Substituent effects on the formation of benzyl ions from *ortho*-methoxy substituted 1,1-diarylalkanes under electron ionization: correlations between the abundance of the process and the ^{13}C-NMR chemical shifts of the neutral precursors

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Dedicated to Professor Domenico Spinelli on his 70th birthday
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Abstract
Good linear relationships have been obtained between the abundance of the formation process of benzyl ions from *ortho*-methoxy- substituted 1,1-diarylalkanes, through consecutive rearrangement reactions induced by electron ionization, and ^{13}C- NMR chemical shift values of C-1 of the *ortho*-methoxy- substituted aromatic ring of the neutral precursors for a large number of compounds: 1,1-diphenylethanes **1–19**, 2-methyl-1,1-diphenylpropanes **20–37**, and 1,1,1-trichloro-2,2-diphenylethanes **38–44**. This result is satisfying as good linear relationships between the ion abundances in the mass spectrum and the substituent effects are not easily obtained. Further, the abundance of the process depends on the effects of substituents linked to the *ortho*-methoxy- substituted benzene ring (ring A) while measurable effects of substituents linked to the other benzene ring (ring B) have not been observed.

Keywords: 1,1-diarylalkanes, electron ionization, rearrangement processes, substituent effects, ^{13}C NMR Chemical Shifts, cross-correlations

Introduction

It has been reported[1] that the electron ionization (EI) mass spectra (MS) of 1,1-diphenylalkanes bearing an *ortho*-methoxy group are characterized by the presence of abundant benzyl (or tropylium) ions, which are completely absent in derivatives lacking the *ortho*- methoxy

substituent. In fact, the EI/MS of such *ortho*-substituted compounds are dominated by the molecular ion ($\mathbf{M}^{+\bullet}$), the diphenylmethyl cation **a** (arising from loss of the alkyl group linked to the benzyl carbon, as a radical)**,** and the benzyl ion **b**, as can be seen in the 70 eV EI/MS of 2-methoxy-1,1-diphenylethane (**1**) (Figure 1).

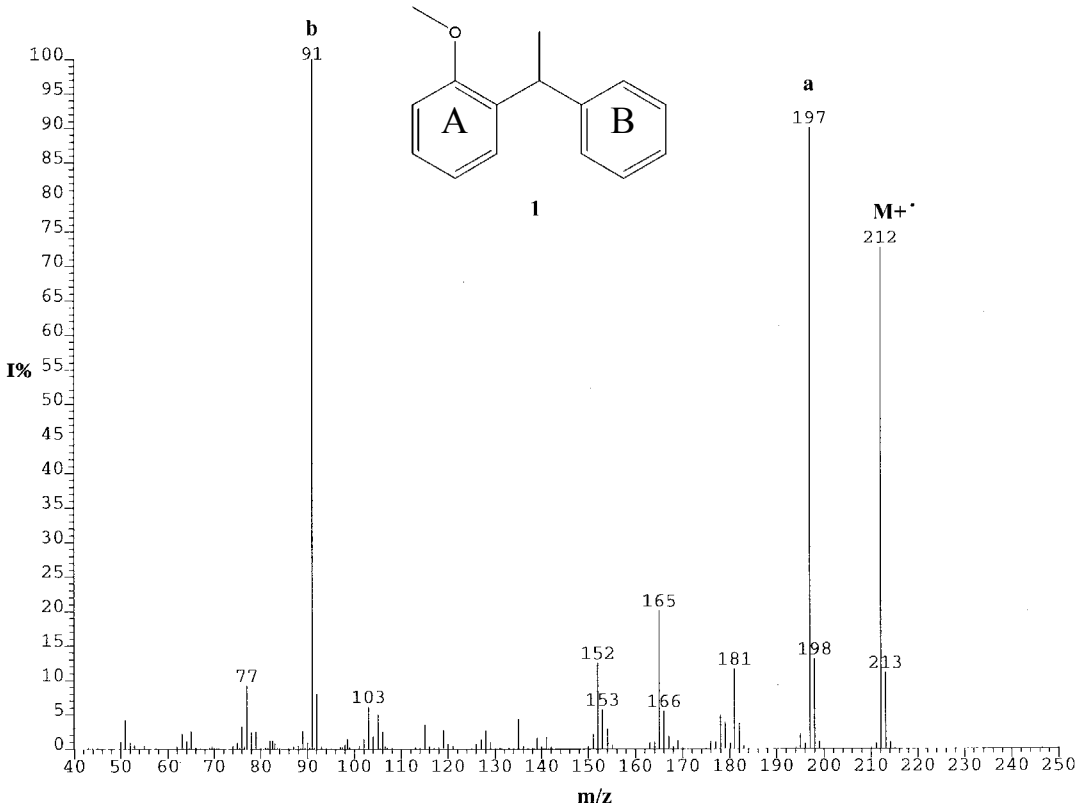
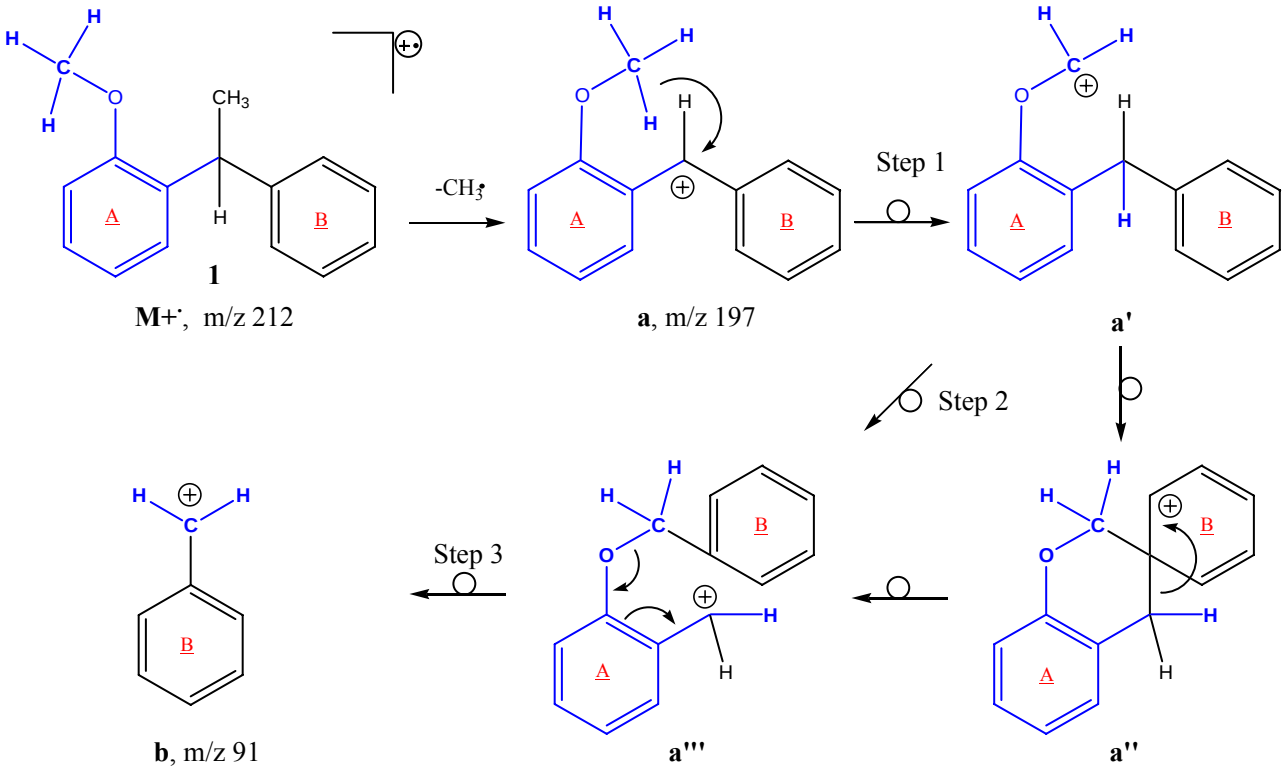


Figure 1. 70 eV EI/MS of 2-methoxy-1,1-diphenylethane (**1**).

The presence of abundant metastable ions generated in the first field-free region, as well as the presence of the appropriate peaks in mass analyzed ion kinetic energy (MIKE)- or linked scan (B/E = constant, B^2/E = constant) spectra, indicates the ion **a** as the precursor of the ion **b**.[2,3] It has been unequivocally demonstrated by experiments with ^{2}H- and ^{13}C-labeled compounds that the whole process of benzyl ion formation involves migration of the methylene residue of the methoxy group linked to the 2-position of an aromatic ring (ring A) to the other aromatic ring (ring B).[1–4] Further investigation revealed that such a reaction occurs also for *ortho*-alkoxy derivatives (OEt, O*i*Pr) by migration of an alkylidene residue other than methylene, as well as for *ortho*-alkyl-hetero (NHMe, NMe_2, SMe) 1,1-diarylalkanes.[4] Finally, it has been determined that the formation of the benzyl- (or tropylium) ions **b** constitutes the main unimolecular decomposition reaction of *ortho*-alkylhetero- substituted diaryl- or alkyldiaryl- or triaryl- methyl cations, **a**, generated either under electron ionization[5] or chemical ionization conditions.[6]

This previously unreported formation of benzyl ions from diphenylmethane derivatives[7] through skeletal rearrangement induced by proximity effects is therefore to be considered an important general fragmentation reaction of the cations **a** occurring over a wide range of internal energy. From a mechanistic point of view it has been suggested [1,4] that the formation of the ion **b** involves consecutive rearrangements (steps 1 and 2) of *ortho*-methoxy diphenylmethyl cations **a**, followed by a simple cleavage reaction (step 3) as shown in Scheme 1 for compound **1**.



Scheme 1

In particular, a hydrogen migration as hydride from the α-position of the ortho-methoxy group to the carbenium center affords the rearrangement ion **a'** (Step 1). This latter undergoes a further rearrangement to **a'''** by electrophilic attack of the charged alkylidene (Step 2), probably through a six-membered transition state (**a''**), followed by a carbon–carbon displacement reaction. Finally, the benzylic cleavage of ion **a'''** gives the rearrangement benzyl ion **b**.

The small kinetic energy release values, calculated from the width of the peak at half-height ($T_{1/2}$) in the MIKE spectra for the **a** ➔ **b** process, agree with a last step involving a simple cleavage reaction.[2] The isotopic effect indicates that the hydrogen migration affording the rearrangement ion **a'** is the rate- determining process, and the close values in 70 eV- (k_H/k_D = 1.4),[1,3] and in MIKE- (k_H/k_D = 1.6),[2] spectra agree with a loose transition state for the hydrogen migration.[8]

An appropriate geometry of the transition state that should account for the hydride migration involves the ring A being perpendicular to the sp^2 system of the charged benzyl carbon, with the methyl of the *ortho*-alkylhetero group oriented toward the carbenium center.[2]

In order to achieve detailed mechanistic insight and information on the arrangement of the transition state related to the process involving the hydrogen migration, the determination of substituent effects on the abundance of the benzyl ion formation process could be used as a valuable tool. Hence, in this work we correlate the substituent effects with the values of the ratio **Z** between the abundance of the benzyl ion **b** and the sum of the abundances of the benzyl ion **b** with that of its precursor ion **a** [$\mathbf{Z} = I_b\%/(I_a\% + I_b\%)$]. The ratio **Z** is, in good approximation, a measure of the fraction of ions **a** reacting to form ions **b**. It has been proved previously that **Z** is a valuable quantitative parameter for correlating the abundance of the process with the degree-of-freedom effect, as well as with the approximate activation energy.[2]

Results and Discussion

As our starting point, we compared the **Z%** value of the 2-methoxy-1,1-diphenylethane (**1**) with those of derivatives **2–11** characterized by an unsubstituted ring B and bearing substituents at the 4- and/or 5-position in the ring A (Table 1).

The EI/MS (see Experimental Section) of the compounds **1–11** are dominated by the peaks corresponding to the molecular ion $\mathbf{M}^{+\cdot}$, the ion **a**, and the rearrangement benzyl ion, **b** (*m/z* 91).

Analysis of the 5-substituted derivatives **2–5** shows a **Z%** = 57 for the 5-methyl-derivative **2**, very close to that of **1** (**Z%** = 53), which agrees with the poor electronic effects of the methyl group. A significant small increase of **Z%** with respect to **1** is observed for the 5-methoxy derivative **3** (**Z%** = 63), the 5-nitro derivative **4** (**Z%** = 64) and the 5-bromo derivative **5** (**Z%** = 62). These substituents linked at the 5-position exert a small electron-withdrawing effect with respect to the *meta*- positions (C-1 and C-3).

Similarly, the poor effect of a methyl group linked to the 4-position is evidenced by the value of **Z%** = 55 for the 4-methyl derivative **6**. On the contrary, a relevant reduction in **Z%** is achieved by the presence of strong *para*- electron-donating groups linked at the 4-position of the ring A, as observed for the 4-methoxy derivative **7** (**Z%** = 34), the 4-amino-5-methoxy derivative **8** (**Z%** = 20), the 4-*N*-methylamino-5-methoxy derivative **9** (**Z%** = 11), and the 4-*N*,*N*-dimethylamino-5-methoxy derivative **10** (**Z%** = 17). Finally, the biggest Z**%** value is observed for 5-methoxy-4-nitro-1,1-diphenylethane (**11**) (**Z%** = 89).

All these findings revealed a meaningful dependence of **Z%** on the substituents of the ring A. In particular, the substituents which exert an electron-withdrawing effect on C-1 increase the abundance of the process, while strong electron-donating groups produce a dramatic decrease in **Z%**. In fact, the lower is the electron density on C-1 of the ring A of the ion **a** is, the higher is the fraction of ions **a** affording ions **b**.

In addition to such a qualitative approach, it seemed of interest to verify whether linear relationships occur with the electronic effects of the substituents. However, the use of electronic constants in our substrates, which are characterized by the presence of several substituents, could be strongly affected by severe limitations owing to the occurrence of *ortho*- interactions, which are not easily evaluated, *a priori*.

The ^{13}C NMR chemical shift constitutes a physical parameter related to the electronic density of the carbon atoms.[9] However, NMR experiments on the diaryl cations **a** are complicated by the difficulty of generating them in the solution phase. In fact, this should involve the use of superacids on the appropriate precursors, and low temperature experiments.[10] Hence, the reasonable assumption that a substituent could play a role in the same direction either in ions **a** or in their neutral precursors prompted us to correlate the ^{13}C NMR chemical shift values (used as electronic parameters) of the neutral precursors, the 2-methoxy-1,1-diphenylethanes, with **Z%**. This approach has been applied successfully in the study of the reactivity of carbanions in solution.[11]

Then, taking the chemical shift value of C-1 carbon atom of the ring A for **1** as reference, a correlation between the substituent- induced chemical shift variations (**cs**) for compounds **1–11** (Table 1) and the **Z%** values was carried out.

The results shown in Figure 3 show that a good linear correlation (*s* 3.67 ± 0.21, *i* 57.59 ± 1.40, *n* 11, *r* 0.986) has been obtained.

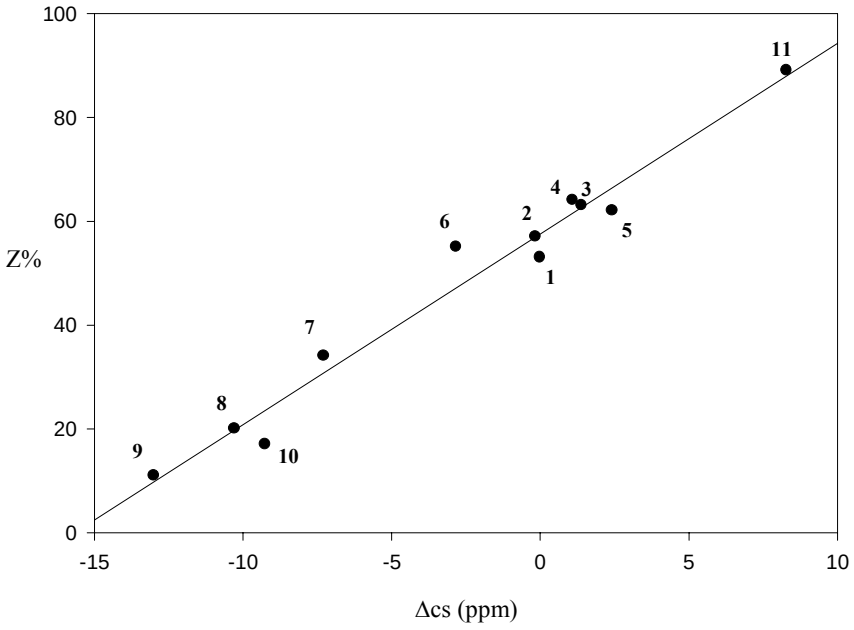


Figure 3. Plot of Z% values *vs.* □cs (C-1) of compounds **1–11**. Refer to Table 1 for the values.

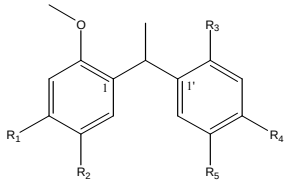
Once the close dependence of the process on the electronic density of C-1 has been asserted, it seemed of interest to verify a possible influence of substitutions at the ring B. Comparison of the **Z%** value of the 4'-methoxy derivative **12** (Table 1) with that of **1** shows that the presence of the 4'-methoxy group in the ring B does not produce significant change (**Z%** = 57). Similarly, the introduction of the 4'-nitro group into the structure **11**, *i.e*., compound **13**, leads to a value of **Z%** = 87, practically identical to the **Z%** value of **11**. Incidentally, the 70 eV EI/MS of the dimethoxy-$^2H_6$ isotopomer, **13-d$_6$**, gives evidence of an isotopic effect, calculated by the ratio of I% of *m/z* 136 (ion **b** for **13**)/ I% of *m/z* 138 (ion **b** for **13-d$_6$**), K_H/K_D = 1.5, very close to that previously determined for other derivatives[1,3] lacking electron-withdrawing substituents on the ring B. This means that the hydride migration step 1 (Scheme 1) constitutes the rate-determining reaction also in the presence of a *para*-nitro group in the ring B, which should enhance the activation energy of the electrophilic substitution involved in Step 2.

Furthermore, good linear relationships between **Z%** and **cs** of C-1 for all **1–11**, together with the polysubstituted compounds **12–19**, have been obtained (*s* 3.74 ± 0.25, *i* 60.84 ± 1.50, *n* 19, *r* 0.963). The substantial absence of effects of the substituents linked to the ring B on the abundance of the process was also stressed by the lack of any correlation between **Z%** and the ^{13}C-NMR chemical shift values of C-1′ of the ring B.

Finally in this context, we extended our investigation to substrates with complex substitution patterns, namely the *ortho*-methoxy 2-methyl-1,1-diphenylpropanes **20–37** (Table 2) and *ortho*-methoxy-1,1,1-trichloro-2,2-diphenylethanes, **38–44** (Table 3), which generate ions **a** by loss of isopropyl and trichloromethyl radicals, respectively, from the molecular ion. In order to calculate the **Δcs** values of C-1, the compounds **20** and **38** have been used as references for the **20**–**37** and **38–44** series, respectively.

Satisfactory linear relationships have also been obtained for both series, **20–37** (*s* 2.33 ± 0.20, *i* 53.14 ± 1.05, *n* 18, *r* 0.947), and **38–44** (*s* 2.87 ± 0.49, *i* 49.78 ± 2.31, *n* 7, *r* 0.935).

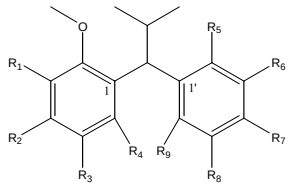
Table 1. ^{13}C- NMR data[a] and Z%[b] of **1–19**



Compd.	R_1	R_2	R_3	R_4	R_5	C-1	C-1'	□cs (C-1)	Z%
1	H	H	H	H	H	134.76	146.28	0.00	53
2	H	Me	H	H	H	134.61	146.41	-0.15	57
3	H	OMe	H	H	H	136.16	145.97	1.40	63
4	H	NO_2	H	H	H	135.86	144.63	1.10	64
5	H	Br	H	H	H	137.19	145.44	2.43	62
6	Me	H	H	H	H	131.94	146.57	-2.82	55
7	OMe	H	H	H	H	127.48	146.72	-7.28	34
8	NH_2	OMe	H	H	H	124.48	146.97	-10.28	20
9	NHMe	OMe	H	H	H	121.77	147.13	-12.99	11
10	NMe_2	OMe	H	H	H	125.51	146.49	-9.25	17
11	NO_2	OMe	H	H	H	143.06	144.27	8.30	89
12	H	H	H	OMe	H	135.22	138.45	0.46	57
13	NO_2	OMe	H	NO_2	H	140.47	152.25	5.71	87
14	H	H	Cl	OMe	H	133.90	135.79	-0.86	66
15	H	H	Br	OMe	H	133.92	137.45	-0.84	68
16	H	H	OMe	H	H	134.84	134.84	0.08	67
17	OMe	H	H	OMe	H	128.02	138.84	-6.74	38
18	OMe	H	OMe	OMe	H	127.49	127.49	-7.27	42
19	OMe	Br	OMe	OMe	Br	128.53	128.53	-6.23	37

[a] Chemical shift values for C-1 are in ppm; Δcs(C-1) values are calculated as differences between δ(C-1) of each compound and δ(C-1) of compound 1. [b] Z% are calculated as I_b%/(I_a% + I_b%) per cent.

Table 2. ^{13}C NMR data[a] and Z%[b] of **20–37**



Comp.	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	C-1	□cs (C-1)	Z%
20	H	H	H	H	H	OMe	OMe	H	H	133.42	0.00	56
21	H	OMe	H	H	OMe	H	OMe	H	H	126.00	-7.42	36
22	H	OMe	H	H	H	OMe	OMe	H	H	126.00	-7.42	35
23	H	H	OMe	H	OMe	H	H	OMe	H	134.58	1.16	60
24	H	H	OMe	H	H	OMe	OMe	H	H	135.02	1.60	49
25	OMe	H	H	H	H	OMe	OMe	H	H	138.95	5.53	66
26	OMe	OMe	H	H	H	OMe	OMe	H	H	131.28	-2.14	43
27	H	OMe	OMe	H	H	OMe	OMe	H	H	125.00	-8.42	35
28	H	H	Me	H	OMe	H	H	Me	H	133.11	-0.31	58
29	H	H	Me	H	H	OMe	OMe	H	H	133.14	-0.28	45
30	H	Br	OMe	H	OMe	H	Br	OMe	H	132.75	-0.70	47
31	H	OMe	Br	H	OMe	H	OMe	Br	H	126.65	-6.77	36
32	Br	Br	OMe	H	OMe	Br	Br	OMe	H	137.03	3.61	60
33	Br	OMe	Br	H	H	OMe	OMe	Br	Br	135.36	1.94	60
34	OMe	H	Br	Br	H	OMe	OMe	Br	Br	137.20	3.78	63
35	H	OMe	H	Cl	H	OMe	OMe	H	H	123.96	-9.46	34
36	H	NO_2	OMe	H	OMe	H	NO_2	OMe	H	138.81	5.39	72
37	H	OMe	NO_2	H	OMe	H	OMe	NO_2	H	123.96	-9.46	33

[a] Chemical shift values for C-1 are in ppm; Δcs(C-1) values are calculated as differences between δ(C-1) of each compound and δ(C-1) of compound 20. [b] Z% are calculated as $I_b\%/(I_a\% + I_b\%)$ per cent.

Conclusions

The choice of the ^{13}C-NMR chemical shift values of C-1 of the ring A of the neutral precursor of the benzyl ions **b**, formed by consecutive rearrangements of the diarylmethyl cations **a**, leads to good linear relationships with the fraction of ions **a** affording the ions **b**, measured by the ratio **Z%**, for a large number of compounds.

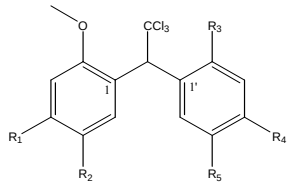
This result is quite satisfying, as good linear relationships between the ion abundances in the mass spectrum and the substituent constants are not easily obtained. In fact, this approach does

suffer severe limitations owing to: (i) the fact that the ion abundances in the mass spectrum results from competitive and consecutive reactions of precursors with a relatively large range of internal energy; (ii) there is the possible occurrence of isolated electronic states, not easily predictable *a priori* and, (iii), there is the degree-of-freedom effect on the fragment-ion abundances.[8]

Further, our findings give evidence that the abundance of the formation process of benzyl ions **b** depends on the effects of substituents linked to the *ortho*-methoxy- substituted benzene ring (ring A). In particular, the lower is the electron density of C-1 of the ring A of the neutral precursor, the higher is the fraction of ion **a** which give benzylic ion **b**. On the other hand, measurable effects of substituents linked to the other benzene ring (ring B) have not been observed.

Finally, it seems possible to estimate the ion-abundances in the EI/MS of *ortho*-alkylhetero-substituted 1,1-diarylalkanes by means of a unique parameter which reflects the overall effects of the substituents, that is, the C-1 ^{13}C NMR value of the neutral precursor.

Table 3. ^{13}C NMR data[a] and Z%[b] of **38–44**



Comp.	R_1	R_2	R_3	R_4	R_5	C-1	□cs(C-1)	Z%
38	H	H	H	OMe	H	127.76	0.00	56
39	H	OMe	OMe	H	OMe	126.33	0.57	56
40	OMe	H	OMe	OMe	H	120.36	-7.40	29
41	H	Me	OMe	H	Me	127.22	-0.54	52
42	OMe	OMe	OMe	OMe	OMe	118.97	-8.79	22
43	Br	OMe	OMe	Br	OMe	126.81	-0.95	40
44	NO_2	OMe	OMe	NO_2	OMe	132.53	4.77	58

[a] Chemical shift values for C-1 and C-1' are in ppm; Δcs(C-1) values are calculated as differences between δ(C-1) of each compound and δ(C-1) of compound **38**. [b] Z% are calculated as I_b%/(I_a% + I_b%) per cent.

Experimental Section

General Procedures. Melting points were measured on a Büchi 510 melting point apparatus and are uncorrected.[1]H- and ^{13}C- NMR spectra were recorded on a Bruker AC 250 spectrometer in deuteriochloroform solutions. ^{13}C- NMR chemical shifts (in ppm) are given from $CDCl_3$ (77.00) and were taken from fully decoupled spectra. The carbon signals were assigned on the basis of known substituent effects and, when necessary, multiplicities were also determined by proton gated decoupled experiments. For compounds **1–15**, **17**, **20**, **22**, **24**–**27**, **29**, **33**, **34**, **35** and **38** the C′ symbol refers to carbon atoms of ring B.

Low resolution (LR) - and high resolution (HR) - mass spectra were recorded by the Autospec Ultima o-TOF (Micromass, U.K.) mass spectrometer connected with a GC system HP 6890 series (Hewlett Packard) of the "Rete di Spettrometria di Massa-CNR" operating in the Dipartimento di Chimica e Tecnologie Farmaceutiche-Palermo. LRMS were performed under the following experimental conditions: electron beam energy, 70 eV; source temperature 220 °C; trap current 250 μA; accelerating voltage 8 kV; resolution power 1,500. Even though the analyzed samples **1–44** were pure by TLC, in order to avoid possible interference peaks, they were introduced into the ion source through the GC system. The GC conditions were: injector temperature 250 °C; column AT^{TM-5} (from Alltech), film thickness 0.25 μm, length 30 m, ID 0.25 mm, carrier gas (helium) flow 1.0 mL/min, Ramp 100 °C (3 min), 100–300 °C (10 °C/min), 300 °C (7 min). Better reproducibility of the ion intensities was achieved by averaging the spectra from the initial half-height to the end half-height of the GC peak (3–5 scans averaged for each analysis) with background subtraction. The values of **Z%** were reproducible (± 2). The **Z%** values reported in Tables 1–3 and the ion abundances (with respect to the base peak) of the partial mass spectra (**M$^{+\cdot}$,** ion **a,** ion **b**, which are responsible of the most abundant peaks in the MS) of compounds **1–44** refer to the mean of three independent analyses for each sample.

The elemental composition of compounds has been confirmed by HRMS measurements, with resolving power of 5,000 (10% resolution valley definition) using PFK as internal standard. All the values found were within ±10 ppm of the calculated ones.

IR spectra were obtained with a Perkin-Elmer Model 1310 IR spectrophotometer.

All commercial products were from Aldrich. Silica gel 60 (Merck, 0.06–0.2 mm) was used for column chromatography. Analytical- and [1]H- NMR data confirmed the assigned structures for all synthesized compounds.

Compounds **1**,[3] **18**, **19**, **30–33**, [12] **20–25**, **27**,[1] **36, 37** [13] were synthesized according to reported methods. For these compounds we report the ^{13}C NMR chemical shift values, not previously reported. Syntheses and ^{13}C NMR chemical shift values for compounds **38–42** have been reported previously.[11] For these compounds we report only the partial mass spectra (**M$^{+\cdot}$**, ion **a**, and ion **b**).

1-(2-Methoxyphenyl)-1-phenylethane (1). ^{13}C NMR: 20.83 (CH*C*H$_3$), 37.33 (*C*HCH$_3$), 55.19 (OCH$_3$), 110.45 (C-3), 120.42 (C-5), 125.59 (C-4'), 126.97 (C-4), 127.55 (C-6), 127.62 (C-2',6'), 128.00 (C-3',5'), 134.76 (C-1), 146.28 (C-1'), 156.71 (C-2). EI/MS, *m/z* (I%): 212 (72.78) $\mathbf{M}^{+\bullet}$; 197 (90.10) **a**; 91 (100.00) **b**.

1,1-Bis(2,4-dimethoxyphenyl)-ethane (18). ^{13}C NMR: 20.25 (CH*C*H$_3$), 30.32 (*C*HCH$_3$), 55.02 (OCH$_3$), 55.33 (OCH$_3$), 98.61 (2 C-3), 103.60 (2 C-5), 127.49 (2 C-1), 127.92 (2 C-6), 157.88 (2 C-2), 158.92 (2 C-4). EI/MS, *m/z* (I%): 302 (37.25) $\mathbf{M}^{+\bullet}$; 287 (100.00) **a**; 151 (72.17) **b**.

1,1-Bis(5-bromo-2,4-dimethoxyphenyl)-ethane (19). ^{13}C NMR: 19.81 (CH*C*H$_3$), 30.95 (*C*HCH$_3$), 55.99 (OCH3), 56.47 (OCH$_3$), 97.43 (2 C-3), 101.91 (2 C-5), 128.53 (2 C-1), 131.69 (2 C-6), 154.91 (2 C-4), 157.30 (2 C-2). EI/MS, *m/z* (I%): [458 (30.58), 460 (60.44), 462 (31.30)] $\mathbf{M}^{+\bullet}$; [443 (51.59), 445 (100.00), 447 (51.06)] **a**; [229 (60.76), 231 (57.56)] **b**.

1-(2-Methoxyphenyl)-1-(3,4-dimethoxyphenyl)-2-methylpropane (20). ^{13}C NMR: 21.55 (CH*C*H$_3$), 21.96 (CH*C*H$_3$), 31.37 [*C*H(CH$_3$)$_2$], 51.13 [*C*HCH(CH$_3$)$_2$], 55.26 (OCH$_3$), 55.62 (OCH$_3$), 55.68 (OCH$_3$), 110.78 (C-3), 110.99 (C-5'), 111.97 (C-2'), 120.24 (C-6'), 120.56 (C-5), 126.65 (C-4), 127.37 (C-6), 133.42 (C-1), 137.65 (C-1'), 146.97 (C-4'), 148.49 (C-3'), 157.01 (C-2). EI/MS, *m/z* (I%): 300 (20.48) $\mathbf{M}^{+\bullet}$; 257 (78.57) **a**; 151 (100.00) **b**.

1,1-Bis(2,4-dimethoxyphenyl)-2-methylpropane (21). ^{13}C NMR: 21.61 (CH*C*H$_3$), 31.08 [*C*H(CH$_3$)$_2$], 43.67 [*C*HCH(CH$_3$)$_2$], 55.37 (2 OCH$_3$), 55.45 (2 OCH$_3$), 98.59 (2 C-3), 103.99 (2 C-5), 126.00 (2 C-1), 129.04 (2 C-6), 158.47 (2 C-4), 158.50 (2 C-2). EI/MS, *m/z* (I%): 330 (13.61) $\mathbf{M}^{+\bullet}$; 287 (100.00) **a**; 151 (56.90) **b**.

1-(2,4-Dimethoxyphenyl)-1-(3,4-dimethoxyphenyl)-2-methylpropane (22). ^{13}C NMR: 21.58 (CH*C*H$_3$), 22.03 (CH*C*H$_3$), 31.47 [*C*H(CH$_3$)$_2$], 50.82 [*C*HCH(CH$_3$)$_2$], 55.00 (OCH$_3$), 55.28 (OCH$_3$), 55.66 (OCH$_3$), 55.70 (OCH$_3$), 98.55 (C-3), 104.38 (C-5), 111.09 (C-5'), 111.89 (C-2'), 120.13 (C-6'), 126.00 (C-1), 127.82 (C-6), 138.11 (C-1'), 146.91 (C-4'), 148.51 (C-3'), 157.95 (C-2), 158.73 (C-4). EI/MS, *m/z* (I%): 330 (8.80) $\mathbf{M}^{+\bullet}$; 287 (100.00) **a**; 151 (55.05) **b**.

1,1-Bis(2,5-dimethoxyphenyl)-2-methylpropane (23). ^{13}C NMR: 21.55 [CH(*C*H$_3$)$_2$], 31.12 [*C*H(CH$_3$)$_2$], 45.28 [*C*HCH(CH$_3$)$_2$], 55.59 (2 OCH$_3$), 56.47 (2 OCH$_3$), 110.57 (2 C-4), 112.26 (2 C-3), 115.79 (2 C-6), 134.58 (2 C-1), 152.31 (2 C-2) 153.67 (2 C-5). EI/MS, *m/z* (I%): 330 (32.18) $\mathbf{M}^{+\bullet}$; 287 (66.28) **a**; 151 (100.00) **b**.

1-(2,5-Dimethoxyphenyl)-1-(3,4-dimethoxyphenyl)-2-methylpropane (24). ^{13}C NMR: 21.48 (CH*C*H$_3$), 21.63 (CH*C*H$_3$), 31.40 [*C*H(CH$_3$)$_2$], 51.23 [*C*HCH(CH$_3$)$_2$], 55.54 (OCH$_3$), 55.73 (OCH$_3$), 55.76 (OCH$_3$), 56.23 (OCH$_3$), 110.07 (C-4), 110.95 (C-5'), 111.90 (C-3 and C-2'), 114.46 (C-6), 120.14 (C-6'), 135.02 (C-1), 137.43 (C-1'), 146.97 (C-4'), 148.45 (C-3'), 151.53 (C-2), 153.65 (C-5). EI/MS, *m/z* (I%): 330 (40.82) $\mathbf{M}^{+\bullet}$; 287 (100.00) **a**; 151 (94.90) **b**.

1-(2,3-Dimethoxyphenyl)-1-(3,4-dimethoxyphenyl)-2-methylpropane (25). ^{13}C NMR: 21.82 (CH*C*H$_3$), 21.88 (CH*C*H$_3$), 31.77 [*C*H(CH$_3$)$_2$], 51.20 [*C*HCH(CH$_3$)$_2$], 55.52 (OCH$_3$), 55.79 (2 OCH$_3$), 60.57 (OCH$_3$ at C-2), 109.56 (C-4), 111.00 (C-5'), 111.86 (C-2'), 119.24 (C-6), 120.12 (C-6'), 123.90 (C-5), 137.67 (C-1'), 138.95 (C-1), 146.85 (C-2), 147.02 (C-4'), 148.53 (C-3'), 152.73 (C-3). EI/MS, *m/z* (I%): 330 (36.73) $\mathbf{M}^{+\bullet}$; 287 (52.19) **a**; 151 (100.00) **b**.

1-(2,4,5-Trimethoxyphenyl)-1-(3,4-dimethoxyphenyl)-2-methylpropane (27). ^{13}C NMR: 21.14 (CH*C*H$_3$), 21.53 (CH*C*H$_3$), 31.09 [*C*H(CH$_3$)$_2$], 50.47 [*C*HCH(CH$_3$)$_2$], 55.33 (OCH$_3$), 55.36 (OCH$_3$), 55.58 (OCH$_3$), 56.24(OCH$_3$), 56.51 (OCH$_3$), 97.87 (C-3), 110.69 (C-5'), 111.44 (C-2'), 111.87 (C-6), 119.61 (C-6'), 125.00 (C-1), 137.52 (C-1'), 142.84 (C-5), 146.60 (C-4), 147.28 (C-4'), 148.16 (C-3'), 151.07 (C-2'). EI/MS, *m/z* (I%): 360 (30.61) **M**$^{+\bullet}$; 317 (100.00) **a**; 151 (55.80) **b**.

1,1-bis(4-Bromo-2,5-dimethoxyphenyl)-2-methylpropane (30). ^{13}C NMR: 21.57 CH(*C*H$_3$)$_2$, 30.26 [*C*H(CH$_3$)$_2$], 47.06 [*C*HCH(CH$_3$)$_3$], 56.36 (2 OCH$_3$), 57.15 (2 OCH$_3$), 109.11 (2 C-4), 114.34 (2 C-6), 116.59 (2 C-3), 132.75 (2 C-1), 150.14 (2 C-5), 152.42 (2 C-2). EI/MS, *m/z* (I%): [486 (15.48), 488 (30.25), 490 (15.17)] **M**$^{+\bullet}$; [443 (53.10), 445 (100.00), 447 (54.21)] **a**; [229 (94.70), 231 (92.81)] **b**.

1,1-bis(5-Bromo-2,4-dimethoxyphenyl)-2-methylpropane (31). ^{13}C NMR: 21.48 (CH*C*H$_3$)$_2$, 30.13 [*C*H(CH$_3$)$_2$], 45.12 [*C*HCH(CH$_3$)$_2$], 55.87 (2 OCH$_3$), 56.29 (2 OCH$_3$), 97.23 (2 C-3), 101.79 (2 C-5), 126.65 (2 C-1) 132.90 (2 C-6), 154.53 (2 C-4), 157.76 (2 C-2). EI/MS, *m/z* (I%): [486 (39.35), 488 (74.10), 490 (39.02)] **M**$^{+\bullet}$; [443 (55.07), 445 (100.00), 447 (54.36)] **a**; [229 (60.37), 231 (58.09)] **b**.

1,1-Bis(3,4-dibromo-2,5-dimethoxyphenyl)-2-methylpropane (32). ^{13}C NMR: 21.59 (CH*C*H$_3$)$_2$, 32.78 [*C*H(CH$_3$)$_2$], 46.44 [*C*HCH(CH$_3$)$_2$], 57.03 [2 (OCH$_3$ at C–5)], 61.12 [2 (OCH$_3$ at C-2)], 110.89 (2 C-6), 114.21 (2 C-4), 122.48 (2 C-3) 137.03 (2 C-1), 150.87 (2 C-2), 153.65 (2 C-5). EI/MS, *m/z* (I%): [642 (5.41), 644 (22.04), 646 (33.00), 648 (21.65), 650 (5.38)] **M**$^{+\bullet}$; [599 (9.88), 601 (34.07), 603 (49.25), 605 (33.65), 607 (9.21)] **a**; [307 (52.04), 309 (100.00), 311 (50.65)] **b**.

1-(3,5-Dibromo-2,4-dimethoxyphenyl)-1-(2,3-dibromo-4,5-dimethoxyphenyl)-2-methylpropane (33). ^{13}C NMR: 20.21 (CH*C*H$_3$), 21.78 (CH*C*H$_3$), 33.04 [*C*H(CH$_3$)$_2$], 51.71 [*C*HCH(CH$_3$)$_2$], 56.04 (OCH$_3$ at C-5'), 60.36 (OCH$_3$), 60.54 (OCH$_3$), 60.99 (OCH$_3$),111.75 (C-6'), 112.42 (C-5), 114.68 (C-3), 118.99 (C-2'), 121.83 (C-3'), 130.41 (C-6), 135.36 (C-1), 140.06 (C-1'), 145.97 (C-4'), 152.40 (C-5'), 153.52 (C-4), 156.67 (C-2). EI/MS, *m/z* (I%): [642 (6.08), 644 (22.36), 646 (32.00), 648 (21.64), 650 (6.10)] **M**$^{+\bullet}$; [599 (8.27), 601 (33.84), 603 (52.04), 605 (33.30), 607 (7.81)] **a**; [307 (52.67), 309 (100.00), 311 (50.84)] **b**.

1,1-Bis(2,5-dimethoxy-4-nitrophenyl)-2-methylpropane (36). ^{13}C NMR: 21.43 [CH(*C*H$_3$)$_2$], 30.01 [*C*H(CH$_3$)$_2$], 48.30 [*C*HCH(CH$_3$)$_2$], 56.34 (2 OCH$_3$) 57.58 (2 OCH$_3$), 108.30 (2 C-3), 116.54 (2 C-6), 138.10 (2 C-4) 138.81 (2 C-1), 147.60 (2 C-5), 151.45 (2 C-2) .EI/MS, *m/z* (I%): 420 (36.08) **M**$^{+\bullet}$; 377 (38.21) **a**; 196 (100.00) **b**.

1,1-Bis(2,4-dimethoxy-5-nitrophenyl)-2-methylpropane (37). ^{13}C NMR: 21.62 [CH(*C*H$_3$)$_2$], 28.94 [*C*H(CH$_3$)$_2$], 47.22 [*C*HCH(CH$_3$)$_2$], 56.00 (2 OCH$_3$) 56.64 (2 OCH$_3$), 96.33 (2 C-3), 123.96 (2 C-1), 127.87 (2 C-6) 132.06 (2 C-5), 154.39 (2 C-4), 162.68 (2 C-2). EI/MS, *m/z* (I%): 420 (6.35) **M**$^{+\bullet}$; 377 (100.00) **a**; 196 (50.20) **b**.

1,1,1-Trichloro-2-(2-methoxyphenyl)-2-(4-methoxyphenyl)ethane (38). EI/MS, *m/z* (I%): [344 (13.96), 346 (13.27), 348 (4.50), 350 (0.56)] **M**$^{+\bullet}$; 227 (77.16) **a**; 121 (100.00) **b**.

1,1,1-Trichloro-2,2-bis(2,5-dimethoxyphenyl)ethane (39). EI/MS, *m/z* (I%): [404 (22.17), 406 (21.37), 408 (7.18), 410 (0.85)] $\mathbf{M}^{+\bullet}$; 287 (79.73) **a**; 151 (100.00) **b**.
1,1,1-Trichloro-2,2-bis(2,4-dimethoxyphenyl)ethane (40). EI/MS, *m/z* (I%): [404 (5.26), 406 (5.07), 408 (1.71), 410 (0.20)] $\mathbf{M}^{+\bullet}$; 287 (100.00) **a**; 151 (40.54) **b**.
1,1,1-Trichloro-2,2-bis(2-methoxy-5-methylphenyl)ethane (41). EI/MS, *m/z* (I%): [372 (15.90), 374 (15.33), 376 (5.08), 378 (0.60)] $\mathbf{M}^{+\bullet}$; 255 (92.00) **a**; 135 (100.00) **b**.
1,1,1-Trichloro-2,2-bis(2,4,5-trimethoxyphenyl)ethane (42). EI/MS, *m/z* (I%): [464 (9.43), 466 (9.21), 468 (3.14), 470 (0.39)] $\mathbf{M}^{+\bullet}$; 347 (100.00) **a**; 181 (27.52) **b**.

Compounds 2, **3**, **5**, **7**, **12**, **14**, **15**, **17**, **26**, **29**, and **35** were synthesized by the following general procedure.
A solution of the appropriate alcohol (10 mmol) in glacial acetic acid (25 ml) was added to a stirred solution of appropriate aromatic substrate (50 mmol) in glacial acetic acid (25 ml) / 70% H_2SO_4 (25 ml) at 20 °C. After standing at room temperature overnight, the mixture was poured onto crushed ice and the oil obtained was extracted with ethyl acetate, neutralized and concentrated under reduced pressure. The unreacted aromatic substrate was removed by steam distillation. Finally the residue was extracted with ethyl acetate, dried and concentrated at reduced pressure. The utilized alcohol and aromatic substrate, together with the purification method, are reported below.

For compounds **2**, **3**, **5**, and **7**, commercial *sec*-phenylethanol was utilized and aromatic substrates were 4-methylanisole, 1,4-dimethoxybenzene, 4-bromoanisole, and 1,3-dimethoxybenzene, respectively. The crude products were chromatographed over silica gel, employing cyclohexane:diethyl ether (95:5) as eluent.

For compounds **12**, **14**, and **15**, the alcohol utilized was 1-(2-methoxyphenyl)ethanol,[14] and the aromatic substrates were anisole, 3-chloroanisole, and 3-bromoanisole, respectively. The crude products were chromatographed over silica gel, employing cyclohexane:diethyl ether (80:20) for **12** and cyclohexane:diethyl ether (95:5) for **14** and **15**, as eluent.

For compound **17**, commercial 4-methoxy-α-methylbenzyl alcohol and 1,3-dimethoxybenzene were utilized. The crude product was chromatographed over silica gel, employing cyclohexane:ethyl acetate (96:4) as eluent.

For compounds **26**, **29**, and **35**, the alcohol used was 1-(3,4-dimethoxyphenyl)-2-methylpropan-1-ol,[15] and the aromatic substrates were 1,2,3-trimethoxybenzene, 4-methylanisole and 5-chloro-1,3-dimethoxybenzene, respectively. The crude products were chromatographed over silica gel, employing as eluent cyclohexane:diethyl ether (90:10) for **26** and **29,** and cyclohexane:ethyl acetate (90:10) for **35**.
1-(5-Methyl-2-methoxyphenyl)-1-phenylethane (2). Pale yellow oil (yield 55%). ^{13}C NMR: 20.68 (CH_3), 20.88 (CH_3), 37.25 ($CHCH_3$), 55.53 (OCH_3), 110.61 (C-3), 125.59 (C-4'), 127.25 (C-4), 127.65 (C-2',6'), 128.03 (C-3',5'), 128.34 (C-6), 129.52 (C-5), 134.61 (C-1), 146.41 (C-1'), 154.72 (C-2). EI/MS, *m/z* (I%): 226 (66.88) $\mathbf{M}^{+\cdot}$; 211 (73.97) **a**; 91 (100.00) **b**.

1-(2,5-Dimethoxyphenyl)-1-phenylethane (3). Yellow oil (yield 85%). ^{13}C NMR: 20.79 ($CHCH_3$), 37.45($CHCH_3$), 55.36 (OCH_3), 55.91 (OCH_3), 110.30 (C-4), 111.41 (C-3), 114.62 (C-6), 125.66 (C-4'), 127.56 (C-2',6'), 128.03 (C-3',5'), 136.16 (C-1), 145.97 (C-1'), 151.08 (C-2), 153.49 (C-5). EI/MS, *m/z* (I%): 242 (100.00) $\mathbf{M}^{+\cdot}$; 227 (36.22) **a**; 91 (61.46) **b**.

1-(5-Bromo-2-methoxyphenyl)-1-phenylethane (5). White oil (yield 40%). ^{13}C NMR: 20.74 ($CHCH_3$), 37.38 ($CHCH_3$), 55.61 (OCH_3), 112.27 (C-3), 112.94 (C-5), 125.94 (C-4'), 127.59 (C-2',6'), 128.20 (C-3',5'), 129.69 (C-4), 130.47 (C-6), 137.19 (C-1), 145.44 (C-1'), 155.90 (C-2). EI/MS, *m/z* (I%): [290 (48.67), 292 (48.31)] $\mathbf{M}^{+\bullet}$; [275 (31.41), 277 (31.06)] **a**; 91 (100.00) **b.**

1-(2,4-Dimethoxyphenyl)-1-phenylethane (7). White oil (yield 90%). ^{13}C NMR: 21.04 ($CHCH_3$), 36.93 ($CHCH_3$) 55.26 (OCH_3), 55.38 (OCH_3), 98.60 (C-3), 103.88 (C-5), 125.55 (C-4'), 127.48 (C-1), 127.48 (C-2',6'), 127.93 (C-6), 128.03 (C-3',5'), 146.72 (C-1'), 157.72 (C-2), 159.03 (C-4). EI/MS, *m/z* (I%): 242 (55.11) $\mathbf{M}^{+\bullet}$; 227 (100.00) **a**; 91 (51.07) **b.**

1-(2-Methoxyphenyl)-1-(4-methoxyphenyl)ethane (12). Yellow oil (yield 70%). ^{13}C NMR: 21.01 ($CHCH_3$), 36.48 ($CHCH_3$), 55.14 (OCH_3), 55.39 (OCH_3), 110.51 (C-3), 113.43 (C-3',5'), 120.45 (C-5), 126.91 (C-4), 127.49 (C-6), 128.56 (C-2',6'), 135.22 (C-1), 138.45 (C-1'), 156.71 (C-2), 157.55 (C-4'). EI/MS, *m/z* (I%): 242 (47.20) $\mathbf{M}^{+\cdot}$; 227 (76.33) **a**; 121 (100.00) **b**.

1-(2-Methoxyphenyl)-1-(2-chloro-4-methoxyphenyl)ethane (14). White oil (yield 72%). ^{13}C NMR: 20.08 ($CHCH_3$), 34.10 ($CHCH_3$), 55.33 (OCH_3), 55.44 (OCH_3), 110.53 (C-3), 112.57 (C-5'), 114.60 (C-3'), 120.27 (C-5), 127.14 (C-4), 127.27 (C-6), 128.72 (C-6'), 133.90 (C-1), 134.28 (C-2'), 135.79 (C-1'), 156.97 (C-2), 157.99 (C-4'). EI/MS, *m/z* (I%): [276 (41.97), 278 (13.68)] $\mathbf{M}^{+\cdot}$; [261 (52.14), 263 (16.73)] **a**; [155 (100.00), 157 (31.49)] **b**.

1-(2-Methoxyphenyl)-1-(2-bromo-4-methoxyphenyl)ethane (15). White oil (yield 60%). ^{13}C NMR: 20.24 ($CHCH_3$), 36.70 ($CHCH_3$), 55.35 (OCH_3), 55.44 (OCH_3), 110.51 (C-3), 113.24 (C-5'), 117.80 (C-3'), 120.25 (C-5), 124.87 (C-2'), 127.16 (C-4), 127.18 (C-6), 128.68 (C-6'), 133.92 (C-1), 137.45 (C-1'), 157.07 (C-2), 157.98 (C-4). EI/MS, *m/z* (I%): [320 (47.76), 322 (47.63)] $M^{+\cdot}$; [305 (46.08), 307 (45.33)] **a**; [199 (100.00), 201 (97.14)] **b**.

1-(2,4-Dimethoxyphenyl)-1-(4-methoxyphenyl)ethane (17). Yellow oil (yield 50%). ^{13}C NMR: 21.19 ($CHCH_3$), 36.14($CHCH_3$), 55.19 (OCH_3), 55.28 (OCH_3), 55.43 (OCH_3), 98.68 (C-3), 104.00 (C-5), 113.47 (C-3',5'), 127.86 (C-6), 128.02 (C-1), 128.47 (C-2',6'), 138.84 (C-1'), 157.55 (C-4'), 157.71 (C-2), 159.01 (C-4). EI/MS, *m/z* (I%): 272 (38.27) $M^{+\cdot}$; 257 (100.00) **a**; 121 (61.58) **b**.

1-(2,3,4-Trimethoxyphenyl)-1-(3,4-dimethoxyphenyl)-2-methylpropane (26). Pale yellow oil (yield 85%). ^{13}C NMR: 21.86 ($CHCH_3$), 21.96 ($CHCH_3$), 31.76 [$CH(CH_3)_2$], 51.30 [$CHCH(CH_3)_2$], 55.71 (OCH_3), 55.77 (2 OCH_3), 60.50 (OCH_3), 60.74 (OCH_3), 107.42 (C-5), 111.08 (C-5'), 111.82 (C-2'), 120.15 (C-6'), 121.51 (C-6), 131.28 (C-1), 138.01 (C-1'), 142.21 (C-3), 147.04 (C-4'), 148.59 (C-3'), 151.57 (C-4), 151.76 (C-2). EI/MS, *m/z* (I%): 360 (21.77) $M^{+\cdot}$; 317 (100.00) **a**; 151 (73.95) **b**.

1-(5-Methyl-2-methoxyphenyl)-1-(3,4-dimethoxyphenyl)-2-methylpropane (29). White crystals from EtOH (yield 60%), m.p. 71 °C. ^{13}C NMR: 20.58 (CH_3), 21.39 ($CHCH_3$), 21.78

($CHCH_3$), 31.15 [$CH(CH_3)_2$], 51.20 [$CHCH(CH_3)_2$], 55.43 (OCH_3), 55.55 (OCH_3), 55.60 (OCH_3), 110.80 and 110.95 (C-3 and C-5'), 112.03 (C-2'), 120.04 (C-6'), 126.77 (C4), 128.07 (C-6), 129.37 (C-5) 133.14 (C-1), 137.68 (C-1'), 146.82 (C-4'), 148.34 (C-3'), 154.85 (C-2). EI/MS, *m/z* (I%): 314 (20.41) $M^{+\cdot}$; 271 (100.00) **a**; 151 (83.37) **b**.

1-(6-Chloro-2,4-dimethoxyphenyl)-1-(3,4-dimethoxyphenyl)-2-methylpropane (35). White crystals from EtOH (yield 65%), m.p. 85 °C. ^{13}C NMR: 21.49 ($CHCH3$), 22.49 ($CHCH_3$), 28.72 [$CH(CH_3)_2$], 53.67 [$CHCH(CH_3)_2$], 55.30 (2 OCH_3), 55.71 (2 OCH_3), 98.47 (C-3), 106.11 (C-5), 110.61 (C-5'), 112.40 (C-2'), 121.15 (C-6'), 123.96 (C-1), 135.18 (C-6), 136.36 (C-1'), 147.04 (C-4'), 148.21 (C-3'), 158.51 (C-2), 159.25 (C-4). EI/MS, *m/z* (I%): [364 (27.10), 366 (9.31)] $M^{+\cdot}$; [321 (100.00), 323 (36.28)] **a**; 151 (70.20) **b**.

1-(4-Methyl-2-methoxyphenyl)-1-phenylethane (6). To a solution of 3-methylanisole (13 mmol), *N,N,N',N'*-tetramethyl-ethylenediamine (TMEDA) (13 mmol) in anhydrous diethyl ether (10 ml), 1.6 M n-BuLi solution in hexane (16 mmol) was added at 0 °C, under an argon atmosphere. The mixture was then allowed to stir at room temperature for 2 h, then a solution of commercial (1-bromoethyl)benzene (13 mmol) in anhydrous diethyl ether (10ml) was added. After stirring overnight at room temperature, the reaction was quenched with solution of ammonium chloride, then extracted with diethyl ether, neutralized and dried. After solvent evaporation *in vacuo*, the oily residue was chromatographed over silica gel. Elution with cyclohexane gave pure **6** (yield 65 %) as a white oil. ^{13}C NMR: 20.92 ($CHCH_3$), 21.38 (CH_3), 37.09 ($CHCH_3$), 55.36 (OCH_3), 111.57 (C-3), 121.02 (C-5), 125.57 (C-4'), 127.42 (C-6), 127.64 (C-2',6'), 128.04 (C-3',5'), 131.94 (C-1), 136.85 (C-4), 146.57 (C-1'), 156.65 (C-2). EI/MS, *m/z* (I%): 226 (56.93) $\mathbf{M^{+\cdot}}$; 211 (80.34) **a**; 91 (100.00) **b.**

1,1-bis-(5-Methyl-2-methoxyphenyl)-2-methylpropane (28). To a solution of 4-methylanisole (81 mmol) and isobutyraldehyde (27 mmol) in glacial acetic acid (50 ml), 98% H_2SO_4 (30 ml) was added dropwise with stirring. External cooling with ice was necessary in order to maintain the reaction temperature below 20 °C. After standing at room temperature overnight, the mixture was poured onto crushed ice and the oil obtained was extracted with ethyl acetate, neutralized, and concentrated under reduced pressure. The unreacted 4-methylanisole was removed by steam distillation. Finally, the residue was extracted with ethyl acetate, dried and concentrated at reduced pressure. Pure **28** was obtained by chromatography over silica gel, employing cyclohexane: diethyl ether (90:10), as eluent. White crystals from EtOH (yield 60%), m.p. 101 °C. ^{13}C NMR: 20.78 (2 CH_3), 21.58 [$CH(CH_3)_2$], 31.09 [$CH(CH_3)_2$], 44.45 [$CHCH(CH_3)_2$], 55.84 (2 OCH_3), 111.13 (2 C-3), 126.72 (2 C-4), 129.23 (2 C-5), 129.58 (2 C-6), 133.11 (2 C-1), 155.70 (2 C-2). EI/MS, *m/z* (I%): 298 (18.37) $\mathbf{M^{+\cdot}}$; 255 (71.20) **a**; 135 (100.00) **b.**

Compounds **4**, **11** and **44** were obtained by the following nitration procedure. A solution of **1** or **3** or **39** (2.4 mmol) in Ac_2O (25 ml) was placed in a two-necked round-bottomed flask with a mechanical stirrer and a reflux condenser protected by a $CaCl_2$ tube. To the stirred solution, $CuNO_3 \cdot 3H_2O$ (1.2 mmol for **4** and **11**, and 2.4 mmol for **44**) was added. The mixture was heated at 40–50 °C during 0.5 h. The cooled mixture was poured in water, then extracted with $CHCl_3$,

neutralized, dried, and evaporated *in vacuo*. The crude products were chromatographed over silica gel, employing cyclohexane: ethyl acetate (90:10) and (95:5) for **3** and **5**, respectively, as eluent. Pure **44** was obtained by crystallization of the crude product.

1-(2-Methoxy-5-nitrophenyl)-1-phenylethane (4). White crystals from EtOH (yield 83%), m.p. 101 °C. ^{13}C NMR: 20.67 (CH*C*H$_3$), 37.49 (C*H*CH$_3$), 56.01 (OCH$_3$), 109.93 (C-3), 123.24 (C-6), 123.76 (C-4), 126.21 (C-4'), 127.44 (C-2',6'), 128.73 (C-3',5'), 135.86 (C-1), 242 (C-5), 144.63 (C-1'), 161.79 (C-2). EI/MS, m/z (I%): 257 (42.93) $\mathbf{M}^{+\cdot}$; 242 (55.07) **a**; 91 (100.00) **b**.

1-(2,5-Dimethoxy-4-nitrophenyl)-1-phenylethane (11). Yellow crystals from EtOH (yield 80 %), m.p. 89 °C. ^{13}C NMR: 20.33 (CH*C*H$_3$), 37.89 (*C*HCH$_3$) 56.14 (OCH3), 57.03 (OCH3), 107.78 (C-3), 114.08 (C-6), 126.37 (C-4'), 127.56 (C-2',6'), 128.38 (C-3',5'), 136.98 (C-4), 143.06 (C-1), 144.27 (C-1'), 147.80 (C-5), 150.17 (C-2). EI/MS, *m/z* (I%): 287 (73.58) $\mathbf{M}^{+\cdot}$; 272 (12.45) **a**; 91 (100.00) **b**.

1-(2,5-Dimethoxy-4-nitrophenyl)-1-(4-nitrophenyl)-ethane (13). This compound was obtained from **11** (2.4 mmol) and $CuNO_3 \cdot 3H_2O$ (1.2 mmol) by the nitration procedure describe above. The crude product was chromatographed over silica gel, employing cyclohexane: ethyl acetate (80:20) as eluent. Yellow crystals from EtOH (yield 70%), m.p. 130°C. ^{13}C NMR: 20.13 (CH*C*H$_3$), 38.29 (*C*HCH$_3$) 56.12 (OCH$_3$), 57.24 (OCH$_3$), 107.94 (C-3), 113.85 (C-6), 123.67 (C-3',5'), 128.30 (C-2',6'), 137.65 (C-4), 140.47 (C-1), 146.44 (C-4'), 147.75 (C-5), 150.15 (C-2), 152.25 (C-1'). EI/MS, *m/z* (I%): 332 (100.00) $\mathbf{M}^{+\bullet}$; 317 (4.69) **a**; 136 (31.85) **b.**

1-(2,5-[Dimethoxy-^{2}H$_6$]-4-nitrophenyl)-1-(4-nitrophenyl)-ethane (13-d$_6$). This compound was synthesized by the same reaction series as for **13**, using 1,4-hexadeuterodimethoxybenzene. Analytical, ^{1}H- and ^{13}C NMR data confirmed the assigned structure. EI/MS, *m/z* (I%): 338 (100.00) $\mathbf{M}^{+\cdot}$; 323 (4.30) **a**; 138 (20.30) **b**.

1,1,1-Trichloro-2,2-bis(2,5-dimethoxy-4-nitrophenyl)-ethane (44). Yellow crystals from EtOH (yield 85%), m.p. 187 °C. ^{13}C NMR: 53.21(C*H*CCl$_3$), 56.59 (2 OCH$_3$), 57.36 (2 OCH$_3$), 99.94 (CCl$_3$), 108.16 (2 C-3), 116.21 (2 C-6), 132.53 (2 C-1), 138.86 (2 C-4), 146.70 (2 C-5), 151.24 (2 C-2). EI/MS, *m/z* (I%): [494 (13.55), 496 (13.15), 498 (4.54), 500 (0.56)] $M^{+\cdot}$; 377 (73.31) a; 196 (100.00) **b**.

1-(4-Amino-2,5-dimethoxyphenyl)-1-phenylethane (8). To a solution of **11** (3.5 mmol) in EtOH (25 ml) was added 10% Pd–C (0.35 mmol). The mixture was hydrogenated in a Parr apparatus for 72 h. Elimination of catalyst and evaporation of solvent at reduced pressure produced a solid residue. Crystallization of the crude product from EtOH afforded pure **8** as pale pink crystals (yield 75%), m.p. 88 °C. IR (Nujol): νmax 3350 and 3450 cm^{-1} (NH2). ^{13}C NMR: 21.09 (CH*C*H$_3$), 36.94 (*C*HCH$_3$), 56.28 (OCH$_3$), 56.34 (OCH$_3$), 100.32 (C-3), 111.40 (C-6), 124.48 (C-1), 125.46 (C-4'), 127.48 (C-2',6'), 127.98 (C-3',5'), 134.79 (C-4), 141.31 (C-5), 146.97 (C-1'), 151.40 (C-2). EI/MS, *m/z* (I%): 257 (65.32) $\mathbf{M}^{+\bullet}$; 242 (100.00) **a**; 91 (24.61) **b.**

1-(4-*N*-Methyl-2,5-dimethoxyphenyl)-1-phenylethane (9) and 1-(4-*N*,*N*-Dimethylamino-2,5-di-methoxyphenyl) -1-phenylethane (10). Methyl iodide (30 mmol) and K_2CO_3 (30 mmol) were added to a solution of **8** (6 mmol) in acetone (20 ml). The mixture was refluxed for 5 h.

After cooling, the solid material was removed by filtration and the solution was diluted with water and extracted with diethyl ether. The ethereal extracts were treated with 10% aqueous sodium hydroxide solution, then neutralized, dried and evaporated *in vacuo*. The residue obtained was chromatographed on silica gel employing cyclohexane:ethyl acetate (90:10) as eluent. The elution order of the compounds was: **10**, **9**.

Pure **9** was obtained as pale pink crystals from petroleum ether (b.p. 40–60 °C) (yield 25%), m.p. 53 °C. IR (Nujol): νmax 3420 cm^{-1} (NH). ^{13}C NMR: 21.07 (CH*C*H_3), 30.41 (NCH_3), 36.74 (*C*HCH_3), 56.12 (OCH_3), 56.57 (OCH_3), 95.64 (C-3), 110.00 (C-6), 121.77 (C-1), 125.35 (C-4'), 127.45 (C-2',6'), 127.93 (C-3',5'), 138.31 (C-4), 141.01 (C-5), 147.13 (C-1'), 151.69 (C-2). EI/MS, *m/z* (I%): 271 (63.57) $\mathbf{M}^{+\cdot}$; 256 (100.00) **a**; 91 (12.14) **b**.

Pure **10** was obtained as pale pink crystals from petroleum ether (b.p. 40–60 °C) (yield 50%), m.p. 58 °C. ^{13}C NMR: 20.84 (CH*C*H_3), 37.08 (*C*HCH_3), 43.19 [N(*C*H_3)$_2$], 55.79 (OCH_3), 56.40 (OCH_3), 103.27 (C-3), 111.63 (C-6), 125.51 (C-1), 125.51 (C-4'), 127.47 (C-2',6'), 127.96 (C-3',5'), 140.90 (C-5), 146.33 (C-4), 146.49 (C-1'), 150.86 (C-2). EI/MS, *m/z* (I%): 285 (79.78) $\mathbf{M}^{+\cdot}$; 270 (100.00) **a**; 91 (20.40) **b**.

1,1-bis-(2-Methoxyphenyl)-ethane (16). To a solution of 1,1-bis-(2-methoxyphenyl)-ethanol[16] (8 mmol) in glacial acetic acid (25 ml) was added 10% Pd-C (0.8 mmol). The mixture was hydrogenated in a Parr apparatus for 24 h. Elimination of catalyst and evaporation of solvent at reduced pressure produced a solid residue. Crystallization of the crude product from EtOH afforded pure **16** as white crystals (yield 90%), m.p. 68 °C. ^{13}C NMR: 19.88 (CH*C*H_3), 31.28 (*C*HCH_3), 55.57 (2 OCH_3), 110.64 (2 C-3), 120.24 (2 C-5), 126.75 (2 C-4), 127.68 (2 C-6), 134.84 (2 C-1), 157.04 (2 C-2). EI/MS, *m/z* (I%): 242 (58.48) $\mathbf{M}^{+\bullet}$; 227 (48.86) **a**; 121 (100.00) **b**.

1-(2,3-Dibromo-5,6-dimethoxyphenyl)-1-(2,3-dibromo-4,5-dimethoxyphenyl)-2-methylpropane (34). A solution of **25** (5 mmol) in $CHCl_3$ (10ml) was stirred at room temperature during the dropwise addition of a solution of bromine (50 mmol) in $CHCl_3$ (20ml). The solution was then set aside at room temperature until the hydrogen bromide gas evolution was complete (1 week). The solid obtained after evaporation of the solvent *in vacuo*, was crystallized from EtOH. White crystals (yield 92%), m.p. 205 °C. ^{13}C NMR: 20.40 (CH*C*H_3), 22.15 (CH*C*H_3), 30.71 [*C*H(CH_3)$_2$], 55.86 and 56.15 (2 OCH_3 at C-5 and C-5'), 58.25 [*C*HCH(CH_3)$_2$], 59.64 and 60.45 (2 OCH_3 at C-6 and C-4'), 114.98 (C-6'), 115.71 (C-4), 119.63 (C-2'), 120.00 (C-3), 121.55 (C-3'), 121.63 (C-2), 137.20 (C-1), 139.29 (C-1'), 145.93 (C-4'), 147.14 (C-6), 151.41 (C-5'), 152.35 (C-5). EI/MS, *m/z* (I%): [642 (4.52), 644 (17.43), 646 (25.34), 648 (17.18), 650 (4.56)] $\mathbf{M}^{+\bullet}$; [599 (7.69), 601 (29.66), 603 (44.50), 605 (29.21), 607 (7.39)] **a**; [307 (50.69), 309 (100.00), 311 (51.00)] **b**.

1,1,1-Trichloro-2,2-bis-(4-bromo-2,5-dimethoxyphenyl)ethane (43). Compound **43** was obtained from **39** [11] by the bromination procedure describe above, using 2 equiv. of bromine (reaction time 48 h). The obtained solid was crystallized from EtOH. White crystals (yield 90%), m.p. 167 °C. ^{13}C NMR: 52.60 (*C*HCCl$_3$), 56.72 (2 OCH$_3$), 57.06 (2 OCH$_3$), 101.44 (CCl$_3$), 111.57 (2 C-4), 114.16 (2 C-6), 116.83 (2 C-3), 126.81 (2 C-1), 149.69 (2 C-5), 152.28 (2 C-2). EI/MS, *m/z* (I%): [560 (7.12), 562 (20.99), 564 (22.87), 566 (11.53), 568 (2.76), 570 (0.28)] $\mathbf{M}^{+\bullet}$; [443 (50.21), 445 (100.00), 447 (50.23)] **a**; [229 (68.97), 231 (66.52)] **b**.

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