DABCO-Mediated Synthesis and Biological Activity of Cyanohydrin Esters

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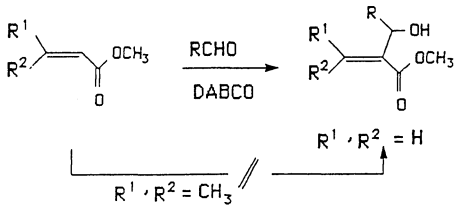
Cyanohydrin esters **1—31** have been prepared from α-ketonitriles and aldehydes using DABCO (1,4-diazabicyclo[2.2.2] octane) as nucleophilic acylation catalyst. The modified piperonal **8** was found to inhibit the formation of thromboxane synthetase.

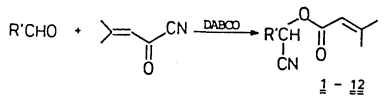
Recently we have reported the carbon-carbon bond formation between acrylic ester and aldehydes using DABCO as a catalyst. The utilization of this novel reaction in synthesis of natural products has also been reported.[1] It is well known that the introduction of one or two alkyl groups at the terminal double bond of acrylic ester reduces its quality as a Michael acceptor.



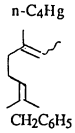
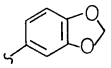
However, α,β-unsaturated ketonitriles are more reactive Michael acceptors than acrylic ester derivatives, also in the Diels-Alder cycloaddition reaction with inverse electron demand.[2,3] In the recent study we tested the effect of the better electron withdrawing group -COCN on the course of DABCO-catalyzed coupling reactions with aldehydes.

We have found that DABCO is also a useful nucleophilic catalyst for acylations with acyl cyanides, i.e.,

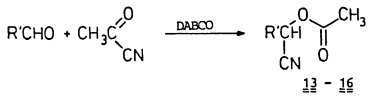
Survey of α-cyanohydrin esters 1 – 31



1 - 12

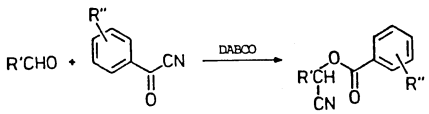
	R'	% Yield		R'	% Yield
1	n-C_3H_7	46	7	C_6H_4-OC_6H_5-(3)	67
2	n-C_4Hg	33			
3		43[a]	8		58[b]
			9	3-pyridyl	62
4	$CH_2C_6H_5$	42	10	2-pyridyl	35
5	C_6H_5	51	11	3-thienyl	40
6	C_6H_4Cl-(4)	59	12	2-thienyl	35

a) R'CHO - Citral b) R' CHO = Piperonal

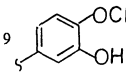


13 - 16

	R'	% Yield
13	CH_3	58
14	C_6H_5	79
15	C_6H_4CN(4)	54
16	3-Pyridyl	40



17 - 31

	R'	R"	% Yield		R'	R"	% Yield
17	CH_3	H	80	25	C_6H_5	H	71
18	CH_3	4-CN	71	26	C_6H_5	4-OCH_3	42
19	n-C_3H_7	H	47	27	C_6H_4Cl-(4)	H	62
20	iso-C_3H_7	H	78	28	C_6H_4CN-(4)	H	66
21	n-C_4Hg	H	75	29		H	17
22		H	30	30	3-pyridyl	H	56
23		H	Ca.40a)	31	2-thienyl	H	25
24		H	8				

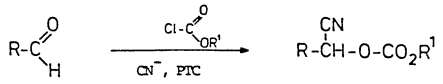
a) R' CHO = citral. A mixture of E- and Z-isomers (65:35) was analyzed by GC.

for C-O bond formation. Thus cyanohydrin esters can simply be prepared by mixing an aldehyde and α-ketonitrile including α,β-unsaturated derivatives, more simple aliphatic and aromatic acyl cyanides, with (method B) or without solvent (method A), in the presence of a catalytic amount of DABCO.

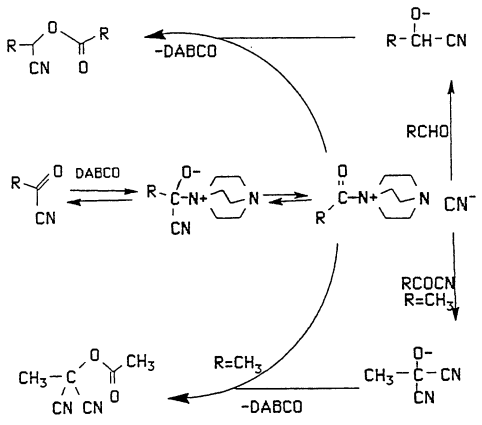
Discussion

Generally cyanohydrin esters are of synthetic interest

as efficient latent acyl anions in the preparation of ketones and in 1,4-addition reactions,[4,5] i.e. as Michael donors. Hitherto they have been synthesized by several routes.[6,7] Recently, Chenevert et al.[8] have prepared cyanohydrin esters using solid-liquid phase transfer (PTC) conditions and an excess of cyanide ion. Due to the presence of 18-crown-6 the nucleophilicity and solubility of cyanide ion in dichloromethane is dramatically increased. Similarly Au[4] has used chloroformic esters as electrophiles under PTC conditions obtaining α-cyanocarbonates.



It is well known that α-keto nitriles are sensitive towards hydrolysis giving the corresponding acids and liberating hydrogen cyanide. Hence, the two phase method with aqueous phase is less attractive than the solid-liquid method,[8] which uses 18-crown-6 and three equivalents of potassium cyanide. The DABCO promoted acylation works well for converting aldehydes into cyanohydrin esters under homogeneous and mild conditions, with and without solvent. It is also attractive from the standpoint of safty and convenience. Our method is not efficient for the coupling ordinary ketones with keto nitriles, perhaps because of the capability of an α-keto nitrile to couple with itself[11] and also because of the relative low concentration of the free cyanide ion under our conditions, as we have found, acetyl cyanide tends to dimerize to **32** in ca. 50% yield in the presence of DABCO.



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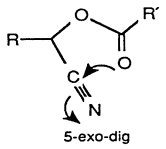
Spectroscopic Identification

Of the 31 cyanohydrin esters (**1**—**31**) which we have prepared, all compounds, with the exception of the *p*-cyanophenyl derivatives **15**, **18**, and **28** show no nitrile band in the IR spectrum. Apparently, introduction of the acetoxy group quenches the C≡N absorption intensity by nucleophilic interaction (5-exo-dig) with the nitrile carbon, which agrees with literature data.[9,10] Compounds **1**—**12** and **17**—**31** also show a carbonyl band between 1725 and 1730 cm^{-1}, while cyanohydrin acetates **13**—**16** show a carbonyl band at 1760 cm^{-1}. In the ^{13}C NMR spectra, they show a characteristic peak between δ 57.1 and 66.8 as a doublet. In the ^{1}H NMR spectra, the aldehydic proton signal disappeared and is shifted to high field and appears between δ 5.3 and 6.7.



Biological Activity

Cyanohydrin esters occur naturally in the defensive secretions of millipedes and have practical interest as insecticides.[5] A selected number of them have been tested for their biological activity. The cyanohydrin ester **9** of nicotinic aldehyde showed slight CNS sedation (at 10 mg/kg ip); however, a marked toxicity was observed at doses of 25 mg/kg ip and above. The cyanohydrin ester **8** of piperonal was less toxic (50 mg/kg ip and above) and was found to enter into the metabolism of arachidonic acid and to inhibit the formation of thromboxane synthetase.

Experimental

α-Keto nitriles were prepared according to literature methods.[12,13] Infrared spectra were recorded on Perkin-Elmer 457 and 580 infrared spectrometers. NMR spectra ($CDCl_3$) were determined on a Bruker WH 90 spectrometer (Me_4Si internal standard), mass spectra were obtained with a Varian CH 5 (70 eV) mass spectrometer. Microanalyses are due to Mrs. Bartetzko of the Institut für Organische Chemie.

General Procedure. A. Without Solvent: 10 mmol of α-keto nitrile was stirred together with 10 mmol of aldehyde under a nitrogen atmosphere, then 1 mmol of 1,4-diazabicyclo[2.2.2]octane (DABCO) was added (exothermic reaction). After several hours, the product was extracted with ether or pentane and washed twice with water and dried (Na_2SO_4). The organic solvent was evaporated and the residue was distilled bulb-to-bulb.

B. With Solvent: 10 mmol of α-keto nitrile and 10 mmol of aldehyde were dissolved together in 10 ml of dichloromethane and stirred under argon. 1 mmol of DABCO in 5 ml of dichloromethane was added dropwise during 10 min. The progress of the reaction was monitored by GC. After several hours, DABCO was washed out with water, the organic layer was dried (Na_2SO_4) filtered, evaporated and the product was distilled bulb-to-bulb.

1-Cyanobutyl-3-methyl-2-butenoate (1): Yield 46% IR ($CHCl_3$) 1732, 1650 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=0.93 (t, *J*=7 Hz; 3H), 1.33—1.88 (m, 4H), 1.95 (d, *J*=1 Hz, 3H, Me), 2.2 (d, *J*=1 Hz, 3H, Me), 5.35 (t, *J*=7 Hz, 1H), 5.7 (pent, *J*=1 Hz, 1H). ^{13}C NMR: δ=13.3 (q), 18 (t), 20.5 (q), 27.6 (q), 34.5 (t), 60.1 (d), 114.2 (d), 117.4 (s), 160.8 (s), 164.3 (s).

1-Cyanopentyl 3-Methyl-2-butenoate (2): Yield 33% IR ($CHCl_3$) 1729, 1649 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=0.93—1.78

(br. m, 9H), 1.94 (d, J=1.5Hz, 3H, Me), 2.19 (d, J=1.5Hz, 3H, Me), 5.27 (t, J=1.5 Hz, 1H). ^{13}C NMR: 13.8 (q), 22.1 (t), 26.8 (t), 32.2(t), 42.7(t), 60.3 (d), 114.1 (d), 115.5 (s), 117.4 (s), 164.4 (s), MS (rt) m/z=195 (M^+, 7%), 180 (2), 166 (2), 150 (9), 101 (12), 106 (46), 99 (15), 96 (16), 85 (19), 83 (100), 82 (59), 55 (55).

1-Cyano-3,7-dimethyl-2,6-octadienyl 3-Methyl-2-butenoate (3): Yield 43%, IR ($CHCl_3$) 1730, 1650 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=1.6 (s, 3H, Me), 1.68 (s, 3H, Me), 1.78 (d, J=1 Hz, 3H, Me), 1.93 (d, J=1 Hz, 3H, Me), 2.05—2.16 (m, 4H), 2.18 (d, J=1 Hz, 3H), 4.88—5.22 (br. m, 1H), 5.36 (m, J=9 Hz, 1H), 5.67 (m, J=1 Hz, 1H). The product is a mixture of E-Z-isomers (65/35) analyzed by GC.

α-Cyanophenethyl 3-Methyl-2-butenoate (4): Yield 42%, IR ($CHCl_3$) 1730, 1650 cm^{-1}, ^{1}H NMR ($CDCl_3$): 1.92 (d, J=1 Hz, 3H, Me), 2.16 (d, J=Hz, 3H, Me), 3.17 (d, J=7 Hz, 2H, CH_2), 5.49 (t, J=7 Hz, 1H), 5.66 (pent., J=1 Hz, 1H), 7.3 (s, 5H, aromatic H's). ^{13}C NMR: δ=20.5 (q), 27.5 (q), 38.6 (t), 61.2 (d), 113.9 (d), 119.9 (s), 127.7 (d), 128.7 (d), 129.6 (d), 133.8 (s), 161.1 (s), 164.0 (s).

α-Cyanobenzyl 3-Methyl-2-butenoate (5): Yield 51%, IR ($CHCl_3$) 1730, 1645 cm^{-1}, ^{1}H NMR ($CDCl_3$): 1.9 (d, J=1.5 Hz, 3H, Me), 2.18 (d, J=1.5 Hz, 3H, Me), 5.71 (pent. J=1.5 Hz, 1H), 6.43 (s, 1H), 7.2—7.66 (m, 5H, aromatic H's). MS (rt) m/z=215 (M^+, 29%), 117 (14), 116 (50), 115 (10), 105 (11), 89 (12), 83 (100).

α-Cyano-4-chlorobenzyl 3-Methyl-2-butenoate (6): Yield 59%, IR ($CHCl_3$) 1734, 1648 cm^{-1}, ^{1}H NMR ($CDCl_3$): 1.94 (d, J=1.8 Hz, 3H, Me), 2.0 (d, J=1.8 Hz, 3H, Me), 5.7 (t, J=1.8 Hz, 1H), 6.42 (s, 1H), 7.44 (s, 4H). ^{13}C NMR: δ=20.6 (q), 27.6 (q), 61.4 (d), 113.7 (d), 115.6 (s) 116.3 (s), 129.2 (d),129.4 (d), 131.0 (s), 136.2 (s), 163.8 (s). MS (rt) m/z=M^+/M^++2 (5%/2%), 221/223 (4/2), 150/152 (34/11), 122/124 (12/4), 114 (8), 99 (8), 83 (100), 55 (18).

α-Cyano-3-phenoxybenzyl 3-Methyl-2-butenoate (7): Yield 67%, IR ($CHCl_3$) 1733, 1648 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=1.92 (d, J=1.7 Hz, 3H, Me), 2.19 (d, J=1.7 Hz, 3H, Me), 5.7 (t, J=1.7 Hz, 1H), 6.5 (s, 1H), 6.95—7.46 (m, 9H). ^{13}C NMR: 20.5 (q), 27.5 (q), 61.6 (d), 113.7 (s), 115.6 (s), 116.3 (d), 117.7 (s), 119.2 (d), 122.0 (d), 123.9 (d), 129.6 (d), 129.9 (d), 130.2 (d), 130.3 (d), 130.6 (d), 134.1 (s), 156.3 (s), 158.02 (s), 163.8 (s). MS (50 °C) m/z=307 (M^+, 13%), 225 (7), 181 (14), 83 (100), 82 (17), 77(9), 55 (18).

α-Cyanopiperonyl 3-Methyl-2-butenoate (8): Yield 58%, IR ($CHCl_3$) 1730, 1640 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=1.93 (d, J=1.5 Hz, 3H, Me), 2.2 (d, J=1.5 Hz, 3H, Me), 5.7 (pent., J=1.5 Hz, 1H), 6.01 (s, 2H, OCH_2O), 6.34 (s, 1H), 6.72—7.11 (m, 3H). ^{13}C NMR: δ=20.6 (q), 27.5 (q), 61.9 (d), 101.8 (t), 108.1 (t), 108.6 (d), 113.9 (d), 116.7 (s), 122.2 (d), 126 (s), 148.4 (s), 149.2 (s), 161.4 (s), 164 (s).

Cyano-(3-pyridyl)methyl 3-Methyl-2-butenoate (9): Yield 62%, IR ($CHCl_3$) 1730, 1640 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=1.95 (d, J=1.5 Hz, 3H, Me), 2.22 (d, J=1.5 Hz, 3H, Me), 5.73 (pent., J=1.5 Hz, 1H), 6.51 (s, 1H), 7.3—7.5 (m, 1H), 7.82—8.0 (dt, J=2 Hz, 1H), 8.64—8.72 (dd, J=2 Hz, 1H), 8.77 (d, J=2.5 Hz, 1H). ^{13}C NMR: 20.6 (q), 27.6 (q), 60.2 (d), 113.6 (d), 116 (s), 123.9 (d), 128.6 (s), 135.4 (d), 148.9 (d), 151.3 (d), 162.3 (s), 163.7 (s).

Cyano-(2-pyridyl)methyl 3-Methyl-2-butenoate (10): Yield 35%, IR ($CHCl_3$) 1730, 1650 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=1.95 (d, J=1.5 Hz, 3H, Me), 2.22 (d, J=1.5 Hz, 3H, Me), 5.79 (pent., J=1 Hz, 1H), 7.22—8.0 (m, 4H), 8.66 (dq, J=1 Hz, 1H). ^{13}C NMR: δ=20.6 (q), 27.6 (q), 60.2 (d), 113.6 (d), 116 (s), 121.7 (d), 124.6 (d), 137.7 (d), 149.9 (d), 151.5 (s), 162.1 (s), 163.7 (s), Calcd for $C_{12}H_{12}N_2O_2$: C, 66.65; H, 5.59; N, 12.96; Found: C, 66.54; H, 5.60; N, 12.72.

α-Cyano-3-thienyl 3-Methyl-2-butenoate (11): Yield 40%, IR ($CHCl_3$) 1730, 1642 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=1.9 (d, J=1 Hz, 3H, Me), 2.18 (d, J=1 Hz, 3H, Me), 5.68 (m, 1H), 6.5 (s, 1H), 7.11—7.66 (m, 3H). ^{13}H NMR: δ=20.5 (q), 27.5 (q), 57.6 (d), 113.8 (d), 116.4 (s), 126 (d), 126.3 (d), 127.6 (d), 132.8 (s), 161.5 (s), 163.9 (s).

α-Cyano-3-thienyl 3-Methyl-2-butenoate (12): Yield 35%, IR ($CHCl_3$) 1725, 1640 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=1.93 (d, J=1 Hz, 3H, Me), 2.2 (d, J=1 Hz, 3H, Me), 5.7 (m, 1H), 6.66 (s, 1H), 7.01 (dd, J=4 Hz, 1H), 7.22—7.55 (m, 2H). ^{13}C NMR: δ=20.6 (q), 27.5 (q), 57.4 (d), 113.7 (d), 115.9 (s), 127.1 (d), 128.6 (d), 129.1 (d), 134.1 (s), 161.8 (s), 163.8 (s).

1-Cyanoethyl Acetate (13): Yield 58%, IR ($CHCl_3$) 1760, 1380 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=1.63 (d, J=6 Hz, 3H, Me), 2.14 (s, 3H), 5.38 (q, J=6 Hz, 1H). ^{13}C NMR: 18.7 (q), 20.4 (q), 57.3 (d), 117.7 (s), 169.1 (s).

α-Cyanobenzyl Acetate(14): Yield 79%, IR ($CHCl_3$) 1760, 1600 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=2.16 (s, 3H, Me), 6.39 (s, 1H), 7.69 (m, 5aromatic H's), ^{13}C NMR: δ=20.36 (q), 62.9 (q), 116.3 (dd), 127.9 (s), 129.3 (d), 129.4 (d), 131.9 (s), 168.9(s).

4,α-Dicyanobenzyl Acetate (15): Yield 54%, IR ($CHCl_3$) 2240, 1760, 1500 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=2.2 (s, 3H, Me), 6.47 (s, 1H), 7.6—7.84 (m, 4H), ^{13}C NMR: δ=20.3 (q), 62.1 (d), 114.2 (ss), 115.5 (s), 128.4 (d), 129.9 (s), 133 (d), 136.5 (s), 163.7 (s). MS (rt) m/z=200 (M^+, 8%), 158 (49), 141 (28), 140 (28), 131 (19), 130 (32), 114 (23), 102 (20), 75 (13), 43 (100).

Cyano-(3-pyridyl)methyl Acetate (16): Yield 40%, IR ($CHCl_3$) 1760, 1600 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=2.19 (s, 3H, Me), 6.48 (s, 1H), 7.32—7.5 (m, 1H), 7.83—7.98 (m, 1H), 8.68—8.78 (m, 2H), ^{13}C NMR: δ=20.3 (q), 61 (d), 115.7 (s), 123.9 (d), 128.2 (s), 135.5 (d), 149 (d), 151.5 (d), 168.8 (s).

1-Cyanoethyl Benzoate (17): Yield 80%, IR ($CHCl_3$) 1735, 1605 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=1.76 (d, J=7 Hz, 3H), 5.63 (q, J=7 Hz, 1H), 7.34—7.62 (m, 3H), 7.99—8.1 (m, 2H), ^{13}C NMR: δ=18.8 (q), 57.9 (d), 117.7 (s), 128.3 (s), 128.6 (d), 129.9 (d), 133.9 (d), 164.7 (s).

1-Cyanoethyl *p*-Cyanobenzoate (18): Yield 71%, mp 95—96 °C, IR ($CHCl_3$) 2240, 1734, 1612 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=1.77 (d, J=7 Hz, 3H, Me), 5.54 (q, J=7 Hz, 1H), 7.74—8.22 (m, 4H), ^{13}C NMR: δ=18.2 (q), 59.1 (d), 116.4 (s), 118 (s), 130.1 (d), 132 (s), 132.8 (d), 163.3 (s). MS (50 °C) m/z=200 (M^+, 12%), 146 (27), 130 (100), 102 (44), 76 (10), 75 (19).

1-Cyanobutyl Benzoate (19): Yield 47%, IR ($CHCl_3$) 1730, 1605 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=1.03 (t, J=7 Hz, 3H, Me), 1.26—2.17 (m, 4H), 5.59 (t, J=7 Hz, 1H), 7.27—7.64 (m, 3H), 8.0—8.17 (m, 2H), ^{13}C NMR: δ=13.4 (q), 18.1 (t), 34.4 (t), 61.55 (d), 117 (s), 128.4 (s), 128.7 (d), 129.9 (d) 133.9 (d), 164.8 (s).

1-Cyano-2-methylpropyl Benzoate (20): Yield 78%, IR ($CHCl_3$) 1730, 1600 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=1.18—1.23 (2d, J=7 Hz, 6H), 2.06—2.56 (m, 1H), 5.43 (d, J=6 Hz, 1H), 7.22—7.77 (m, 3H), 7.94—8.17 (m, 2H), ^{13}C NMR: δ=13.8 (q), 22.1 (t), 32.2 (t), 61.8 (d), 117.1 (s), 128.5 (s), 128.7 (d), 129.9 (d), 134 (d), 164.8 (s).

1-Cyanopentyl Benzoate (21): Yield 75%, IR ($CHCl_3$) 1735, 1605 cm^{-1}, ^{1}H NMR ($CDCl_3$): δ=0.96 (t, J=7 Hz, 3H), 1.23—1.66 (m, 4H), 1.93—2.18 (m, 2H), 5.58 (t, J=7 Hz, 1H), 7.26—7.71 (m, 3H), 7.8—8.11 (m, 2H), ^{13}C NMR: δ=13.8 (q), 22.1 (t), 26.7 (t), 32.2 (t), 61.8 (d), 117.1 (s), 128.5 (s), 128.7 (d), 129.9 (d), 134 (d), 164.8 (s).

1-Cyano-3-methyl-2-butenyl Benzoate (22): Yield 30%, IR ($CHCl_3$) 1730, 1670, 1600 cm^{-1}, ^1H NMR ($CDCl_3$): δ=1.8 (s, 6H, 2Me), 5.43—5.53 (m, 1H), 6.26 (d, J=5 Hz, 1H), 7.22—7.6 (m, 3H), 7.99—8.1 (m, 2H), ^{13}C NMR 18.6 (q), 25.6 (q), 58.6 (s), 115.8 (s), 116.7 (d), 128.6 (d), 129.9 (d), 133.9 (d), 144.4 (d), 164.6 (s).

1-Cyano-3,7-dimethyl-2,6-octadienyl Benzoate (23): Yield 40%, IR ($CHCl_3$) 1730, 1605 cm^{-1}, ^1H NMR ($CDCl_3$): δ=1.63 (s, 3H), 1.66 (s, 3H), 1.86 (d, J=1 Hz, 3H), 2.0—2.33 (m, 4H), 4.88—5.22 (m, 1H), 5.38—5.55 (br. d, J=9 Hz, 1H), 6.26 (d, J=9 Hz, 1H), 7.26—7.69 (m, 3H), 7.98—8.1 (dt, J=2 Hz, 2H), The product is a mixture o *E*-*Z*-isomers (65/35) analyzed by GC.

Cyano-(6,6-dimethylbicyclo[3.1.1]hept-2-yl)methyl Benzoate (24): Yield 8%, IR ($CHCl_3$) 1733, 1606 cm^{-1}, ^1H NMR ($CDCl_3$): δ=0.78—2.85 (m, 15H), 5.51 (d, J=11 Hz, 1H), 7.35—8.13 (m, 5H), ^{13}C NMR: δ=17.7 (q), 19.81 (q), 22.6 (t), 25.5 (t), 27.6 (d), 32.8 (d), 38.5 (s), 40.7 (t), 41.1 (t), 43 (d), 64.5 (d), 123.4 (s), 128.6 (d), 130 (d), 133.9 (d), 164.9 (s). MS (50 °C) m/z=283 (M^+, 3%), 227 (1), 177 (2), 160 (12), 146 (7), 134 (6), 123 (18), 105 (100), 77 (40).

α-Cyanobenzyl Benzoate (25): Yield 71%, IR ($CHCl_3$) 1735, 1600 cm^{-1}, ^1H NMR ($CDCl_3$): δ=6.67 (s, 1H), 7.23—7.69 (m, 8H), 7.99—8.11 (m, 2H), ^{13}C NMR: δ=63.4 (d), 116.3 (s), 127.3 (d), 127.8 (d), 128.6 (d), 129.3 (d), 130 (d),134 (s), 164.5 (s).

α-Cyanobenzyl *p*-Methoxybenzoate (26): Yield 42%, IR ($CHCl_3$) 1730, 1610 cm^{-1}, ^1H NMR ($CDCl_3$): δ=3.85 (s, 3H, Me), 6.66 (s, 1H), 6.86—6.98 (m, 2H), 7.41—7.68 (m, 5H), 8.0—8.1 (m, 2H), ^{13}C NMR: 55.5 (q), 63.1 (d), 113.9 (d), 116.4 (s), 120.4 (s), 129.3 (d), 130.3 (d), 131.6 (d), 132.3 (d), 164.3 (s).

4-Chloro-α-cyanobenzyl Benzoate (27): Yield 62%, IR ($CHCl_3$) 1735, 1600 cm^{-1}, ^1H NMR ($CDCl_3$): δ=6.64 (s, 1H), 7.24—7.62 (m, 7H), 7.99—8.1 (m, 2H), ^{13}C NMR: δ=62.7 (d), 115 (s), 127.9 (d), 128.7 (d), 129.3 (d), 129.5 (d), 130 (d), 130.5 (d), 134.2 (d), 136.6 (s), 164.5(s).

4,α-Dicyanobenzyl Benzoate (28): Yield 66%, IR ($CHCl_3$) 2240, 1741, 1605 cm^{-1}, ^1H NMR ($CDCl_3$): δ=6.72 (s, 1H), 7.37—8.11 (m, 9H), ^{13}C NMR: δ=62.6 (d), 114.3 (s), 115.6 (s), 127.6 (s), 128.4 (d), 128.8 (d), 130 (d), 132.7 (s), 133 (d), 134.4 (d), 136.6 (s), 164.4 (s). MS (50 °C) m/z=M^+ 262 (10%), 141 (14), 119 (10) 105 (100), 77 (40), 74 (18), 59 (30).

3-Hydroxy-4-methoxy-α-cyanobenzyl Benzoate (29): Yield 17%, :IR ($CHCl_3$) 1737, 1610 cm^{-1}, ^1H NMR ($CDCl_3$): δ=3.89 (s, 3H, OCH_3), 5.27 (s, 1H), 6.56 (s, 1H), 6.28—8.26 (m, 8H), ^{13}C NMR: 56.1 (q), 63.2 (d), 114.2 (d), 116.4 (s), 123.7 (d), 124.9 (s), 128.7 (d), 130.2 (d), 130.3 (d), 133.8 (d), 134 (d), 146.3 (s), 164.7 (s). MS (rt), m/z 283 (M^+, 3%), 256 (6), 162 (3), 161 (3), 151 (3), 105 (100), 86 (45), 84 (68), 77 (38).

Cyano-(3-pyridyl)methyl Benzoate (30): Yield 56%, IR ($CHCl_3$) 1730, 1595 cm^{-1}, ^1H NMR ($CDCl_3$): δ=6.73 (s, 1H), 7.26—7.73 (m, 4H), 7.9—8.1 (m, 3H), 8.7—8.86 (m, 2H), ^{13}C NMR: 6.14 (d), 115.5 (s), 124 (d), 127.7 (d), 129.3 (s), 130.1 (d), 134.3 (d), 135.5 (d), 149.1 (s), 151.6 (d), 164.4 (s), $C_{14}H_{10}N_2O_2$ Calcd for C, 70.58: H, 4.23; N, 11.76. Found: C, 70.30; H, 4.29; N, 11.56.

α-Cyano-2-thienyl Benzoate (31): Yied 25%, IR ($CHCl_3$) 1730, 1670 cm^{-1}, ^1H NMR ($CDCl_3$): δ=6.88 (s, 1H), 7.16 (dd, J=4 Hz, 1H), 7.33—7.72 (m, 5H), 8.0—8.22 (m, 2H). $C_{13}H_9NSO_2$: C, 64.20; H, 3.73; N, 5.76. Found: C, 64.26; H, 3.75; N, 5.56.

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