methyl-2,6-octadienyl phosphate, 60699-32-3; cyclohexanecarboxaldehyde, 2043-61-0; hexanal, 66-25-1; cyclohexanone, 108-94-1; lithium chloride, 7447-41-8.

Supplementary Material Available: A carbon NMR spectrum of each new compound (24 pages). This material is contained in many libraries on microfiche, immediately follows this article in the microfilm version of the journal, and can be ordered from the ACS; see any current masthead page for ordering information.

Preparation of Polyfunctional Nitro Olefins and Nitroalkanes Using the Copper-Zinc Reagents RCu(CN)ZnI

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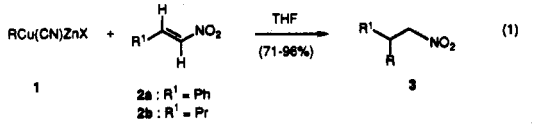
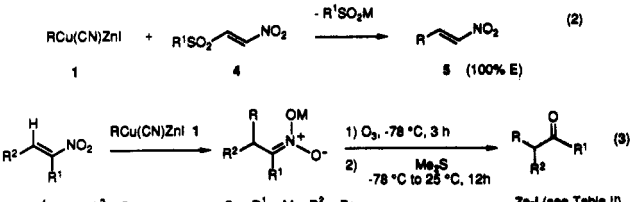
Received April 24, 1992

The addition of the copper-zinc reagents RCu(CN)ZnX to a variety of nitro olefins produces polyfunctional nitroalkanes in high yields. The intermediate zinc or copper nitronates can be directly submitted to a Nef reaction (O_3, -78 °C) and converted to polyfunctional ketones in a one-pot procedure. The addition of RCu(CN)ZnX to nitro olefins bearing a leaving group (RSO_2, RS) in the β-position provides pure (*E*)-nitro olefins in excellent yields. The reaction has been applied for the stereoselective preparation of 1,3-nitrodienes and for a Diels-Alder reaction precursor.

Nitro olefins are exceptional Michael acceptors, and this property dominates the chemistry of this class of compounds.[2] They provide a unique and very general way for constructing polyfunctional nitro derivatives since a wide range of nucleophiles add in good yields to nitro olefins.[3] Several types of organometallic reagents such as organolithium,[2-4] -magnesium,[5] -cadmium,[6] -zinc,[7] and -aluminum[8] reagents as well as allylic or allenic tin[9] and silicon[10] derivatives add to nitro olefins in fair to excellent yields. Copper reagents derived from organolithiums have also been used;[11] however, in this case the intermediate lithium nitronates are reactive enough to add to the remaining nitro olefin leading to a partial polymerization and to moderate yields of the Michael-adduct. In strong contrast, we have found that the copper compounds RCu(CN)ZnX **1** prepared from organozinc halides[12] add very cleanly to various nitro olefins **2** affording polyfunctional nitroalkanes **3** in excellent yields (eq 1).[13]



Obviously, the intermediate zinc nitronate is not reactive enough to induce a polymerization of the nitro olefin **2**. It is also possible to add these reagents to nitro olefins **4** bearing a leaving group in the β-position[14,15] providing a unique synthesis of pure (*E*)-nitro olefins of type **5** (eq 2).



Here we report the scope and limitations of these methods as well as a new one-pot reaction allowing us convert di-

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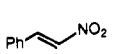
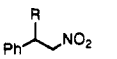
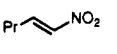
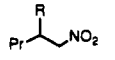
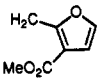
Table I. Nitroalkanes 3a–3l Prepared by the Addition of RCu(CN)ZnX 1 to Nitro Olefins 2

entry	RCu(CN)ZnI 1	nitro olefin 2	product	R	yield[a] (%)
					
1	1a	2a	3a	$(CH_2)_3CO_2Et$	90
2	1b	2a	3b	$(CH_2)_3C{\equiv}CPent$	77
3	1c	2a	3c	$(CH_2)_3CN$	84
4	1d	2a	3d	c-Hex	71
5	1e	2a	3e	$(CH_2)_3CH(OPiv)CH_3$	90
					
6	1a	2b	3f	$(CH_2)_3CO_2Et$	94
7	1f	2b	3g	$(CH_2)_6OAc$	76
8	1g	2b	3h	CH_2Ph	96
9	1h	2b	3i	$(CH_2)_4Cl$	90
10	1i	2b	3j	$(CH_2)_3CN$	94
11	1j	2b	3k		81
12	1l	2b	3l		75

[a] Yields of isolated products (>98% pure by GC analysis) showing satisfactory spectral data (IR, ^1H and ^{13}C NMR, mass spectra, and high-resolution mass spectra).

rectly the intermediate nitronate 6 to ketones of type 7 (Nef reaction)[16] in excellent overall yields (eq 3)

Results and Discussion

Primary and secondary aliphatic iodides (RI) react in THF (25–50 °C, 0.5–3 h) with zinc dust previously activated with 3 mol % of 1,2-dibromoethane and 1% of Me_3SiCl to provide the corresponding alkylzinc iodides RZnI in over 85% yield.[12] Similarly, benzylic bromides (or chlorides) are converted to benzylic zinc halides without a significant amount of Wurtz coupling if the reaction is performed at 0 °C.[17] Remarkably, this preparation is compatible with the presence of most organic functionalities in the organic halide, and only alcohol, nitro, or azide functionalities prevent the organometallic formation.[18] As a consequence of this high functional group tolerance, organozinc halides do not react efficiently with most organic electrophiles; however, the addition of a THF soluble copper salt CuCN·2LiCl affords the organocopper reagent RCu(CN)ZnX 1 which displays an excellent reactivity toward various electrophiles (eq 4). Also, compared to copper compounds derived from organolithiums, the copper compounds 1 do not participate readily in one-electron-transfer reactions.[19]

$$RI \xrightarrow[\substack{THF\\25\text{–}50\ ^\circ C,\ 0.5\text{–}3\ h}]{\text{Zn dust}} RZnI \xrightarrow[0\ ^\circ C,\ 5\ min]{CuCN\cdot 2LiCl} \underset{1}{RCu(CN)ZnI} \qquad (4)$$

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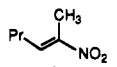
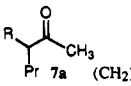
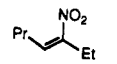
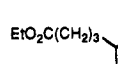
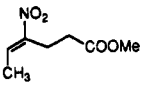
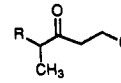
Table II. Ketones 7a–i Obtained in a One-Pot Procedure from the Nitro Olefins 2c–e by the Addition of RCu(CN)ZnI and Subsequent Nef Reactions

entry	RCu(CN)ZnI 1	nitro olefin 2	nef reaction condns[a]	product 7	R	yield[b] (%)
						
1	1a	2c	A	7a	$(CH_2)_3CO_2Et$	82
2	1c	2c	B	7b	$(CH_2)_3CN$	76
3	1f	2c	A	7c	$(CH_2)_6OAc$	71
						
4	1a	2d	C	7d		85
						
5	1a	2e	C	7e	$(CH_2)_3CO_2Et$	87
6	1c	2e	C	7f	$(CH_2)_3CN$	74
7	1d	2e	C	7g	c-Hex	76
8	1f	2e	C	7h	$(CH_2)_6OAc$	75
9	1k	2e	C	7i	$(CH_2)_2P(O)(OEt)_2$	78

[a] Nef reaction conditions: A, aqueous saturated NH_4Cl, 25 °C; B, 10% HCl, 25 °C, overnight; C, O_3, −78 °C, 3 h; then Me_2S, −78 to 25 °C, 12 h at 25 °C. [b] Yields of isolated products are over 98% pure by GC analysis.

Thus, the addition of a nitro olefin to a THF solution of RCu(CN)ZnX 1 at −78 °C, followed by the slow warming of the reaction mixture to 0 °C, led to a smooth Michael addition and to a complete conversion after a few hours at 0 °C. A conjugated nitro olefin such as nitrostyrene (**2a**) was found to be less reactive than an aliphatic unsaturated nitro compound like 1-nitropentene (**2b**) (Table I). It was also noticed that the (*Z*)-isomer of **2b** reacts much faster with 1 than the (*E*)-isomer, probably because of the more severe 1,3-allylic interactions.[20] For example, if an *E*/*Z* mixture of **2b** (82:18)[21] was reacted at −40 °C with the copper reagent **1c**, a complete reaction of the *Z*-isomer was observed at this low temperature (entry 10 of Table I). A wide variety of functionalized zinc–copper derivatives 1 could be added to **2a–b** and the presence of functional groups such as an ester, nitrile, chloride, or triple bond did not interfere with the addition reaction. However, we found that zinc–copper organometallics bearing a heteroatom at the α-carbon such as sulfur ((R)(H)(SPh)CCu(CN)ZnX),[22] nitrogen ($(RCO)_2NCH_2Cu(CN)ZnX$)[23] or boron ($(RO)_2B(R^1)(H)CCu(CN)ZnX$)[24] were too unreactive to add to nitro olefins. Benzylic zinc–copper reagents like **1g**, **1j–l** reacted as expected and produced aromatic and heteroaromatic systems (**3h**, **3k–l**) in 96–75% yield (entries 8, 11, and 12 of Table I). All reactions were quenched at −30 °C with a weak acid like acetic acid in order to obtain the nitroalkane **3** as the sole product and avoid any ketone formation (Nef reaction).[16] This procedure was very successful as long as a *primary* nitroalkane was formed; however, in the case of the formation of secondary nitroalkanes, the production of substantial amounts of the corresponding ketone was observed. A workup procedure

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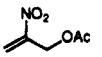
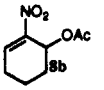
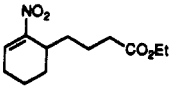
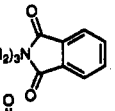
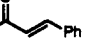
(24) Knochel, P. *J. Am. Chem. Soc.* **1990**, *112*, 7431.

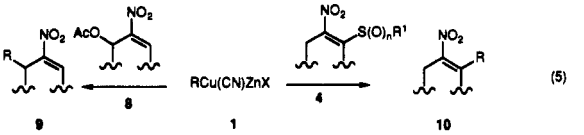
Table III. Polyfunctional Nitro Olefins 9 and 10 Obtained by the Reaction of RCu(CN)ZnX with Nitro Olefins of Type 8 or 4

entry	RCu(CN)ZnX	nitro olefin 4 or 8	product 9 or 10	R	yield[a] (%)
					
1	1a	8a	9a	$(CH_2)_3CO_2Et$	92
2	1d	8a	9b	c-Hex	94
3	1f	8a	9c	$(CH_2)_6OAc$	88
4	1a	 8b	9d 		72
5	1a	 4a	10a 	$(CH_2)_3CO_2Et$	79
6	1l	4a	10b 		87
7	1m	4a	10c 		82
8	1c	4a	10d	$(CH_2)_3CN$	85
9	1n	4a	10e	$CH(OAc)CH(CH_3)_2$	74
10	1o	4a	10f	$CH(OAc)(CH_2)_3OPiv$	74
11	1p	4a	10g	(Z)-Bu(H)C=C(H)	82(92)[b]
12	1q	4a	10h	(E)-Hex(H)C=C(H)	81
13	1r	 4b	10i	CH(OAc)Pent	80
					
14	1a	4c	10j	$(CH_2)_3CO_2Et$	89
15	1c	4c	10k	$(CH_2)_3CN$	85
16	1s	4c	10l	$(CH_2)_2P(O)(OEt)_2$	79
17	1q	4c	10m	(E)-(H)C=C(H)Hex	90

[a] Yield of isolated products is over 98% pure by GC analysis. [b] Yield after purification by flash chromatography ((1E,3Z):(1E,3E) = 14:86).

consisting of stirring the reaction mixture with 10% aqueous HCl (entry 2 of Table II) or saturated aqueous NH_4Cl (entries 1 and 3) provided the ketone 7 as the sole product (71–82%). Although very simple, this procedure lacked of generality and the direct ozonolysis[25] of the zinc and copper nitronate, followed by a reductive workup (Me_2S), proved to be very effective (entries 4–9 of Table II) and allowed a unique preparation of polyfunctional carbonyl compounds. The one-pot procedure which included the addition of the copper–zinc reagent (−78 to 0 °C, 2–3 h), the ozonolysis (O_3, CH_2Cl_2, −78 °C, 3 h), and the reductive workup (Me_2S excess, −78 to 25 °C, 12 h) proceeded in consistently high overally yields (74–87%).

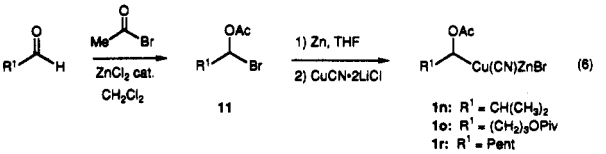
Addition–elimination reactions of the copper–zinc reagents 1 to nitro derivatives of type 8 or 4 afforded polyfunctional nitro olefins of type 9 and 10 (eq 5 and Table III). The nitro olefin 8a prepared in three steps from nitromethane[4c] displayed a very high reactivity toward the copper reagents 1, and the substitution reaction



(5)

was usually complete after a few minutes at −55 °C (entries 1–3 of Table III). The reaction was performed in the presence of Me_3SiCl in order to trap any base which could induce the polymerization of the sensitive unsubstituted nitro olefins **9a–c**. The substituted reagent 6-acetoxy-1-nitrocyclohexene (**8b**) was far less reactive[2b,5c] and required warming of the reaction mixture to 0 °C. No further addition of **1** to the nitro olefins **9a–d** occurred under these reactions conditions showing the higher reactivity of the multicoupling[28] reagents **8a** and **8b** compared to the nitro olefin products.[4c]

Nitro olefins **4** bearing an alkylthio[27] or a phenylsulfonyl group[28] in β-position to the nitro group have been known to undergo addition–elimination with various nucleophiles.[15,29] We found[14] that various polyfunctional copper–zinc reagents RCu(CN)ZnX **1** reacted with (*E*)-1-nitro-2-(phenylsulfonyl)ethylene (**4a**),[27a] (*E*)-1-nitro-2-(ethylsulfonyl)ethylene (**4b**), or 2-(ethylthio)-1-nitro-1-cyclohexene[27h] (**4c**) leading to stereochemically pure (*E*)-polyfunctional nitro olefins **10a–m** in excellent yields (72–94% yield). The addition–elimination reactions were very fast in the case of **4a** and **4b** (−60 °C to −50 °C, 5 min), but required higher reaction temperatures in the case of **4c** (−20 to 25 °C) affording substituted nitrocyclohexenes which were quite unreactive toward further nucleophilic attack (entries 14–17 of Table III).[26,30] The remarkable stereoselectivity observed in these coupling reactions permitted a unique preparation of pure functionalized (*E*)-nitro olefins bearing ester, cyano, and phthalimido groups. It also led to an expeditive preparation of 3-nitroallylic acetates[3] such as **10e,f,i** by the addition of an α-acetoxyalkylcopper–zinc reagent (**1n,o,r**; see entries 9, 10, and 13 of Table III and eq 6) to **4a** or **4b**. These



(6)

1n: $R^1 = CH(CH_3)_2$
1o: $R^1 = (CH_2)_3OPiv$
1r: R^1 = Pent

organometallics were readily prepared by the direct zinc insertion[32] to α-bromoalkyl acetates **11** which were con-

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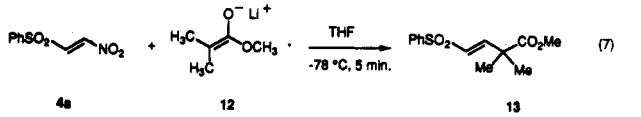
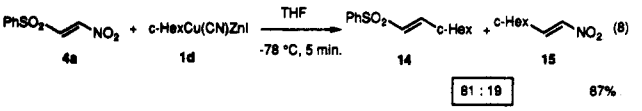
(31) (a) Rappoport, Z.; Topol, A. *J. Org. Chem.* **1989**, *54*, 5967. (b) Bernasconi, C. F.; Killion, R. B.; Fassberg, J.; Rappoport, Z. *J. Am. Chem. Soc.* **1989**, *111*, 6862. (c) Bernasconi, C. F.; Fassberg, J.; Killion, R. B.; Rappoport, Z. *J. Am. Chem. Soc.* **1990**, *112*, 3169.

(32) (a) Chou, T.-S.; Knochel, P. *J. Org. Chem.* **1990**, *55*, 4791. (b) Knochel, P.; Chou, T.-S.; Chen, H. G.; Yeh, M. C. P.; Rozema, M. J. *J. Org. Chem.* **1989**, *54*, 5202.

veniently obtained[33] by the reaction of the corresponding aldehyde with acetyl bromide (1.5 equiv) in CH_2Cl_2 in the presence of a catalytic amount of $ZnCl_2$ (25 °C, 2 h, 85–90%).

In the addition of **1n** to **4a** we observed the formation of 10% of (*E*)-3-acetoxy-4-methyl-1-(phenylsulfonyl)-1-pentene formed by a nucleophilic attack at the carbon α to the nitro group followed by an elimination of a nitrite anion. This behavior was observed for other bulky nucleophiles such as the lithium ester enolate **12** which gave the vinylic sulfone **13** as the sole product (THF, −78 °C, 5 min; 75% yield; eq 7). Similarly, the reaction of the copper reagent derived from cyclohexylzinc iodide with **4a** provided a mixture of the vinylic sulfone **14** and the nitro olefin **15** in the ratio 81:19 (87% yield; eq 8). The large

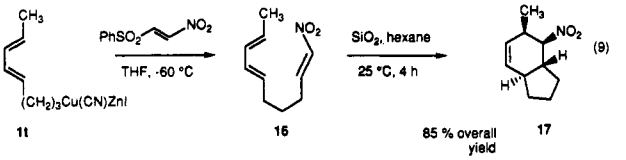




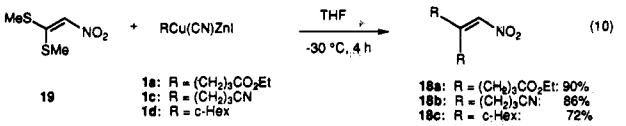
steric hindrance of the phenylsulfonyl group might be responsible for this abnormal regioselectivity, since the reaction of 3-(*ethylsulfonyl*)nitroethylene (**4b**) with the α-acetoxyalkylzinc–copper reagent **1r** provided exclusively the nitro olefin **10i** (80% yield; entry 13 of Table III).[34]

The nitro olefins **4a** and **4c** also allowed the preparation of nitro 1,3-dienes.[35] The stereochemically well-defined alkenylzinc–copper reagents **1p** and **1q** (entries 11 and 12 of Table III) were prepared from the corresponding 1-iodoalkenes. Thus, the addition of BuLi (1.05 equiv) to the iodoalkene (ether, −78 °C, 1 h)[36] produced the corresponding alkenyllthium which was treated successively with ZnI_2 (1 equiv in 1:1 Et_2S (or Me_2S)/THF, −78 to 25 °C) and CuCN·2LiCl (1 equiv, −78 °C). These reaction conditions were crucial since the absence of either ZnI_2 or the cosolvent R_2S led to a substantial reductive dimerization of the alkenylcopper derivatives. The reaction of the vinylic organometallic **1p** with **4a** provided (1*E*,3*Z*)-1-nitro-1,3-octadiene (**10g**) in 82% isolated yield as a 96:4 mixture of 1*E*,3*Z* and 1*E*,3*E* 3*E* isomers (entry 11 of Table III). Before distillation, the isomeric purity was 98:2 and purification[37] via flash chromatography led to extensive isomerization of the double bonds. The reaction of the (*E*)-alkenylcopper **1q** with **4a** gave the expected nitro diene **10h** in 97% stereoisomeric purity; however, after chromatography this nitro diene was also isolated as a (1*E*,3*Z*)/1*E*,3*E*) mixture of 12:88.

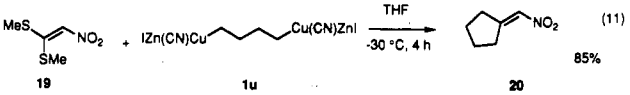
The cyclic (*E*)-nitro diene **10m** (entry 17 of Table III) was less sensitive to isomerization and was isolated after flash chromatography as only one isomer. Also, unconjugated dienes were configurationally stable, and the nitrotriene **16** obtained by the reaction of the zinc–copper reagent **1t** with **4a** (−60 °C, 5 min) was found to be an excellent precursor for an intramolecular Diels–Alder reaction.[38] The stirring of **16** over silica gel[39] in hexane for 4 h afforded the cycloadduct **17** as a single diastereoisomer via an anti transition state in 85% overall yield[40] (eq 9). The presence of a polar solvent (ether, THF) inhibited the silica gel catalysis. Interestingly, the thermal cycloaddition is nonstereospecific, in strong contrast to this silica gel reaction.[41]



Finally, a range of polyfunctional β-disubstituted nitro olefins **18** was prepared from the reaction of commercially available 2,2-bis(methylthio)-1-nitroethylene (**19**) with functionalized copper–zinc reagents **1** (3 equiv, THF, −78 to −30 °C, 4 h; eq 10). These nitro olefins are not readily



prepared by a nitro-aldol condensation since this reaction is reversible if ketones are used as substrates.[2] With the 1,4-bimetallic[42] of copper and zinc **1u**, it was possible to prepare the *exo*-(nitromethylidene)cyclopentane[43] (**20**) in 85% yield. No migration of the double bond was observed under our reaction conditions (eq 11).



In summary, we have shown that the very efficient reaction of the copper–zinc reagents RCu(CN)ZnI **1** with nitro olefins represents a powerful and unique method for the preparation of a variety of polyfunctional nitroalkanes and nitro olefins. The utility of nitro compounds as synthetic intermediates[2a] is demonstrated in the one-pot Nef reaction which allows a direct preparation of polyfunctional ketones.

Experimental Section

General. The products described were all purified by flash chromatography using a mixture of hexane and ether or ethyl acetate as eluant. The resulting oils had a purity higher than 98% by capillary GC analysis (DB5 column). The zinc dust was obtained from Aldrich Chemical Co., Inc. (−325 mesh). The following starting materials were prepared according to the literature: 1-nitropentene (**2b**),[21] 2-nitro-2-hexene (**2c**),[21] 3-nitro-3-heptene (**2d**),[21] methyl 4-nitro-4-hexenoate (**2e**),[21,44] 2′-nitro-2′-propen-1′-yl

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acetate (8a),[4c] 6-acetoxy-1-nitrocyclohexene (8b),[4d] (*E*)-1-nitro-2-(phenylsulfonyl)ethylene (4a),[27a] (*E*)-1-nitro-2-(ethylsulfonyl)ethylene (4b),[27a] 2-(ethylthio)-1-nitro-1-cyclohexene (4c),[27b] *N*-(3-iodopropyl)phthalimide,[45] diethyl 2-(bromoethyl)-phosphonate,[46] (*Z*)-1-iodohexene,[47] (*E*)-1-iodooctene,[48] 1-iodo-4,6-octadiene.[49] The functionalized organozinc compounds were prepared as described previously.[12-14,17,19c,32,42,45,46]

Methyl 4-Nitrohex-4-enoate (2e). Methyl 4-nitrobutanoate and methyl 5-hydroxy-4-nitrohexanoate were prepared according to literature procedures.[44] The dehydration of the nitro alcohol was done by using DCC:[21] IR (neat) 2999 (w), 2955 (m), 1736 (s), 1672 (m), 1520 (s) cm^{-1}; ^1H-NMR ($CDCl_3$, 360 MHz) δ 7.23 (q, 1 H, J = 7.4 Hz), 3.63 (s, 3 H), 2.88 (t, 2 H, J = 7.4 Hz), 2.53 (t, 2 H, J = 7.4 Hz), 1.91 (d, 3 H, J = 7.4 Hz); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 172.4, 150.4, 133.6, 51.7, 31.5, 21.5, 13.5; MS (EI, 70 eV) 174 (MH^+, 1), 85 (100), 67(75), 59 (76), 41 (78). Anal. Calcd for $C_7H_{11}NO_4$: C, 48.55; H, 6.40; N, 8.09. Found: C, 48.77; H, 6.10; N, 7.98.

Typical Procedure for the Addition of a Copper-Zinc Reagent RCu(CN)ZnI 1 to a Nitro Olefin. The Addition of the 4-Chlorobutylcopper Derivative 1h to 1-Nitropentene (2b) (Entry 9 of Table I). All reactions were performed using 10 mmol of the copper–zinc reagent and 7.5 mmol of the nitro olefin. 4-Chlorobutylzinc iodide was prepared from zinc dust (1.62 g, 25 mmol), 1-chloro-4-iodobutane (2.47 g, 12 mmol), and THF (5 mL; 25–45 °C, 2 h) as reported previously[12,45] and was converted to the corresponding zinc–copper derivative **1h** by the addition at 0 °C of a THF solution of CuCN·2LiCl prepared from CuCN (900 mg, 10 mmol) and LiCl (840 mg, 20 mmol) and THF (10 mL). After 5 min, the reaction mixture was cooled back to −78 °C, and 1-nitropentene (**2b**) (0.86 g, 7.5 mmol) was added dropwise. The reaction mixture was warmed to 0 °C and allowed to stir at this temperature for 4 h. In the case of nitrostyrene, the reaction mixture was stirred 12 h at 0 °C. The reaction was monitored by GC analysis of reaction aliquots. The reaction was then cooled to −78 °C, quenched with acetic acid (2 mL) in THF (5 mL), warmed to 0 °C, and worked up by pouring the reaction mixture into a saturated aqueous NH_4Cl solution which was extracted with ether (200 mL). The organic phase was washed with a saturated aqueous NH_4Cl solution (50 mL), brine (50 mL), and brine (20 mL) and dried ($MgSO_4$). The crude oil obtained after evaporation of the solvents was purified by flash chromatography (20:1 hexane/Et_2O) giving pure 1-chloro-5-(nitromethyl)octane (**3i**) (1.40 g, 90% yield): IR (neat) 2959 (s), 2872 (m), 1557 (s), 1462 (m), 1446 (m) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 4.28 (dd, 2 H, J = 7.0, 2.2 Hz), 3.50 (t, 2 H, J = 6.5 Hz), 2.18 (m, 1 H), 1.73 (quint, 2 H, J = 6.5 Hz), 1.37 (m, 8 H), 0.88 (t, 3 H, J = 6 Hz); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 79.3, 44.6, 37.0, 33.2, 32.3, 30.4, 23.3, 19.2, 13.9; MS (CI, CH_4) 208 (22), 161 (100), 125 (25), 119 (25), 83 (28); exact mass calcd for $C_9H_{18}NO_2ClH^+$ 208.1104, obsd 208.1118.

Analytical Data of the Nitroalkanes 3a–l As Described in Table I. Ethyl 6-nitro-5-phenylhexanoate (3a): IR (neat) 3043 (m), 3028 (m), 2988 (m), 1731 (s), 1553 (s) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 7.25 (m, 5 H), 4.58 (dd, 2 H, J = 8.0, 2.0 Hz), 4.12 (q, 2 H, J = 8.6 Hz), 3.49 (m, 1 H), 2.40 (t, 2 H, J = 6.8 Hz), 1.70 (m, 2 H), 1.50 (m, 2 H), 1.20 (t, 3 H, J = 8.6 Hz); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 173.0, 138.9, 129.0, 127.8, 127.5, 80.8, 60.4, 44.2, 33.8, 32.3, 22.3, 14.2; MS (CI, CH_4) 266 (MH^+, 1), 144 (49), 131 (100), 91 (73), 71 (44); exact mass calcd for $C_{14}H_{20}NO_4H^+$ 266.1392, obsd 266.1382.

1-Nitro-2-phenyl-6-dodecyne (3b): IR (neat) 3054 (w), 2952 (s), 2860 (m), 1553 (s), 1455 (m) cm^{-1}; ^1H-NMR ($CDCl_3$, 360 MHz) δ 7.25 (m, 5 H), 4.51 (dd, 2 H, J = 9.3, 1.7 Hz), 3.49 (m, 1 H), 2.20 (m, 4 H), 1.80 (m, 2 H), 1.4 (m, 8 H), 0.90 (t, 3 H, J = 8.7 Hz); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 139.7, 128.2, 127.6, 127.4, 82.4, 82.1, 79.2, 44.8, 32.2, 31.9, 29.8, 27.1, 22.3, 18.7, 14.2; MS (CI, NH_4^+) 305 (MNH_4^+, 100), 227 (26), 157 (33), 131 (24), 117 (28); exact mass calcd for $C_{18}H_{25}NO_2NH_4^+$ 305.2229, obsd 305.2225.

6-Nitro-5-phenylhexanenitrile (3c): IR (neat) 2939 (s), 2916 (m), 2246 (s), 1945 (w), 1550 (s) cm^{-1}; ^1H-NMR ($CDCl_3$, 360 MHz) δ 7.25 (m, 5 H), 4.52 (d, 2 H, J = 8.4 Hz), 3.48 (m, 1 H), 2.36 (t, 2 H, J = 7.6 Hz), 1.81 (m, 2 H), 1.52 (m, 2 H); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 138.1, 129.2, 128.1, 127.4, 118.9, 80.5, 43.7, 31.8, 22.9, 16.9; MS (EI, 70 eV) 218 (1), 171 (35), 118 (87), 104 (30), 91 (100); exact mass calcd for $C_{12}H_{14}N_2O_2$ 218.1055, obsd 218.1047.

1-Cyclohexyl-2-nitro-1-phenylethane (3d): IR (neat) 3025 (m), 2894 (w), 2244 (w), 2042 (w), 1549 (s) cm^{-1}; ^1H-NMR ($CDCl_3$, 360 MHz) δ 7.30 (m, 5 H), 4.82 (dd, 1 H, J = 9.0, 4.5 Hz), 4.62 (dd, 1 H, J = 9.2, 9.0 Hz), 3.35 (m, 1 H), 1.65 (m, 6 H), 1.10 (m, 4 H); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 138.7, 128.4, 128.1, 127.2, 78.7, 50.1, 40.8, 30.9, 30.5, 26.0; MS (EI, 70 eV) 233 (1), 186 (27), 104 (100), 83 (25), 55 (41); exact mass calcd for $C_{14}H_{19}NO_2$ 233.1416, obsd 233.1413.

1-Methyl-6-nitro-5-phenylhexyl 2,2-dimethylpropanoate (mixture of diastereomers (1:1)) (3e): IR (neat) 2975 (s), 2936 (s), 1721 (s), 1553 (s), 1480 (m) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 7.25 (m, 5 H), 4.80 (m, 1 H), 4.53 (d, 2 H, J = 7.6 Hz), 3.41 (m, 1 H), 1.58 (m, 4 H), 1.21 (m, 5 H), 1.09 (s, 9 H); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 177.9, 177.9, 139.1, 139.0, 128.8, 127.5, 127.4, 80.8, 80.7, 69.8, 69.6, 44.2, 44.1, 38.5, 35.5, 35.3, 32.7, 32.5, 26.9, 22.7, 22.5, 19.8, 19.7; MS (CI, CH_4) 322 (MH^+, 97), 173 (100), 131 (57), 117 (80), 91 (79); exact mass calcd for $C_{18}H_{28}NO_4$ 322.2018, obsd 322.2013.

Ethyl 5-(nitromethyl)octanoate (3f): IR (neat) 2961 (s), 2874 (m), 1734 (vs), 1553 (vs), 1464 (m) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 4.24 (d, 2 H, J = 6.8 Hz), 4.03 (q, 2 H, J = 7.2 Hz), 2.21 (t, 2 H, J = 7.2 Hz), 2.13 (m, 1 H), 1.57 (m, 2 H), 1.27 (m, 6 H), 1.16 (t, 3 H, J = 7.1 Hz), 0.82 (t, 3 H, J = 7 Hz); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 172.9, 79.2, 60.1, 36.9, 33.9, 33.2, 30.6, 21.4, 19.2, 14.0, 13.8; MS (CI, NH_4^+ and CH_4) 249 (MNH_4^+, 18), 186 (100), 150 (60), 139 (27), 122 (20); exact mass calcd for $C_{11}H_{21}NO_4H^+$ 232.1549, obsd 232.1542

7-(Nitromethyl)decyl acetate (3g): IR (neat) 2934 (s), 1740 (s), 1554 (s), 1466 (m), 1435 (m) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 4.22 (d, 2 H, J = 6.8 Hz), 3.95 (t, 2 H, J = 6.7 Hz), 2.11 (m, 1 H), 1.95 (s, 3 H), 1.53 (quint, 2 H, J = 6.6 Hz), 1.25 (m, 12 H), 0.83 (t, 3 H, J = 6.6 Hz); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 170.7, 79.4, 64.2, 37.0, 33.4, 31.0, 29.1, 28.3, 25.9, 25.6, 20.7, 19.2, 13.9; MS (CI, NH_4^+ and CH_4) 277 (MNH_4^+, 28), 260 (78), 200 (100), 97 (86), 83 (57); exact mass calcd for $C_{13}H_{25}NO_4H^+$ 260.1862, obsd 260.1870.

2-Benzyl-1-nitropentane (3h): IR (neat) 2960 (s), 2933 (s), 2873 (m), 1554 (s), 1455 (s) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 7.25 (m, 5 H), 4.26 (d, 2 H, J = 6.4 Hz), 2.64 (m, 3 H), 1.40 (m, 4 H), 0.92 (t, 3 H, J = 6.7 Hz); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 138.5, 129.1, 128.6, 126.6, 78.7, 39.2, 37.7, 33.4, 19.5, 14.0; MS (CI, NH_4^+) 225 (MNH_4^+, 100), 176 (16), 117 (14), 108 (20), 91 (55); exact mass calcd for $C_{12}H_{17}NO_2NH_4^+$ 225.1603, obsd 225.1599.

5-(Nitromethyl)octanenitrile (3j): IR (neat) 2961 (s), 2935 (s), 1551 (vs), 1460 (m), 1433 (m) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 4.26 (t, 2 H, J = 6.5 Hz), 2.30 (t, 2 H, J = 7 Hz), 2.15 (m, 1 H), 1.63 (m, 2 H), 1.43 (m, 2 H), 1.28 (m, 4 H), 0.84 (m, 3 H); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 119.0, 78.8, 36.3, 33.0, 30.2, 22.0, 19.0, 16.9, 13.7; MS (CI, NH_4^+, and CH_4) 202 (MNH_4^+, 17), 185 (37), 138 (100), 119 (9); exact mass calcd for $C_9H_{16}N_2O_2H^+$ 185.1290, obsd 185.1282.

1-(3-Thienyl)-2-(nitromethyl)pentane (3k): IR (neat) 2960 (s), 2932 (s), 2873 (m), 1546 (s), 1528 (m) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 7.30 (m, 1 H), 7.01 (m, 1 H), 6.94 (m, 1 H), 4.27 (dd, 2 H, J = 5.5, 1.8 Hz), 2.72 (m, 2 H), 2.51 (q, 1 H, J = 5.5 Hz), 1.39 (m, 4 H), 0.92 (m, 3 H); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 138.4, 128.3, 125.9, 122.1, 78.6, 38.4, 33.3, 31.8, 19.5, 13.9; MS (EI, 70 eV) 213 (3), 123 (53), 97 (100), 85 (48), 45 (74); exact mass calcd for $C_{10}H_{15}NO_2S$ 213.0824, obsd 213.0817.

1-(3-Carbomethoxy-2-furyl)-2-(nitromethyl)pentane (3l): IR (neat) 2935 (m), 2875 (w), 1718 (s), 1550 (s), 1440 (m) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 7.30 (d, 1 H, J = 1.6 Hz), 6.66 (d, 1 H, J = 1.6 Hz), 4.34 (dd, 2 H, J = 6.0, 2.7 Hz), 3.83 (s, 3 H), 3.11 (m, 2 H), 2.70 (m, 1 H), 1.37 (m, 4 H), 0.92 (m, 3 H); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 163.9, 159.2, 141.2, 114.8, 110.7, 78.8, 51.3, 36.7,

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33.6, 29.2, 19.3, 13.8; MS (EI, 70 eV) 255 (1), 152 (42), 139 (100), 123 (47), 109 (70), 41 (70); exact mass calcd for $C_{12}H_{17}NO_5$ 255.1107, obsd 255.1105.

Typical Procedure for the One-Pot Nef Reactions. (a) Solvolytic Method (Aqueous NH_4Cl or 10% HCl; Methods A and B). Preparation of 6-Oxo-5-propylheptanenitrile (7b) (Entry 2 of Table II). 2-Nitro-2-hexene (2c) (0.97 g, 7.5 mmol) was added to a THF solution of the 3-cyanopropylcopper derivative 1c prepared as described above.[12-14,45,46] After workup, a mixture of ketone and oxime was obtained. The reaction mixture was stirred overnight at 25 °C with a saturated aqueous NH_4Cl solution (method A) or with a 10% HCl aqueous solution (20 mL; method B) and worked up as usual. After evaporation of the solvents and purification by flash chromatography (4:1–2:1 hexane/EtOAc), the keto nitrile **7b** was obtained as the sole product (0.95 g, 76% yield): IR (neat) 2959 (s), 2974 (s), 2246 (m), 1770 (s), 1427 (s) cm^{-1}; ^1H-NMR ($CDCl_3$, 360 MHz) δ 2.47 (m, 1 H), 2.40 (t, 2 H, J = 7.2 Hz), 2.10 (s, 3 H), 1.68 (m, 1 H), 1.55 (m, 4 H), 1.38 (m, 1 H), 1.23 (m, 2 H), 0.87 (t, 3 H, J = 8.7 Hz); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 211.2, 118.3, 52.3, 33.5, 31.2, 29.2, 23.2, 21.1, 18.3, 13.8; MS (CI, CH_4) 168 (MH^+, 100), 150 (8), 126 (5), 91 (4); exact mass calcd for $C_{10}H_{17}NOH^+$ 168.1388, obsd 168.1383.

(b) Oxidative Method (O_3; Method C). Preparation of Methyl 7-(diethoxyphosphinoyl)-4-oxo-5-methylheptanoate (7i) (Entry 9 of Table II). A solution of the 2-(diethoxyphosphinoyl)ethylcopper reagent **1k** prepared as reported previously[46] (in THF (8 mL), 8 mmol) was added at −78 °C to methyl 4-nitrohex-4-enoate (1.04 g, 6 mmol).[49] The reaction mixture was allowed to warm to 0 °C and was stirred 4 h at this temperature and diluted with CH_2Cl_2 (30 mL). This solution was cooled to −78 °C, and a stream of ozone–oxygen was passed through. After 3 h, the reaction mixture was purged with a nitrogen stream to remove the excess ozone, was treated with Me_2S (10 mL) at −78 °C, and was slowly allowed to warm to room temperature. After the solution was stirred for 12 h, volatile material was removed on the rotary evaporator. The residue was taken up in EtOAc, extracted with saturated aqueous NH_4Cl, washed with brine, dried ($MgSO_4$), concentrated, and purified by flash chromatography (CH_2Cl_2/MeOH (99:1)) to give **7i** as a clear oil (1.44 g, 78% yield): IR (neat) 2936 (m), 2911 (m), 1739 (s), 1713 (s), 1440 (m) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 4.01 (m, 4 H), 3.57 (s, 3 H), 2.67 (m, 3 H), 2.49 (t, 2 H, J = 6.4 Hz), 1.87 (m, 1 H), 1.60 (m, 3 H), 1.23 (t, 6 H, J = 7.0 Hz), 1.04 (d, 3 H, J = 7.0 Hz); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ (J_{PC}) 211.1, 172.7, 61.1, 61.1, 51.2, 45.7 (d, J = 15 Hz), 35.3, 27.2, 25.1, 25.0, 22.7, (d, J = 141 Hz), 16.0, 15.9; MS (EI, 70 eV) 308 (5), 194 (45), 152 (100), 125 (41), 84 (42). Anal. Calcd for $C_{13}H_{25}O_6P$: C, 50.64; H, 8.17. Found: C, 50.53; H, 8.06.

Analytical Data of the Nef Products 7a–7i As Described in Table II. Ethyl 6-oxo-5-propylheptanoate (7a) (method A): IR (neat) 2961 (s), 2874 (s), 1735 (s), 1712 (s), 1573 (m) cm^{-1}; ^1H-NMR ($CDCl_3$, 360 MHz) δ 4.14 (q, 2 H, J = 9.6 Hz), 2.48 (m, 1 H), 2.36 (t, 2 H, J = 7.4 Hz), 2.17 (s, 3 H), 1.55 (m, 8 H), 1.2 (t, 3 H, J = 9.6 Hz), 0.90 (t, 3 H, J = 8.3 Hz); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 212.8, 173.4, 62.1, 52.5, 33.1, 32.4, 30.8, 29.1, 22.3, 20.9, 15.0; MS (EI, 70 eV) 214 (1), 126 (25), 71 (30), 55 (49), 43 (100); exact mass calcd for $C_{12}H_{22}O_3$ 214.1569, obsd 214.1577.

9-Acetoxy-3-propylnonan-2-one (7c) (method A): IR (neat) 2957 (s), 2859 (s), 1740 (s), 1713 (s), 1451 (s) cm^{-1}; ^1H-NMR ($CDCl_3$, 360 MHz) δ 4.07 (t, 2 H, J = 8.3 Hz), 2.48 (m, 1 H), 2.1 (s, 3 H), 2.0 (s, 3 H), 1.57 (m, 4 H), 1.25 (m, 10 H), 0.82 (t, 3 H, J = 7.6 Hz); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 212.7, 171.0, 64.4, 52.9, 33.8, 31.5, 29.3, 28.6, 28.5, 27.3, 25.7, 20.9, 20.6, 14.1; MS (CI, CH_4) 243 (MH^+, 32), 183 (100), 155 (33), 95 (34), 81 (40); exact mass calcd for $C_{14}H_{26}O_3H^+$ 243.1960, obsd 243.1964.

Ethyl 6-oxo-5-propyloctanoate (7d) (method C): IR (neat) 2960 (s), 2875 (m), 1736 (s), 1713 (s), 1564 (w) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) 4.06 (q, 2 H, J = 7.1 Hz), 2.43 (m, 3 H), 2.22 (t, 2 H, J = 6.9 Hz), 1.44 (m, 6 H), 1.15 (m, 5 H), 0.99 (t, 3 H, J = 7.3 Hz), 0.83 (t, 3 H, J = 7.2 Hz); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 214.5, 173.0, 60.0, 51.4, 35.1, 34.0, 33.8, 30.8, 22.7, 20.4, 14.0, 13.9, 7.4; MS (EI, 70 eV) 228 (6), 125 (46), 97 (32), 83 (30), 57 (100); exact mass calcd for $C_{13}H_{24}O_3$ 228.1725, obsd 228.1708.

Methyl 8-carbethoxy-5-methyl-4-oxooctanoate (7e) (method C): IR (neat) 2973 (m), 2955 (m), 2937 (m), 1739 (s), 1461 (m) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 4.10 (q, 2 H, J = 7.2 Hz), 3.65 (s, 3 H), 2.75 (m, 2 H), 2.56 (t, 3 H, J = 6.5 Hz), 2.27 (t, 2 H, J = 7.5 Hz), 1.54 (m, 4 H), 1.23 (t, 3 H, J = 7.1 Hz), 1.09 (d, 3 H, J = 7.0 Hz); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 211.9, 173.2, 172.3, 60.2, 51.6, 46.0, 35.5, 34.2, 32.2, 27.7, 22.6, 16.3, 14.2; MS (EI, 70 eV) 258 (1), 181 (19), 115 (100), 69 (19), 55 (44); exact mass calcd for $C_{13}H_{22}O_5H^+$ 259.1545, obsd 259.1531.

Methyl 8-cyano-4-oxo-5-methyloctanoate (7f) (method C): IR (neat) 2938 (m), 2246 (w), 1735 (s), 1714 (s), 1438 (s) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 3.65 (s, 3 H), 2.65 (m, 5 H), 2.33 (dt, 2 H, J = 7.1, 2.0 Hz), 1.81 (m, 1 H), 1.56 (m, 3 H), 1.13 (d, 3 H, J = 7.1 Hz); ^{13} C-NMR ($CDCl_3$, 75.5 MHz) δ 211.5, 173.0, 119.3, 51.5, 45.3, 35.3, 31.4, 27.4, 22.8, 17.0, 16.3; MS (EI, 70 eV) 211 (1), 115 (100), 96 (22), 55 (74), 41 (39); exact mass calcd for $C_{11}H_{17}NO_3H^+$ 212.1287, obsd 212.1288.

Methyl 5-cyclohexyl-4-oxohexanoate (7g) (method C): IR (neat) 2929 (s), 2853 (s), 1746 (s), 1738 (s), 1438 (s) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 3.67 (s, 3 H), 2.75 (dt, 2 H, J = 7.1, 3.3 Hz), 2.56 (t, 2 H, J = 6.4 Hz), 2.37 (quint., 1 H, J = 7.1 Hz), 1.64 (m, 6 H), 1.07 (m, 5 H), 1.03 (d, 3 H, J = 7.0 Hz); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 212.6, 173.2, 51.9, 51.5, 40.0, 36.5, 31.5, 29.2, 27.5, 26.2, 13.0; MS (CI, CH_4) 267 ($MC_3H_5^+$, 4), 227 (52), 195 (100), 119 (30), 101 (11); exact mass calcd for $C_{13}H_{22}O_3H^+$ 227.1647, obsd 227.1638.

Methyl 11-acetoxy-5-methyl-4-oxoundecanoate (7h) (method C): IR (neat) 2935 (m), 1740 (s), 1714 (s), 1767 (w), 1438 (w) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 4.03 (t, 2 H, J = 6.7 Hz), 3.66 (s, 3 H), 2.75 (m, 2 H), 2.57 (m, 3 H), 2.03 (s, 3 H), 1.64 (m, 3 H), 1.29 (m, 7 H), 1.08 (d, 3 H, J = 7.0 Hz); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 212.3, 173.1, 171.0, 64.3, 51.5, 46.1, 35.4, 32.7, 29.1, 28.4, 27.5, 26.9, 25.6, 20.7, 16.2; MS (EI, 70 eV) 287 (1), 144 (42), 115 (96), 55 (68), 43 (100). Anal. Calcd for $C_{15}H_{26}O_5$: C, 62.91; H, 9.15. Found: C, 62.60; H, 8.99.

Typical Procedure for the Preparation of Pure (*E*)-Nitro Olefins 10a–m. Preparation of 6-Nitro-5-hexenenitrile (10d) (Entry 8 of Table III). A solution of (*E*)-1-nitro-2-(phenylsulfonyl)ethylene (**4a**) (1.28 g, 6 mmol) in THF (10 mL) was added dropwise at −78 °C to a solution of the 3-cyanopropylcopper–zinc reagent **1c** prepared as reported previously.[12a] The reaction mixture was warmed to −50 °C, quenched after 5 min with saturated aqueous NH_4Cl, and worked up as usual. Flash chromatography purification (10:10:1 hexane/CH_2Cl_2/EtOAc) of the resulting crude oil obtained after evaporation of the solvent gave 710 mg (85% yield) of pure **10d**. If 2-(ethylthio)-1-nitrocyclohexene (**4c**) was used, the reaction mixture was warmed to 25 °C and stirred 12 h at this temperature: IR (neat) 2943 (s), 2867 (m), 2246 (w), 1512 (s), 1425 (m) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 7.20 (m, 1 H), 7.02 (d, 1 H, J = 12.1 Hz), 2.45 (m, 4 H), 1.88 (quint., 2 H, J = 7.1 Hz); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 140.7, 139.5, 118.5, 27.0, 23.5, 16.6; MS (CI, NH_4) 158 (MNH_4^+, 100), 142 (11), 125 (13), 108 (62), 82 (70); exact mass calcd for $C_6H_8N_2O_2NH_4^+$ 158.1399, obsd 158.1393.

Analytical Data of the Nitro Olefins 9a–d and 10a–m As Described in Table III. Ethyl 6-nitrohept-6-enoate (9a): IR (neat) 2882 (s), 2871 (m), 1735 (vs), 1532 (vs), 1422 (m) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 6.42 (d, 1 H, J = 1.8 Hz), 5.56 (s, 1 H), 4.11 (q, 2 H, J = 7.1 Hz), 2.61 (t, 2 H, J = 7.3 Hz), 2.33 (t, 2 H, J = 7.0 Hz), 1.63 (m, 4 H), 1.26 (t, 3 H, J = 7.1 Hz); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 172.7, 157.5, 116.8, 60.0, 33.5, 29.5, 26.3, 23.8, 13.9; MS (CI, CH_4) 202 (MH^+, 52), 156 (74), 8 (61), 81 (100), 67 (36); exact mass calcd for $C_9H_{15}NO_4H^+$ 202.1079, obsd 202.1078.

3-Cyclohexyl-2-nitropropene (9b): IR (neat) 2826 (s), 2853 (s), 1526 (s), 1449 (m) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 6.37 (d, 1 H, J = 1.5 Hz), 5.47 (s, 1 H), 2.44 (d, 2 H, J = 7 Hz), 1.75 (m, 5 H), 1.49 (m, 1 H), 1.17 (m, 3 H), 0.90 (m, 2 H); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 156.8, 117.7, 37.7, 35.5, 32.7, 26.1, 25.8; MS (CI, CH_4) 170 (MH^+, 4), 123 (6), 99 (7), 83 (100), 81 (49); exact mass calcd for $C_9H_{15}NO_2H^+$ 170.1181, obsd 170.1189.

9-Acetoxy-2-nitrononene (9c): IR (neat) 2935 (s), 2859 (m), 1740 (s), 1530 (s), 1466 (w) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 6.42 (s, 1 H), 5.54 (s, 1 H), 4.04 (t, 2 H, J = 7.5 Hz), 2.59 (t, 2 H, J = 7.5 Hz), 2.04 (s, 3 H), 1.56 (m, 4 H), 1.35 (bs, 6 H); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 170.9, 158.1, 116.7, 64.3, 29.9, 28.7, 28.6, 28.4, 27.0, 25.6, 20.8; MS (CI, CH_4) 230 (MH^+, 43), 170 (36), 123 (37), 93 (32), 81 (100); exact mass calcd for $C_{11}H_{19}NO_4H^+$ 230.1392, obsd 230.1398.

Ethyl 4-[6-(1-nitro-1-cyclohexenyl)]butyrate (9d): IR (neat) 2979 (m), 2942 (s), 2870 (m), 1733 (s), 1519 (s) cm^{-1}; ^1H-NMR

($CDCl_3$, 360 MHz) δ 7.13 (t, 1 H, J = 5 Hz), 4.00 (q, 2 H, J = 7.1 Hz), 2.80 (m, 1 H), 2.21 (m, 4 H), 1.70 (m, 2 H), 1.50 (m, 5 H), 1.26 (m, 1 H), 1.14 (t, 3 H, J = 7.1 Hz); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 172.9, 153.3, 134.0, 59.9, 33.7, 32.3, 31.3, 25.3, 24.6, 22.4, 16.5, 13.9; MS (CI, CH_4) 242 (MH^+, 17), 196 (100), 126 (16), 121 (19), 107 (12); exact mass calcd for $C_{12}H_{19}NO_4H^+$ 214.1392, obsd 242.1394.

Ethyl 6-nitro-5(*E*)-hexenoate (10a): IR (neat) 3105 (w), 2983 (m), 1732 (s), 1650 (m), 1526 (s) cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 7.23 (dt, 1 H, J = 13.8, 6.9 Hz), 6.98 (d, 1 H, J = 13.4 Hz), 4.12 (q, 2 H, J = 7.1 Hz), 2.35 (m, 4 H), 1.84 (quint., 2 H, J = 7.4 Hz), 1.24 (t, 3 H, J = 7.1 Hz); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 172.5, 141.2, 140.0, 60.4, 33.1, 27.5, 22.8, 14.0; MS (CI, CH_4 and NH_4^+) 205 (MNH_4^+, 5), 142 (100), 124 (50), 113 (34), 96 (81). Anal. Calcd for $C_8H_{13}NO_4$: C, 51.33; H, 7.00; N, 7.48. Found: C, 51.73; H, 6.87; N, 6.79.

***N*-[1-(5-Nitro-4(*E*)-pentenyl)]phthalimide (10b)**: solid (mp 123–125 °C); IR (KBr) 3119 (w), 1712 (s), 1648 (m), 1517 (s), 1401 (s) cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 7.75 (m, 4 H), 7.21 (dt, 1 H, J = 13.4, 7.2 Hz), 6.98 (d, 1 H, J = 14.4 Hz), 3.70 (t, 2 H, J = 6.9 Hz), 2.31 (q, 2 H, J = 7.3 Hz), 1.89 (quint., 2 H, J = 7.1 Hz); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 168.2, 140.6, 140.2, 134.1, 132.0, 123.2, 36.9, 26.7, 25.7; MS (CI, CH_4 and NH_4^+) 278 (MNH_4^+, 100), 261 (4), 245 (15), 231 (21), 136 (38). Anal. Calcd for $C_{13}H_{12}N_2O_4$: C, 60.00; H, 4.65; N, 10.76. Found: C, 59.91; H, 4.72; N, 10.82.

6-Nitro-5(*E*)-hexenyl 3-phenyl-2(*E*)-propenoate (10c): solid (mp 63–65 °C); IR (KBr) 3098 (w), 2940 (w), 2898 (w), 1709 (s), 1520 (s) cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 7.69 (d, 1 H, J = 16.0 Hz), 7.53 (m, 2 H), 7.39 (m, 3 H), 7.28 (dt, 1 H, J = 15.0, 9.0 Hz), 7.02 (d, 1 H, J = 13.8 Hz), 6.44 (d, 1 H, J = 16.0 Hz), 4.24 (t, 2 H, J = 6.2 Hz), 2.35 (q, 2 H, J = 7.3 Hz), 1.68 (m, 4 H); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 166.6, 144.7, 141.5, 139.8, 134.3, 130.1, 128.7, 127.9, 117.9, 63.5, 28.0, 27.7, 24.1; MS (EI, 70 eV) 275 (3), 147 (23), 131 (100), 103 (40), 77 (31); exact mass calcd for $C_{15}H_{17}NO_4$ 275.1158, obsd 275.1161.

1-Isopropyl-3-nitro-2-propenyl acetate (10e): IR (neat) 2970 (s), 2937 (s), 1748 (s), 1657 (m), 1531 (s) cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 7.12 (dd, 1 H, J = 5.0, 13.3 Hz), 7.00 (d, 1 H, J = 13.4 Hz), 5.31 (m, 1 H), 2.09 (s, 3 H), 2.01 (m, 1 H), 0.94 (m, 6 H); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 169.6, 140.7, 137.9, 73.9, 32.0, 20.4, 17.7, 17.5; MS (CI, CH_4) 188 (29), 172 (14), 145 (29), 128 (97), 83 (12); exact mass calcd for $C_8H_{13}NO_4H^+$ 188.0923, obsd 188.0915.

4-Acetoxy-6-nitro-5-hexenyl pivalate (10f): IR (neat) 2972 (s), 2937 (m), 1659 (m), 1532 (s), 1480 (s) cm^{-1}; ^{1}H-NMR ($CDCl_3$, 360 MHz) δ 7.15 (dd, 1 H, J = 5.0, 13.3 Hz), 7.06 (d, 1 H, J = 13.4 Hz), 5.55 (m, 1 H), 4.07 (t, 2 H, J = 6.2 Hz), 2.13 (s, 3 H), 1.73 (m, 4 H), 1.19 (s, 9 H); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 178.2, 169.5, 140.1, 138.7, 68.9, 63.1, 38.6, 30.0, 27.0, 24.0, 20.6; MS (CI, NH_4^+) 305 (MNH_4^+, 25), 213 (23), 198 (58), 136 (100); exact mass calcd for $C_{13}H_{21}NO_6NH_4^+$ 305.1713, obsd 305.1719.

1-Nitro-1(*E*),3(*Z*)-decadiene (10g): IR (neat) 2930 (s), 2857 (m), 1641 (s), 1607 (m), 1515 (s) cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 7.87 (m, 1 H), 7.08 (d, 1 H, J = 13.5 Hz), 6.14 (m, 2 H), 2.32 (q, 2 H, J = 7.2 Hz), 1.36 (m, 4 H), 0.89 (t, 3 H, J = 6.9 Hz); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 147.9, 139.2, 133.5, 121.1, 31.1, 28.3, 22.1, 13.6; MS (EI, 70 eV) 183 (7), 69 (31), 66 (56), 55 (72), 43 (100). Anal. Calcd for $C_{10}H_{17}NO_2$: C, 65.64; H, 9.35; N, 7.64. Found: C, 65.64; H, 9.05; N, 7.61.

1-Nitro-1(*E*),3(*E*)-decadiene (10h): IR (neat) 2929 (s), 2857 (m), 1641 (s), 1609 (m), 1513 (s) cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 7.57 (dd, 1 H, J = 13.1, 13.0 Hz), 7.05 (d, 1 H, J = 13.1 Hz), 6.44 (m, 1 H), 6.18 (m, 1 H), 2.24 (q, 2 H, J = 7.0 Hz), 1.44 (q, 2 H, J = 7.2 Hz), 1.29 (m, 6 H), 0.88 (t, 3 H, J = 6.7 Hz); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 151.3, 139.2, 137.4, 123.1, 33.3, 31.5, 28.7, 20.3, 22.4, 13.8; MS (EI, 70 eV) 183 (6), 69 (36), 66 (39), 55 (71), 43 (100); exact mass calcd for $C_{10}H_{17}NO_2$ 183.1259, obsd 183.1257.

1-Pentyl-3-nitro-2-propenyl acetate (10i): IR (neat) 2958 (s), 2932 (s), 2863 (s), 1658 (m), 1531 (s) cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 7.15 (dd, 1 H, J = 5.0, 13.3 Hz), 7.04 (d, 1 H, J = 13.4 Hz), 5.50 (m, 1 H), 2.11 (s, 3 H), 1.72 (m, 2 H), 1.30 (m, 6 H), 0.88 (t, 3 H, J = 6.7 Hz); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 169.6, 139.8, 139.3, 69.4, 33.4, 31.1, 24.2, 22.1, 20.5, 13.6; MS (CI, NH_4) 233 (NH_4, 100), 200 (5), 173 (6), 142 (9), 136 (50); exact mass calcd for $C_{10}H_{17}NO_4NH_4^+$ 233.1501, obsd 233.1497.

Ethyl 4-[1-(2-nitro-1-cyclohexenyl)]pentanoate (10j): IR (neat) 2979 (m), 2942 (s), 2867 (m), 1734 (s), 1515 (s) cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 4.13 (q, 2 H, J = 7.1 Hz), 2.56 (m, 2 H), 2.31 (m, 6 H), 1.85 (m, 2 H), 1.68 (m, 4 H), 1.26 (t, 3 H, J = 7.1 Hz); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 173.0, 146.0, 141.3, 60.2, 33.8, 33.1, 30.2, 26.4, 22.9, 22.1, 21.4, 14.1; MS (CI, CH_4) 242 (MH^+, 16), 194 (87), 166 (37), 149 (100), 136 (35). Anal. Calcd for $C_{12}H_{19}NO_4$: C, 59.73; H, 7.94; N, 5.80. Found: C, 59.35; H, 7.74; N, 5.40.

1-(3-Cyanopropyl)-2-nitrocyclohexene (10k): IR (neat) 2943 (s), 2867 (m), 2246 (w), 1644 (w), 1512 (s) cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 2.58 (t, 2 H, J = 6.2 Hz), 2.43 (m, 4 H), 2.26 (m, 2 H), 1.89 (m, 2 H), 1.76 (m, 2 H), 1.64 (m, 2 H); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 146.9, 139.7, 119.0, 32.9, 30.4, 26.4, 23.6, 22.0, 21.4, 16.9; MS (CI, NH_4) 212 (MNH_4^+, 100), 196 (11), 179 (13), 163 (62), 136 (70); exact calcd for $C_{10}H_{14}N_2O_2NH_4^+$ 212.1399, obsd 212.1393.

1-[1-(2-Diethylphosphinoyl)ethyl]-2-nitrocyclohexene (10l): IR (neat) 2982 (m), 2939 (m), 2868 (m), 1654 (w), 1514 (s) cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 4.09 (m, 4 H), 2.55 (m, 4 H), 2.26 (t, 2 H, J = 6.0 Hz), 1.95 (m, 2 H), 1.67 (m, 4 H), 1.32 (t, 6 H, J = 7.0 Hz); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ (J_{PC}) 146.3, 141.0 (d, J = 17 Hz), 61.6, 61.5, 30.2, 27.2, 26.3, 23.9 (d, J = 141 Hz), 21.9, 21.4, 16.2, 16.1; MS (EI, 70 eV) 292 (MH^+, 2), 244 (100), 187 (88), 79 (92), 41 (73); exact mass calcd for $C_{12}H_{22}PNO_5H^+$ 292.1314, obsd 292.1297.

1-Nitro-2-(1(*E*)-octenyl)cyclohexene (10m): IR (neat) 2929 (s), 2857 (m), 1541 (w), 1513 (s), 1464 (w) cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 6.60 (d, 1 H, J = 15.8 Hz), 6.04 (dt, 1 H, J = 15.0, 6.6 Hz), 2.62 (t, 2 H, J = 6.1 Hz), 2.40 (t, 2 H, J = 6.1 Hz), 2.14 (q, 2 H, J = 7.1 Hz), 1.70 (m, 4 H), 1.32 (m, 8 H), 0.86 (t, 3 H, J = 7.0 Hz); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 145.6, 137.0, 134.7, 125.5, 33.2, 31.6, 28.9, 28.8, 27.2, 26.1, 22.5, 22.1, 21.5, 14.0; MS (EI, 70 eV) 237 (6), 122 (100), 79 (36), 55 (68), 43 (97). Anal. Calcd for $C_{14}H_{23}NO_2$: C, 70.85; H, 9.77; N, 5.90. Found: C, 70.45; H, 9.69; N, 5.56.

Methyl 2,2-dimethyl-4-(phenylsulfonyl)-3(*E*)-butenoate (13): IR (neat) 3059 (w), 2982 (m), 1733 (s), 1624 (m), 1447 (s) cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 7.86 (m, 2 H), 7.58 (m, 3 H), 7.16 (d, 1 H, J = 15.3 Hz), 6.33 (d, 1 H, J = 15.3 Hz), 3.69 (s, 3 H), 1.34 (s, 6 H); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 174.2, 149.0, 140.2, 133.3, 129.3, 129.1, 127.4, 52.3, 44.4, 24.1; MS (EI, 70 eV) 269 (MH^+, 1), 127 (100), 95 (24), 77 (37), 67 (55). Anal. Calcd for $C_{13}H_{16}SO_4$: C, 58.19; H, 6.01. Found: C, 57.82; H, 6.09.

***(5R*,9S*)*-3(*R**)-Methyl-4(*R**)-nitrobicyclo[4.3.0]non-1-ene (17)**. The addition of the copper–zinc reagent 1t prepared from 8-iodo-2(*E*),4(*E*)-octadiene (2.36 g, 10.0 mmol) to (E)-1-nitro-2-(phenylsulfonyl)ethylene (**4a**) (1.60 g, 7.5 mmol) was performed as described in the typical procedure. The crude oil obtained was purified by flash chromatography (hexane/Et_2O (49:1)) to give a mixture of uncyclized and cyclized products **16** and **17**. This mixture was further stirred in hexane over silica gel at 25 °C for 4 h. A second purification (SiO_2, hexane/Et_2O (49:1)) gave 1.15 g (85% yield) of pure **17** as an oil: IR (neat) 3024 (m), 2972 (s), 2910 (m), 2873 (s), 1545 (s) cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 5.78 (d, 1 H, J = 9.7 Hz), 5.49 (m, 1 H), 4.65 (dd, 1 H, J = 11.7, 7.0 Hz), 3.04 (m, 1 H), 1.88 (m, 6 H), 1.25 (m, 2 H), 0.92 (d, 3 H, J = 7.1 Hz). The attribution of the relative stereochemistry was made by examinating the coupling constants: $^3J_{H1,H2}$ = 11.5 Hz, $^3J_{H2,H3}$ = 11.7 Hz, $^3J_{H3,H4}$ = 7.0 Hz. To confirm the assignment of the relative stereochemistry between H_3 and H_4, **17** was hydrogenated leading to a coupling constant $^3J_{H3,H4}$ = 5 Hz (see eq 9); compare with refs 40 and 41. ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 130.5, 128.6, 90.3, 44.7, 41.3, 35.1, 28.9, 27.3, 22.1, 16.1; MS (EI, 70 eV) 181 (1), 135 (71), 91 (100), 79 (83), 41 (66). Anal. Calcd for $C_{10}H_{15}NO_2$: C, 66.27; H, 8.34; N, 7.73. Found: C, 66.24; H, 8.14; N, 7.31.

Ethyl 8-carbethoxy-5-(nitromethylene)octanoate (18a): oil; 2.03 g (90% yield) prepared from ethyl 4-iodobutanoate (4.84 g, 20.0 mmol) and 2,2-bis(methylthio)nitroethylene (**19**) (1.24 g, 7.5 mmol); reaction conditions −30 °C, 4 h; purified by flash chromatography (hexane/Et_2O (2:1)); IR (neat) 2982 (m), 2940 (m), 1733 (s), 1635 (m), 1521 (s) cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 6.84 (s, 1 H), 4.04 (q, 4 H, J = 7.1 Hz), 2.56 (m, 2 H), 2.31 (t, 2 H, J = 7.3 Hz), 2.26 (t, 2 H, J = 7.2 Hz), 2.18 (m, 2 H), 1.76 (m, 4 H), 1.17 (t, 6 H, J = 7.2 Hz); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 172.5, 172.3, 154.5, 135.6, 60.3, 60.2, 34.5, 33.7, 33.1, 30.2, 22.8,

22.3, 14.0; MS (CI, CH_4 and NH_4^+) 319 (MNH_4^+, 82), 284 (73), 192 (100), 166 (96), 136 (87); exact mass calcd for $C_{14}H_{23}NO_6H^+$ 302.1604, obsd 302.1605.

8-Cyano-5-(nitromethylene)octanenitrile (18b): IR (neat) 3098 (w), 2933 (s), 2850 (m), 1622 (m), 1508 (s) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 6.83 (s, 1 H), 3.47 (m, 1 H), 2.21 (m, 1 H), 1.68 (m, 10 H), 1.24 (m, 10 H); ^{13}C-NMR ($CDCl_3$, 90 MHz) δ 164.4, 135.3, 40.1, 39.8, 34.2, 29.7, 26.6, 25.9, 25.8; MS (CI, CH_4, and NH_4^+) 255 (MNH_4^+, 39), 238 (100), 222 (20), 208 (20), 156 (31); exact mass calcd for $C_{14}H_{23}NO_2H^+$ 238.1807, obsd 238.1817.

2,2-Dicyclohexylnitroethylene (18c): solid (mp 44–46 °C); IR (KBr) 3099 (w), 2933, (s), 2850 (m), 1622 (m), 1508 (s) cm^{-1}; ^1H-NMR ($CDCl_3$, 300 MHz) δ 6.83 (s, 1 H), 3.48 (m, 1 H), 2.21 (m, 1 H), 1.72 (m, 10 H), 1.25 (m, 10 H); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 164.4, 135.3, 40.1, 39.8, 34.2, 29.7, 26.6, 25.9, 25.8; MS (EI, 70 eV) 238 (MH^+, 1), 138 (84), 67 (59), 55 (100), 41 (89); exact mass calcd for $C_{14}H_{23}NO_2H^+$ 238.1807, obsd 238.1817.

Nitromethylenecyclopentane (20): purified by vacuum distillation 45 °C (0.05 mmHg); ^1H-NMR ($CDCl_3$, 300 MHz) δ 7.09 (s, 1 H), 2.94 (t, 2 H, J = 7.5 Hz), 2.50 (t, 2 H, J = 7.5 Hz), 1.76 (m, 4 H); ^{13}C-NMR ($CDCl_3$, 75.5 MHz) δ 163.4, 132.1, 33.9, 33.2, 25.9, 25.5. See ref 50.

Acknowledgment. We thank the donors of the Petroleum Research Fund, administered by the Americal Chemical Society, and the University of Michigan (Office of the Vice President for Research) for support of this work.

Supplementary Material Available: ^{13}C NMR spectra of **3e–f, 3h–l, 7d–g, 9a–d, 10c–f, 10h-i, 10k–l, 18a–c** (26 pages). This material is contained in many libraries on microfiche, immediately follows this article in the microfilm version of the journal, and can be ordered from the ACS; see any current masthead page for ordering information.

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Asymmetric Functionalization of Conformationally Distinctive C_s-Symmetric Cis[*n*.3.1] Bicyclic Ketones. Definition of the Absolute Course of Enantio- and Diastereodifferentiation

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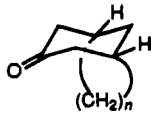
Received May 6, 1992

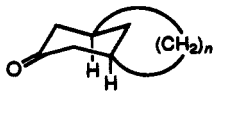
The four C_s-symmetric cis[*n*.3.1] bicyclic ketones where n = 3, 5, 7, and 9 were acetalized with (*R*,*R*)-2,4-pentanediol, and the resulting derivatives were cleaved with triisobutylaluminum (TRIBAL). The first three examples, all of which have their polymethylene chain rigidly fixed in a diaxial orientation, undergo ring opening with very high diastereoselectivity to give **5**. In the fourth case (n = 9), the chain is sufficiently long to be attached in a diequatorial manner. The response of **4d** to TRIBAL is to deliver a 1:1 mixture of **11** and **12**. The stereochemical course of epoxidation and cyclopropanation reactions of these enol ethers has been assessed. Where **5** and **11** are concerned, these functionalization reactions are 100% π-facially selective. Only **12** is the exception. Also examined in this study was the enantioselective deprotonation of the same ketones with the enantiomerically pure lithium amide base **27**. The resulting enolates were trapped as their silyl enol ethers and transformed directly into optically active α-hydroxy ketones and α,β-unsaturated enones by epoxidation and selenenylation–oxidative elimination, respectively. The sense of the observed enantioselectivity was the same irrespective of the diaxial or diequatorial disposition of the $(CH_2)_n$ loop. However, the asymmetry induced by this means was consistently opposite to that realized by TRIBAL-promoted acetal cleavage. When these complementary processes are compared at the α-hydroxy ketone stage, the acetal cleavage–epoxidation option was invariably 100% enantioselective; greater variability in optical purity was seen via the deprotonation–silylation–epoxidation option. The possible mechanistic basis of these observations is explored.

The conversion of cyclic, prochiral ketones into optically active enolates via their direct deprotonation with homochiral lithium amide bases has met with considerable success.[2] The regiocontrolled triisobutylaluminum (TRIBAL)-induced isomerization of chiral acetals of meso ketones to optically active enol ethers has been accorded similar interest.[3] Notwithstanding, little mechanistic insight has been gained into the factors that control these asymmetric transformations. In recent work,[4] we provided crystallographic substantiation of the conformational crossover that materializes when the polymethylene chain of cis-3,5-annulated cyclohexanones is increased from n = 3, 5, or 7 to n = 9. A loop constituted of <9 methylene groups was shown to be too short to be accommodated diequatorially as in **2**. The alternative diaxial orientation



1

(n = 3, 5, 7)



2

(n = 9)

depicted in **1** need therefore be adopted. To what extent might the diaxial/diequatorial dichotomy of these unique, conformationally-locked [*n*.3.1] bicyclic ketones and their corresponding chiral acetals impact on the outcome of those enantio- and diastereodifferentiating processes alluded to above? Might the topologically distinctive features of **1**, **2**, and their derivatives underscore the combinatorial diversity of associated asymmetric reactions and

(1) National Institutes of Health Postdoctoral Fellow, 1990–1992.
(2) For a comprehensive review, consult: Cox, P. S.; Simpkins, N. S. *Tetrahedron Asymmetry* **1991**, *2*, 1.
(3) For a survey of this process, see: Alexakis, A.; Mangeney, P. *Tetrahedron Asymmetry* **1990**, *1*, 477.
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