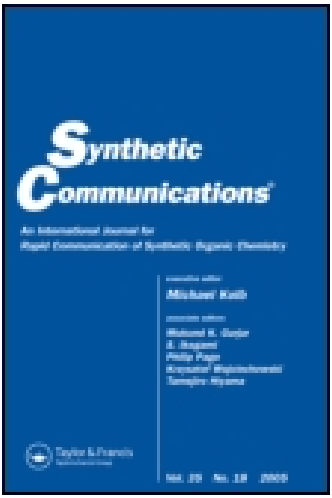


Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/lsyc20

PALLADIUM-CATALYZED CROSS-COUPLING OF ORGANOLEAD(IV) TRIACETATES WITH TERMINAL ALKYNES

Suk-Ku Kang [a] , Hyung-Chul Ryu [a] & Sang-Ho Lee [a]
[a] Department of Chemistry , Sungkyunkwan University , Natural Science Campus, Suwon, 440-746, Korea
Published online: 09 Nov 2006.

To cite this article: Suk-Ku Kang , Hyung-Chul Ryu & Sang-Ho Lee (2001) PALLADIUM-CATALYZED CROSS-COUPLING OF ORGANOLEAD(IV) TRIACETATES WITH TERMINAL ALKYNES, Synthetic Communications: An International Journal for Rapid Communication of Synthetic Organic Chemistry, 31:7, 1059-1064, DOI: 10.1081/SCC-100103537

To link to this article: http://dx.doi.org/10.1081/SCC-100103537

SYNTHETIC COMMUNICATIONS, 31(7), 1059–1064 (2001)

PALLADIUM-CATALYZED CROSS-COUPLING OF ORGANOLEAD(IV) TRIACETATES WITH TERMINAL ALKYNES

Suk-Ku Kang,* Hyung-Chul Ryu, and Sang-Ho Lee

Department of Chemistry, Sungkyunkwan University,
Natural Science Campus, Suwon 440-746, Korea

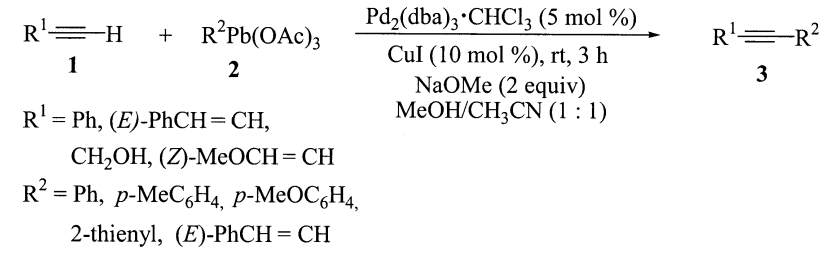
ABSTRACT

The palladium-catalyzed carbon-carbon bond formation of organolead(IV) triacetates with terminal alkynes was accomplished with $Pd_2(dba)_3{\cdot}CHCl_3$ (5 mol%) and CuI (10 mol%) in the presence of NaOMe (2 equiv.) in MeOH/CH_3CN (1:1) at room temperature.

The palladium-catalyzed cross-coupling of terminal alkynes with aryl or vinyl halides (or triflates) in the presence of cuprous iodide as co-catalyst, known as the Sonogashira coupling reaction,[1–3] now has become a versatile synthetic method in carbon-carbon bond formation. As an alternative to organic electrophiles, we have reported the palladium-catalyzed coupling of terminal alkynes with hypervalent iodonium salts and iodanes in aqueous medium under mild conditions.[4] Although Pinhey et al.[5–7] reported the arylation, alkenylation, and alkynylation of organolead(IV) compounds with soft carbon nucleophiles, such as active methylene compounds, no coupling of terminal alkynes by organolead(IV) compounds has been known.[8] In connection with our programs to utilize organolead triacetates in the cross-coupling reaction[9–11] we report here the palladium-catalyzed

* Corresponding author.

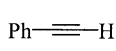
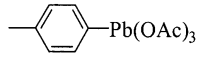
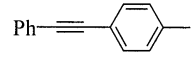
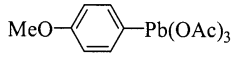
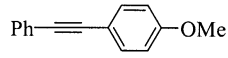
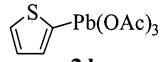
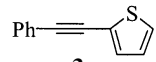
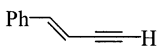
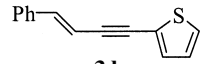
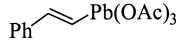
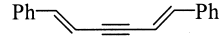
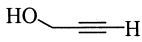
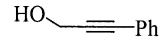
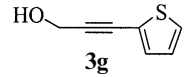
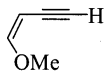
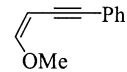
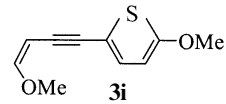
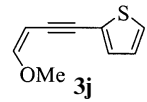
coupling of terminal alkynes with organolead(IV) triacetates using CuI as co-catalyst in the presence of sodium methoxide (Scheme 1).



Scheme 1.

The results of the palladium-catalyzed cross-coupling of terminal alkynes with organolead(IV) triacetates are summarized in Table 1. To achieve the coupling for the coupling of phenylacetylene (**1a**) with *p*-tolyllead triacetate (**2b**), we have found that the addition of 2 equivalents of NaOMe as a base was critical.[12] Presumably organolead methoxide intermediate $RPb(OMe)_2OAc$ is formed from $RPb(OAc)_3$ and NaOMe (2 equiv.), which drives facile oxidative addition with Pd(0), followed by transmetallation and reductive elimination. We examined for the reaction of **1a** with **2b**, with various catalysts, for $Pd_2(dba)_3{\cdot}CHCl_3$, $Pd(OAc)_2$, $Pd(PPh_3)_4$, and $PdCl_2$. $Pd_2(dba)_3{\cdot}CHCl_3$ was the best choice. To avoid homocoupling of organolead compounds,[13] it is essential to add CuI as co-catalyst. Of the solvents tested ($CHCl_3$, NMP, DMF, and benzene), the co-solvent MeOH/CH_3CN(1 : 1) was the best choice for this cross-coupling. When phenylacetylene (**1a**) reacted with *p*-$CH_3C_6H_4Pb(OAc)_3$ (**2b**)[14] (1 equiv.) in the presence of $Pd_2(dba)_3{\cdot}CHCl_3$ (5 mol%) and CuI (10 mol%) in with NaOMe (2 equiv.) in MeOH/CH_3CN (1 : 1) at room temperature for 3 h, the coupled product **3a** was afforded in 74% yield (entry 1 in Table 1). Under the same conditions, the reaction of **1a** with *p*-$MeOC_6H_4Pb(OAc)_3$ (**2c**)[15] gave the substituted alkynes **3b** in 78% yield (entry 2). The 2-thienyllead(IV) triacetate (**2d**)[13] was subjected to couple with **1a** and **1b** to afford the coupled product **3c** and **3d** in 79% and 72% yields, respectively (entries 3 and 4). This coupling was also applied to alkenyllead(IV) triacetates **2e**[16] to provide the ynene **3e** in 80% yield (entry 5). For the propargylic alcohol **1c** without protection, organolead(IV) triacetates **2a** and **2d** were smoothly coupled to afford **3f** and **3g** in 78% and 76% yields, respectively (entries 6 and 7). It is notable that the methoxyvinyl-substituted terminal alkynes **1d** was readily coupled under mild conditions to afford the substituted alkynes **3h**, **3i**, and **3j** in moderate yields (entries 8–10).

Table 1. The Palladium-Catalyzed Coupling of Organolead Compounds with Terminal Alkynes

Entry	Substrate	Organolead Compounds	Product	Isolated Yield (%)
1	 **1a**	 **2b**	 **3a**	74
2	**1a**	 **2c**	 **3b**	78
3	**1a**	 **2d**	 **3c**	79
4	 **1b**	**2d**	 **3d**	72
5	**1b**	 **2e**	 **3e**	80
6	 **1c**	$PhPb(OAc)_3$ **2a**	 **3f**	78
7	**1c**	**2d**	 **3g**	76
8	 **1d**	**2a**	 **3h**	76
9	**1d**	**2c**	 **3i**	77
10	**1d**	**2d**	 **3j**	77

In summary, organolead(IV) triacetate was utilized as a novel reagent for direct arylation and alkenylation of terminal alkynes under mild conditions.

EXPERIMENTAL

Typical Procedure

Method A: Preparation of 1-Methoxy-4-(phenylethynyl)-benzene (**3b**)

To a stirred solution of *p*-methoxyphenyllead triacetate (**2c**) (280 mg, 0.58 mmol) and NaOMe (63 mg, 1.16 mmol) in MeOH/CH_3CN (1 : 1, 5 mL) was added $Pd_2(dba)_3{\cdot}CHCl_3$ (28 mg, 5 mol%) and CuI (10 mg, 10 mol%), followed by phenylacetylene (**1a**) (60 mg, 0.58 mmol) via syringe at room temperature under N_2 charged. The mixture was stirred at room temperature for 3 h. The reaction mixture was extracted with ether (20 mL × 3) and washed with water (3 times), and the organic layer was dried over anhydrous $MgSO_4$ and evaporated in vacuo. The crude product was separated by SiO_2 column chromatography (EtOAc/hexanes = 1 : 10, $R_f = 0.52$) to give coupled product **3b** (94 mg, 78%). TLC, SiO_2, EtOAc/hexanes 1 : 10, $R_f = 0.52$. ^1H NMR (400 MHz, $CDCl_3$), δ 3.83 (s, 3H), 6.89 (dd, 2H, $J = 4.2$, 2.0 Hz), 7.33 (m, 3H), 7.51 (m, 4H). IR (KBr) = 3080, 2958, 1617, 1405 cm^{-1}. MS (EI): m/e (relative inensity) = 208(M^+), 207 (100), 193 (49), 165 (52).

Method B: Preparation of 3-(2-thiophenyl)propyn-1-ol (**3g**)

To a stirred solution of propargyl alcohol (33 mg, 0.58 mmol) and NaOMe (63 mg, 1.16 mmol) in MeOH/CH_3CN (1 : 1, 5 mL) was added $Pd_2(dba)_3{\cdot}CHCl_3$ (28 mg, 5 mol%) and CuI (10 mg, 10 mol%), followed by 2-thienyllead triacetate (**2d**) (270 mg, 0.58 mmol) in one portion at room temperature under N_2 and stirred at room temperature for 3 h. The reaction mixture was extracted with ether (20 mL × 3) and washed with water, and the organic layer was dried over anhydrous $MgSO_4$ and evaporated in vacuo. The crude product was separated by SiO_2 column chromatography (EtOAc/hexanes = 1 : 5, $R_f = 0.42$) to give coupled product **3g** (61 mg, 76%). TLC, SiO_2, EtOAc/hexanes 1 : 5, $R_f = 0.42$. ^1H NMR (400 MHz, $CDCl_3$) δ 4.50 (d, 2H, $J = 4.4$ Hz), 6.97 (m, 1H), 7.21 (m, 1H), 7.27 (m, 1H). IR (KBr) = 3505, 3055, 1265, 896, 950 cm^{-1}. MS (EI): m/e (relative intensity) = 139 (M^+), 138 (100), 137 (44), 121 (22), 110 (50). HRMS calcd. for C_7H_6OS: 138.0121, found: 138.0139.

(*Z*)-(4-Methoxy-3-buten-1-ynyl)benzene (**3h**)

^{1}H NMR (400 MHz, $CDCl_3$) δ 3.87 (s, 3H), 4.85 (d, 1H, J= 6.4 Hz), 6.40 (d, 1H, J = 6.4 Hz), 7.41 (m, 3H), 7.56 (m, 2H). IR (KBr) = 3075, 2950, 1615, 1410 cm^{-1}. MS (EI): m/e (relative intensity) = 159 (M^+), 158 (M^+, 100), 115 (83). HRMS calcd. for $C_{11}H_{10}O$: 158.0732, found: 158.0733.

1-Methoxy-4-(4-methoxy-3-butten-1-ynyl)benzene (**3i**)

^{1}H NMR (400 MHz, $CDCl_3$) δ 3.69 (s, 3H), 3.70 (s, 3H), 4.62 (d, 1H, J = 6.4 Hz), 6.22 (d, 1H, J = 6.4 Hz), 6.72 (m, 2H), 7.32 (m, 2H). IR (KBr) = 3063, 1710, 1520, 910 cm^{-1}. MS (EI): m/e (relative intensity) = 189 (M^{+1}), 188 (M, 100), 145 (61), 115 (15). HRMS calcd. for $C_{12}H_{12}O_2$: 188.0873, found: 188.0835.

2-(4-Methoxy-3-buten-1-ynyl)thiophene (**3j**)

Hexanes, R_f = 0.35. ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.81 (s, 3H), 4.74 (d, 1H, J = 6.4 Hz), 6.32 (d, 1H, J = 6.4 Hz), 6.95 (dd, 1H, J = 3.7, 1.6 Hz), 7.17 (m, 1H), 7.21 (m, 1H). IR (KBr) = 3060, 2967, 1410, 867 cm^{-1}. MS (EI): m/e (relative intensity) = 165 (9), 164 (100), 121 (79), 63 (10).

ACKNOWLEDGMENTS

Generous financial support from KOSEF-Center for Molecular Design and Synthesis (CMDS) is gratefully acknowledged.

REFERENCES AND NOTES

1. Sonogashira, K.; Tohda, Y.; Hagihira, N. Tetrahedron Lett. **1975**, *16*, 4467–4470.
2. Sonogashira, K. In Comprehensive Organic Synthesis; Trost, B.M.; Fleming, I., Eds.; Pergamon: Oxford, 1991; Vol. 3, 521.
3. Rossi, R.; Carpita, A.; Bellina, F. Org. Prep. Proc. Int. **1995**, *27*, 129.
4. Kang, S.-K.; Lee, H.-W.; Jang, S.-B.; Ho, P.-S. J. Chem. Soc., Chem. Commun. **1996**, 835–836.
5. Pinhey, J.T. Aust. J. Chem. **1991**, *44*, 1353–1382.
6. Pinhey, J.T. Pure & Appl. Chem. **1996**, *68*, 819–824.

7. Hashimoto, S.; Miyazaki, Y.; Shinoda, T.; Ikegami, S. J. Chem. Soc., Chem. Commun. **1990**, 1100–1102.
8. Phenylation of terminal acetylene by triphenylbismuth difluoride in the presence of CuCl catalyst was known. Lermontov, S.A.; Rakov, I.M.; Zefirov, N.S.; Stang, P.J. Tetrahedron Lett. **1996**, *37*, 4051–4054.
9. Kang, S.-K.; Ryu, H.-C.; Choi, S.-C. J. Chem. Soc., Chem. Commun. **1998**, 1317–1318.
10. Kang, S.-K.; Ryu, H.-C.; Son, H.-J. Synlett **1998**, 771–773.
11. Kang, S.-K.; Choi, S.-C.; Ryu, H.-C.; Yamaguchi, T. J. Org. Chem. **1998**, *63*, 5748–5749.
12. Excess NaOMe (3–4 equiv.) gave the homocoupling product. With Et_3N as base, the homocoupled product of organolead compound was the major product.
13. Kang, S.-K.; Shivkular, U.; Ahn, C.; Choi, S.-C.; Kim, J.-S. Synth. Commun. **1997**, *27*, 1893–1897.
14. Bell, H.C.; Kalman, J.R.; Pinhey, J.T.; Sternhell, S. Aust. J. Chem. **1979**, *32*, 1521–1530.
15. *p*-Methoxyphenyllead triacetate was easily prepared from anisole by treatment of lead tetraacetate. Kozyrod, R.P.; Pinhey, J.T. Org. Synth. **1984**, *62*, 24–29.
16. Hambley, T.W.; Holmes, R.J.; Parkinson, C.J.; Pinhey, J.T. J. Chem. Soc., Perkin Trans. 1 **1992**, 1917–1922.

Accepted May 8, 2000