JOC Article

Expeditious Synthesis of New 1,2,3-Thiadiazoles and 1,2,3-Selenadiazoles from 1,2-Diaza-1,3-butadienes via Hurd−Mori-Type Reactions

Orazio A. Attanasi,[†] Lucia De Crescentini,[†] Gianfranco Favi,[†] Paolino Filippone,*[,†] Gianluca Giorgi,[‡] Fabio Mantellini,[†] and Stefania Santeusanio[†]

Istituto di Chimica Organica, Università degli Studi di Urbino, Piazza della Repubblica 13, 61029 Urbino, Italy, and Centro Interdipartimentale di Analisi e Determinazioni Strutturali, Università degli Studi di Siena, Via Aldo Moro, 53100 Siena, Italy

filippone@uniurb.it

Received September 26, 2002

α-Substituted hydrazones obtained from 1,2-diaza-1,3-butadienes and methylenic or methinic activated substrates gave rise to a wide range of cyclic compounds. In particular, in the presence of thionyl chloride as solvent-reagent, they were transformed into 1,2,3-thiadiazoles,[1] with selenium oxychloride in new 4-substituted 2,3-dihydro-1,2,3-selenadiazoles, while with selenium dioxide, they were transformed into 4-substituted 1,2,3-selenadiazoles. We have also examined the nucleophilic behavior of 1,2,3-thiadiazole **4a** in the reaction with 1,2-diaza-1,3-butadienes that produced, under basic conditions, 4-hydrazono-1-(1,2,3-thiadiazolyl)pentane derivatives. This event represents an interesting example of stereoselective synthesis because it leads exclusively to the formation of the *RR*/*SS* racemic mixture. These latter compounds, treated with thionyl chloride, gave the corresponding 1,3-di-1,2,3-thiadiazolylpropane derivatives, while with sodium methoxide they afforded 1,2,3-thiadiazolyl-2-oxo-2,3-dihydro-1*H*-pyrrole systems.

Introduction

In our 25 years of experience in the field of the heterocyclic chemistry,[2] 1,2-diaza-1,3-butadienes were demonstrated to have considerable potential toward a wide range of nucleophiles.[3,4] This behavior is ascribable to the presence of the azo group in conjugated azoalkenes that is also able to determine the regioselectivity of such attack on the terminal carbon atom. Hence, the synthesis of α-substituted hydrazone derivatives is obtained as a consequence of 1,4-conjugated addition (Michael-type) of nucleophiles to the heterodiene system of 1,2-diaza-1,3-butadienes. In continuation of our ongoing interest in the chemistry of 1,2-diaza-1,3-butadienes, we have recently reported the synthesis of 4-substituted 1,2,3-thiadiazoles via Hurd−Mori reaction[5] from α-substituted hydrazones.[6−8] Based on this experience and considering the increased interest in the chemical and bioactive nature of several organosulfur[9−,14] or organoselenium[3,15,16] com-

* To whom correspondence should be addressed. Fax: +39-0722-2907. E-mail: (O.A.A.) attanasi@uniurb.it.

[†] Università degli Studi di Urbino.

[‡] Università degli Studi di Siena.

(1) Stanetty, P.; Turner, M.; Mihovilovic, M. D. In *Targets in Heterocyclic Systems—Chemistry and Properties*; Attanasi, O. A., Spinelli, D., Eds.; Società Chimica Italiana: Rome, 1999; Vol. 3, p 265. Meier, H.; Hanold, N. In *Methoden der Organischen Chemie*; Houben-Weyl, Thieme, G.: Stuttgart, New York, 1994; Vol. E8D, p 60. Thomas, E. W. In *Comprehensive Heterocyclic Chemistry II*; Storr, R. C., Katritzky, A. R., Rees, C. W., Sriven, E. F. V., Series Eds.; Pergamon: London, 1996; Vol. 4, p 289.

(2) Attanasi, O. A.; Filippone, P. In *Topics in Heterocyclic Systems, Synthesis, Reactions and Properties*; Attanasi, O. A., Spinelli, D., Eds.; Società Chimica Italiana: Rome, 1996; Vol. 1, p 157. Attanasi, O. A.; Filippone, P. *Synlett* **1997**, 1128. Attanasi, O. A.; De Crescentini, L.; Filippone, P.; Foresti, E.; Mantellini, F. *J. Org. Chem.* **2000**, *65*, 2820. Attanasi, O. A.; De Crescentini, L.; Filippone, P.; Mantellini, F.; Tietze, L. F. *Tetrahedron* **2001**, *57*, 5855. Attanasi, O. A.; De Crescentini, L.; Filippone, P.; Mantellini, F.; Santeusanio, S. *Helv. Chim. Acta* **2001**, *84*, 2379. Rossi, E.; Arcadi, A.; Abbiati, G.; Attanasi, O. A.; De Crescentini, L. *Angew. Chem., Int. Ed.* **2002**, *41*, 1400. Attanasi, O. A.; De Crescentini, L.; Favi, G.; Filippone, P.; Mantellini, F.; Santeusanio, S. *Synthesis* **2002**, 1546. Attanasi, O. A.; De Crescentini, L.; Favi, G.; Filippone, P.; Mantellini, F.; Santeusanio, S. *J. Org. Chem.* **2002**, *67*, 8178.

(3) Banert, K. In *Targets in Heterocyclic Systems—Chemistry and Properties*; Attanasi, O. A., Spinelli, D., Eds.; Società Chimica Italiana: Rome, 2000; Vol. 3, p 1. Polanc, S. In *Targets in Heterocyclic Systems—Chemistry and Properties*; Attanasi, O. A., Spinelli, D., Eds.; Società Chimica Italiana: Rome, 2000; Vol. 3, p 33 and references therein.

(4) Clarke, S. J.; Gilchrist, T. L.; Lemos, A.; Roberts, T. G. *Tetrahedron* **1991**, *47*, 5615. Gilchrist, T. L.; Lemos, A. *J. Chem. Soc., Perkin Trans. 1* **1993**, 1391.

(5) Attanasi, O. A.; De Crescentini, L.; Filippone, P.; Mantellini, F. *Synlett* **2001**, 557.

(6) Attanasi, O. A.; De Crescentini, L.; Serra-Zanetti, F. *Can. J. Chem.* **1994**, *72*, 2305.

(7) Arcadi, A.; Attanasi, O. A.; Liao, Z.; Serra-Zanetti, F. *Synthesis* **1994**, 605.

(8) Attanasi, O. A.; Filippone, P.; Fiorucci, C.; Foresti, E.; Mantellini, F. *J. Org. Chem.* **1998**, *63*, 9880.

(9) Thomas, E. W.; Nishizawa, E. E.; Zimmermann, D. C.; Williams, D. J. *J. Med. Chem.* **1985**, *28*, 442.

(10) Pain, D. L.; Slack, R. *J. Chem. Soc.* **1965**, 5166. Lewis, G. S.; Nelson, P. H. *J. Med. Chem.* **1979**, *22*, 1214. Lalezari, I.; Shafiee, A.; Yazdany, S. *J. Pharm. Sci.* **1974**, *63*, 628.

(11) Ramsden, S. I.; Ögren, S. O.; Ross, S. S.; Stjernstrom, N. E. *Acta Pharm. Suec.* **1973**, *10*, 285.

(12) FMC Corp. U. S. Pat. 3 874 873, 1975; *Chem. Abstr.* **1973**, *78*, 97663.

(13) Schurter, R.; Kunz, W.; Nyfeler, R. European Patent Appl. EP 0, 313, 512 A2, 1990; *Chem. Abstr.* **1990**, *112*, 17750a. Kunz, W.; Schurter, R.; Maetzke, T. *Pestic. Sci.* **1997**, *50*, 275. Stanetty, P.; Kunz, W. European Patent Appl. EP 780394A1, 1997; *Chem. Abstr.* **1997**, *127*, 121735.

10.1021/jo0264832 CCC: $25.00
Published on Web 02/07/2003

pounds, we have developed a procedure to prepare new 4-substituted 2,3-dihydro-1,2,3-selenadiazoles and 4-substituted 1,2,3-selenadiazoles following a Hurd−Mori-type reaction. We have also corrected a methodology for the preparation of di-1,2,3-thiadiazole and 1,2,3-thiadiazole-2-oxo-2,3-dihydro-1*H*-pyrrole systems, thanks to a further addition of another molecule of 1,2-diaza-1,3-butadiene onto some 1,2,3-thiadiazoles and a subsequent cyclization process.

Results and Discussion

1,2-Diaza-1,3-butadienes **1a**−**d** reacted with activated methylenic and methinic compounds **2a**−**h** to give α-substituted hydrazones **3a**−**m** in good to excellent yields (Scheme 1) by means of 1,4-conjugated addition (Michael type).[6−8]

This reaction easily occurred in tetrahydrofuran in the presence of a catalytic amount of sodium methoxide (for **3a**−**j**) or sodium hydride (for **3k**−**m**).

In a previous work,[5] we described the formation of 1,2,3-thiadiazoles via the Hurd−Mori reaction, starting from these latter substrates. In fact, at room temperature, α-substituted hydrazones **3a**,**b**,**d**,**e**,**g**,**h**,**j**−**l**, derived from 1-*tert*-butoxycarbonyl-1,2-diaza-1,3-butadienes, readily reacted under solvent-free conditions with thionyl chloride, both as solvent and reagent, producing 1,2,3-thiadiazoles **4a**−**i** in good yields (Scheme 1, path A).

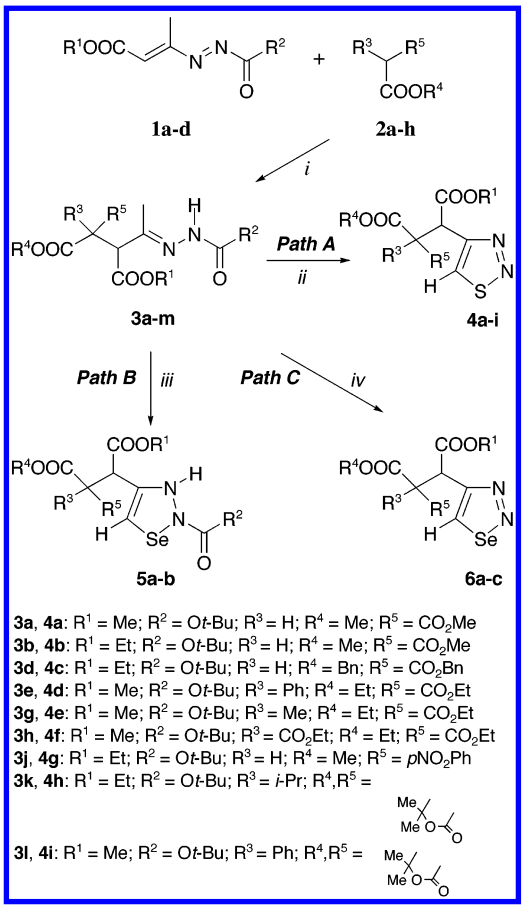
Starting from the same compounds **3b**,**e**, new 4-substituted 2,3-dihydro-1,2,3-selenadiazoles **5a**,**b** were obtained. The reaction happened in the presence of 2 equiv of selenium oxychloride,[17] in dichloromethane, from −20 °C to room temperature (Scheme 1, path B, Table 1).

Under these mild conditions, the aromatization process did not occur, and only 2,3-dihydro compounds were observed. The advantage of this synthetic approach is the ease of workup: in fact, compounds **5a**,**b** were achieved pure solely by addition to the reaction mixture of aqueous saturated solution of sodium hydrogen carbonate and subsequent evaporation of the organic solvent.

Instead, semicarbazones **3f**,**i**,**m**, obtained from 1-aminocarbonyl-1,2-diaza-1,3-butadiene **1d** and methinic derivatives such as diethyl phenylmalonate **2c**, trimethyl methanetricarboxylate **2e**, and 2,2-dimethyl-5-phenyl-1,3-dioxane-4,6-dione **2h**, produced the pertinent 4-substituted 1,2,3-selenadiazoles **6a**−**c** by treatment with 3 equiv of selenium dioxide[18] in acetic acid at 90 °C. Under these more drastic conditions, the aromatization process took place (Scheme 1, path C, Table 2).

Under the same reaction conditions used for **6a**−**c**, the semicarbazone **3c**, obtained from 1-aminocarbonyl-1,2-diaza-1,3-butadiene **1c** and dimethyl malonate **2a**, gave

SCHEME 1[a]



[a] Reagents and conditions: (i) THF/rt, MeONa or NaH; (ii) $SOCl_2$/rt; (iii) $SeOCl_2$ (2 equiv), CH_2Cl_2/from −20 °C to rt; (iv) SeO_2 (3 equiv), AcOH/90 °C.

TABLE 1. Yields and Reaction Times of 4-Substituted 2,3-Dihydro-1,2,3-selenadiazoles (5a,b)

3	R^1	R^2	R^3	R^4	R^5	5	yield[a] (%)	time (h)
3b	Et	O-*t*-Bu	H	Me	CO_2Me	**5a**	77	12.0
3e	Me	O-*t*-Bu	Ph	Et	CO_2Et	**5b**	71	10.0

[a] Yield of pure isolated products.

TABLE 2. Yields and Reaction Times of 4-Substituted 1,2,3-Selenadiazoles (6a−c)

3	R^1	R^2	R^3	R^4	R^5	6	yield[a] (%)	time (h)
3f	Me	NH_2	Ph	Et	CO_2Et	**6a**	87	5.0
3i	Me	NH_2	CO_2Et	Et	CO_2Et	**6b**	75	7.0
3m	Me	NH_2	Ph	Me	Me O O	**6c**	88	8.0

[a] Yield of pure isolated products.

(14) Stanetty, P.; Turner, M.; Mihovilovic, M. D. In *Targets in Heterocyclic Systems—Chemistry and Properties*; Attanasi, O. A., Spinelli, D., Eds.; Società Chimica Italiana: Rome, 2000; Vol. 3, p 265.
(15) Mandour, A. H.; El-Shihi, T. H.; Nehad, A. L.; El-Bazza, Z. E. *Phosphorus, Sulfur Silicon Relat. Elem.* **1996**, *113*, 155. Litvinov, V. P.; Dyachenko, V. D. *Russian Chem. Rev.* **1997**, *66*, 923. Bradley, P. A.; Wilkins, D. J. *Prog. Heterocycl. Chem.* **1998**, *10*, 172 and references therein. Reddy, D. B.; Reddy, M. V. R.; Padmaja, A.; Padmavathi, V. *Phosphorus, Sulfur Silicon Relat. Elem.* **1998**, *141*, 191. Shafiee, A.; Jialilian, A. R., Rezaei, M. J. *J. Heterocycl. Chem.* **2000**, *37*, 1325.
(16) *Selenium in Biology and Human Health*; Burk, R. F., Ed.; Springer-Verlag: New York, 1989. Nishihara, T.; Nishikawa, J.; Kanajama, T.; Dakejama, F.; Saito, K.; Imagawa, M.; Takatori, S.; Kitagawa, Y.; Hori, S.; Utsumi, H. *J. Health Sci* **2000**, *46*, 282. Kim, Y. Y. *J. Anim. Sci. Technol.* **2000**, *42*, 835. Bushnell, D. A.; Cramer, P.; Kornberg, R. D. *Structure* **2001**, *9*, 11. Block, E.; Birringer, M.; Jiang, V.; Nakahodo, T.; Thompson, H. J.; Toscano, P. J.; Vzar, H.; Zhang, X.; Zhu, Z. *J. Agric. Food Chem.* **2001**, *49*, 458. Burling, F. T.; Goldenstein, B. M. *J. Am. Chem. Soc.* **1992**, *114*, 2313.
(17) Grandi, R.; Vivarelli, P. *J. Chem. Res.* **1989**, 186.
(18) Lalezari, I.; Shafiee, A.; Yalpani, M. *Tetrahedron Lett.* **1969**, *58*, 5105. Lalezari, I.; Shafiee, A.; Yalpani, M. *Angew. Chem.* **1970**, *9*, 464.

SCHEME 2

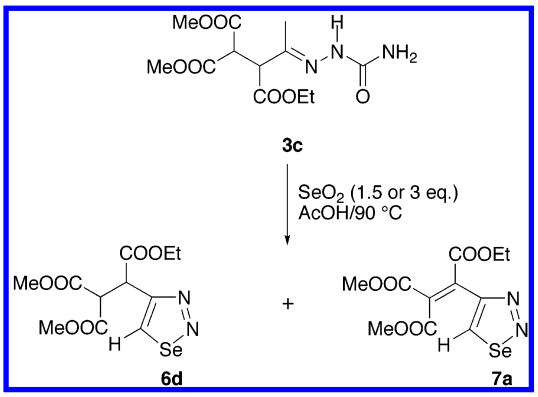


TABLE 3. Yields of 2-Ethyl-1,1-dimethyl-2-(1,2,3-selenadiazol-4-yl)ethane-1,1,2-tricarboxylate (6d) and 2-Ethyl-1,1-dimethyl-2-(1,2,3-selenadiazol-4-yl)-ethylene-1,1,2-tricarboxylate (7a)

3 or **9**	**6**	yield[a] (%)	**7**	yield[a] (%)
3c	**6d**	18[b]	**7a**	58[b]
3c	**6d**	43[c]	**7a**	25[c]

[a] Yield of pure isolated products. [b] Yield refers to use of 3.0 equiv of selenium dioxide. [c] Yield refers to use of 1.5 equiv of selenium dioxide.

a mixture of two products: the expected 4-ethane-1,2,3-selenadiazole **6d** and 4-ethylene-1,2,3-selenadiazole **7a** produced by means of the carbon−carbon single-bond oxidation. Products **6d** and **7a** were separated by chromatographic methods, and **7a** was found to be the main component (**6d**, 18%; **7a**, 58%). The best conditions to enhance the formation of **6d** required the use of 1.5 equiv of selenium dioxide in acetic acid at 90 °C (**6d**, 43%; **7a**, 25%) (Scheme 2, Table 3).

To obtain pure compound **7a**, we planned to start from α,*β*-olefinated hydrazones. These latter compounds were prepared starting from 1,2-diaza-1,3-butadienes **1b**−**d** with dimethyl or diethyl nitromalonates **8a**,**b** in tetrahydrofuran, using a catalytic amount of sodium hydride (Scheme 3, Table 4).[19]

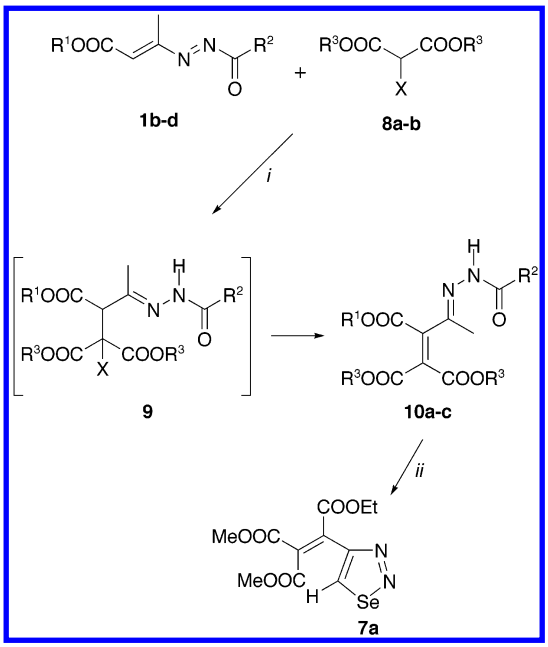
The reaction proceeded via preliminary formation of 1,4-adduct intermediates **9**, and the subsequent elimination of a nitrous acid molecule produced the expected α,*β*-olefinated hydrazones **10a**−**c**. The use of nitromalonate derivatives furnishes a further contribution to the existent literature[19] for the synthesis of similar compounds.

As formerly supposed, α,*β*-olefinated hydrazone **10a**, treated with 3 equiv of selenium dioxide in acetic acid at 90 °C, gave only product **7a** in 7 h in satisfactory purity (yield 79%) (Scheme 3).

The structure of 1,2,3-selenadiazoles **5a**,**b**, **6a**−**d**, and **7a** was confirmed using ^{1}H and ^{13}C NMR techniques by the presence of two satellite peaks, due to the coupling ^{77}Se−C−H. In particular, the proton bound to C5 gives a strong singlet at 9.00−9.50 ppm with a weak doublet (J = 43−45 Hz) in ^{1}H NMR, while C5 shows a signal at 135.0−146.0 ppm with a satellite doublet (J = 134−137 Hz) in ^{13}C NMR, in good agreement with the data reported in the literature.[20]

(19) Attanasi, O. A.; Ballini, R.; De Crescentini, L.; Filippone, P.; Mantellini, F. *J. Org. Chem.* **1999**, *64*, 9653.

SCHEME 3[a]



[a] Reagents and conditions: (i) THF, MeONa or NaH; (ii) SeO_2 (3 equiv), AcOH/90 °C.

TABLE 4. Yields and Reaction Times of α,*β*-Olefinated Hydrazones (10a−c)

1	R^1	R^2	**8**	R^3	X	**10**	yield[a] (%)	time (h)
1c	Et	NH_2	**8a**	Me	NO_2	**10a**	68	7.0
1b	Et	O-*t*-Bu	**8b**	Et	NO_2	**10b**	64	48.0
1d	Me	NH_2	**8b**	Et	NO_2	**10c**	85	8.0

[a] Yield of pure isolated products.

SCHEME 4

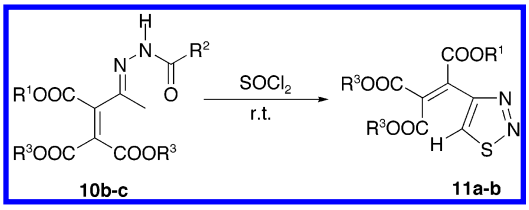


TABLE 5. Yields and Reaction Times of 2-(1,2,3-Thiadiazol-4-yl)ethylene-1,1,2-tricarboxylates (11a,b)

10	R^1	R^2	R^3	**11**	yield[a] (%)	time (h)
10b	Et	O-*t*-Bu	Et	**11a**	61	1.2
10c	Me	NH_2	Et	**11b**	58	168.0

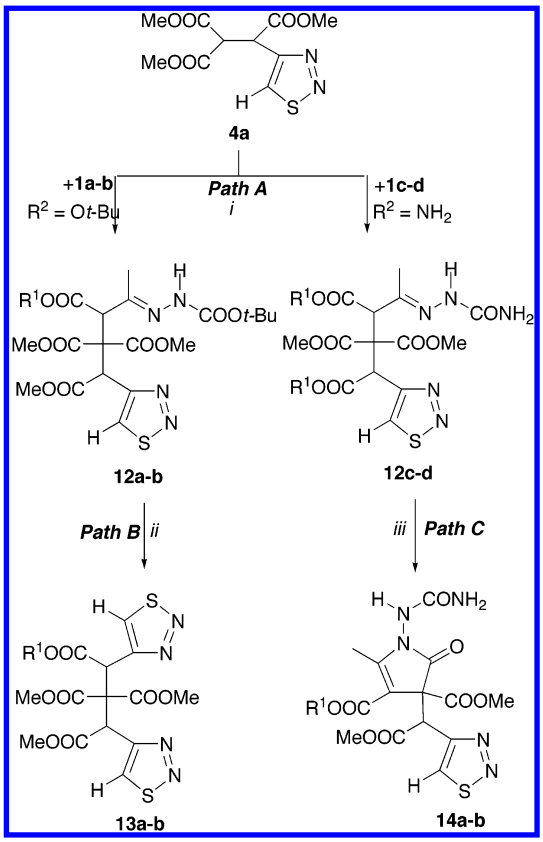
[a] Yield of pure isolated products.

By analogy, α,*β*-olefinated hydrazones **10b**,**c**, treated with thionyl chloride as solvent-reagent, at room temperature afforded the relevant 4-ethylene-1,2,3-thiadiazole derivatives **11a**,**b** (Scheme 4, Table 5).

In these types of reactions, the importance of the leaving group in the Hurd−Mori process was remarkable: we observed that, in the case of **10b**, where the hydrazino moiety was *tert*-butyl carbazate, its transfor-

(20) Lalezari, I.; Shafiee, A.; Yalpani, M. *J. Org. Chem.* **1971**, *36*, 2836. Petrov, M. L.; Abramov, M. A.; Dehaen, W.; Toppet, S. *Tetrahedron Lett.* **1999**, *40*, 3903.

SCHEME 5[a]



[a] Reagents and conditions: (i) THF/rt, MeONa (0.2 equiv); (ii) $SOCl_2$/rt; (iii) THF−MeOH/rt; CH_3ONa (0.4 equiv).

TABLE 6. Yields and Reaction Times of 4-Hydrazono-1-(1,2,3-thiadiazolyl)pentane Derivatives (12a−d), 1,3-Di-1,2,3-thiadiazolylpropane Derivatives (13a,b), and 1,2,3-Thiadiazolyl-2-oxo-2,3-dihydro-1*H*-pyrrole Systems (14a,b)

4	R^1	R^2	12	yield[a] (%)	time (h)	13, 14	yield[a] (%)	time (h)
4a	Me	O-*t*-Bu	**12a**	93	0.2	**13a**	82	4.0
4b	Et	O-*t*-Bu	**12b**	94	0.2	**13b**	60	2.7[12]
4d	Et	NH_2	**12c**	87	2.0	**14a**	61	2.0
4e	Me	NH_2	**12d**	64	2.7	**14b**	78	1.5

[a] Yield of pure isolated products.

mation into the corresponding **11a** occurred in 1.2 h, while, in the case of **10c**, where the hydrazino moiety was semicarbazide, the reaction to give **11b** happened very slowly (168.0 h).

The presence of two carbonyl groups bound at the carbon in position 1 of the side chain makes compound **4a** able to behave as nucleophile. In fact, under basic conditions, the 1,4-addition of this substrate to another molecule of 1,2-diaza-1,3-butadiene **1a**−**d** resulted in the formation of the corresponding 4-hydrazono-1-(1,2,3-thiadiazolyl)pentane derivatives **12a**−**d** (Scheme 5, path A, Table 6).

The ^1H and ^{13}C NMR analysis surprisingly revealed that compounds **12a**−**d** were obtained exclusively as a sole couple of enantiomers. To determine the exact configuration, an X-ray crystallographic study was carried out on **12a**. It crystallizes as two different polymorphs, suggesting that during the crystallization process two crystal lattices, i.e., triclinic (**12a1**) and orthorhombic (**12a2**), are energetically accessible. Both the polymorphs crystallizes as racemic forms *RR*/*SS*. In **12a1** and **12a2,** geometric parameters are quite close each other, while significant differences are in the molecular conformations, mainly due to the orientation of the carboxymethyl groups and to the hydrazone side chain. For example, the torsion angle C(5)−C(8)−C(11)−O(12) is 159.84(14)° in **12a1**, while it is rotated about 184° in **12a2**. The crystal lattices of the two structures are stabilized by van der Waals interactions.

Indeed, it is noteworthy that the formation of **12a**−**d** is highly stereoselective, since the reaction produced exclusively a racemic form of *RR*/*SS* enantiomers.

Compounds **12a**,**b** were then treated with thionyl chloride both as solvent and reagent, and the 1,3-di-1,2,3-thiadiazolylpropane derivatives **13a**,**b** were formed in good yields (Scheme 5, path B, Table 6).

If compounds **12c**,**d** were worked up with sodium methoxide in a tetrahydrofuran−methanol mixture, 1,2,3-thiadiazolyl-2-oxo-2,3-dihydro-1*H*-pyrrole systems **14a**,**b** were obtained, as a 50:50 diastereoisomeric mixture, in good yields (Scheme 5, path C, Table 6). The reaction proceeds by means of an intramolecular nucleophilic attack of the −C=N− nitrogen atom to the ester group derived from the starting malonate, with consequential loss of an alcohol molecule.[6,21]

The NMR spectroscopy and the X-ray evidence unequivocally confirmed that the attack of **4a** onto the azoene system happened by the carbon in position 1 of the exo chain because of its major acidity due to the activation for the presence of two carbonyl groups on this atom. In fact, the ^1H and ^{13}C NMR spectra of compound **13a** (where R^1 = Me) showed a perfect symmetry of the molecule, in accordance with the suggested structure for this compound. If the attack of substrate **4a** onto 1,2-diaza-1,3-butadiene had occurred by means of the carbon atom in position 2 of the exo chain, the structure resulting from the cyclization in the presence of $SOCl_2$ would not have exhibited the above-mentioned symmetry.

Conclusion

In conclusion, this paper reports the elegant and facile synthesis of new 4-substituted 2,3-dihydroselenadiazoles and 4-substituted 1,2,3-selenadiazoles as well as of 4-substituted 1,2,3-thiadiazoles. These compounds have been found to undergo subsequent synthetic transformations and represent in turn useful entries to di-1,2,3-thiadiazole and 1,2,3-thiadiazolyl-2-oxo-2,3-dihydro-1*H*-pyrrole systems. Organosulfur compounds are interesting because of their use in medicinal chemistry for the treatment of thrombosis,[9] as antibacterials[10] or sedatives,[11] and in agricultural chemistry as herbicides,[12] plant activators, or inducers of systemic acquired resistance (SAR) in plants.[13] Otherwise, organoselenium compounds are the object of interest in connection with the role of selenium in a second-line antioxidant defense against lipid autoxidation[22] as well as the bioactive nature of selenium compounds.[3,15,16,23]

(21) Attanasi, O. A.; De Crescentini, L.; Filippone, P.; Mantellini, F. *New J. Chem.* **2001**, *25*, 534.

Experimental Section

General Methods. Dimethyl malonate (**2a**), dibenzyl malonate (**2b**), diethyl phenylmalonate (**2c**), diethyl methylmalonate (**2d**), triethyl methanetricarboxylate (**2e**), ethyl 4-nitrophenylacetate (**2f**), 2,2-dimethyl-5-phenyl-1,3-dioxane-4,6-dione (**2h**), dimethyl nitromalonate (**7a**), and diethyl nitromalonate (**7b**) were commercial materials and were used without further purification. 5-Isopropyl Meldrum's acid derivative (**2g**) was obtained according to literature procedure.[24] Solvents and reagents were purchased and were used without further purification with the exception of THF, which was distilled from sodium hydroxide. Light petroleum refers to the fraction with bp 40−60 °C. 1,2-Diaza-1,3-butadienes **1a**−**d** were synthesized as standard *E*/*Z* isomeric mixture according to previously reported procedure.[25,26] Melting points were determined in open capillary tubes and are uncorrected. IR−FT spectra were obtained as Nujol mulls. Mass spectra were made at an ionizing voltage of 70 eV. All ^{1}H NMR and ^{13}C NMR spectra were recorded at 200 or 400 MHz and at 50.32 or 100.65 MHz, respectively, in DMSO-d_6 solutions unless specified otherwise. Chemical shifts (δ_H) are reported relative to TMS as internal standard. All coupling constants (*J*) values are given in Hz. Chemical shifts (δ_C) are reported relative to DMSO-d_6 as internal standard, unless otherwise stated, in a broad band decoupled mode; the multiplicities were obtained using 135 and 90° DEPT experiments to aid in assignment (q = methyl, t = methylene, d = methine, s = quaternary). The abbreviations used are as follows: s, singlet; d, doublet; t, triplet; q, quartet; ept, eptet; m, multiplet; br, broad. All the NH and NH_2 exchanged with D_2O. Precoated silica gel plates 0.25 mm were employed for analytical thin-layer chromatography and silica gel 60 Å (35−70 μ) for column chromatography. All new compounds showed satisfactory elemental analysis (C ± 0.35; H ± 0.30, N ± 0.30). The nomenclature was generated using ADC/IUPAC Name (version 3.50, 5 Apr 1998), Advanced Chemistry Development Inc., Toronto, ON (Canada).

General Procedure for the Synthesis of α-Substituted Hydrazones 3a−m. Products **3b**,**c**,**f**[6] and **3m**[7] were obtained according to the procedures reported in the literature, while **3a**,**d**−**l** were synthesized as follows: to a magnetically stirred solution of 1,2-diaza-1,3-butadienes **1a**−**d** and activated methylenic and methinic compounds **2a**−**h** (1 mmol) in THF (8 mL) was added a catalytic amount of sodium methoxide (5.4 mg, 0.1 mmol) or sodium hydride (2.4 mg, 0.1 mmol). The mixture was allowed to stand at room temperature until the disappearance of the reagents (0.1−24.0 h, monitored by TLC). The major products **3** were purified by chromatography on a silica gel column and then crystallized as follows: **3a**,**e**,**g**,**i**−**l** from ethyl acetate−light petroleum (40−60 °C), **3b**,**c**,**f**,**m** from THF-*n*-pentane, and **3d** from ethyl ether−light petroleum (40−60 °C), while **3h** is an oil.

Trimethyl 3-[2-(*tert*-butoxycarbonyl)hydrazono]butane-1,1,2-tricarboxylate (3a): mp 133−135 °C; IR ν_{max} 3236, 3160, 1754, 1742, 1727, 1700 cm^{-1}; ^{1}H NMR δ 1.41 (s, 9 H), 1.84 (s, 3 H), 3.60 (s, 3 H), 3.62 (s, 3 H), 3.64 (s, 3 H), 3.86 (d, 1 H, *J* = 10.8), 4.07 (d, 1 H, *J* = 10.8), 9.67 (s, 1 H); ^{13}C NMR δ 16.61 (q), 28.71 (q), 51.87 (d), 53.22 (q), 53.33 (q), 53.41 (d), 53.46 (q), 80.04 (s), 153.42 (s), 167.99 (s), 168.54 (s), 170.51 (s); MS *m*/*z* 360 (6) [M$^+$], 358 (22), 304 (17), 287 (18), 273 (36), 241 (100). Anal. Calcd for $C_{15}H_{24}N_2O_8$: C, 50.00; H, 6.71; N, 7.77. Found: C, 49.89; H, 6.59; N, 7.85.

General Procedure for the Synthesis of 1,2,3-Thiadiazoles 4a−i. α-Substituted hydrazones **3a**,**b**,**d**,**e**,**g**,**h**,**j**−**l** (1 mmol) were magnetically stirred in thionyl chloride (10 mL). The reaction mixture was allowed to stand at room temperature until the disappearance of **3** (0.1−4.5 h, monitored by TLC). At the end of the reaction, the crude was neutralized by adding a saturated aqueous solution of sodium hydrogen carbonate until pH ∼7 and then extracted with ethyl acetate. The organic layer was washed with water and dried on sodium sulfate. Products **4a**−**i** were purified by chromatography on a silica gel column and then crystallized as follows: **4a** from ethyl acetate−diethyl ether, **4b** from ethyl acetate−petroleum ether (40−60 °C), **4c**,**d**,**g**−**i** from diethyl ether−light petroleum (40−60 °C), while **4e**,**f** are oils.

Trimethyl 2-(1,2,3-thiadiazol-4-yl)ethane-1,1,2-tricarboxylate (4a): mp 119−121 °C; IR ν_{max} 3099, 1740, 1731 cm^{-1}; ^{1}H NMR δ 3.48 (s, 3 H), 3.62 (s, 3 H), 3.71 (s, 3 H), 4.45 (d, 1 H, *J* = 10.5), 5.03 (d, 1 H, *J* = 10.5), 9.24 (s, 1 H); ^{13}C NMR δ 44.01 (d), 52.71 (q), 52.77 (q), 52.91 (q), 53.23 (d), 136.41 (d), 156.11 (s), 166.49 (s), 167.14 (s), 169.40 (s); MS *m*/*z* 228 (1) [M$^+$], 257 (24), 225 (100). Anal. Calcd for $C_{10}H_{12}N_2O_6S$: C, 41.67; H, 4.20; N, 9.72. Found: C, 41.85; H, 4.41; N, 9.78.

General Procedure for the Synthesis of 4-Substituted 2-(*tert*-butoxycarbonyl)-2,3-dihydro-1,2,3-selenadiazoles 5a,b. To a magnetically stirred solution of α-substituted hydrazones **3b**,**e** (1.0 mmol) in dichloromethane (20 mL) was added selenium oxychloride (2.0 equiv) at −20 °C. The reaction mixture was allowed to stand at −20 °C for 4.0 h and then was slowly warmed at room temperature (6.0 h). The formation of compounds **5a**,**b** were detected by TLC. The reaction mixture was washed with an aqueous saturated solution of sodium carbonate (2 × 20 mL) and dried with sodium sulfate. This workup procedure gave pure **5a**,**b** as oils.

2-Ethyl 1,1-dimethyl-2-[2-(*tert*-butoxycarbonyl)-2,3-dihydro-1,2,3-selenadiazol-4-yl]ethane-1,1,2-tricarboxylate (5a): IR ν_{max} 3105, 1745, 1725 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 1.19 (t, 3 H, *J* = 7.2), 1.56 (s, 9 H), 3.66 (s, 3 H), 3.80 (s, 3 H), 4.03−4.17 (m, 3 H), 4.36 (d, 1 H, *J* = 7.2), 9.40 (s, 1 H), 9.63 (brs, 1 H); ^{13}C NMR ($CDCl_3$) δ = 14.11 (q), 28.34 (q), 40.87 (d), 50.22 (d), 53.63 (q), 53.81 (q), 62.86 (q), 83.84 (s), 143.02 (s), 151.59 (s), 167.84 (s), 168.15 (s), 168.34 (s), 190.95 (s); MS *m*/*z* 454 (1) [M$^+$ + 3], 452 (3) [M$^+$ + 1], 450 (2), 449 (1), 448 (1), 423 (4), 421 (18), 419 (8), 418 (3), 364 (23), 362 (100). Anal. Calcd for $C_{16}H_{24}N_2O_8Se$: C, 42.58; H, 5.36; N, 6.21. Found: C, 42.71; H, 5.49; N, 6.15.

General Procedure for the Synthesis of 4-Substituted 1,2,3-Selenadiazoles 6a−d and 7a. To a magnetically stirred solution of α-substituted hydrazones **3f**,**i**,**m** (1.0 mmol) in acetic acid (15 mL) was added selenium dioxide (3.0 equiv) at 90 °C. The reaction mixture was allowed to stand at 90 °C until the disappearance of α-substituted hydrazones **3f**,**i**,**m** (5 h, monitored by TLC). When selenium dioxide (1.5 or 3.0 equiv) was added to a solution of **3c** (1 mmol) in acetic acid (15 mL), we observed the concomitant formation of compounds **6d** and **7a** (the synthesis of pure **7a** is described below). The reaction solvent was removed under reduced pressure, and products **6a**−**d** were purified by chromatography on a silica gel column and obtained as brown oils.

1,1-Diethyl 2-methyl 2-(1,2,3-selenadiazol-4yl)-1-phenylethane-1,1,2-tricarboxylate (6a): IR ν_{max} 3077, 1762, 1749, 1736, 1469, 1460 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 1.22−1.34 (m, 6 H), 3.73 (s, 3 H), 4.28−4.38 (m, 4 H), 5.70 (s, 1 H), 7.07−7.20 (m, 5 H), 8.94 (s, 1 H); ^{13}C NMR ($CDCl_3$) δ 13.73 (q), 13.88 (q), 52.06 (d), 52.65 (q), 62.19 (t), 62.43 (t), 65.97 (s), 127.68 (d), 128.70 (d), 134.57 (s), 143.32 (d), 155.63 (s), 166.72 (s), 169.72 (s), 170.54 (s); MS *m*/*z* 442 (1) [M$^+$ + 2], 440 (10) [M$^+$] 438 (4), 437 (1), 436 (1), 413 (1), 411 (13), 409 (5), 407 (1), 397 (5), 395 (27), 393 (15), 391 (4), 354 (13), 352 (100). Anal. Calcd for $C_{18}H_{20}N_2O_6Se$: C, 49.09; H, 4.58; N, 6.36. Found: C, 49.15; H, 4.61; N, 6.31.

(22) Coultate, T. P. *Food, The Chemistry of the Components*; Royal Society of Chemistry: London, 1984; p 174.
(23) Shafiee, A.; Lalezari, I.; Yazdani, S.; Pournorouz, A. *J. Pharm. Sci.* **1973**, *62*, 839. Lalezari, I.; Shafiee, A.; Yazdani, S. *J. Pharm. Sci.* **1974**, *63*, 628.
(24) Chan, C. C.; Huang, X. *Synthesis* **1984**, 224. Hrubowchak, D. M.; Smith, F. X. *Tetrahedron Lett.* **1983**, *24*, 4951.
(25) Sommer, S. *Tetrahedron Lett.* **1977**, 117. Attanasi, O. A.; Filippone, P.; Mei, A.; Santeusanio, S. *Synthesis* **1984**, 671. Attanasi, O. A.; Filippone, P.; Mei, A.; Santeusanio, S. *Synthesis* **1984**, 873.
(26) Sheldrick, G. M. *SHELXL-97*; Rel. 97-2, Universität Göttingen, 1997.

2-Ethyl 1,1-dimethyl 2-(1,2,3-selenadiazol-4yl)ethylene-1,1,2 tricarboxylate (7a): IR ν_{max} 3071, 1742, 1729, 1700 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 1.39 (t, 3 H, J = 7.2), 3.86 (s, 3 H), 3.88 (s, 3 H), 4.45 (q, 2 H, J = 7.2), 9.44 (s, 1 H); ^{13}C NMR ($CDCl_3$) δ 14.22 (q), 53.21 (d), 53.52 (q), 63.01 (t), 127.58 (s), 136.07 (s), 146.31 (d), 163.31 (s), 165.24 (s), 166.01 (s), 169.29 (s); MS m/z 348 (1) [M$^+$], 319 (1), 317 (20), 315 (12), 314 (2), 313 (2), 262 (17), 260 (100). Anal. Calcd for $C_{11}H_{12}N_2O_6Se$: C, 37.93; H, 3.48; N, 8.05. Found: C, 37.81; H, 3.52; N, 8.19.

General Procedure for the Synthesis of α,β-Olefinated Hydrazones 10a−c. To a magnetically stirred solution of 1,2-diaza-1,3-butadienes **1b**,**d** and dimethyl or diethyl nitromalonate (**8a**,**b**) in THF (8 mL) was added a catalytic amount of sodium hydride (2.4 mg, 0.1 mmol). The stirring was maintained until the disappearance of the reagents (7.0−48.0 h, monitored by TLC). The products **10a−c** were purified by chromatography on a silica gel column and then crystallized from ethyl acetate−light petroleum.

1,1-Dimethyl 2-ethyl 3-[2-(aminocarbonyl)hydrazono]-but-1-ene-1,1,2-tricarboxylate (10a): mp 170−173 °C; IR ν_{max} 3476, 3234, 1742, 1729, 1698 cm^{-1}; ^{1}H NMR δ 1.24 (t, 3 H, J = 7.0), 1.86 (s, 3 H), 3.71 (s, 3 H), 3.72 (s, 3 H), 4.25 (q, 2 H, J = 7.0), 6.01 and 6.52 (2 brs, 2 H), 10.07 (s, 1 H); ^{13}C NMR δ 19.51 (q), 19.82 (q), 58.59 (q), 58.88 (q), 67.81 (t), 143.73 (s), 150.01 (s), 156.04 (s), 161.79 (s), 168.71 (s), 170.93 (s), 171.01 (s); MS m/z 315 (1) [M$^+$], 213 (32), 181 (24), 167 (100). Anal. Calcd for $C_{12}H_{17}N_3O_7$: C, 45.72; H, 5.43; N, 13.33. Found: C, 45.61; H, 5.51; N, 13.28.

General Procedure for the Synthesis of Pure 4-Substituted 1,2,3-Selenadiazole 7a. To a magnetically stirred solution of α,β-olefinated hydrazone **10a** (1.0 mmol) in acetic acid (15 mL) was added selenium dioxide (3.0 equiv) at 90 °C. The reaction mixture was allowed to stand at 90 °C for 7.0 h, until the disappearance of **10a** (monitored by TLC). The reaction solvent was removed under reduced pressure, and product **7a** was purified by chromatography on a silica gel column.

General Procedure for the Synthesis of 4-Ethylene-1,2,3-Thiadiazoles 11a,b. α,β-Olefinated hydrazones **10b**,**c** (1 mmol) were magnetically stirred in thionyl chloride (10 mL). The reaction mixture was allowed to stand at room temperature until the disappearance of **10** (1.2−168.0 h, monitored by TLC). At the end of the reaction, the crude was neutralyzed by adding a saturated aqueous solution of sodium hydrogen carbonate until pH ∼7 and then extracted with ethyl acetate. The organic layer was washed with water and dried on sodium sulfate. Products **11a**,**b** were purified by chromatography on a silica gel column and obtained as yellow oils.

1,1,2-Triethyl 2-(1,2,3-thiadiazol-4-yl)ethylene-1,1,2-tricarboxylate (11a): IR ν_{max} 3108, 1740, 1725, 1640 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 1.22−1.39 (m, 9 H), 4.28−4.48 (m, 6 H), 8.65 (s, 1 H); ^{13}C NMR ($CDCl_3$) δ 14.36 (q), 14.39 (q), 14.48 (q), 63.13 (t), 63.30 (t), 63.57 (t), 130.41 (s), 134.76 (s), 138.39 (d), 155.68 (s), 163.74 (s), 165.42 (s), 166.86 (s); MS m/z 328 (1) [M$^+$], 283 (25), 252 (12), 212 (100). Anal. Calcd for $C_{13}H_{16}N_2O_6S$: C, 47.56; H, 4.91; N, 8.53. Found: C, 47.45; H, 4.99; N, 8.65.

General Procedure for the Synthesis of 4-Hydrazono-1-(1,2,3-thiadiazolyl)pentane Derivatives 12a−d. To a magnetically stirred solution of 1,2,3-thiadiazole **4a** and sodium methoxide (0.2 mmol) in tetrahydrofuran (6 mL) was added dropwise a solution of 1,2-diaza-1,3-butadienes **1a−d** in THF (6 mL). The reaction mixture was allowed to stand at room temperature until the disappearance of the reagents (0.2−2.7 h, monitored by TLC). Products **12a−d** were purified by chromatography on a silica gel column and then crystallized as follows: **12a**,**d** from diethyl ether−light petroleum (40−60 °C), **12b** from ethyl acetate−cyclohexane, and **12c** from tetrahydrofuran.

Tetramethyl (3*RS*,5*RS*)-4-[2-(*tert*-butoxycarbonyl)hydrazono]-1-(1,2,3-thiadiazol-4-yl)pentane-1,2,2,3-tetracarboxylate (12a): mp 175−177 °C; IR ν_{max} 3289, 3156, 1759, 1733 cm^{-1}; ^{1}H NMR δ 1.47 (s, 9 H), 1.60 (s, 3 H), 3.16 (s, 1 H), 3.55 (s, 3 H), 3.59 (s, 3 H), 3.67 (s, 3 H), 3.71 (s, 3 H), 5.48 (s, 1 H), 8.95 (s, 1 H), 9.68 (brs, 1 H); ^{13}C NMR δ 18.97 (q), 29.00 (q), 47.72 (d), 53.08 (q), 53.19 (q), 53.64 (q), 56.41 (d), 60.27 (s), 80.10 (s), 139.82 (d), 146.05 (s), 153.48 (s), 156.33 (s), 169.06 (s), 169.49 (s), 169.75 (s), 170.83 (s); MS m/z 516 (4) [M$^+$], 485 (4), 429 (18), 398 (100). Anal. Calcd for $C_{20}H_{28}N_4O_{10}S$: C, 46.51; H, 5.46; N, 10.85. Found: C, 46.65; H, 5.41; N, 10.77.

X-ray Crystal Structure Determination of 12a. Single crystals of **12a** were obtained by dissolving a few milligrams in methanol and allowing the solution to concentrate at room temperature. Two set of crystals were obtained: needles (approximate dimensions 0.5 × 0.2 × 0.2 mm) and prisms (approximate dimensions 0.5 × 0.4 × 0.4 mm). A Siemens P4 four-circle diffractometer with graphite-monochromated Mo Kα radiation (λ = 0.710 73 Å) and the $\omega/2\theta$ scan technique were used for data collections.

The two structures were solved by direct methods implemented in the SHELXS-97 program. [Sheldrick, G. M. *SHELXL-97*, Rel. 97-2, Universität Göttingen, 1997] The refinements were carried out by full-matrix anisotropic least-squares methods on F^2 for all reflections for non-H atoms by using the SHELXL-97 program.[26] The two sets of crystals were revealed to be two different polymorphs (**12a1** and **12a2**) of the same molecule. In the structure of polymorph 2, disorder at the *tert*-butyl group has been treated by refining two different positions for atoms C(22) and C(23). The refined site occupation factors are 0.55(6) for one position and 0.45(6) for the other.

Tetramethyl (3*RS*,5*RS*)-4-[2-(aminocarbonyl)hydrazono]-1-(1,2,3-thiadiazol-4-yl)pentane-1,2,2,3-tetracarboxylate (12c): mp 173−177 °C; IR ν_{max} 3471, 3450, 3221, 1749, 1734, 1703, 1607 cm^{-1}; ^{1}H NMR δ 1.65 (s, 3 H), 3.23 (s, 1 H), 3.56 (s, 3 H), 3.59 (s, 3 H), 3.64 (s, 3 H), 3.71 (s, 3 H), 5.32 (s, 1 H), 6.27 and 6.58 (2 brs, 2 H), 8.91 (s, 1 H), 9.47 (s, 1 H); ^{13}C NMR δ 18.80 (q), 47.88 (d), 53.33 (q), 53.47 (q), 53.52 (q), 53.64 (q), 56.05 (d), 60.21 (s), 140.08 (d), 142.95 (s), 155.89 (s), 157.57 (s), 168.81 (s), 169.52 (s), 170.64 (s), 171.60 (s); MS m/z 459 (6) [M$^+$], 428 (8), 414 (31), 400 (61), 354 (28), 327 (63), 316 (100). Anal. Calcd for $C_{16}H_{21}N_5O_9S$: C, 41.83; H, 4.61; N, 15.24. Found: C, 41.68; H, 4.63; N, 15.17.

General Procedure for the Synthesis of 1,3-Di-1,2,3-thiadiazolylpropane Derivatives 13a,b. 4-Hydrazono-1-(1,2,3-thiadiazolyl)pentane derivatives **12a**,**b** (1 mmol) were magnetically stirred in thionyl chloride (10 mL). The reaction mixture was allowed to stand at room temperature until the disappearance of **12a**,**b** (2.7−4.0 h, monitored by TLC). At the end of the reaction, the crude was neutralized by adding saturated aqueous solution of sodium hydrogen carbonate until pH ∼7 and then extracted with ethyl acetate. The organic layer was washed with water and dried on sodium sulfate. Products **13a**,**b** were purified by chromatography on a silica gel column and then crystallized from diethyl ether−light petroleum (40−60 °C).

Tetramethyl (1*RS*,3*RS*)-1,3-di(1,2,3-thiadiazol-4-yl)-propane-1,2,2,3-tetracarboxylate (13a): mp 153−155 °C; IR ν_{max} 3114, 3098, 1742 cm^{-1}; ^{1}H NMR δ 3.52 (s, 6 H), 3.77 (s, 6 H), 4.73 (s, 2 H), 8.88 (s, 2 H); ^{13}C NMR δ 47.79 (d), 52.65 (q), 53.12 (q), 60.28 (s), 139.63 (d), 154.69 (s), 168.69 (s), 169.13 (s); MS m/z 412 (31) [M$^+$], 383 (100). Anal. Calcd for $C_{15}H_{16}N_4O_8S_2$: C, 40.54; H, 3.63; N, 12.61. Found: C, 40.66; H, 3.48; N, 12.78.

General Procedure for the Synthesis of 1,2,3-Thiadiazolyl-2-oxo-2,3-dihydro-1*H*-pyrrole Systems 14a,b. To a magnetically stirred solution of 4-hydrazono-1-(1,2,3-thiadiazolyl)pentane derivatives **12c**,**d** (1 mmol) in THF/MeOH mixture (5:5 mL) was added sodium methoxide (9.6 mg, 0.4 mmol). The stirring was allowed to stand at room temperature until disappearance of the reagents (1.5−2.0 h, monitored by TLC). Products **14a**,**b** were purified by chromatography on a silica gel column and then crystallized from ethyl acetate−light petroleum (40−60 °C) as 50:50 diastereoisomeric mixtures.

Dimethyl 1-[(aminocarbonyl)amino]-5-methyl-3-[methyl (1,2,3-thiadiazol-4-yl)methyl-1-carboxylate]-2-oxo-2,3-dihydro-1*H*-pyrrole-3,4-dicarboxylate (14a): mp 202−204 °C; IR ν_{max} 3297, 3156, 1745, 1717, 1675, 1609 cm^{-1}; ^1H NMR δ 1.97 and 2.12 (2 s, 3 H), 3.29, 3.42, 3.57, 3.62, 3.64 and 3.69 (6 s, 9 H), 5.59 and 5.62 (2 s, 1 H), 5.88, 6.17 and 6.52 (3 brs, 2 H), 8.99 and 9.03 (2 s, 1 H), 9.08 and 9.24 (2 brs, 1 H); ^{13}C NMR δ 14.70 (q), 14.96 (q), 46.78 (d), 47.43 (d), 51.83 (q), 52.03 (q), 53.26 (q), 53.43 (q), 54.13 (s), 54.26 (q), 59.13 (s), 59.64 (s), 103.17 (s), 103.29 (s), 138.83 (d), 139.12 (d), 155.97 (s), 156.08 (s), 157.39 (s), 157.84 (s), 159.33 (s), 159.46 (s), 162.52 (s), 162.94 (s), 166.79 (s), 167.07 (s), 169.40 (s), 169.57 (s), 170.85 (s), 171.79 (s); MS *m*/*z* 427 (9) [M^+], 411 (10), 383 (51), 368 (20), 353 (35), 338 (18), 278 (38), 251 (100). Anal. Calcd for $C_{15}H_{17}N_5O_8S$: C, 42.15; H, 4.01; N, 16.39. Found: C, 42.19; H, 4.13; N, 16.27.

Acknowledgment. This work was supported by financial assistance from the Ministero dell'Università e della Ricerca Scientifica e Tecnologica-MURST-Roma (National Project "Building-blocks da e/o per sistemi eterociclici. Processi innovativi e sintesi di molecole di potenziale attività biologica"), the Consiglio Nazionale delle Ricerche-CNR-Roma, and the Università degli Studi di Urbino.

Supporting Information Available: Yields and reaction times for compounds **3a**−**m** and **4a**−**i**. Product characterization data, ^1H and ^{13}C NMR peak listings for **3b**−**m**, **4b**−**i**, **5b**, **6b**−**d**, **10b**,**c**, **11b**, **12b**,**d**, **13b**, and **14b**. ORTEPS and X-ray data for **12a**. This material is available free of charge via the Internet at http://pubs.acs.org.

JO0264832