Available online at www.sciencedirect.com

SCIENCE DIRECT®

Tetrahedron Letters 45 (2004) 3787–3788

Tetrahedron Letters

Platinum(II)-catalyzed addition of alcohols to alkynes

John W. Hartman* and Luke Sperry

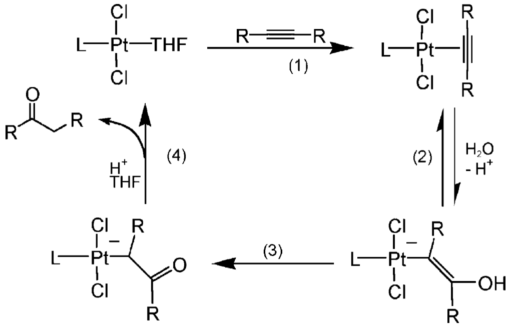
Department of Chemistry, Western Illinois University, Macomb, IL 61455, USA

Received 28 January 2004; revised 11 March 2004; accepted 12 March 2004

Abstract—A simple, high-yielding synthesis of acetals from the platinum(II)-catalyzed addition of alcohols to alkynes is described. The regioselectivity of the method and its mechanism are also discussed.

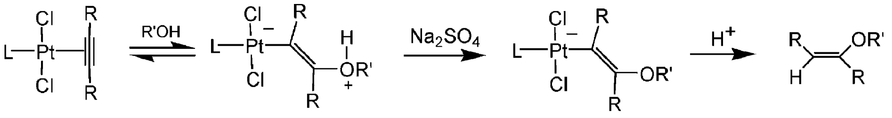
In previous reports, platinum(II) in the form of Zeise's Dimer [di-μ-chloro-dichlorobis(ethylene)diplatinum(II)] and simpler Pt(II) halides have been shown to catalyze the hydration of unactivated alkynes to yield ketones.[1,2] With unsymmetrical alkynes, modest to excellent regioselectivity of water addition was observed and resulted from either enhancement of steric effects or by chelation control of the catalyst depending on the structure of the substrate.[3]

The platinum catalyst system has also exhibited an interesting chemoselectivity for water over alcohol. Even when an alkyne was treated with platinum(II) in neat alcohol, the only observed product was trace ketone from adventitious water. This result indicated that the nucleophilic addition, shown in step 2 of the proposed hydration mechanism in Scheme 1, is reversible when tautomerism to a carbonyl is not available, which would be the case if alcohol were the nucleophile. We now wish to report our further investigations into the mechanism of the platinum(II)-catalyst system and the successful addition of alcohols to unactivated alkynes.



Scheme 1. Proposed hydration mechanism. L = neutral ligand (e.g., ethylene, THF, alkyne).

According to the proposed hydration mechanism, if alcohol is used as the nucleophile the initial product would be a platinum-bound protonated vinyl ether in the equilibrium shown in Eq. 1. Since tautomerism is not possible for this species then the addition of an appropriate base could abstract the acidic proton from the intermediate and drive the equilibrium forward. The choice of base is crucial in order to maintain catalytic activity. Consequently, anhydrous sodium sulfate or potassium sulfate was used as the basic co-catalyst.



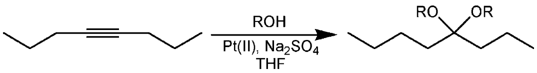
(1)

Keywords: Platinum; Catalysis; Hydration; Alcohol addition; Alkyne; Acetal.

* Corresponding author. Tel.: +1-309-298-2261; fax: +1-309-298-2180; e-mail: jw-hartman@wiu.edu

0040-4039/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.tetlet.2004.03.069

Table 1



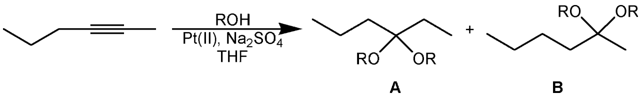
R	% Conversion of 4-octyne
Me	89
Et	80
n-Pr	68
i-Pr	45
t-Bu	0
Ph	0

Table 1 summarizes the results obtained from using anhydrous sodium sulfate with platinum(II) in adding a series of alcohols to 4-octyne.[4] The results clearly indicate that the co-catalyst provides high percent conversions of the alkyne to the corresponding acetal products. In the absence of the co-catalyst, only starting alkyne and alcohol are isolated. There also appears to be an inverse relationship between reaction rate and increasing size of the alcohol alkyl group, and a failure to add *tert*-butyl alcohol and phenol, which indicates the acidity of the hydroxyl proton and nucleophilicity of the alcohol oxygen are essential factors of the reaction.

Attempts to limit the addition of alcohol in order to observe and isolate a vinyl ether have been futile resulting in the isolation of the alkyne and proportionate amounts of the acetal. This seems to suggest that the second alcohol addition to the platinum-bound vinyl ether is faster than the primary addition of alcohol to the alkyne. In an experiment using methanol and 2,3-dihydropyran in the presence of the platinum catalyst system, only 25% of the dihydropyran was converted to the acetal after 18 h at room temperature.[5] This result indicates that although platinum(II) can behave as a traditional Lewis acid catalyst, the rate of conversion of free vinyl ether to acetal is much too slow, suggesting that the second addition is occurring while the vinyl ether moiety is still attached to the platinum.

Regioselectivity of this system was briefly investigated using 2-hexyne yielding the results shown in Table 2. Modest regioselectivity was observed with the selectivity corresponding to increasing alcohol chain length most likely attributable to slower reaction times. The decrease in regioselectivity with 2-propanol compared to 1-propanol is expected considering the steric bulk of the nucleophile may hinder its attack at the more sterically encumbered acetylenic carbon.

Table 2



R	Product ratio **A**:**B**
Me	54:46
Et	56:44
n-Pr	62:38
i-Pr	59:41

Table 3

Co-catalyst	% Conversion of 4-octyne[a]
Na_2SO_4	89
$MgSO_4$	90
CH_3CO_2K	8
Diisopropylethylamine	0
2,6-Lutidine	0
2,6-Di-*t*-butylpyridine	81

[a] 1 mol% Pt(II), 2 mol% co-catalyst, 3 equiv CH_3OH.

In order to discern the role of the sulfate ion in the reaction, attention was focused on finding other anhydrous and basic reagents to serve as co-catalysts. Table 3 summarizes the results of that investigation. Two of the anhydrous salts demonstrated good activity as co-catalysts, although both were only sparingly soluble in the reaction solvent. The apparent lack of activity by Hunig's base and 2,6-lutidine is most likely a result of strong coordination of the amine with the platinum catalyst thereby preventing the alkyne coordination requisite for reaction progress. The fact that the extremely bulky amine base 2,6-di-*tert*-butylpyridine displayed activity comparable to sulfate ion indicates that the co-catalyst is functioning primarily as a base for proton abstraction and not as a ligand on platinum.[6,7]

In conclusion, an efficient, selective, and versatile catalyst system for the addition of alcohols to alkynes has been developed. The scope of this reaction system with regard to activated alkyne substrates (e.g., conjugated alkynyl ketones) is already under investigation.

Acknowledgements

Support from the Western Illinois University Research Council (WIU-URC) and the WIU Department of Chemistry is gratefully acknowledged.

References and notes

1. Hiscox, W.; Jennings, P. W. *Organometallics* **1990**, *9*, 1997.
2. Hartman, J. W.; Hiscox, W. C.; Jennings, P. W. *J. Org. Chem.* **1993**, *58*, 7613.
3. Jennings, P. W.; Hartman, J. W.; Hiscox, W. C. *Inorg. Chim. Acta* **1994**, *222*, 317.
4. *General procedure for alcohol addition reactions*: To a flame-dried 25-mL-round bottomed flask fitted with a septum and stirbar were added 10 mL anhydrous THF, 18 mmol alcohol, 6 mmol alkyne, 1 mol% platinum(II) (as Zeise's Dimer or a simple dihalide salt), and 2 mol% co-catalyst. The reaction mixture was then allowed to stir at room temperature for at least 12 h. The product was then isolated by Kugelrohr bulb-to-bulb distillation, and the distillate analyzed by capillary gas chromatography.
5. Hartman, J. W. Ph.D. Thesis, Montana State University, **1996**.
6. Appleton, T. G.; Berry, R. D.; Davis, C. A.; Hall, J. R.; Kimlin, H. A. *Inorg. Chem.* **1984**, *23*, 3514.
7. Appleton, T. G.; Hall, J. R.; Neale, D. W. *Inorg. Chim. Acta* **1985**, *104*, 19.