[1] a) M. D. Frank-Kamenetskii, *J. Mol. Struct. (Theochem)* **1995**, *336*, 235 – 243; b) N. C. Seeman, *Annu. Rev. Biophys. Biomol. Struct*. **1998**, *27*, 225 – 248; c) K. Ryan, E. T. Kool, *Chem. Biol.* **1998**, *5*, 59 – 67; d) N. C. Seeman, *Angew. Chem.* **1998**, *110*, 3408 – 3428; *Angew. Chem. Int. Ed.* **1998**, *37*, 3220 – 3238.

[2] a) M. D. Frank-Kamenetskii, *Unraveling DNA: The most important molecule of life*, Addison-Wesley, Reading, MA, USA, **1997**, p. 214; b) R. Sinden, *DNA Structure and Function*, Academic Press, San Diego, CA, USA, **1994**, p. 398.

[3] a) N. C. Seeman, *Acc. Chem. Res.* **1997**, *30*, 357 – 363; b) C. M. Niemeyer, *Angew. Chem.* **1997**, *109*, 603 – 606; *Angew. Chem. Int. Ed. Engl.* **1997**, *36*, 585 – 587.

[4] a) M. Nilsson, H. Malmgren, M. Samiotaki, M. Kwiatkowski, B. P. Chowdhary, U. Landegren, *Science* **1994**, *265*, 2085 – 2088; b) M. Nilsson, K. Krejci, J. Koch, M. Kwiatkowski, P. Gustavsson, U. Landegren, *Nat. Gen*. **1997**, *16*, 252 – 254; c) P. M. Lizardi, X. Huang, Z. Zhu, P. Bray-Ward, D. C. Thomas, D. C. Ward, *Nat. Gen*. **1998**, *19*, 225 – 232; d) J. Banér, M. Nilsson, M. Mendel-Hartvig, U. Landegren, *Nucleic Acids Res.* **1998**, *26*, 5073 – 5078.

[5] a) N. O. Bukanov, V. V. Demidov, P. E. Nielsen, M. D. Frank-Kamenetskii, *Proc. Natl. Acad. Sci. USA* **1998**, *95*, 5516 – 5520; b) V. V. Demidov, N. O. Bukanov, M. D. Frank-Kamenetskii in *PNA: Protocols and Applications* (Eds.: P. E. Nielsen, M. Egholm), Horizon Scientific, Wymondham, UK, **1999**, pp. 187 – 195.

[6] a) P. E. Nielsen, *Pure Appl. Chem*. **1998**, *70*, 105 – 110; b) E. Uhlmann, A. Peyman, G. Breipohl, D. W. Will, *Angew. Chem.* **1998**, *110*, 2954 – 2983; *Angew. Chem. Int. Ed*. **1998**, *37*, 2796 – 2823.

[7] The optimal yield of linked product **III** is about 70 – 80 % after a single ligation step. The major factor affecting the yield is the ODN concentration: the yield of **III** decreases significantly when the ODN concentration is too low (< 0.1 μM) or too high (> 1 μM). Still, under optimal conditions 20 to 30 % of the dsDNA molecules remain topologically unlinked with cODN. A second round of ligation, which is performed after dissociation at elevated temperatures of ODNs bound to and yet unlinked with dsDNA, results in virtually quantitative yield of linked products.

[8] a) V. V. Demidov, M. V. Yavnilovich, M. D. Frank-Kamenetskii, *Biophys. J.* **1997**, *72*, 2763 – 2769; b) H. Kuhn, V. V. Demidov, M. D. Frank-Kamenetskii, P. E. Nielsen, *Nucleic Acids Res.* **1998**, *26*, 582 – 587.

[9] a) U. Landegren, R. Kaiser, J. Sanders, L. Hood, *Science* **1988**, *241*, 1077 – 1080; b) D. Y. Wu, R. B. Wallace, *Gene* **1989**, *76*, 245 – 254; c) K. Harada, L. E. Orgel, *Nucleic Acids Res.* **1993**, *21*, 2287 – 2291.

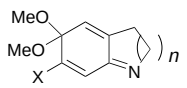
[10] ExoVII is an exodeoxyribonuclease that digests ssDNA from both the 3′ and 5′ ends. The cODN is not a substrate for this enzyme. ExoVII has been previously used to prove the formation of the padlock.[4a]

[11] a) M. Egholm, L. Christensen, K. L. Dueholm, O. Buchardt, J. Coull, P. E. Nielsen, *Nucleic Acids Res.* **1995**, *23*, 217 – 222; b) L. Christensen., R. Fitzpatrick, B. Gildea, K. H. Petersen, H. F. Hansen, T. Koch, M. Egholm, O. Buchardt, P. E. Nielsen, J. Coull, R. H. Berg, *J. Peptide Sci.* **1995**, *3*, 175 – 183.

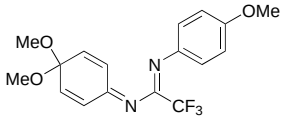
Direct Synthesis of *N*-Arylquinone Imine Acetals and Quinol Imines from Acetals**

M. Carmen Carreño,* Juan M. Cuerva, María Ribagorda, and Antonio M. Echavarren*

Although quinone imines and diimines have a long history in chemistry,[1] their synthetic potential has not been extensively exploited.[2, 3] The most general method for the preparation of these derivatives relies on the chemical oxidation of *p*-methoxyanilides or *p*-phenylenediamides[3a, b] with cerium(IV) salts[4] or $Pb(AcO)_4$.[5] However, the presence of an imide (*N*-acyl or *N*-arylsulfonyl group) is required to prevent decomposition of the oxidation product. Although N-acylated quinone imine acetals[6] are easily available by the anodic oxidation of substituted anilides,[7] the electrochemical oxidation of *p*-aminophenols[8] only allows for the in situ formation of simple quinone imines, which cannot be isolated in pure form due to their lack of stability under the oxidation conditions. The few examples of *N*-alkylquinone imines described to date refer to the labile derivatives of type **I**.[9] Recently, compound **II**, a new type of N-protected quinone imine acetal, has been isolated by oxidation of the trifluoromethylamidine precursor.[10]



I : X = MeO, Br; *n* = 1, 2



II

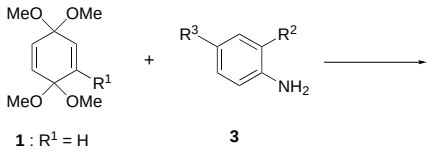
In connection with a project directed towards the total synthesis of pyridoacridine alkaloids based on cycloaddition chemistry,[11] we examined the condensation of quinone acetals with anilines. Surprisingly, we found that acetals react with anilines to yield the corresponding imines in the absence of any added catalyst.

As shown in Table 1, bisacetal **1**[12] reacted with anilines at 36 – 80 °C to give derivatives **4** [Eq. (1)]. The reactions were carried out without especial precautions in the presence of air. Interestingly, while *p*-methoxyaniline (**3b**) failed to react with **1** (entry 1), less nucleophilic *p*-nitroaniline (**3c**) reacted cleanly to give quinone imine monoacetal **4c** (entry 2). Reaction of **1** with *o*-aminocinnamaldehyde *N*,*N*-dimethylhydrazone[13] was carried out in the absence of solvent to give **4g** (entry 3). Bisacetal **2**[12] was more reactive than **1** and led

[*] Prof. M. C. Carreño, Prof. A. M. Echavarren, Dr. J. M. Cuerva, M. Ribagorda
Departamento de Química Orgánica
Universidad Autónoma de Madrid
Cantoblanco, E-28049 Madrid (Spain)
Fax: (+349) 1-397-3966

[**] We thank the Ministerio de Educación y Cultura (Spain) for the award of a predoctoral fellowship to M.R. This research was supported by the Dirección General de Investigación Científica y Técnica (DGICYT; projects PB95-0174 to M.C.C. and PB97 – 0002 to A.M.E.).

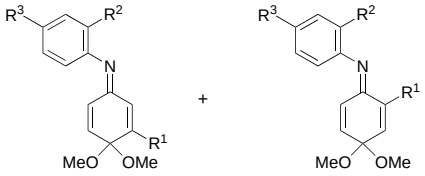
Supporting information for this article is available on the WWW under http://www.wiley-vch.de/home/angewandte/ or from the author.



1 : R^1 = H
2 : R^1 = OMe

3

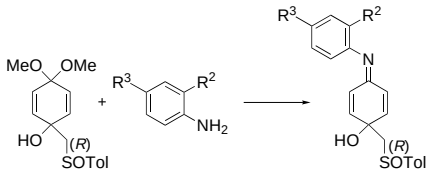
(1)



4 : R^1 = H
5 : R^1 = OMe

6 : R^1 = OMe

regioselectively to compounds **5** as mixtures of *anti* and *syn* isomers in good to excellent yields (entries 4–13). In a few instances, minor amounts of regioisomers **6** were also detected in the crude reaction mixtures. Although the condensations were usually carried out in CH_2Cl_2 or $CHCl_3$, best results were obtained in the condensation between **2** and anilines **3f** or **3g** in methanol (entries 11 and 13). Quinol derivative **7**[14] (Tol = tolyl = $CH_3C_6H_4$) reacted readily with the anilines at room temperature to afford *N*-aryl-*p*-quinol imines **8** [Eq. (2); Table 1, entries 14–17].[15,16]



7 **3** **8**

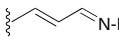
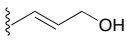
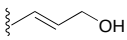
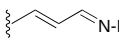
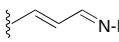
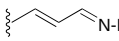
(2)

As expected, some of the condensations leading to the quinone imine acetals and quinol imines could also be catalyzed by TsOH (4-methylbenzenesulfonic acid) at room temperature. However, the reaction mixtures were less clean under these conditions, and decomposition of the imines was observed after a few hours. Significantly, one-electron oxidants such as $(NH_4)_2[Ce(NO_3)_6]$ and $AgBF_4$ also catalyzed the reaction between **2** and **3b**. These results point to the formation of the aniline radical cation as the active acidic species in the catalysis.[17, 18] Indeed, no reaction was observed between **2** and **3b** after the reagents were stirred in thoroughly deoxygenated $CDCl_3$. Brief exposure of the reaction mixture to air triggered the desired condensation to form **5b** (Table 1, entry 5). On the other hand, alkylamines do not condense with the acetals under these conditions, and more basic amines such as Et_3N inhibit the reaction.

Interestingly, *p*-nitroaniline (**3c**) was about five times more reactive towards diacetal **2** (room temperature, $CDCl_3$) than *p*-methoxyaniline (**3b**). The higher acidity of the radical cation of anilines bearing electron-withdrawing groups[19] is in accord with the higher reactivity of otherwise less nucleophilic *p*-nitroaniline (**3c**) in the condensation reaction (compare entries 1, 2 and 5, 6). Therefore, the formation of the imines appears to be catalyzed by the aniline radical cation or the acid liberated upon its decomposition. In accordance with this proposal, in a competing experiment the more acidic radical cation of *p*-nitroaniline (**3c**) should be able to promote the formation of the imine of the more nucleophilic aniline. Indeed, when a 1:1:1 mixture of **3b**, **3c**, and **2** was allowed to react in $CDCl_3$ at room temperature, exclusive formation of imine **5b** was observed.

It is important to note that this procedure allows the isolation of acid-labile substrates. Thus, for example, the

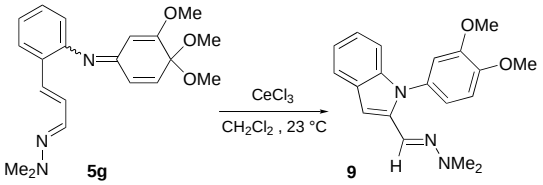
Table 1. Reactions of acetals **1**, **2**, and **7** with anilines **3** [Eqs. (1) and (2)].

Entry	Acetal	Aniline	R^2	R^3	Solvent	T [°C]	Product (*anti*:*syn*)	Yield [%]
1	**1**	**3b**	H	OMe	$CHCl_3$	65	–[a]	–
2	**1**	**3c**	H	NO_2	CH_2Cl_2	36	**4c**	60
3	**1**	**3g**		H	–	80	**4g**	35
4	**2**	**3a**	H	H	CH_2Cl_2	36	**5a** (3:2)	68
5	**2**	**3b**	H	OMe	$CHCl_3$	65	**5b** (2:1)[b]	95
6	**2**	**3c**	H	NO_2	$CHCl_3$	23	**5c** (3:1)[c]	77
7	**2**	**3d**	OMe	H	CH_2Cl_2	23	**5d** (2:1)[d]	59
8	**2**	**3d**	OMe	H	$CHCl_3$	65	**5d** (3:2)	83
9	**2**	**3e**	Br	H	CH_2Cl_2	36	**5e** (3:2)	82
10	**2**	**3f**		H	CH_2Cl_2	23	**5f** (3:2)	40
11	**2**	**3f**		H	MeOH	23	**5f** (3:2)	100
12	**2**	**3g**		H	CH_2Cl_2	23	**5g** (2:1)	62
13	**2**	**3g**		H	MeOH	23	**5g** (2:1)	95
14	**7**	**3a**	H	H	CH_2Cl_2	23	**8a**[e]	55
15	**7**	**3b**	H	OMe	CH_2Cl_2	23	**8b**[e]	100
16	**7**	**3c**	H	NO_2	CH_2Cl_2	23	**8c**[e]	50[f]
17	**7**	**3g**		H	CH_2Cl_2	23	**8g**[e]	83

[a] No reaction was observed. [b] The minor regioisomer **6b** was also formed (10%). [c] The minor regioisomer **6c** was also formed (5%). [d] The minor regioisomer **6d** was also formed (20%). [e] A 1:1 mixture of R,R_{sulfur} and S,R_{sulfur} diastereomers. [f] Additionally, compounds **A** and **B** were obtained in 40% yield.[16]

  1433-7851/99/3810-1450 $ 17.50+.50/0

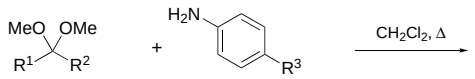
mixture of diastereomers **5g** (entry 13) reacted readily in the presence of protic acids to give indole **9** [Eq. (3)].[20] After a



(3)

thorough search of acid catalysts, best results for this cyclization were obtained with $CeCl_3$ (15 mol%, CH_2Cl_2, 23 °C, 64 h; 90%). This rather remarkable transformation presumably involves the addition of an electrophilic nitrogen atom to C2 of the side chain to form a benzylic carbocation.

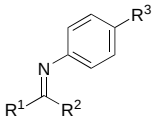
Simple ketone and aldehyde acetals **10**–**12** also react with anilines **3b** and **3c** in CH_2Cl_2 under reflux conditions to afford Schiff bases **13**–**16** in quantitative yields [Eq. (4)].[21] In



10 : $R^1 = R^2$ = Me
11 : R^1 = Ph, R^2 = Me
12 : R^1 = *p*-MeOC$_6$H$_4$, R^2 = H

3b : R^3 = OMe
3c : R^3 = NO_2

(4)



13 : $R^1 = R^2$ = Me, $R^3 = NO_2$
14 : R^1 = Ph, R^2 = Me, $R^3 = NO_2$
15 : R^1 = Ph, R^2 = Me, R^3 = OMe
16 : R^1 = *p*-MeOC$_6$H$_4$, R^2 = H, $R^3 = NO_2$

accordance with the arguments advanced before, aniline **3c** was more reactive than **3b** in the condensations with acetophenone dimethyl acetal (**11**). However, when both **3b** and **3c** were allowed to react with **11** ($CDCl_3$, room temperature), selective formation of **15** was observed.

In summary, we have uncovered the unprecedented reaction of acetals with arylamines to afford the corresponding imines in the absence of an added catalyst. The available evidence suggests that the reaction is catalyzed by the acidic radical cation formed in situ by the ready one-electron oxidation of the arylamine. This transformation is particularly valuable for the ready formation of acid-labile quinone imine acetals and quinol imines.

Experimental Section

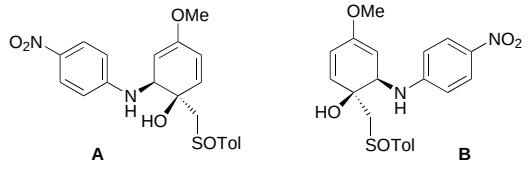
General procedure for the reactions summarized in Table 1 [Eqs. (1), (2), and (4)]: A solution of acetals **1**, **2**, **7** (0.5 mmol), or **10**–**12** and the corresponding aniline **3** (0.5 mmol) was stirred in the corresponding solvent (5 mL) at the stated temperature for 24–48 h. When the reaction was completed (thin-layer chromatography), the solvent was evaporated and the residue was purified by flash-column chromatography (hexane/EtOAc; see the supporting information for spectroscopic data).

9: A mixture of **5g** (23 mg, 0.07 mmol) and $CeCl_3$ (4 mg, 0.01 mmol) in CH_2Cl_2 (5 mL) was stirred at 23 °C for 64 h. The mixture was partitioned between CH_2Cl_2 and water. After extractive workup and chromatography (hexane/EtOAc 7/3), indole **9** (19 mg, 90%) was obtained as a colorless solid: m.p. 158–160 °C; ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 7.68$–7.57 (m, 1H), 7.15–7.08 (m, 3H), 7.00–6.85 (m, 5H), 3.99 (s, 3H), 3.77 (s, 3H), 2.90 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 149.20$, 148.47, 138.82, 137.64, 130.59, 128.16, 123.76, 121.67, 120.38 (2C), 111.63, 111.01, 110.00, 98.83, 56.01 (2C), 42.58 (2C) (one C signal was not observed); EI-MS: *m/z* (%): 323 (100, $[M^+]$), 279 (38), 265 (41); HR-MS calcd for $C_{19}H_{21}N_3O_2$: 323.1634, found: 323.1634.

Received: October 16, 1998 [Z12533IE]
German version: *Angew. Chem.* **1999**, *111*, 1552–1555

Keywords: acetals · quinones · radical ions · Schiff bases

[1] Reviews: a) *The Chemistry of Quinonoid Compounds* (Eds.: S. Patai, Z. Rappoport), Wiley, New York, **1988**; b) C. Grundmann, *Methoden der Organischen Chemie (Houben-Weyl) 4th. ed. 1952–*, Vol. 7/3b, **1977**.
[2] For recent synthetic applications of *p*-quinone monoimines, see a) T. A. Engler, W. Chai, K. O. LaTessa, *J. Org. Chem*. **1996**, *61*, 9297, and references therein; b) T. A. Engler, W. Chai, *Tetrahedron Lett.* **1996**, *37*, 6969.
[3] For synthetic applications of *p*-quinone bisimines, see a) T. A. Engler, J. Wanner, *Tetrahedron Lett*. **1997**, *38*, 6135; b) T. A. Engler, S. P. Meduna, K. O. LaTessa, W. Chai, *J. Org. Chem*. **1996**, *61*, 8598; c) D. L. Boger, H. Zarrinmayeh, *J. Org. Chem*. **1990**, *55*, 1379; d) D. L. Boger, R. S. Coleman, *J. Am. Chem. Soc*. **1988**, *110*, 4796; e) T. J. Holmes, R. G. Lawton, *J. Org. Chem*. **1983**, *48*, 3146.
[4] T. A. Engler, W. Chai, K. O. Lynch, *Tetrahedron Lett*. **1995**, *36*, 7003.
[5] a) R. Adams, W. Reifschneider, *Bull. Soc. Chim. Fr*. **1958**, 23; b) R. Adams, J. H. Looker, *J. Am. Chem. Soc*. **1951**, *73*, 1145; c) R. Adams, L. Whitaker, *J. Am. Chem. Soc*. **1956**, *78*, 658.
[6] a) J. S. Swenton, B. R. Bonke, C.-P. Chen, C.-T. Chou, *J. Org. Chem*. **1989**, *54*, 51; b) J. S. Swenton, B. R. Bonke, W. M. Clark, C.-P. Chen, K. V. Martin, *J. Org. Chem*. **1990**, *55*, 2027; *N*-acyl-*p*-quinol imine ethers: c) M. Novak, J. S. Helmick, N. Oberlies, K. S. Rangappa, W. M. Clark, J. S. Swenton, *J. Org. Chem*. **1993**, *58*, 867; d) J. S. Swenton, T. N. Biggs, W. M. Clark, *J. Org. Chem*. **1993**, *58*, 5607.
[7] C.-P. Chen, C.-T. Chou, J. S. Swenton, *J. Am. Chem. Soc*. **1987**, *109*, 946.
[8] a) S. P. Harmalker, D. T. Sawyer, *J. Org. Chem*. **1984**, *49*, 3579; b) T. E. Young, W. T. Beidler, *J. Org. Chem*. **1984**, 49, 4833; c) T. E. Young, B. W. Babbitt, *J. Org. Chem*. **1983**, *48*, 562.
[9] J. S. Swenton, C. Shih, C.-P. Chen, C.-T. Chou, *J. Org. Chem*. **1990**, *55*, 2019.
[10] M. Kobayashi, K. Uneyama, *J. Org. Chem*. **1996**, *61*, 3902.
[11] a) A. M. Echavarren in *Advances in Nitrogen Heterocycles, Vol. 2* (Ed.: C. J. Moody), JAI, Greenwich, **1996**, chap. 5; b) J. M. Cuerva, A. M. Echavarren, *Synlett* **1997**, 173.
[12] a) D. R. Henton, R. L. McCreery, J. S. Swenton, *J. Org. Chem*. **1980**, *45*, 369; b) D. R. Henton, K. Anderson, M. J. Manning, J. S. Swenton, *J. Org. Chem*. **1980**, *45*, 3422; c) M. G. Dolson, J. S. Swenton, *J. Am. Chem. Soc.* **1981**, *103*, 2361.
[13] A. M. Echavarren, *J. Org. Chem*. **1990**, *55*, 4255.
[14] a) M. C. Carreño, M. Pérez González, J. Fischer, *Tetrahedron Lett*. **1995**, *36*, 4893; b) M. C. Carreño, M. Pérez González, K. N. Houk, *J. Org. Chem.* **1997**, *62*, 9128.
[15] Derivatives **8** were obtained as 1:1 mixtures of C4 epimers.
[16] a) *p*-Nitroaniline (**3c**) reacted with **7** to give stereoselectively[16b] S_N2'-type reaction products **A** and **B** (1:1 ratio, 40%) besides the corresponding imine derivatives (50%, 1:1 mixture of diastereomers).



In accordance with the expected stereodirecting effect of the vicinal hydroxyl and bulky *p*-tolylsulfinylmethyl groups,[16b] we tentatively assign a *cis* relationship between the hydroxyl and the aniline

  1433-7851/99/3810-1451 $ 17.50+.50/0

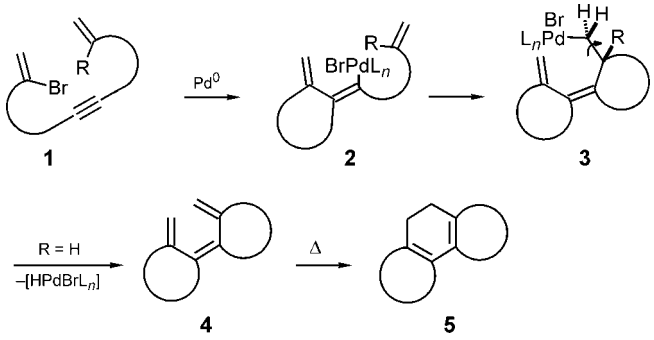
moieties; b) M. C. Carreño, M. Pérez González, M. Ribagorda, K. N. Houk, *J. Org. Chem*. **1998**, *63*, 3687.
[17] Wurster's reagent (*N*,*N*,*N*′,*N*′-tetramethyl-1,4-phenylenediamine) does not promote the condensation process. Decomposition of the generated aniline radical cation would release the proton required for the catalysis. For a review on radical cation promoted reactions, see M. Schmittel, A. Burghart, *Angew. Chem.* **1997**, *109*, 2658; *Angew. Chem. Int. Ed. Engl.* **1997**, *36*, 2550.
[18] For formation of radical cations of amines in chlorinated solvents, see E. A. Fitzgerald, P. Wuelfing, H. H. Richtol, *J. Phys. Chem.* **1971**, *75*, 2737.
[19] X.-M. Zhang, F. G. Bordwell, J. E. Bares, J.-P. Cheng, B. C. Petrie, *J. Org. Chem*. **1993**, *58*, 3051, and references therein.
[20] a) Reaction of **5g** with $TsOH \cdot H_2O$ (10 mol%) as the catalyst in THF at 23 °C afforded **9** in 52% yield; b) cyclization to form an indole was also observed with **5f** ($Yb(OTf)_3$ catalyst). Details of this cyclization will be published elsewhere.
[21] For the acid-catalyzed reaction of acetals with amines, see a) J. Hoch, *Compt. Rend.* **1935**, *201*, 560; b) T. Mukaiyama, K. Sato, *Bull. Chem. Soc. Jpn.* **1963**, *36*, 99; c) H. Heaney, M. T. Simcox, A. M. Z. Slawin, R. G. Giles, *Synlett* **1998**, 640.

Two New Modes of Pd-Catalyzed Domino-Tetracyclization of Bromodienynes—5-*exo-trig* Cyclization Wins over β-Hydride Elimination**

Stefan Schweizer, Zhi-Zhong Song, Frank E. Meyer, Philip J. Parsons, and Armin de Meijere*

Dedicated to Professor Heinz Georg Wagner on the occasion of his 70th birthday

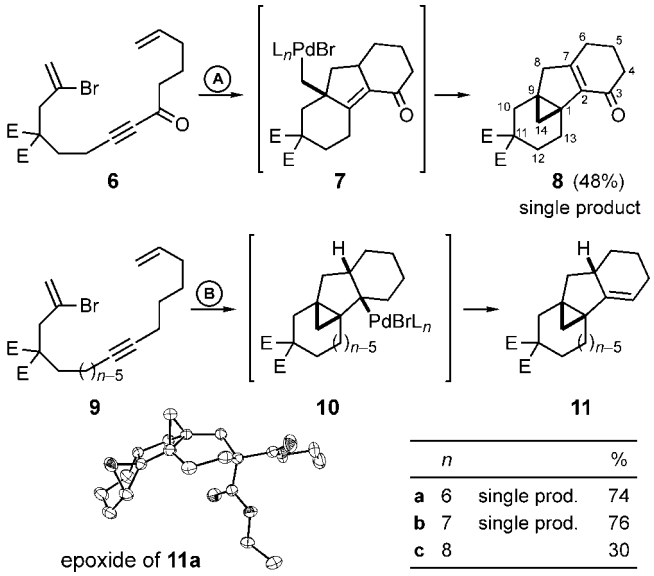
Multistep sequential transformations—domino[1] or cascade[2] reactions—which permit remarkable increases in molecular complexity in a single synthetic operation are gaining steadily increasing importance for the construction of complex organic molecules.[1–3] Among them, a variety of transition metal and in particular palladium-catalyzed multistep cascades are especially noteworthy in terms of atom economy, stereocontrol, and overall efficiency.[4, 5] As we have previously demonstrated, 2-bromododeca-1,11-diene-6-ynes and 2-bromotrideca-1,12-diene-7-ynes, under palladium catalysis, cleanly undergo overall tricyclizations in a sequence of two consecutive intramolecular Heck-type couplings and subsequent 6π electrocyclization (Scheme 1).[6, 7] Only when



Scheme 1.

the β-hydride elimination in the penultimate step is blocked by a substituent R ≠ H adjacent to the alkene terminus of the starting material **1**, does the intermediate **3** follow a different route to eventually yield a tetracyclic system with a bridging cyclopropane moiety between the A- and B-rings of its tricyclic skeleton.[6a, 8] We now report that 2-bromotetradeca-1,13-diene-7-ynes, which would have to give tricyclo[8.4.0.$0^{2,7}$]tetradeca-1(10),2(7)-dienes (1,2,3,4,5,6,7,8,9,10-decahydrophenanthrenes) by the usual Heck–Heck 6π-electrocyclization sequence, in reality undergo two types of tetracyclization depending on the pattern and the nature of substitution.

When the bromodieneynone **6**[9] was treated with palladium acetate, triphenylphosphane, and silver carbonate in acetonitrile at 80 °C, complete conversion was observed after three days, and the tetracyclo[7.4.1.$0^{1,9}$.$0^{2,7}$]tetradec-2(7)-en-3-one **8** was isolated in 45% yield.[10] Apparently, the alkylpalladium bromide intermediate of type **3** formed after two 6-*exo-trig* cyclizations undergoes a 5-*exo-trig* carbopalladation more rapidly than a β-hydride elimination, the neopentyl-type alkylpalladium bromide **7** then must continue to react by a 3-*exo-trig* carbopalladation before β-hydride elimination can occur (Scheme 2). The same type of tetracyclization occurred



	n		%
a	6	single prod.	74
b	7	single prod.	76
c	8		30

Scheme 2. A) Palladacycle[11] (5 mol%), K_2CO_3 (2.5 equiv), n-Bu_4NBr (0.5 equiv), LiCl (0.5 equiv), DMF, 110 °C, 2 d; B) $Pd(OAc)_2$ (10 mol%), PPh_3 (20 mol%), Ag_2CO_3 (3 equiv), MeCN, 80 °C, 3 d. Below: Structure of the epoxide obtained from **11a** with dimethyldioxirane in the crystal.[13] E = CO_2Et.

[*] Prof. Dr. A. de Meijere, Dipl.-Chem. S. Schweizer, Dr. Z.-Z. Song, Dr. F. E. Meyer
Institut für Organische Chemie der Universität
Tammannstrasse 2, D-37077 Göttingen (Germany)
Fax: (+49) 551-39-9475
E-mail: ameijer1@uni-goettingen.de
Prof. Dr. P. J. Parsons
Department of Chemistry, University of Sussex
Falmer, Brighton, BN1 2QJ (UK)

[**] This work was supported by the Fonds der Chemischen Industrie as well as BASF AG, Bayer AG, Degussa AG, and Chemetall GmbH (chemicals). The authors are indebted to Dr. Mathias Noltemeyer, Institut für Anorganische Chemie, Universität Göttingen, for carrying out the structure analyses of compounds **14a**, *cis*-**17** and to Dr. B. Knieriem for his careful proofreading of the manuscript.

  1433-7851/99/3810-1452 $ 17.50+.50/0