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Conjugated Azoalkenes. Part XVI. Reaction of some Conjugated Azoalkenes with β-nitrocarbonyl derivatives.

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Abstract: *Unknown 2-hydroxy-3-nitro-2,3-dihydro-1-aminopyrrole derivatives were directly obtained by easy reaction of conjugated azoalkenes with 2-nitro-1,3-indanedione. The treatment of the same reagents with benzoylnitromethane or β-nitroesters gave α,β-olefinated-γ-carbonyl- or α,β-olefinated-γ-alkoxycarbonylhydrazone derivatives, respectively. New asymmetric α-azinohydrazones were isolated from the reaction of the above-mentioned materials with some β-nitroketone tosylhydrazones.*

INTRODUCTION

Aliphatic nitro derivatives are versatile compounds that have found widespread use in organic synthesis because the nitro group may be easily converted into a large number of other functional groups by means of simple transformations. Furthermore, the nitro substituent possessing powerful electron withdrawing ability can readily produce an α-carbanion (nitronate anion) able to provide new carbon-carbon bonds by nucleophilic reaction with appropriate substrates.[1]

Indeed, conjugated azoalkenes have been demonstrated to be useful substrates for nucleophilic attack on the azo-ene system giving at first hydrazone derivatives by 1,4-conjugate addition (Michael-type). These 1,4-adduct intermediates frequently led to new widely substituted 1-aminopyrroles, 1-amino-2,3-dihydropyrrol-2-ols, 1,2-diaminopyrroles, pyrrolo[2,3-*b*]pyrroles, 1-amino-1*H*-pyrrol-2(3*H*)-ones and 1-aminopyrrol-2-ols by heterocyclization process.[2]

For these reasons we decided to investigate the reaction between conjugated azoalkenes and some b-nitrocarbonyl derivatives (i.e. β-nitroketones, β-nitroesters, and β-nitroketone tosylhydrazones) containing active methylenic or methinic groups.

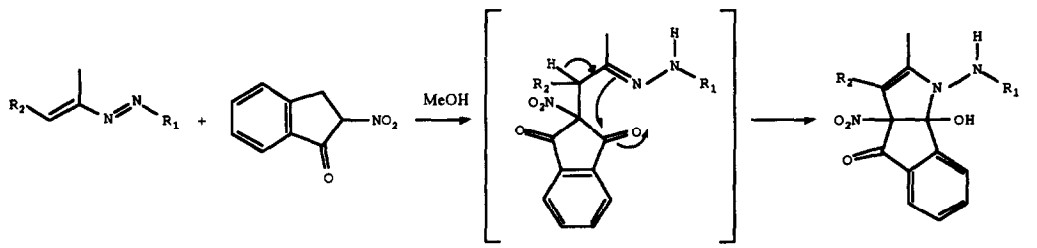
RESULTS AND DISCUSSION

1-Amino-2,3-dihydropyrrol-2-ols were at first isolated by us as stable intermediates in the reaction between β-dicarbonyl compounds (i.e. β-diketones and β-ketoesters) and aroylazoalkenes arising by the intramolecular ring closure of the first hydrazonic 1,4-adduct intermediate. These products exhibited the ready loss of a water molecule to provide the more stable 1-aminopyrroles.[3] Furthermore, we studied in detail the reaction of conjugated azoalkenes with compounds containing activated methine groups (i.e. CH-substituted cyclic β-dicarbonyl derivatives) for the synthesis of unknown 1-amino-2,3-dihydropyrrol-2-ols derivatives.[4]

Based on these findings and considering that hydroxypyrrolines are in general difficult to synthesize by other methods, we decided to investigate the reactions between aminocarbonyl- (**1a-d**) and alkoxycarbonyl-azoalkenes (**1e-h**) with 2-nitro-1,3-indanedione in order to tentatively reach new 8*b*-hydroxy-2-methyl-3*a*-nitro-4-oxo-1-ylcarbonyl-1-ureido-1,3*a*,8*b*-trihydro-indan[2,3-*b*]pyrrole-3-carboxylate (**2a-d**) and 1-alkoxycarbonylamino-8*b*-hydroxy-2-methyl-3*a*-nitro-4-oxo-1,3*a*,8*b*-trihydro-indan[2,3-*b*]pyrrole-3-carboxylate (**2e-h**).

These reactions easily proceeded, likely *via* preliminary 1,4-conjugate adducts, in methanol at room temperature directly giving the cyclized products **2a-h** as a mixture of isomers in excellent yields after a partial evaporation of the solvent under reduced pressure (**2a-d**) or after a silica gel column chromatography (**2e-h**) (Scheme 1). Times, yields and melting points of **2a-h** are listed in Table 1.

It is noteworthy that the products obtained by this one-flask procedure present three fused rings containing at the same time powerful functional groups (nitro, hydroxy, carbonyl and aminocarbonyl group) suitable for further interesting transformations.



1a-h **2a-h**

Scheme 1

Afterwards, we turned our attention to the reaction between conjugated azoalkenes **1a-f** and benzoylnitromethane (**3a**), ethyl nitroacetate (**3b**) or ethyl 2-nitropropionate (**3c**) containing an active methylene or methyne group. In the first step, the reactions took place in THF with a catalytic amount of sodium methoxide

at ice-bath temperature by a nucleophilic attack of the carbanions generated from **3a-c** on the azo-ene of conjugated azoalkene system affording hydrazonic intermediates by 1,4-conjugate addition (Michael-type).

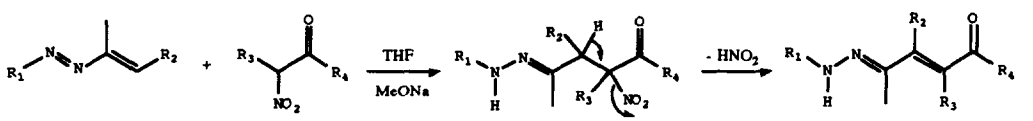
Table 1 -Time, yield and melting points of 2-hydroxy-3-nitro-2,3-dihydro-1-aminopyrrole derivatives **2a-h**.

2	R_1	R_2	t/h	Yield[a] (%)	Mp[b] (°C)
a	$CONH_2$	CO_2Me	0.1	73	171-172
b	$CONH_2$	CO_2Et	0.1	82	165-166
c	CONHPh	CO_2Me	1.0	90	171-172
d	CONHPh	CO_2Et	0.75	86	163-165
e	CO_2Me	CO_2Me	0.1	66	155-157
f	CO_2Me	CO_2Et	0.2	74	151-153
g	CO_2Bu^t	CO_2Me	0.2	78	120-122
h	CO_2Bu^t	CO_2Et	0.1	86	140-143

[a]Yield of pure isolated product. [b]Melting points are uncorrected and always occur with decomposition.

In principle, depending on the reaction conditions (e.g. different catalysts, solvents or temperatures),[5,6,7] the 1,4-adduct intermediate **4** at first formed, should undergo an intramolecular ring closure on the carbonyl or alkoxycarbonyl group to afford different cyclization products[6,7] or an elimination of the nitro group to give α,β-unsaturated hydrazonic compounds.[5] Indeed, we mainly observed this latter pathway (Scheme 2) even in different reaction conditions (solvents, temperatures, bases) obtaining α,β-olefinated hydrazones **5a-j**.

In particular, the products **5a-e** promptly resulted in one-pot while, the reactions for the synthesis of the products **5f-j** required an additional time in methanol under reflux for the completion (see Table 2), due to the presence of the products **5** together with the pertinent intermediates **4** in the reaction mixtures.



1a-f **3a-c** **4f-h** **5a-j**

Scheme 2

For the isolation and characterization of the 1,4-adduct intermediates **4f-h** the reactions were carried out in ethyl acetate at ice-bath temperature (0-5 °C) and the intermediates were precipitated by addition of petroleum ether (30-60 °C) (see Experimental).

The present procedure provides in good yields (Table 2) α,β-unsaturated hydrazone derivatives in which a

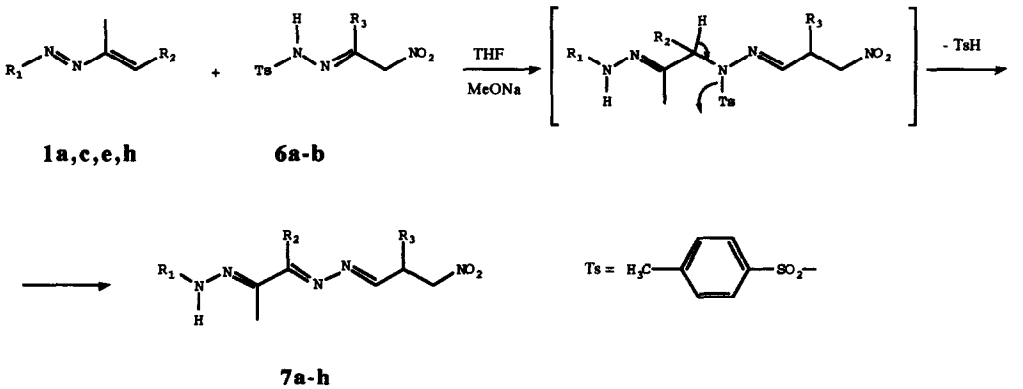
Table 2 -Time, yield and melting points of α,β-olefinated hydrazone derivatives **5a-j.**

			Products					t/h		Yield[a] (%)		Mp[b] (°C)	
1	R_1	R_2	**3**	R_3	R_4	***4***	***5***	***4***	***5***	***4***	***5***	***4***	***5***
a	$CONH_2$	CO_2Me	**a**	H	Ph	-	**a**	-	3.0	-	73	-	150-152
b	$CONH_2$	CO_2Et	**a**	H	Ph	-	**b**	-	3.4	-	56	-	140-145
c	CONHPh	CO_2Me	**a**	H	Ph	-	**c**	-	0.4	-	69	-	98-104
d	CONHPh	CO_2Et	**a**	H	Ph	-	**d**	-	0.5	-	78	-	144-147
e	CO_2Me	CO_2Me	**b**	H	OEt	-	**e**	-	0.3	-	78	-	157-165
c	CONHPh	CO_2Me	**b**	H	OEt	**f**[c]	**f**	0.3[d]	0.7[e]	98	96	130-135	142-150
a	$CONH_2$	CO_2Me	**c**	CH_3	OEt	**g**[c]	**g**	0.3[d]	3.0[e]	97	98	107-112	124-131
c	CONHPh	CO_2Me	**c**	CH_3	OEt	**h**[c]	**h**	1.0[d]	5.5[e]	95	81	90-100	131-137
e	CO_2Me	CO_2Me	**c**	CH_3	OEt	-	**i**	0.3[d]	2.0[e]	-	93	-	94-96
f	CO_2Bu^t	CO_2Me	**c**	CH_3	OEt	-	**j**	0.3[d]	2.0[e]	-	95	-	85-89

[a]Yield of pure isolated product [b]Melting points are uncorrected and often occur with decomposition. [c]For the isolation of **4f-h** the reactions were carried out in ethyl acetate. [d]The reaction directly provided mixtures of **4** and **5** without the possibility to isolate the intermediate **4**. [e]This time refers to the additional time in methanol under reflux for the complete formation of **5**.

carbon-carbon double bond is conjugated both with carbon-nitrogen and carbon-oxygen (ketonic or esteric) double bonds. Such a conjugate system may be useful in organic chemistry, in addition, α,β-unsatured-γ-diketones or γ-ketoesters may be derived by means of one of the numerous methods reported in literature for the conversion of hydrazones into parent carbonyl compounds.

Furthermore we also studied the reaction between conjugated azoalkenes (**1a,c,e,h**) and α-nitroacetone and benzoylnitromethane in the form of the related hydrazonic derivatives.[8] We immediately observed the nearly complete inactivity of the methylene group in α-position in respect to the nitro and C=N hydrazonic groups. In fact, the N,N-dimethylhydrazone derivatives of both the above-mentioned β-nitroketones exhibit almost no reaction with conjugated azoalkenes, even in strong basic catalytic conditions. In the case of treatment of these latter reagents with benzoylnitromethane (**6a**) or α-nitroacetone (**6b**) *p*-toluensulphonyhydrazones, the NH was hydrazonic hydrogen shown to be active in the 1,4-conjugate addition (Michael-type) affording 1,4-adducts from which, by loss of a *p*-toluensulphinic acid molecule, asymmetric α-azinohydrazone derivatives **7a-h** were isolated as main products (Scheme 3).



1a,c,e,h **6a-b**

7a-h

Scheme 3

The reactions occurred in THF with a catalytic amount of sodium methoxide at room temperature and the reaction mixtures were quite complex (many spots by TLC analysis) but subsequent selective crystallization from methanol gave directly the main desired product.

Despite the moderate yield of asymmetric a-azinohydrazones produced they represent attractive products and versatile intermediates not easily synthesizable by other procedures considering the simultaneous presence of three carbon-nitrogen conjugated double bonds, the nitro and carbonylamino functions. Retention of the nitro group appears to be very important as this could be of further utility for functional group transformations.[1] Times, yields and melting points are recorded in Table 3.

Table 3 -Time, yield and melting points of α-azinohydrazone derivatives **6a-h**.

		Products				t/h	Yield[a] (%)	Mp[b] (°C)
1	R_1	R_2	**6**	R_3	**7**			
a	$CONH_2$	CO_2Me	**a**	Ph	**a**	4.0	37	168-170
c	CONHPh	CO_2Me	**a**	Ph	**b**	1.0	36	174-177
e	CO_2Me	CO_2Me	**a**	Ph	**c**	2.0	38	162-167
h	CO_2Bu^t	CO_2Et	**a**	Ph	**d**	3.0	40	158-162
a	$CONH_2$	CO_2Me	**b**	Me	**e**	1.0	38	158-165
c	CONHPh	CO_2Me	**b**	Me	**f**	0.5	36	184-187
e	CO_2Me	CO_2Me	**b**	Me	**g**	0.4	32	168-170
h	CO_2Bu^t	CO_2Et	**b**	Me	**h**	1.0	48	157-160

[a]Yield of pure isolated product [b]Melting points are uncorrected and always occur with decomposition.

EXPERIMENTAL

Conjugated azoalkenes **1a-h** were prepared as previously reported.[9,10] 2-Nitro-1,3-indanedione dihydrate, benzoylnitromethane **3a**, ethyl nitroacetate **3b**, ethyl 2-nitropropionate **3c** and α-nitroacetone dicyclohexylamine salt, were commercial materials (Aldrich or Lancaster) and were used without further purification. Benzoylnitromethane and a-nitroacetone *p*-toluensulphonylhydrazone derivatives **6a-b** were synthesised as previously reported.[8] Mps were determined in capillary tubes with a Büchi (Tottoli) apparatus, and are uncorrected. The products often decompose at melting points. IR spectra were obtained in Nujol mull with a Perkin-Elmer 298 spectrophotometer. ^1H NMR spectra were recorded on a Bruker AC-200 in DMSO-d_6. Chemical shifts (δ) are reported in ppm downfield from internal TMS and coupling constats (J) in Hz. The abbreviations used are as follows: s, singlet; d, doublet; t, triplet; q, quartet; m, multiplet; br, broad; D_2O ex, D_2O exchange. Macherey-Nagel precoated silica gel SIL G-25 UV_{254} plates (0.25 mm) were employed for analytical thin layer chromatography and Baker silica gel (0.063-0.200 mm) for column chromatography. All compounds prepared showed a satisfactory elemental analysis (C±0.35; H±0.4; N±0.3 %).

General procedure for the synthesis of 2-hydroxy-3-nitro-2,3-dihydro-1-aminopyrrole derivatives 2a-h. To a stirred solution of 2-nitro-1,3-indanedione dihydrate (1 mmol) dissolved in methanol (3 ml), was added dropwise a solution of azoalkenes **1a-h** (1 mmol) dissolved in methanol (3 ml). The reaction mixture was magnetically stirred at room temperature until the orange-red colour of the azoalkene disappeared and the reaction was complete (see Table 1). In all cases a TLC check revealed as major components two very near spots corresponding to a mixture of isomers of product **2**. The products **2a-d** were obtained in good yields by a partial evaporation of the methanol under reduced pressure. For the products **2e-h** it was useful to purify the crude product by chromatography on a silica gel column (elution with methylene chloride-ethyl acetate mixtures). Further purification of the products **2e-h** was achieved by crystallization from methylene chloride-petroleum ether (30-60 °C) or n-pentane.

2a: IR 3460, 3350, 3280 (overlap), 1730, 1690, 1635, 1600, 1560, 1350 cm^{-1}; ^1H NMR 2.18 (3H, s), 3.60 (3H, s), 6.19 and 6.40 (2H, 2 br s, D_2O ex), 7.70-7.86 (4H, m), 8.28 (1H, s, D_2O ex), 8.49 and 8.79 (1H, 2 br s, D_2O ex) ppm.

2b: IR 3440, 3350, 3280, 3150 (overlap), 1735, 1690, 1640 1600, 1560, 1340 cm^{-1}; ^1H NMR 1.19 (3H, t, J=7.0 Hz), 2.18 (3H, s), 4.08 (2H, q, J=7.0 Hz), 6.20 and 6.42 (2H, 2 br s, D_2O ex), 7.49-7.87 (4H, m), 8.26 (1H, s, D_2O ex), 8.48 and 8.79 (1H, 2 br s, D_2O ex) ppm.

2c: IR 3340, 3250, 3210, 1725, 1695, 1660, 1590, 1560, 1340 cm^{-1}; ^1H NMR 2.24 (3H, s), 3.63 (3H, s), 6.94-8.0 (9H, m), 8.39 and 8.76 (1H, 2s, D_2O ex), 8.94 and 9.20 (1H, 2s, D_2O ex) ppm.

2d: IR 3350, 3260, 3220, 1725, 1695, 1660 1590, 1560, 1350 cm^{-1}; ^1H NMR 1.20 (3H, t, J=7.0 Hz), 2.24 (3H, s), 4.09 (2H, q, J=7.0 Hz), 6.94-7.99 (9H, m), 8.35 and 8.74 (1H, 2s, D_2O ex), 8.92 and 9.18 (1H, 2 s, D_2O ex) ppm.

2e: IR 3320, 3220, 1760, 1730, 1670, 1600, 1560, 1350 cm^{-1}; ^1H NMR 2.17 (3H, s), 3.00, 3.54, 3.62, 3.70 and 3.78 (6H, 5 s), 7.72-7.94 (4H, m), 8.36 and 8.52 (1H, 2 s, D_2O ex), 9.85 and 10.26 (1H, 2 s, D_2O ex) ppm.

2f: IR 3310, 3130, 1755, 1735, 1660, 1600, 1540, 1340 cm^{-1}; ^1H NMR 1.19 (3H, t, J=7.0 Hz), 2.16 (3H, s), 3.00, 3.53 and 3.70 (3H, 3 s), 4.06 (2H, q, J=7.0 Hz), 7.71-7.93 (4H, m), 8.32 and 8.48 (1H, 2 s, D_2O ex), 9.84 and 10.25 (1H, 2 s, D_2O ex) ppm.

2g: IR 3250, 3180, 1740, 1730, 1670, 1600, 1520, 1350 cm^{-1}; ^1H NMR 1.31, 1.46 and 2.08 (9H, 3 s), 2.14 and 2.19 (3H, 2 s), 3.59 and 3.61 (3H, 3 s), 7.65-7.95 (4H, m), 8.40, (1H, s, D_2O ex), 9.52 and 9.97 (1H, 2 s, D_2O ex) ppm.

2h: IR 3320, 3100, 1745, 1730, 1695, 1650 1600, 1510, 1355 cm^{-1}; ^1H NMR 1.19 (3H, t, J=7.0 Hz), 1.31 and 1.47 (9H, 2 s),2.14 and 2.19 (3H, 2 s), 4.08 (2H, q, J=7.0 Hz), 7.65-7.95 (4H, m), 8.38, (1H, s, D_2O ex), 9.51 and 9.98 (1H, 2 s, D_2O ex) ppm.

General procedure for the synthesis of a,b-olefinated hydrazone derivatives 5a-j. To a stirred solution of benzoylnitromethane (**3a**), ethyl nitroacetate (**3b**) or ethyl-2-nitropropionate (**3c**) (1 mmol) dissolved in THF (3 ml) was added a catalytic amount of sodium methoxide (0.1 mmol) and the mixture was allowed to stand under magnetic stirring at room temperature for 5 min. Then, to this stirred solution cooled at ice-bath temperature (0-5 °C) was added dropwise a solution of azoalkenes **1a-f** (1 mmol) dissolved in THF (3 ml). The mixture was magnetically stirred at ice-bath temperature for the appropriate reaction time (see Table 2). In the case of **5a-e** the reaction mixture was concentrated to a small volume under reduced pressure at room temperature and the crude α,β-olefinated hydrazone derivatives **5a-e** were purified by chromatography on a silica gel column (cyclohexane-ethyl acetate mixtures) and subsequent crystallization from dichloromethane-petroleum ether (30-60 °C). In all other cases a TLC check showed as major components two very near spots corresponding to the

intermediate **4** and the final product **5** in different ratios. Therefore, the reaction mixtures were concentrated under reduced pressure, dissolved in methanol (10 ml) and refluxed for an additional time (0.7-2.0 h) to achieve the completion. After the evaporation of methanol, the products **5f-j** may be isolated and purified with the same methodology as the products **5a-e**. For the isolation and characterization of the 1,4-adduct intermediates **4f-h**, the reaction was carried out under magnetic stirring at 0-5 °C (ice-bath) using ethyl acetate as a solvent. When the mixture became colourless or pale yellow, petroleum ether (30-60 °C) was added and the first white solid precipitate was collected by suction and identified as the 1,4-adduct intermediates **4f-h.**

4f: IR 3380, 3210, 3140, 3110, 1755, 1745, 1695, 1645, 1595, 1575, 1320 cm^{-1}; ^1H NMR 1.17 (3H, t, J=7.0 Hz), 2.01 (3H, s), 3.71 (3H, s), 4.23 (2H, q, J=7.0 Hz), 4.50-4.57 (1H, m), 6.72-6.79 (1H, m), 7.02 (1H, t, J=7.0 Hz), 7.31 (2H, t, J=7.0 Hz), 7.57 (2H, d, J=7.0 Hz), 8.37 (1H, s, D_2O ex), 9.92 (1H, s, D_2O ex) ppm.

4g: IR 3480, 3360, 3290, 3210, 3160, 1740, 1690, 1655, 1585, 1560, 1310 cm^{-1}; ^1H NMR 1.17 (3H, t, J=7.0 Hz), 1.87 (6H, s), 3.65 and 3.68 (3H, 2 s), 4.20 (2H, q, J=7.0 Hz), 4.50 and 4.53 (1H, 2s), 6.27 (2H, br s, D_2O ex), 9.47 (1H, s, D_2O ex) ppm.

4h: IR 3380, 3200, 3100, 1745, 1690, 1640, 1600, 1530 1310 cm^{-1}; ^1H NMR 1.17 (3H, t, J=7.0 Hz), 1.96 (6H, s), 3.71 (3H, s), 4.23 (2H, q, J=7.0 Hz), 4.66 and 4.69 (1H, 2s), 7.02 (1H, t, J=7.0 Hz), 7.31 (2H, t, J=7.0 Hz), 7.54 (2H, d, J=7.0 Hz), 8.17 (1H, s, D_2O ex), 9.86 (1H, s, D_2O ex) ppm.

5a: IR 3460, 3200, 3120, 1735, 1710, 1650, 1595 cm^{-1}; ^1H NMR 2.15 (3H, s), 3.76 (3H, s), 6.29 (2H, br s, D_2O ex), 7.43 (1H, s), 7.53-7.69 (3H, m), 8.09 (2H, d, J=7.0 Hz), 10.05 (1H, s, D_2O ex) ppm.

5b: IR 3460,3360, 3200, 3120, 1735, 1710, 1650, 1595 cm^{-1}; ^1H NMR 1.28 (3H, t, J=7.0 Hz), 1.82 (3H, s), 4.27 (2H, q, J=7.0 Hz), 5.93 (2H, br s, D_2O ex), 7.40 (1H, s), 7.48-7.68 (3H, m), 7.80 (2H, d, J=7.0 Hz), 9.30 (1H, s, D_2O ex) ppm.

5c: IR 3360, 3190, 3100, 1720, 1690, 1655, 1590 cm^{-1}; ^1H NMR 1.91 (3H, s), 3.83 (3H, s), 6.99 (1H, t, J=7.0 Hz), 7.22-7.62 (8H, m), 7.81 (2H, d, J=7.0 Hz), 7.90 (1H, s, D_2O ex), 9.88 (1H, s, D_2O ex) ppm.

5d: IR 3370, 3200, 3110, 1735, 1695, 1660, 1600, 1595 cm^{-1}; ^1H NMR 1.30 (3H, t, J=7.0 Hz), 1.91 (3H, s), 4.29 (2H, q, J=7.0 Hz), 7.00 (1H, t, J=7.0 Hz), 7.23-7.63 (8H, m), 7.81 (2H, d, J=7.0 Hz), 7.90 (1H, s, D_2O ex), 9.87 (1H, s, D_2O ex) ppm.

5e: IR 3280, 1755, 1710, 1640, 1580 cm^{-1}; ^1H NMR 1.21 (3H, t, J=7.0 Hz), 2.01 (3H, s), 3.69 (6H, s), 4.16 (2H, q, J=7.0 Hz), 6.25 (1H, s), 10.56 (1H, s, D_2O ex) ppm.

5f: IR 3380, 3200, 3100, 1750, 1715, 1685, 1650, 1595 cm^{-1}; ^1H NMR 1.23 (3H, t, J=7.0 Hz), 2.08 (3H, s), 3.81 (3H, s), 4.16 (2H, q, J=7.0 Hz), 6.35 (1H, s),7.05 (1H, t, J=7.0 Hz), 7.33 (2H, t, J=7.0 Hz), 7.44 (2H, d, J=7.0 Hz), 8.29 (1H, s, D_2O ex), 10.48 (1H, s, D_2O ex) ppm.

5g: IR 3520, 3480, 3390, 3360, 3200, 3140, 1720, 1680, 1640, 1585 cm^{-1}; ^1H NMR 1.14 (3H, t, J=7.0 Hz), 1.83 (3H, s), 2.07 (3H, s), 3.74 (3H, s), 4.05 (2H, q, J=7.0 Hz), 6.33 (2H, br s, D_2O ex), 9.48 (1H, s, D_2O ex) ppm.

5h: IR 3360, 3190, 3120, 3070, 1730, 1685, 1630, 1595 cm^{-1}; ^1H NMR 1.11 (3H, t, J=7.0 Hz), 1.93 (3H, s), 2.14 (3H, s), 3.77 (3H, s), 4.05 (2H, q, J=7.0 Hz), 7.05 (1H, t, J=7.0 Hz), 7.30 (2H, t, J=7.0 Hz), 7.53 (2H, d, J=7.0 Hz), 8.31 (1H, s, D_2O ex), 10.04 (1H, s, D_2O ex) ppm.

5i: IR 3240, 1740, 1730, 1725, 1650 cm^{-1}; ^1H NMR 1.14 (3H, t, J=7.0 Hz), 1.88 (3H, s), 2.10 (3H, s), 3.65 (3H, s), 3.73 (3H, s), 4.06 (2H, q, J=7.0 Hz), 10.11 (1H, s, D_2O ex) ppm.

5j: IR 3225, 3125, 1735, 1725, 1690, 1635 cm^{-1}; ^1H NMR 1.22 (3H, t, J=7.0 Hz), 1.46 (9H, s), 1.93 (6H, s), 3.66 (3H, s), 4.16 (2H, q, J=7.0 Hz), 9.90 (1H, s, D_2O ex) ppm.

General procedure for the synthesis of asymmetric α-azinohydrazone derivatives 7a-h. To a stirred solution of benzoylnitromethane tosylhydrazone (**6a**) or α-nitroacetone tosylhydrazone (**6b**) (1 mmol) dissolved in THF (3 ml) was added a catalytic amount of sodium methoxide (0.1 mmol) and the mixture was allowed to stand under magnetic stirring at room temperature for 5 min. Then, to this stirred solution was added dropwise a solution of azoalkenes **1a,c,e,h** (2 mmol) dissolved in THF (6 ml). The reaction mixture was magnetically stirred at room temperature until the reagents disappearance was complete and the solution became bright yellow (see Table 3). A TLC check revealed a complicated mixture but, after the evaporation of the reaction solvent under reduced pressure at room temperature, cold crystallization from methanol afforded the asymmetric α-azinohydrazone derivatives **7a-h** in good purity. Improvement of the yields of **7a-h** may be obtained by coloumn chromatography of the mother liquor.

7a: IR 3500, 3470, 3370, 3210, 3130, 1740, 1705, 1600, 1570 and 1345 cm^{-1}; ^1H NMR 1.95 and 2.01 (3H, 2s), 3.84 (3H, s), 6.20 (4H, 1s and 1 br s, D_2O ex), 7.51-7.55 (3H, m), 7.91-7.95 (2H, m), 10.28 and 10.63 (1H, 2s, D_2O ex) ppm.

7b: IR 3380, 3200, 3130, 1745, 1690, 1605, 1595, 1550 and 1325 cm^{-1}; ^1H NMR 2.16 and 2.29 (3H, 2s), 3.89 (3H, s), 6.23 (2H, s, D_2O ex), 7.05-7.98 (10H, m), 8.57 (1H, s, D_2O ex), 10.63 (1H, s, D_2O ex) ppm.

7c: IR 3230, 1755, 1725, 1545, 1595, 1560 and 1335 cm^{-1}; ^1H NMR 2.11 (3H, s), 3.73 (3H, s), 3.79 (3H, s), 6.20 (2H, s, D_2O ex), 7.52-7.56 (3H, m), 7.91-7.95 (2H, m), 10.93 (1H, s, D_2O ex) ppm.

7d: IR 3215, 3150, 1740, 1705, 1590, 1550 and 1320 cm^{-1}; ^1H NMR 1.27 (3H, t, J=7.0 Hz), 1.47 (9H, s), 2.09 (3H, s), 4.29 (2H, q, J=7.0 Hz), 6.20 (2H, s, D_2O ex), 7.49-7.55 (3H, m), 7.92-7.96 (2H, m), 10.60 (1H, s, D_2O ex) ppm.

7e: IR 3460, 3190, 3140, 1730, 1705, 1605, 1580 and 1340 cm^{-1}; ^1H NMR 2.02 and 2.08 (3H, 2s), 3.72 and

3.93 (3H, 2s), 5.51, 6.69 and 12.84 (2H, 3s, D_2O ex), 6.52 (2H, br s, D_2O ex), 10.00 and 10.16 (1H, 2s, D_2O ex) ppm.

7f: IR 3350, 3190, 3080, 1700, 1680, 1590, 1530 and 1340 cm^{-1}; ^1H NMR 2.04 and 2.14 (3H, 2s), 2.16 and 2.25 (3H, 2s), 3.77 and 3.97 (3H, 2s), 5.53, 6.97 and 13.07 (2H, 3s, D_2O ex), 7.03 (1H, t, J=7.0 Hz), 7.31 (2H, t, J=7.0 Hz), 7.52 (2H, d, J=7.0 Hz), 8.65 (1H, s, D_2O ex), 10.39 (1H, s, D_2O ex) ppm.

7g: IR 3220, 3140, 1730, 1705, 1610, 1590 and 1330 cm^{-1}; ^1H NMR 2.02 and 2.09 (3H, 2s), 2.20 and 2.24 (3H, 2s), 3.68 and 3.71 (3H, 2s), 3.81 and 3.89 (3H, 2s), 5.51, 6.95 and 12.77 (2H, 3s, D_2O ex), 10.69 (1H, s, D_2O ex) ppm.

7h: IR 3220, 3140, 1730, 1700, 1610, 1590 and 1330 cm^{-1}; ^1H NMR 1.31 (3H, t, J=7.0 Hz), 1.45 (9H, s), 2.00 and 2.06 (3H, 2s), 2.18 and 2.23 (3H, 2s), 4.35 (2H, q, J=7.0 Hz), 5.49, 6.94 and 12.64 (2H, 3s, D_2O ex), 10.40 (1H, s, D_2O ex) ppm.

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