Orientation Effect of Side Chain Substituents in Aromatic Substitution. Induced *Ortho* Nitration

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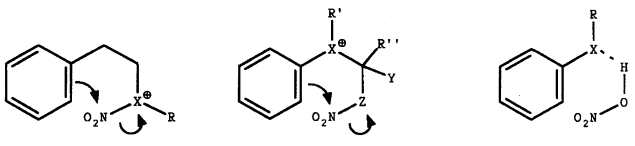
The presence of a free carboxyl or ester function on the α-carbon of toluene induces the nitration of the phenyl ring in the *ortho* position at or above the statistical value (*chaperon* effect), when pure HNO_3 is used in CH_2Cl_2 solution. This is at variance with the results of classical nitration in H_2SO_4, where *p*-nitration predominates by far and *m*-nitration occurs at a remarkable extent. The new finding is explained in terms of precomplex formation.

Aromatic nitration of benzene derivatives with a single electron releasing substituent leads to substitution at the *o*- and *p*-positions according to a statistical distribution, from which a shift to higher concentrations of the *p*-products may be caused by steric hindrance (Table 1).[1] Abnormally high *o*/*p* ratios in aromatic nitrations were recorded in two instances. One such case occurred when a suitable substituent was placed in the aromatic ring, having the property of coordinating the NO_2^+ ion and eventually *chaperonizing* it into the *ortho* position (transition state A);[2] the other instance was offered by a reagent which was able both to link itself to a strategically positioned heteroatom in the side chain and to the nitryl ion to yield an intermediate similar to that of the former case (transition states B and C, Chart 1).[2a] The possibility of overcoming more or less strong steric hindrance to *o*-substitution by the introduction of a function which could be eventually replaced by a H atom or be liable to undergo useful transformations is deemed of high synthetic interest. One such function is the interchangeable carboxyl or alkoxycarbonyl group, which can be placed in the α-position of an aromatic side chain. Thus, benzeneacetic acid (**1**) and its esters are the simplest model compounds on which the essential observations were made.



A B C

Chart 1.

Results and Discussion

Mononitration of the free acid **1** and its methyl (**2**) and ethyl (**3**) esters in H_2SO_4 with a stoichiometric amount of 100% HNO_3 could be carried out at room temperature within 1 min in a clean reaction, which neither left any starting material nor produced any dinitration product, but only yielded the three mononitration isomers in practically identical ratios (Table 1). Excess HNO_3 and longer reaction durations led to dinitration, mainly to *o*,*p*-dinitro isomers. A comparison of the isomeric distribution and reaction course with those of similar nitrations of alkylbenzenes[3] showed variances and similarities (Table 1). The effect of steric hindrance of the alkoxycarbonylmethyl group is more pronounced than that caused by an isopropyl group; but the observation of an abnormally high conversion to *m*-derivatives (ca. 30%) hinted that the substituent was much less effective in inducing *o*,*p*-orientation by hyperconjugation.[4] The alkoxycarbonyl function had a leveling effect on the regiospecificity of the nitration. Competitive nitrations between the acid **1** and its esters **2** and **3** did not show any appreciable difference in the rates of overall mononitration of these substrates (Table 2). Previous reports on the direct nitrations with pure HNO_3 or with HNO_3 in H_2SO_4 on **1** were preparative works which did not record isomeric distributions, although the likely presence of the *o*-isomer **4a** was sometimes signalled (Scheme 1):[5c,5d] Thus, 4-nitrobenzeneacetic acid (**4c**) was prepared in unspecified yields with fuming HNO_3[5a,5b] or HNO_3 in H_2SO_4[5d] and 2,4-dinitrobenzeneacetic acid (**7**) was prepared from the acid **1** in fuming HNO_3[6] or HNO_3 in H_2SO_4.[7]

When a mixture of the three isomeric acids **4a**—**c** was allowed to react with a deficient amount of HNO_3 in H_2SO_4, we observed that the most reactive substrate

Table 1. Nitrations in H_2SO_4

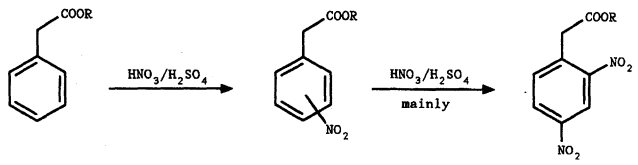
Substrate (S)	$[HNO_3]_0[S]_0^{-1}$	$[HNO_3]_0$	Reaction time min	Isomer distribution (%) *o*-	*m*-	*p*-	Conversion[a]	Notes
PhMe[b]	1.0	9.00	b)	59	4	37	b)	
PhEt[b]	1.0	9.00	b)	45	6	49	b)	
Ph*i*Pr[b]	1.0	9.00	b)	30	8	62	b)	
Ph*t*Bu[b]	1.0	9.00	b)	16	11	73	b)	
1	1.1	0.17	60	18	32	50	100	c)
1	1.6	2.10	1	25	29	46	90	c)
1	1.6	2.10	60	9	34	57	100	53%[d]
2	1.1	0.17	60	19	29	52	100	c)
2	1.6	2.10	1	20	28	52	97	6%[d]
3	1.1	0.17	60	19	31	50	100	c)
3	1.3	0.60	1	12	23	65	100	23%[d]

a) Based on limiting reagent. b) Data taken from Ref. 3; HNO_3 (d=1.42 g mL^{-1}) dissolved in H_2SO_4 was added over 4 h to the neat hydrocarbon at room temperature, the reaction was then kept 2 h at room temperature and subsequently 1 h at 40 °C. Yields of mononitration products were ca. 80%. Conversions were not reported. c) The mononitro derivatives were the only reactions products. d)Yield of dinitro derivatives: the 2,4-dinitro derivative was by far the prevalent isomer.

Table 2. Competitive Nitration Experiments[a]

Substrates (S′,S″)	Solvent	$[HNO_3]_0$	$[HNO_3]_0([S']_0+[S'']_0)^{-1}$	$[S']_0[S'']_0^{-1}$	$[S']_t[S'']_t^{-1}$ (time/min)
1, **3**	H_2SO_4	1.0	0.50	1.00	0.82 (60)
2, **3**	H_2SO_4	1.0	0.50	1.00	1.00 (60)
1, **3**	CH_2Cl_2	0.7	2.50	1.00	1.22 (1440)

a) The material balance for the reactions was accounted for by unreacted starting material only.



Scheme 1.

was the *o*-isomer, whose drop in final concentration was the largest; the same phenomenon can be evidenced from the longer duration experiments with excess HNO_3 reported in Table 1. The production of significant concentrations of *m*-isomers is of some preparative interest: In fact, the acid **4b** is by far the most expensive isomer on the retail market. We shall also recall another, often quoted, report of an alleged *m*-orientation induced by Cu $(NO_3)_2$ in Ac_2O (yield unspecified):[8] Careful repetition of this work was completely disappointing.

To these dismaying results, if one aims at directing nitration into the *o*-position, is to be contrasted a report[4c] on the mononitration of **3** in acetic anhydride, leading to a more favorable *o*-proportion in the isomeric distribution. Incidentally, it was also observed that toluene was some seven times more reactive than **3** in the nitration reaction, but benzene was found to be slower. These results may be interpreted as follows. The α-ethoxycarbonyl group rapidly precomplexes the nitryl ion, which is then deposited onto the close *o*-position in what amounts to a *chaperon* effect. Of course, some of the substrate follows the usual bimolecular nitration mechanism. Our initial rationale was that the ethoxycarbonyl group was made less solvated in the Ac_2O–HNO_3 system, whereas it was at least hydrogen-bonded in the strongly protic system H_2SO_4–HNO_3. Under the former conditions, six membered cyclic precomplexes **10** and/or **11** were more favorably formed (Chart 2). In this framework, we deemed that a still more inert solvent might enhance complex formation and, by consequence, lead to higher *o*-orientation. We used CH_2Cl_2 because of the ready solubility of both the substrates and HNO_3 in it;[9] moreover, among chlorinated solvents, it offered obvious advantages, like low boiling point and low entropy of vaporization, chemical stability, low cost and acceptable toxicological properties.

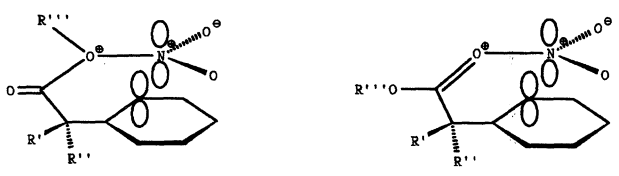


Chart 2.

Solutions of alkylbenzenes in CH_2Cl_2 were nitrated exclusively and completely to mononitroderivatives by the action of five molar amounts of 100% HNO_3 within 1 h (Table 3). The isomeric distributions for all the observed cases repeated quite closely the results of nitrations of these substrates in H_2SO_4. No matter which the actual structure of HNO_3 in CH_2Cl_2 was, the transition states evidenced identical activation free energy differences among themselves and, most likely, extremely similar structures, in particular, with identical steric interactions. In similar experiments, carried out with the same concentration and ratios of reactants, the acid **1** and esters **2** and **3** showed definite increments of *o*-nitration products, whereas the isomer distribution was practically identical for all three substrates (Table 3). In H_2SO_4 no *o*-orientation above expectation was discernible over a wide range of concentration (Table 1). Alkylbenzenes, on the other hand, were nitrated much faster than **1**, **2**, and **3**, confirming the decreased activating power of the carboxymethyl and alkoxycarbonylmethyl substituents. The p/m ratios were also consistent with this observation and coherent with the results in H_2SO_4: the lessened activation of the *o,p*-positions towards electrophilic substitution causes some leveling effect among the different locations. Limited variances of the isomeric distribution during the course of reaction were an indication that the mechanistic parameters were not changing. If one thinks that there is only a redistribution of the *missing* natural relative amount of *o*-product—taking toluene as the standard—between the *m*- and *p*-positions in the cases where steric hindrance is a factor, the relative production of the *m*-isomers in the nitrations of $PhCH_2COOR$ in H_2SO_4 was expected to be ca. 8%, whereas the observed value was 29%. On the other hand, competitive nitrations of PhMe and $PhCH_2COOR$ showed that the former is overall much more reactive than the latter, an indication of a decreased orientation-activation effect of the CH_2COOR substituents. If we compare the only available σ_p^+ data for CH_2COOR (-0.16)[10] and CH_2COOH (-0.02)[11] with the analogous value for CH_3 (-0.31),[11a,12] the lesser orientation-activation effect becomes quite evident. The nitration in H_2SO_4 is also very sensitive to the electronic effects ($\rho=-6.5$).[13]

We then thought that a dilution of the system could lead to a reaction less resembling the conditions of a nitration in concentrated protic strong acids. The results of these experiments are collected in Table 4. Whereas the isomeric ratios obtained for the alkylbenzenes were essentially the same once again, a dramatic shift towards *o*-nitration became apparent with the three substrates **1**, **2**, and **3** which showed marked differences in orientation power. The reactions were much slower than those in H_2SO_4; moreover, even under these conditions, the alkylbenzenes appeared more reactive. It can be noticed from comparison of the results collected in Tables 2 and 3 that acid **1** appeared more reactive than the esters in the reactions run with more concentrated HNO_3. On the other hand, an ad hoc competitive experiment between acid **1** and ester **3** under the more diluted conditions showed a slight rate prevalence of the latter: This is taken as an indication of a rather large structural change of HNO_3 upon dilution. It is to be remarked that the NO_2-adduct **12″** (R=H) of **1** may lose a proton to yield **13** (Scheme 2), thus becoming less reactive in a less acidic solution, a fact impossible for the alkoxycarbonyl adducts (**12″**, R=Me, Et). The *o*-derivative **5a**, which appeared to be the most reactive in the second nitration in H_2SO_4, could not be nitrated further at all by bringing it into contact with six molar amounts of 100% HNO_3 in CH_2Cl_2. This is a further indication of the depressed reactivity in nitration reactions of HNO_3 in CH_2Cl_2, where the acid may be thought to be present associated in small clusters by hydrogen bonds with surrounding CH_2Cl_2 molecules and tiny concentrations of nitryl ions. When the reactivity of toluene was contrasted with that of **1** towards HNO_3 in CH_2Cl_2 the former substrate was found by far more reactive. This experiment confirmed that the system **1** has a lessened reactivity, but a stronger *o*-directing aptitude due to a specific structural aspect.

Our nitration procedure seems to offer a unique opportunity to obtain higher yields of useful *o*-products in quite a simple and safe way, amenable to industrial production, because of the essential ease of operations and low energy requests. Interestingly, $CHCl_3$, which also yields homogeneous solutions with HNO_3, did not give such interesting results. The synthetically useful[14] *o*-nitrobenzeneacetic acid (**1a**) itself, from which the alkyl esters are obtained smoothly by Fischer esterification,[15] was so far prepared by rather expensive and cumbersome routes.[14a,16]

Experimental

Materials. Fuming HNO_3 (100%) was used as received (Pravisani S.p.A., Udine); its assay was checked before use. Commercially available reagents and solvents were purchased from Aldrich (USA) and were used without further purification. Products which were not commercially available, namely 2- and 3-nitroethylbenzene,[3] 2- and 3-nitroisopropylbenzene,[3] 2-, 3-, and 4-nitro-*t*-butylbenzene,[17] methyl 2-nitrobenzeneacetate (**5a**),[16b] methyl 3-nitrobenzeneacetate (**5b**),[18] methyl 4-nitrobenzeneacetate (**5c**),[15] ethyl 2-nitrobenzeneacetate (**6a**),[4c] ethyl 3-nitrobenzeneacetate (**6b**),[4c] and ethyl 4-nitrobenzeneacetate (**6c**),[4c] were prepared by conventional methods. Spectral data of compounds **4a**—**c** and **7** are reported in Table 5. Alcohol-free dry CH_2N_2 in Et_2O was obtained according to a described procedure,[19] followed by treatment with solid KOH.

Equipment and Methods. Solutions of 100% HNO_3 in CH_2Cl_2 or H_2SO_4 were freshly prepared and used immediately by adding them in one lot in the necessary amounts to stirred solutions in the same solvent as the organic substrates to be nitrated; aliquots were taken from time to time, quenched onto ice and, in the cases of acid substrates, methylated with excess ethereal CH_2N_2 before GC analyses. The

Table 3. Nitrations in CH_2Cl_2 (Concentrated Solution)

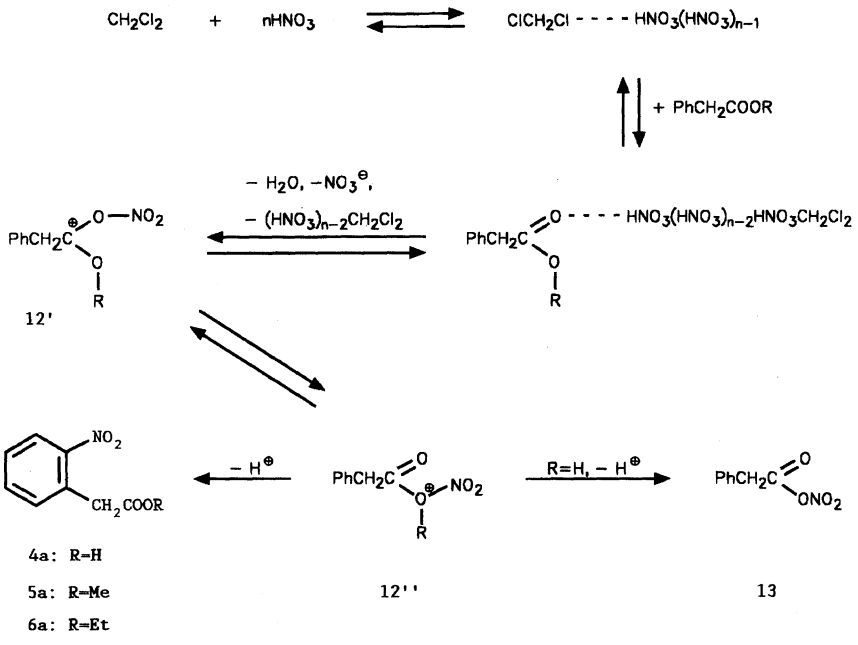
Substrate (S)	$[HNO_3]_0[S]_0^{-1}$	$[HNO_3]_0$	Reaction time h	Isomer distribution (%) *o*-	*m*-	*p*-	Conversion %S_0	Notes[a]
PhMe	5.0	12.5	1	56	5	39	100	
PhEt	5.0	12.5	1	44	5	51	100	
Ph*i*Pr	5.0	12.5	1	23	5	72	91	5% PhCOMe, 3% $O_2NPhC(=CH_2)Me$
Ph*t*Bu	5.0	12.5	1	12	10	78	100	
1	5.0	12.5	1	47	10	43	100	
2	5.0	12.5	1	48	10	42	78	
3	5.0	12.5	1	49	10	41	79	

a) Unless specified otherwise, the material balance was fully accounted for by unreacted starting material.

Table 4. Nitrations in CH_2Cl_2 (Diluted Solution)

Substrate (S)	$[HNO_3]_0[S]_0^{-1}$	$[HNO_3]_0$	Reaction time h	Isomer distribution (%) *o*-	*m*-	*p*-	Conversion %S_0	Notes[a]
PhMe	5.0	1.5	24	53	5	42	100	
PhEt	5.0	1.5	24	45	5	50	100	
Ph*i*Pr	5.0	1.5	24	27	5	68	100	6% PhCOMe
Ph*t*Bu	5.0	1.5	24	17	9	74	100	
1	5.0	1.5	24	66	10	24	100	
2	5.0	1.5	24	75	8	17	100	
3	5.0	1.5	24	80	6	14	100	

a) The material balance was fully accounted for the indicated products.



Scheme 2.

courses of all the reactions described were monitored by GC and GC-MS and/or by ^{1}H NMR after dilution of the quenched reaction mixture as such with a suitable deuterated solvent.

Melting points were determined in open-ended capillary tubes and are uncorrected. Boiling points refer to the center cut of small distillations and are uncorrected. Elemental analyses were obtained for all isolated compounds and were satisfactory. GC analyses were performed with a Carlo Erba HRGC gas chromatograph equipped with a 0.25 mm i.d. ×30 m fused silica capillary column (Supelchem, Milano, Italy) coated with SE-54 silicon polymer, operating with suitable temperature programming between 60 and 300 °C and with the injector temperature usually kept at 280 °C. Mass spectra in the EI positive ions mode were obtained with a Finningan 1020 mass spectrometer equipped with a

Table 5. Spectral Data of Compounds **4a**—**c** and **7**

Compound	IR	MS	^{1}H NMR	^{13}C NMR
	cm^{-1}	m/z; rel%	δ	δ
4a	2924s (br), 1707s, 1614m, 1581w, 1523s, 1434m, 1422m, 1352s, 1315w, 1298w, 1287w, 1238s, 1190w, 938w, 862w, 831w, 790m, 752w, 711s, 666m, and 613w.	45 (100), 92 (73), 120 (70), 65 (68), 41 (66), and 181 (M^+, 5).	4.06 (s, 2H, CH_2), 7.36 (dd, 1H, arom, J=7.5 and 1.6 Hz), 7.47 (td, 1H, arom, J=7.6 and 1.6 Hz), 7.60 (td, 1H, arom, J=7.5 and 1.5 Hz), 8.12 (dd, 1H, arom, J=8.0 and 1.5 Hz), and 8.40 (br s, 1H, COOH).	39.40, 125.34. 128.84, 129.12, 133.38, 133.62, 148.76, and 175.37.
4b	3069s (br), 1707s, 1623w, 1525s, 1487w, 1411m, 1400m, 1350s, 1241s, 1207m, 906w, 884w, 808m, 739w, 717m, 665w, and 609w.	41 (100), 136 (62), 181 (M^+, 61), 90 (46), and 89 (34).	3.78 (s, 2H, CH_2), 7.46—7.56 (m, 1H, arom), 7.59—7.66 (m, 1H, arom), 8.10—8.19 (m, 2H, arom), and 11.03 (br s, 1H, COOH).	40.31, 122.50, 124.44, 129.53, 135.04, 135.54, 148.48, and 176.35.
4c	2929s (br), 1700s, 1601m, 1511s, 1431w, 1406m, 1345s, 1307m, 1254s, 1204m, 1108w, 952m, 852m, 821s, 751w, 710s, 658w, and 492w.	181 (M^+, 100), 45 (78), 91 (75), 41 (43), and 77 (41).	3.78 (s, 2H, CH_2), 6.67 (br s, 1H, COOH), 7.47 (sym m, 2H, arom), and 8.20 (sym m, 2H, arom).	40.53, 123.81, 130.40, 140.31, 147.35, and 175.81.
7	3116s (br), 1698s, 1605m, 1538s, 1439m, 1397w, 1352s, 1277m, 1241s, 1199w, 1065w, 909m, 854w, 823w, 730w, 717m, and 655w.	45 (100), 165 (94), 89 (55), 63 (42), 119 (32), and 226 (M^+, 6),	[a]4.27 (s, 2H, CH_2), 7.63 (br s, 1H, COOH), 7.91 (dd, 1H, arom, J=8.5 and 0.4 Hz), 8.54 (dd, 1H, arom, J=8.5 and 2.4 Hz), and 8.85 (d, 1H, arom, J=2.4 Hz).	[a]30.45, 111.95, 119.31, 127.02, 129.04, 139.16, 140.91, and 161.62.

a) Spectrum recorded in $(CD_3)_2CO$; ^{13}C chemical shifts are reported in ppm relative to the center line of the solvent multiplet (20.83).

conventional ion source operating at 70 eV; the five most intense peaks, with bracketed relative intensities, and the parent ion are reported. IR spectra were recorded on a JASCO infrared spectrophotometer model DS-702G using the KBr technique; the peak intensity is designated s (strong), m (medium), or w (weak). ^{1}H and ^{13}C NMR spectra were recorded on a Bruker AC-F spectrometer at 200 and 50 MHz, respectively, in $CDCl_3$ unless otherwise specified. Proton chemical shifts are reported in ppm on the δ scale relative to TMS as an internal reference (0.00). Carbon chemical shifts are reported in ppm relative to the center line of the $CHCl_3$ triplet (77.0). Coupling constants are reported in Hz.

GC quantitative analyses had to be performed with great caution, because we observed that *m*- and *p*-isomers **2b**, **2c**, **3b**, and **3c** were selectively strongly retained by the columns used below certain injected amounts. Beside, therefore, injecting sufficient amounts of the analytes in order to obtain consistent values, a simultaneous quantitative analysis by ^{1}H NMR spectroscopy was performed, where the methylene peaks of the unnitrated substrates **1**, **2**, and **3** and of their *o*-nitro derivatives **1a**, **2a**, and **3a**, as well as those of the 2,4-dinitro derivatives **7**, **8**, and **9**, showed neatly separated locations; the chemical shifts for the *m*- and *p*-derivatives were to be found in a different single location at an intermediate field (Table 5). The two methods finally gave results matching within ±3%. Similar quantitative analytical procedures were used for the determination of the isomeric distribution of mononitration experiments on hydrocarbons.

Synthetic Procedures. Most of the nitration experiments were carried out in a 5.0 mmol and also on a ca. 5 g substrate scale in order to check that no substantial material losses could occur in the work-up procedure. Recoveries better than 90% were obtained in all instances. Quenching of the reaction mixtures was best performed by addition of the chilled (ca. −10 °C) solutions to a well stirred minimal amount of a Na_2SO_4 saturated solution ketp at −10 °C and with additional CH_2Cl_2 included when needed. The organic layer was washed with a saturated Na_2SO_4 solution ($NaHCO_3$ in the case of ester nitrations) to eliminate residual mineral acidity and then was dried over Na_2SO_4. The solvent was carefully evaporated and the weight of the residue recorded.

Stability of Nitration Mixtures. Mixtures of ethyl mononitrobenzeneacetates (**6a**, **6b**, and **6c**) did not undergo changes upon standing in the CH_2Cl_2 nitration mixture and in H_2SO_4 at room temperature during 24 h. Any change of isomer ratio during an experiment was therefore attributed to causes other than isomer interconversions.

Typical Procedure for the Nitrations in H_2SO_4. A solution of 100% HNO_3 (20.0 mmol) in concentrated H_2SO_4 (5.0 mL) was added in one lot at room temperature to a stirred solution of methyl benzeneacetate (**2**, 16.0 mmol) in H_2SO_4 (6.5 mL). After 1 min a quenched aliquot was monitored by GC-MS and found not to contain the original substrate anymore: The only products were the mononitro and dinitro derivatives; hydrolyses and oxidations did not take place. The mixture showed the same composition

after 1 d standing at room temperature. The *p*-isomer **5c** (essay: 85%) could be separated by vacuum distillation (bp 66 °C/13 Pa) and obtained pure either by spontaneous crystallization or by recrystallization from hexane/$CHCl_3$ (mp 53 °C).

Typical Procedure for Nitrations in CH_2Cl_2. To a solution of **1** (50.0 mmol) in CH_2Cl_2 (120 mL), HNO_3 (227.0 mmol) in CH_2Cl_2 (50 mL) was added in one lot under efficient magnetic stirring, at room temperature with full protection from external moisture. After 24 h (100% conversion into mononitro derivatives), the obtained clear solution, chilled to ca. −10 °C, was cautiously poured onto chilled aqueous Na_2SO_4, the separated organic layer was dried over Na_2SO_4 analyzed by GC and concentrated to dryness. The *o*-isomer **4a** could be obtained by fractional crystallization from *t*-butyl methyl ether–hexane (yield: 38%, mp 140 °C). No optimization of conditions was attempted. Experiments were also carried out using less solvent. A solution of 100% HNO_3 (25.0 mmol) in CH_2Cl_2 (1.0 mL) was added in one lot at 0 °C to a solution of the chosen substrate (5.0 mmol) in CH_2Cl_2 (1.0 mL). Other experiments were carried out in much more diluted conditions. A solution of 100% HNO_3 (50 mmol) in CH_2Cl_2 (7.5 mL) was added at room temperature to the chosen substrate (5.0 mmol) in CH_2Cl_2 (25 mL). Renitration of the *o*-nitro acid **4a** in CH_2Cl_2 according to the standard procedure did not yield dinitration products after 24 h.

Esterification of 1a, b, and c with MeOH or EtOH. A mixture of the mononitrobenzeneacetic acids could be quantitatively transformed into the corresponding methyl (**2a**, **b**, and **c**) or ethyl (**3a**, **b**, and **c**) esters by refluxing their alcoholic solutions during 5 h in the presence of catalytic amounts of H_2SO_4.[15]

Competitive Experiments. Competitive experiments were carried out between **1**, **2**, and **3** taken as the pairs **1**—**3** and **2**—**3** in H_2SO_4 and CH_2Cl_2. A solution of 100% HNO_3 (5.5 mmol) in H_2SO_4 (7.5 mL) was added at 0 °C to a stirred solution of 5.0 mmol of each substrate in H_2SO_4 (25 mL). After 1 h, the reaction mixture was analyzed by GC-MS and ^{1}H NMR (Table 2). The competition experiment between **1** and **3** in CH_2Cl_2 was done as described above (more diluted system, monitoring as usual, results in Table 2). Equimolar (0.3 mmol) amounts of **1** and toluene were made to react with fuming HNO_3 (1.2 mmol) in CH_2Cl_2 (16 mL) at room temperature during 24 h; the reaction mixture was analyzed by GC. The following products were detected (bracketed values are the relative yields of the three mononitro derivatives from **1** and toluene): **1a** 3.6% (69%), **1b** 0.5% (10%), **1c** 1.1% (21%), *o*-nitrotoluene 18% (57%), *m*-nitrotoluene 0.8% (2%), and *p*-nitrotoluene 13% (41%). No dinitration products were formed.

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