica gel. Elution with $CHCl_3$ gave 2-nitronaphthalene-1-carbonitrile (IX), which was recrystallized from MeOH to give yellow needles, mp 139.5—140.5°C (lit.,[5] mp 138°C). Yield was 1.058 g (55%).

Reaction of 2-Nitronaphthalene-1-carbonitrile (IX) with Ethyl Cyanoacetate or Diethyl Malonate——2-Nitronaphthalene-1-carbonitrile (IX) (396 mg, 2 mmol) was added to a stirred solution of ethyl cyanoacetate or diethyl malonate (4 mmol) and KOH (4 mmol) in DMF (8 ml). The stirring was continued for the specified time (Table V) at room temperature. The mixture was poured into ice water, neutralized with 10% HCl, and extracted with $CHCl_3$. The $CHCl_3$ extract was dried over Na_2SO_4 and evaporated to dryness. The residue was purified by column chromatography on silica gel with $CHCl_3$ as the eluent, and Xa or c was obtained. Yields were 82 and 95%, respectively. Ethyl 2-cyano-2-(1-cyano-2-naphthyl)acetate (Xa) was recrystallized from ether–petr. ether to give pale yellow prisms, mp 77°C. *Anal.* Calcd for $C_{16}H_{12}N_2O_2$: C, 72.71; H, 4.58; N, 10.60. Found: C, 73.04; H, 4.49; N, 10.58. MS *m/e*: 264 (M^+). IR ν_{max}^{KBr} cm^{-1}: 2225, 2195 (CN), 1740 (>C=O). PMR (in DMSO-d_6) δ: 1.22 (3H, t, J=7 Hz, $-OCH_2C\underline{H}_3$), 4.30 (2H, q, J=7 Hz, $-OC\underline{H}_2CH_3$), 6.22 (1H, s, $-CH<$), 7.79 (1H, d, J=8.5 Hz, C_3-H), 7.67—7.98 (2H, m, $C_{6,7}$-H), 8.11—8.24 (2H, m, $C_{5,8}$-H), 8.44 (1H, d, J=8.5 Hz, C_4-H). Diethyl 2-(1-cyano-2-naphthyl)malonate (Xc) was recrystallized from ether–petr. ether to give yellow needles, mp 58—60°C. *Anal.* Calcd for $C_{18}H_{17}NO_4$: C, 69.44; H, 5.50; N, 4.50. Found: C, 69.60; H, 5.50; N, 4.62. MS *m/e*: 311 (M^+). IR ν_{max}^{KBr} cm^{-1}: 2210 (CN), 1755, 1732 (>C=O). PMR (in $CDCl_3$) δ: 1.27 (6H, t, J=7.5 Hz, $-OCH_2C\underline{H}_3\times 2$), 4.28 (4H, q, J=7.5 Hz, $-OC\underline{H}_2CH_3\times 2$), 5.39 (1H, s, $-CH<$), 7.53—7.74 (2H, m, $C_{6,7}$-H), 7.77 (1H, d, J=8.5 Hz, C_3-H), 7.82—7.95 (1H, m, C_5-H), 8.06 (1H, d, J=8.5 Hz, C_4-H), 8.15—8.27 (1H, m, C_8-H).

Reaction of IX with α-Cyanoacetamide——Compound IX (396 mg) was added to a stirred solution of α-cyanoacetamide (336 mg) and KOH (224 mg) in DMF (8 ml). The stirring was continued for 5 h at room temperature. The mixture was poured into ice water, and neutralized with 10% HCl. The precipitate was collected, washed with water, dried and recrystallized from MeOH to give 2-cyano-2-(1-cyano-2-naphthyl)acetamide (Xb) as colorless needles, 295 mg (63%), mp 205—206°C. *Anal.* Calcd for $C_{14}H_9N_3O$: C, 71.48; H, 3.86; N, 17.86. Found: C, 71.61; H, 3.66; N, 17.90. MS *m/e*: 235 (M^+). IR ν_{max}^{KBr} cm^{-1}: 3405, 3300, 3265 ($-NH_2$), 2235, 2200 (CN), 1680 (>C=O). PMR (in DMSO-d_6) δ: 5.66 (1H, s, $-CH<$), 7.78 (1H, d, J=8.5 Hz, C_3-H), 7.73—7.95 (2H, m, $C_{6,7}$-H), 8.01 (2H, br s, $-CON\underline{H}_2$), 8.09—8.20 (2H, m, $C_{5,8}$-H), 8.41 (1H, d, J=8.5 Hz, C_4-H).

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References and Notes

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