Tetrahedron Letters 50 (2009) 909–915

Contents lists available at ScienceDirect

Tetrahedron Letters

journal homepage: www.elsevier.com/locate/tetlet

Csp^3-tellurium copper cross-coupling: synthesis of alkynyl tellurides a novel class of antidepressive-like compounds

Afamefuna Elvis Okoronkwo [b], Benhur Godoi [a], Ricardo Frederico Schumacher [a], José Sebastião Santos Neto [a], Cristiane Luchese [a], Marina Prigol [a], Cristina Wayne Nogueira [a], Gilson Zeni [a,*]

[a] *Laboratório de Síntese, Reatividade, Avaliação Farmacológica e Toxicológica de Organocalcogênios, Departamento de Química, CCNE, UFSM, Santa Maria, RS, Brazil*

[b] *Department of Chemistry, Federal University of Technology, P.M.B. 704 Akure, Ondo State, Nigeria*

ARTICLE INFO

Article history:
Received 24 October 2008
Revised 1 December 2008
Accepted 5 December 2008
Available online 13 December 2008

Keywords:
Copper cross-coupling
Tellurides
Pharmacological activity

ABSTRACT

We present here the results on the synthesis of functionalized alkynyl tellurides using the reaction of vinyl, alkynyl, and aryl tellurides with several alkynyl iodides catalyzed by copper iodide. The reaction proceeded cleanly under mild reaction conditions, at room temperature, in the absence of base and ligand giving alkynyl tellurides in acceptable yields. The obtained compounds **3a–c** and **3m–o** were screened for antidepressive-like activity using the tail suspension test (TST) in mice. Compounds **3a–c** and **3m–o** administered at 10 mg/kg by oral route produced a significant antidepressant-like effect on the TST in mice.

1. Pharmacology

Depression is a common disorder with high lifetime rates. It is a major cause of disability, and causes death both by suicide and due to raised rates of physical disorders.[1] Because the mechanism of depression is quite complex, many currently available antidepressants have low rates of response and remission and even severe adverse-effects.[2,3] For that reason, it is necessary to research and develop more effective antidepressant drugs. Organotellurium compounds have demonstrated pharmacological properties, such as antioxidant[4–7] and chemoprotective,[8–10] and display low acute toxicity in animals.[6,7,11] Therefore, organotellurium compounds may be an important source of new antidepressant drugs. Following our longstanding interest in pharmacological properties of organochalcogens, the present study was undertaken to investigate whether alkynyl vinyl tellurides **3a**–**c** and **3m**–**o** present antidepressant-like effect, employing tail suspension test (TST) in mice.

2. Chemistry

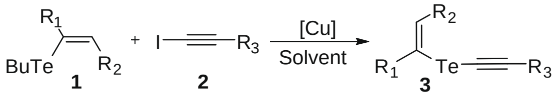
Great progress has been made in carbon-heteroatom bond formation via the cross-coupling reaction of heteroatom compounds using a copper-catalyzed system.[12] These improvements are certainly a consequence of the studies regarding the effects of several ligands, such as aliphatic diamines, 1,10-phenanthroline, amino acids and their derivatives, and others. These important findings allow the use of common organic solvents (dichloromethane, chloroform, toluene, benzene, DMF, and DMSO) and weaker bases (K_2CO_3, Cs_2CO_3, and K_3PO_4), and they also allow the use of not only aryl iodide, but also aryl bromides and chlorides. After that, these reactions became more attractive and nowadays they can be carried out at lower temperatures, under milder conditions, and using a catalytic amount of the copper salts.

Chalcogenide compounds have found such wide utility because of their effects on an extraordinary number of very different reactions, including many carbon–carbon bond formations,[13] under relatively mild reaction conditions. In addition, they have become attractive synthetic targets because of their chemo-, regio-, and stereoselective reactions,[14] used in a wide variety of functional groups, thus avoiding protection group chemistry and useful biological activities.[15] Among chalcogenides, vinylic tellurides are useful intermediates in organic synthesis.[14d,16] Of the two isomers, the *Z*-vinylic tellurides have been employed more frequently as intermediates because of easy availability of these species.[17] Lately, we have employed vinylic tellurides in the synthesis of natural products by using this cross-coupling reaction.[18] To the best of our knowledge, the application of carbon-tellurium single bond in the copper cross-coupling has not been reported so far. In view of the lack of synthetic protocols using tellurides in this cross-coupling, there is a need for the development of a clear and mild procedure that is to be carried out at room temperature in the absence of a

---

* Corresponding author. Tel.: +55 55 3220 9462; fax: +55 55 220 8031.
E-mail addresses: gzeni@quimica.ufsm.br, gzeni@pq.cnpq.br (G. Zeni).

0040-4039/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.tetlet.2008.12.024



Scheme 1.

base and a ligand. Thus, our continuing interest in the organochalcogen chemistry as well as copper-catalyzed cross-coupling reactions prompted us to examine the cross-coupling reaction of vinyl, aryl, and alkynyl tellurides **1** with alkynyl iodides **2** to obtain a new class of tellurium compounds 3 (Scheme 1).

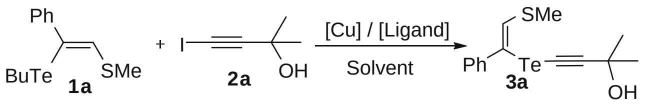
3. Results and discussion

The starting vinylic tellurides **1a–h**, **1j**, and **1k** were readily available by using the process of hydrotelluration of alkynes.[19] The treatment of phenyllithium with elemental tellurium gave in situ the lithium tellurolate anion that was treated with 1-bromobutane to yield the telluride **1i**.[20] Finally, alkynyl tellurides **1l** and **1m** were obtained from reaction of alkynyl lithium derivatives with elemental tellurium followed by reaction with 1-bromobutane.[21]

With the starting materials in hand, our initial studies have focused on the development of an optimum set of reaction conditions. Hence, the coupling reaction of telluride **1a** (1 mmol) with alkynyl iodine **2a** (1.2 mmol) was treated with different copper catalysts under room temperature, in different solvents and in the presence and absence of additives, in order to optimize the reaction conditions.

As shown in Table 1, of the Cu(II) sources investigated, Cu(OAc)$_2$, CuCl$_2$, Cu(acac)$_2$, and Cu(OTf)$_2$ provided similar results giving the products in moderate yields: however, the use of CuBr$_2$ greatly increased the product yield (Table 1, entries 1–5). Cu$_2$O nanoparticles also showed certain activity (Table 1, entry 6). With Cu(I) sources the yields varied from 55 to 96% (Table 1, entries 7–10). Since, using CuI (10 mol %) as catalyst the product was obtained in 96% yield, we considered CuI as the the best copper source for this catalytic system.

Table 1
Optimization of reaction conditions for the formation of **3a**[a]



Entry	Catalyst (mol %)	Solvent	Ligand	Yield (%)[b]
1	Cu(OAc)$_2$(10)	DMF	None	42
2	CuBr$_2$(10)	DMF	—	72
3	CuCl$_2$(10)	DMF	—	55
4	Cu(acac)$_2$(10)	DMF	—	43
5	Cu(OTf)$_2$(10)	DMF	—	42
6	Cu$_2$Onano(10)	DMF	—	42
7	CuCl(10)	DMF	—	69
8	CuBr(10)	DMF	—	55
9	CuI(10)	DMF	—	96
10	CuCN(10)	DMF	—	61
11	CuI(10)	DMSO	—	52
12	CuI(10)	EtOH	—	36
13	CuI(10)	MeCN	—	45
14	CuI(10)	THF	—	34
15	CuI(10)	Hexane	—	40
16	CuI(10)	DMF	1,10-Phen	86
17	CuI(10)	DMF	EDTA	42
18	CuI(10)	DMF	DMEDA	32
19	CuI(10)	DMF	TMEDA	75
20	CuI(10)	DMF	BiPy	—
21	CuI(1)	DMF	—	50
22	CuI(3)	DMF	—	65
23	CuI(5)	DMF	—	65

[a] Reactions were performed in the presence of **1a** (1 mmol), **2a** (1.2 mmol) at room temperature for 6 h.

[b] The yield was determined by GC.

A series of approaches have shown that the use of ligands (such as aliphatic diamines, 1,10-phenanthroline, amino acids and their derivatives, and others) for copper catalysts resulted in numerous advantages.[22] For this reason, in our experiment we also investigated the influence of some inexpensive ligands, such as 1,10-phenanthroline, EDTA, DMEDA, TMEDA, and bipyridine. As listed in Table 1, when the reaction was carried out using EDTA, DMEDA, and bipyridine the target product was not obtained (Table 1, entry 20) or was obtained in moderate yields (Table 1, entries 17 and 18), even though a long reaction time was used. The best ligands were 1,10-phenanthroline and TMEDA (Table 1, entries 16 and 19): however, the reaction was not improved compared to reaction carried out in the absence of ligand (Table 1, entry 9). Regarding the influence of the solvent in this cross-coupling reaction, optimal results were achieved using DMF (Table 1, entry 9). By using DMSO, EtOH, MeCN, THF, and hexane moderate yields were obtained (Table 1, entries 11–15). It is relevant to note that when the amount of catalyst is reduced from 10 to 1 mol %, a notable decrease in the yields was observed (Table 1, entries 21–23). In addition, no reaction occurred in the absence of copper catalyst even after 72 h.

Thus, the careful analysis of the optimized reactions revealed that the optimum conditions for this cross-coupling reaction procedure were the addition of telluride 1a (1 mmol) and the appropriate alkynyl iodine **2a** (1.2 equiv) to a solution of CuI (10 mol %) in DMF (3 mL) at room temperature.[23]

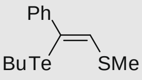
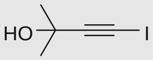
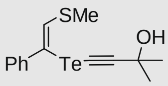
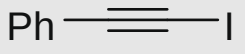
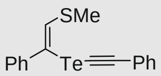
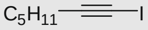
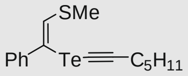
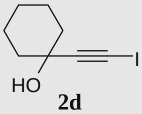
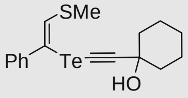
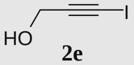
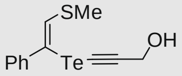
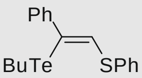
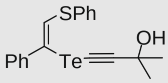
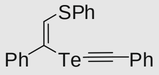
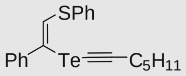
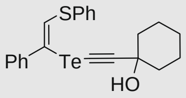
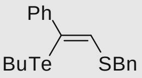
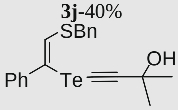
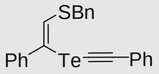
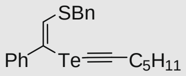
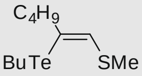
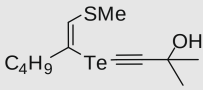
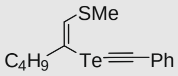
Using this condition, we were able to prepare alkynyl tellurides **3a** in 96% yield. To demonstrate the efficiency of this reaction, we explored the method by extending these conditions to other organotellurium compounds **1a–k** with different alkynyl iodines **2a–e**, and the results are summarized in Table 2.

First we explored the coupling of different vinyl tellurides; functionalized (**1a–g**, **1j,** and **1k**), nonfunctionalized (**1h**), and aryl tellurides (**1i**) gave the desired products in moderate to good isolated yields. Most importantly, the cross-coupling turned out to be general with respect to a diverse array of functionality in the electrophile sources. Satisfactorily, our experiments also showed that the reaction with electrophile sources having aryl, alkyl, and propargyl (**2a–e**) groups gave the product in acceptable yields. Finally, it is worth mentioning that through our methodology, it was possible to prepare highly functionalized organophosphorated alkynyl tellurides **3e′–f′** and **3g′**.

In view of the fact of occurrence of diyne systems in many compounds with biological interest, we attempt to broaden the scope of our methodology performing the reaction using the alkynyl tellurides **1l** and **1m** and iodo alkynes to give symmetrical and unsymmetrical alkynyl tellurides **4**. It was found that the reaction worked well affording the desired coupling products in satisfactory yields. The results are summarized in Table 3.

Our working mechanism for the copper-catalyzed preparation of alkynyl tellurides is based on the following experimental data obtained: (1) in all cases we detected BuI as a side product; (2) the reaction works in the complete absence of reoxidant to change Cu(I)–Cu(0)–Cu(I); (3) no product was obtained when a sp^2-carbon was bound to the tellurium atom in place of Bu group and; (4) no product was obtained using terminal alkynes in place of alkynyl iodide, then it could involve: (a) BuTe complexation with CuI; (b) insertion of CuI into the alkyne followed by nucleophilic attack of the tellurium atom on the copper to give the cationic organo-Cu(III) complex **a**;[24] (c) nucleophilic attack of iodide anion on the butyl group bound to the tellurium atom to give the Cu(III) inter-

Table 2
Copper-catalyzed formation of alkynyl tellurides **3**[a]

Entry	Telluride **1**	Iodine **2**	Product **3**[b]
1	 **1a**	 **2a**	 **3a**-62%
2	**1a**	 **2b**	 **3b**-40%
3	**1a**	 **2c**	 **3c**-72%
4	**1a**	 **2d**	 **3d**-52%
5	**1a**	 **2e**	 **3f**-40%
6	 **1b**	**2a**	 **3g**-44%
7	**1b**	**2b**	 **3h**-48%
8	**1b**	**2c**	 **3i**-43%
9	**1b**	**2d**	 **3j**-40%
10	 **1c**	**2a**	 **3k**-47%
11	**1c**	**2b**	 **3l**-54%
12	**1c**	**2c**	 **3m**-60%
13	 **1d**	**2a**	 **3n**-30%
14	**1d**	**2b**	 **3o**-46%

(*continued on next page*)

Table 2 (*continued*)

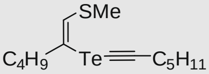
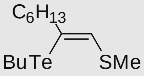
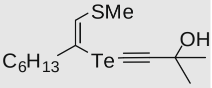
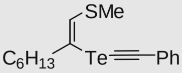
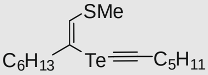
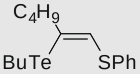
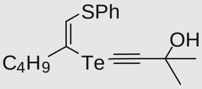
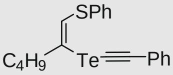
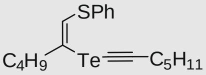
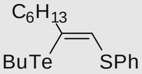
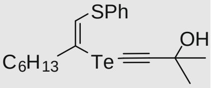
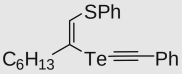
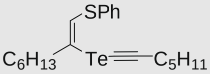
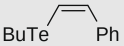
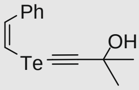
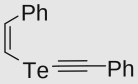
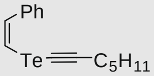
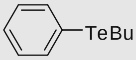
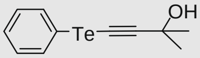
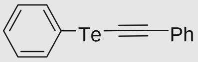
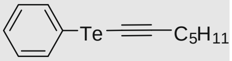
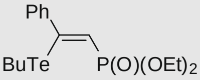
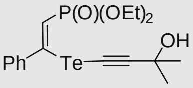
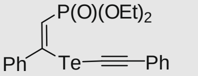
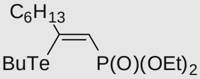
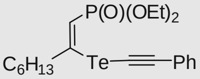
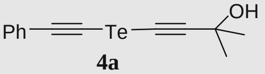
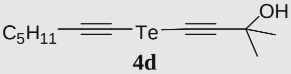
Entry	Telluride **1**	Iodine **2**	Product **3**[b]
15	**1d**	**2c**	 **3p**-50%
16	 **1e**	**2a**	 **3q**-35%
17	**1e**	**2b**	 **3r**-43%
18	**1e**	**2c**	 **3s**-49%
19	 **1f**	**2a**	 **3t**-55%
20	**1f**	**2b**	 **3u**-58%
21	**1f**	**2c**	 **3v**-60%
22	 **1g**	**2a**	 **3w**-51%
23	**1g**	**2b**	 **3x**-47%
24	**1g**	**2c**	 **3y**-70%
25	 **1h**	**2a**	 **3z**-47%
26	**1h**	**2b**	 **3a'**-54%
27	**1h**	**2c**	 **3b'**-60%
28	 **1i**	**2a**	 **3c'**-48%

Table 2 (*continued*)

Entry	Telluride **1**	Iodine **2**	Product **3**[b]
29	**1i**	**2b**	 **3d'**-43%
30	**1i**	**2c**	 **3e'**-47%
31	 **1j**	**2a**	 **3f'**-34%
32	**1j**	**2b**	 **3g'**-48%
33	 **1k**	**2b**	 **3h'**-44%

[a] Reactions were performed in the presence of **1** (0.5 mmol), **2** (0.6 mmol), CuI (10 mol %), using DMF at room temperature.
[b] Yields are given for isolated products.

Table 3
Copper-catalyzed formation of symmetrical and unsymmetrical alkynyl tellurides **4**[a]

Entry	Telluride **1**	Product **4**	Yield[b] (%)
1	$Ph-\equiv-TeBu$ **1l**	 **4a**	25
2	**1l**	$Ph-\equiv-Te-\equiv-Ph$ **4b**	39
3	**1l**	$Ph-\equiv-Te-\equiv-C_5H_{11}$ **4c**	30
4	$C_5H_{11}-\equiv-TeBu$ **1m**	 **4d**	40
5	**1m**	$C_5H_{11}-\equiv-Te-\equiv-Ph$ **4e**	36
6	**1m**	$C_5H_{11}-\equiv-Te-\equiv-C_5H_{11}$ **4f**	35

[a] Reactions were performed in the presence of **1** (0.5 mmol), **2** (0.6 mmol), CuI (10 mol %), using DMF at room temperature.
[b] Yields are given for isolated products.

mediated **b**; (d) the reductive elimination to give the product and regenerate Cu(I) (Scheme 2).

4. Pharmacology

Based on the previous screening for pharmacological activity of alkynyl vinyl tellurides, compounds **3a–c** and **3m–o** were chosen for evaluating antidepressant-like effect of this class of organochalcogens. The obtained compounds **3a–c** and **3m–o** were screened for antidepressant-like activity using the TST in mice.[25] The results of antidepressant-like effect of compounds **3a–c** and **3m–o** on TST are presented in Figure 1. Alkynyl vinyl tellurides **3a–c** and **3m–o**, giving per oral route, produced an antidepressant-like effect on the mouse TST. Alkynyl vinyl tellurides **3a–c** and **3m–o** produced a significant antidepressant-like effect on the TST at doses equal and higher than 10 mg/kg (data not shown) ($p < 0.05$ by Duncan's test). At the dose of 1 mg/kg compounds **3c**, **3m**, **3n,** and **3o** presented antidepressant-like effect on the TST, while compounds **3a** and

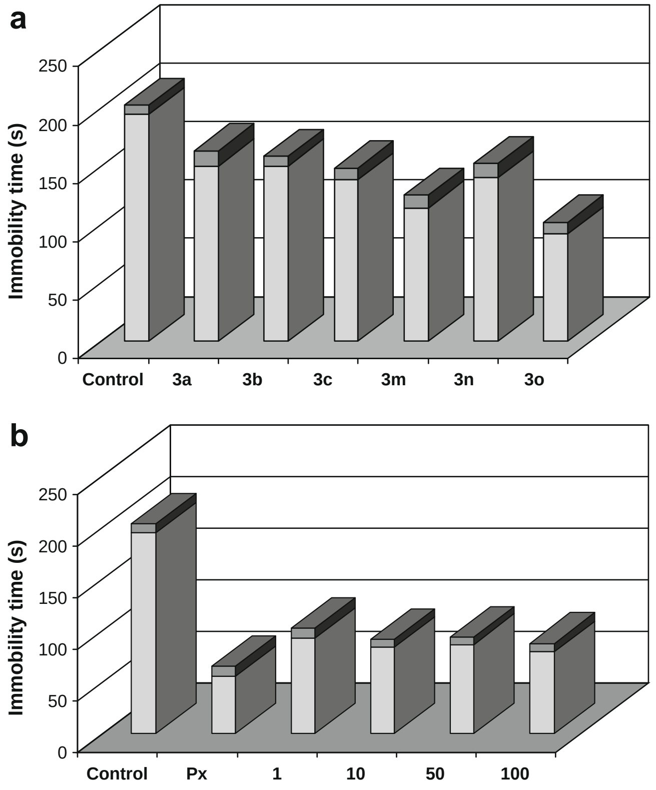
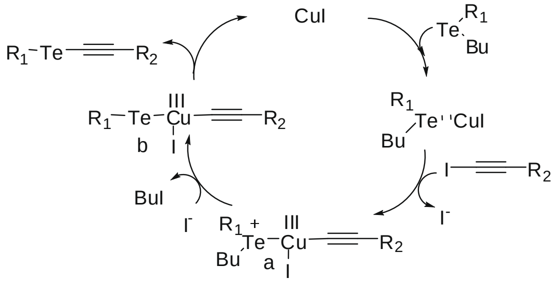


Figure 1. Effect of oral administration of alkynyl vinyl tellurides **3a–c** and **3m–o** at the dose of 1 mg/kg (**a**) and **3o** at the range dose of 1–100 mg/kg (**b**) on the TST in mice. Alkynyl vinyl tellurides **3a–c** and **3m–o** were administered orally 30 min before the challenge test. Paroxetine (Px) at 16 mg/kg was used as a positive control. Values are expressed as mean ± S.E.M. ($n = 9–12$ mice/group).

3b did not present the effect at this dose (Fig. 1a). Alkynyl vinyl telluride **3o** demonstrated the best antidepressant-like action since at 1 mg/kg this compound attained 50% of effect. The effect of compound **3o** is comparable with the effect of paroxetine in the TST (Fig. 1b). The TST is widely accepted animal model used to screen new antidepressant drugs, as it is sensitive to all major classes of antidepressant drugs including tricyclics, serotonin-specific reuptake inhibitors, monoamine oxidase inhibitors, and atypicals.[26,27] However, the TST has some drawbacks, including the possibility of obtaining some false positive results. In order to rule out the possibility that the reduction in the immobility time elicited by a drug is due to an increase in the locomotor activity, the open-field test[19] was employed.[28] In this study, alkynyl vinyl tellurides **3a–c** and **3m–o**, at all doses tested, did not produce any change in numbers of crossings and rearing in the open-field test (data not shown). Therefore, the antidepressant-like effect of alkynyl vinyl tellurides **3a–c** and **3m–o** could not be attributed to an increase in the locomotor activity of the animal.



Scheme 2.

5. Conclusions

In summary, we showed by the procedure described herein that organotellurium compounds having a carbon–tellurium single bond are suitable substrates to copper cross-coupling reactions, providing an interesting protocol for the synthesis of alkynyl tellurides. The synthesized compounds have promising antidepressive-like activity and should be pharmacologically interesting. We expect that these findings would be useful in choosing a method for the synthesis of highly functionalized tellurium alkynes. This reaction associated with electrophilic cyclizations of alkynes[29] or palladium cross-coupling of tellurides[13] can contribute to an interesting alternative route to the preparation of pharmacologically active compounds. The moderate yields obtained for these compounds were consequence of the remarkable instability of these products in front of the purification methods. The application of tellurides **4** in the synthesis of unsymmetrical 1,3-diyne systems using copper and palladium catalysts is currently underway.

Acknowledgments

We are grateful to FAPERGS, CAPES (SAUX / 2007) and CNPq for the financial support. CNPq and CAPES are also acknowledged for the fellowships.

References and notes

1. Paykel, E. S. *Epidemiol. Psichiatr. Soc.* **2006**, *15*, 4.
2. Sarko, J. *Emerg. Med. Clin. North Am.* **2000**, *18*, 637.
3. Sen, S.; Sanacora, G. *Mt. Sinai J. Med.* **2008**, *75*, 204.
4. Kanski, J.; Drake, J.; Aksenova, M. *Brain Res.* **2001**, *12*, 21.
5. Ren, X.; Xue, Y.; Zhang, K.; Liu, J.; Luo, G.; Zheng, J.; Mu, Y.; Shen, J. *FEBS Lett.* **2001**, *377*, 380.
6. Avila, D. S.; Beque, M. C.; Folmer, V.; Braga, A. L.; Zeni, G.; Nogueira, C. W.; Soares, F. A. A.; Rocha, J. B. T. *Toxicology* **2006**, *100*, 107.
7. Savegnago, L.; Borges, V. C.; Alves, D.; Jesse, C. R.; Rocha, J. B. T.; Nogueira, C. W. *Life Sci.* **2006**, *79*, 1546.
8. Rao, A. S.; Freemerman, A. J.; Jarvis, W. D.; Chelliah, J.; Bear, H. D.; Mikkelsen, R.; Grant, S. *Leukemia* **1996**, *10*, 1150.
9. Engman, L.; Kanda, T.; Gallegos, A.; Williams, R.; Powis, G. *Anti-Cancer DrugI* **2000**, *15*, 323.
10. Cunha, L. O. R.; Urano, M. E.; Chagas, J. R.; Almeida, P. C.; Bincoletto, C.; Tersariol, I. L. S.; Comasseto, J. V. *Bioorg. Med. Chem. Lett.* **2005**, *15*, 755.
11. Avila, D. S.; Gubert, P.; Corte, C. L. D.; Alves, D.; Nogueira, C. W.; Rocha, J. B. T.; Soares, F. A. A. *Life Sci.* **2007**, *80*, 1865.
12. (a) Klapars, A.; Huang, X.; Buchwald, S. L. *J. Am. Chem. Soc.* **2002**, *124*, 7421; (b) Antilla, J. C.; Baskin, J. M.; Barder, T. E.; Buchwald, S. L. *J. Org. Chem.* **2004**, *69*, 5578; (c) Shafir, A.; Buchwald, S. L. *J. Am. Chem. Soc.* **2006**, *128*, 8742; (d) Shafir, A.; Lichtor, P. A.; Buchwald, S. L. *J. Am. Chem. Soc.* **2007**, *129*, 3490; (e) Zhang, D.; Liu, Z.; Yum, E. K.; Larock, R. C. *J. Org. Chem.* **2007**, *72*, 251.
13. (a) Zeni, G.; Ludtke, D. S.; Panatieri, R. B.; Braga, A. L. *Chem. Rev.* **2006**, *106*, 1032 (mesma da 3); (b) Zeni, G.; Braga, A. L.; Stefani, H. A. *Acc. Chem. Res.* **2003**, *36*, 731.
14. (a) Wirth, T.. In *Topics in Current Chemistry*; Springer: Heidelberg, 2000; Vol. 208, (b) Krief, A.. In *Comprehensive Organometallic Chemistry II*; Abel, E. V., Stone, F. G. A., Wilkinson, G., Eds.; Pergamon Press: New York, 1995; Vol. 11,. Chapter 13 (c) Paulmier, C.. In Baldwin, J. E., Ed.; Organic Chemistry Series 4; Pergamon Press: Oxford, 1986; (d) Petragnani, N. *Tellurium in Organic Synthesis*; Academic Press: London, 1994.
15. Nogueira, C. W.; Zeni, G.; Rocha, J. B. T. *Chem. Rev.* **2004**, *104*, 6255.
16. Marino, J. P.; Nguyen, N. H. *J. Org. Chem.* **2002**, *67*, 6291.
17. Zeni, G.; Formiga, H. B.; Comasseto, J. V. *Tetrahedron Lett.* **2000**, *41*, 1311.
18. (a) Zeni, G.; Panatieri, R. B.; Lissner, E.; Menezes, P. H.; Braga, A. L.; Stefani, H. A. *Org. Lett.* **2001**, *3*, 819; (b) Nogueira, C. W.; Alves, D.; Zeni, G. *Tetrahedron Lett.* **2005**, *46*, 8761.
19. Dabdoub, M. J.; Baroni, A. C. M.; Lenardão, E. J.; Gianeti, T. R.; Hurtado, G. H. *Tetrahedron* **2001**, *57*, 4271.
20. Cougnon, F.; Feray, L.; Bazin, S.; Bertrand, M. P. *Tetrahedron* **2007**, *63*, 11959.
21. Dabdoub, M. J.; Dabdoub, V. B.; Comasseto, J. V.; Petragnani, N. *J. Organomet. Chem.* **1986**, *308*, 211.
22. (a) Palomo, C.; Oiarbide, M.; Lopez, R.; Gómez-Bengoa, E. *Tetrahedron Lett.* **2000**, *41*, 1283; (b) Yee Kwong, F.; Buchwald, S. L. *Org. Lett.* **2002**, *4*, 3517; (c) Bates, C. G.; Gujadhur, R. K.; Venkataraman, D. *Org. Lett.* **2002**, *4*, 2803; (d) Ranu, B. C.; Saha, A.; Jana, R. *Adv. Synth. Catal.* **2007**, *349*, 2690; (e) Carril, M.; SanMartin, R.; Dominguez, E.; Tellitu, I. *Chem. Eur. J.* **2007**, *13*, 5100; (f) Verma, A. K.; Singh, J.; Chaudhary, R. *Tetrahedron Lett.* **2007**, *48*, 7199.
23. *General procedure for cross-coupling reaction*: A 10 mL Schlenk tube, equipped with a magnetic stir bar, rubber septum, and argon, containing the CuI

(0.0095 g, 0.05 mmol) in DMF (3 mL), was charged sequentially with the desired telluride (0.5 mmol) in DMF (1 mL) and the appropriate alkynyl iodine (0.6 mmol) in DMF (1 mL) drop-by-drop. The mixture was stirred at room temperature, and the reaction time was determined monitoring the reaction by TLC. The reaction mixture was then quenched with aqueous NH$_4$Cl (10 mL), washed with ethyl acetate (3 × 15 mL), dried with MgSO$_4$, and the solvent was removed under vacuum. The products were purified by column chromatography. Selected spectral and analytical data for **3–a′**. Yield: 0.179 g (54%). ^{1}H NMR (CDCl$_3$, 400 MHz), δ (ppm): 7.48 (d, J = 10.27 Hz, 1H), 7.44–7.21 (m, 8H), 7.16 (d, J = 10.02 Hz, 1H), 7.09–7.06 (m, 2H). ^{13}C NMR (CDCl$_3$, 100 MHz), δ (ppm): 138.59, 137.79, 131.78, 128.72, 128.47, 128.16, 127.87, 126.76, 123.20, 111.35, 107.35, 47.92. MS (relative intensity) m/z: 330 ([M-2] 9) 201 (100), 100 (74), 76 (21), 50 (14). Anal. Calcd for C$_{16}$H$_{12}$Te: C, 57.91; H, 3.64. Found: C, 57.98; H, 3.81.

24. Vicente, J.; Herrero, P. G.; Sánchez, Y. G.; Jones, P. G.; Bautista, D. *Eur. J. Inorg. Chem.* **2006**, 115.
25. *Bioassay*: Antidepressant-like activity: The total duration of immobility induced by tail suspension was measured according to the method described by Steru et al.[30] Mice were suspended on the edge of a table 50 cm above the floor by the adhesive tape placed approximately 1 cm from the tip of the tail. Immobility time defined as the absence of escape-oriented behaviors was scored during 6 min, as described previously.[31,32] Mice were treated with alkynyl vinyl tellurides **3a–c** and **3m–o** (1, 10, 50, and 100 mg/kg, per oral (p.o.) or with canola oil (10 ml/kg, p.o.) 30 min before challenge test. Paroxetine, an antidepressant-drug, was used as a positive control and administered (16 mg/kg, intraperitoneal, i.p.) 30 min before the challenge test.[33] To assess the possible effects of alkynyl vinyl tellurides **3a–c** and **3m–o** on the locomotor and exploratory activities and to avoid some false positive results in the TST, mice were evaluated in an open-field test. Open-field test: The open-field was made of polywood and surrounded by walls 30 cm in height. The floor of the open-field, 45 cm in length and 45 cm in width, was divided by masking tape markers into 09 squares (3 rows of 3). Each animal was placed individually at the center of the apparatus and observed for 6 min to record the locomotor (number of segments crossed with the four paws) and exploratory activities (expressed by the number of time rearing on the hind limbs).[34] Statistical analysis: Data were analyzed by using a one-way analysis of variance (ANOVA), followed by Duncan's Multiple Range Test when appropriate. Results were considered significantly different at values of $p < 0.05$.
26. Willner, P. *Trends Pharmacol. Sci.* **1991**, *12*, 131.
27. Zomkowski, A. D. E.; Hammes, L.; Lin, J.; Calixto, J. B.; Santos, A. R. S.; Rodrigues, A. L. S. *NeuroReport* **2002**, *13*, 387.
28. Rosa, A. O.; Kaster, M. P.; Binfare, R. W.; Morales, S.; Martin-Aparicio, E.; Navarro-Rico, M. L.; Martinez, A.; Medina, M.; García, A. G.; Lopez, M. G.; Rodrigues, A. L. S. *Prog. Neuro-Psychoph.* **2008**, *32*, 1549.
29. Alves, D.; Luchese, C.; Nogueira, C. W.; Zeni, G. *J. Org. Chem.* **2007**, *72*, 6726.
30. Steru, L.; Chermat, R.; Thierry, B.; Simon, P. *Psychopharmacology* **1985**, *85*, 367.
31. Rodrigues, A. L. S.; Da Silva, G. L.; Mateussi, A. S.; Fernandes, E. S.; Miguel, O. G.; Yunes, R. A.; Calixto, J. B.; Santos, A. R. S. *Life Sci.* **2002**, *70*, 1347.
32. Mantovani, M.; Pertile, R.; Calixto, J. B.; Santos, A. R. S.; Rodrigues, A. L. S. *Neurosci. Lett.* **2003**, *34*, 1.
33. Ripoll, N.; David, D. J. P.; Dailly, E.; Hascoet, M.; Bourin, M. *Behav. Brain Res.* **2003**, *143*, 193.
34. Walsh, R. N.; Cummins, R. A. *Psychol. Bull.* **1976**, *83*, 482.