CHEMISTRY LETTERS, pp. 423-424, 1977. Published by the Chemical Society of Japan

PALLADIUM CATALYZED THIENYLATION OF ALLYLIC ALCOHOLS

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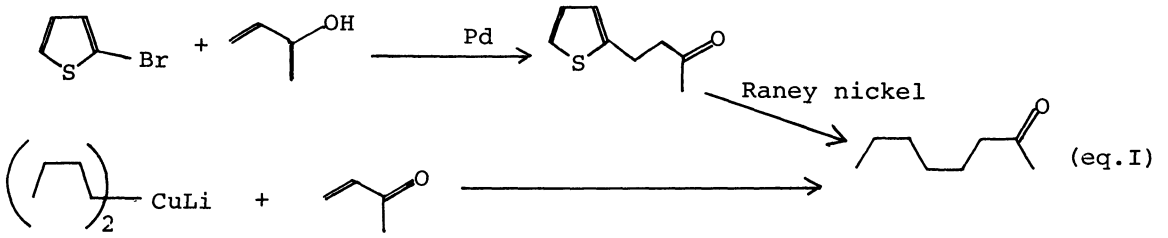
3-(2-Thienyl)-aldehydes and ketones were prepared by catalytic reaction with palladium acetate from 2-bromothiophene and five kinds of allylic alcohols.

One of the most important features of thiophene chemistry is that thiophene serves as a very useful template for the four-carbon homologation reaction.[1] Recently Heck et al.[2a] and Chalk et al.[2b] have reported the phenylation of allylic alcohols catalyzed by palladium salt. This prompted us to present our results on the thienylation of allylic alcohols, where 2-bromothiophene reacted with allylic alcohols in the presence of a catalytic amount of palladium acetate to give 3-thienyl-ketones or aldehydes in excellent to fairly good yields depending on the structure of allylic alcohols (Table 1, eq. 1).



This thienylation, coupled with desulfurization with Raney nickel,[3] is formally equivalent to the addition reaction of lithium dialkylcopper to α,β-unsaturated carbonyl compounds,[4] but the former seems to have some advantages over the latter; for examples a) the manipulation is very easy and applicable to a large scale reaction and b) as mentioned above, thiophene serves as a very useful template and we can introduce substituents appropriately, if necessary, on thiophene ring before or after this reaction.

Table 1 shows the reaction conditions and product distributions on each five kinds of allylic alcohols. In all cases, except for β-methallyl alcohol, 3-thienyl-aldehydes or ketones were obtained selectively. The thienylations of α- and γ-methallyl alcohols proceeded smoothly with 0.1 eq. of $Pd(OAc)_2$. Especially in the case of α-methallyl alcohol, the reaction proceeded to completion even with 0.01 eq. of $Pd(OAc)_2$, while the thienylation of allyl alcohol ceased essentially at ca. 50% conversion and during the prolonged reaction the decomposition of thienylpropionaldehydes and the increased formation of bithienyl were observed.

The representative procedure is as follows: into an argon purged slurry mixture of $Pd(OAc)_2$ (9.0 mg, 0.04 mmol), NaI (21 mg, 0.14 mmol), $NaHCO_3$ (404 mg, 4.8 mmol) in 4 ml of hexamethylphosphoric triamide were added 1-buten-3-ol (432 mg,

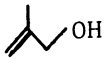
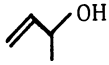
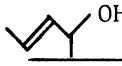
6 mmol) and 2-bromothiophene (652 mg, 4 mmol). This reaction mixture was stirred and heated at 120°C for 3 hrs. under argon atmosphere, and then poured into water. Extraction with ether and distillation (∿102°C/6 mmHg) of extract gave a colorless oily product (474 mg, 77% yields), which consisted of 93.5% of 4-(2-thienyl)-butan-2-one and 6.5% of 3-(2-thienyl)-butan-2-one.

4-(2-Thienyl)-butan-2-one: $\delta_{TMS}^{CDCl_3}$ 2.15 (s, 3H), 2.6-3.3 (A_2B_2 multiplet, 4H) and 6.74-7.21 (m, 3H). ν_{max}^{neat} (cm^{-1}) 3110 (m), 1715 (v.s.), and 695 (s). m/e (%) 154 (77), 111 (96), 97 (100), and 43 (87).

3-(2-Thienyl)-butan-2-one: $\delta_{TMS}^{CDCl_3}$ 1.49 (d, 7Hz, 3H), 2.15 (s, 3H), 4.04 (q, 7Hz, 1H), and 6.81-7.31 (m, 3H). ν_{max}^{neat} (cm^{-1}) 3110 (w), 1710 (v.s.), and 695 (s). m/e (%) 154 (17), 111 (100), 97 (5), 77 (18), and 43 (32).

Some applications and full details of this reaction will be reported in due course.

Table 1. Palladium Catalyzed Thienylation of Allylic Alcohols

Starting Materials (Molar Ratios)[a]		Temp.[b] (°C)	Time (hr)	Conver-sion[c] (%)	Type of Product (Yield %)[d]			
Alcohol	$Pd(OAc)_2$				3-Thienyl	2-Thienyl	Bithie-nyl	Others
 3	0.1	90	4	48	76	2	22	
 3	0.1	100	9	61	25	0	56	19[e]
 3	0.1	100	7.5	93	63	0	37	
 1.5	0.01	120	3	100	90	6	4	
3	0.1	100	9.5	92	(87)[f]		(2)[f]	
 5	0.1	100	5.5	61	60	0	23	17[g]

a. Based on 2-bromothiophene. The usual scale is 2.0 mmol of 2-bromothiophene, 2.4 mmol of $NaHCO_3$, 0.7 mmol of NaI, and the indicated amounts of allylic alcohol and $Pd(OAc)_2$ in 2 ml of HMPA. b. Bath temp. c. Based on 2-bromothiophene consumed. d. The yields were determined by g.l.c. with internal standard and are based on 2-bromothiophene consumed. The structures of all compounds were determined by nmr, ir, mass, and elemental analyses. e. β-Thienylmethacrolein. f. Isolated yields. g. Unspecified product.

References and Note

1. a) A. I. Meyers, "Heterocyclics in Organic Chemistry," John Wiley & Sons, Inc. 1974. b) S. Gronowitz, "Chemistry of Thiophenes," in "Advances in Heterocyclic Chemistry," A. Katritzky, ed., Vol. 1, Academic Press, New York, 1963, pp 1-124.
2. a) J. B. Melpolder and R. F. Heck, J. Org. Chem., 41, 265 (1976). b) A. J. Chalk and S. A. Magennis, ibid., 41, 273, 1206 (1976).
3. G. R. Pettit and E. E. Van Tamelen, "Organic Reactions," Vol. 12, Wiley, New York, 1962.
4. G. H. Posner, "Organic Reactions," Vol. 19, Chapter 1, Wiley, New York, 1972.

(Received February 21, 1977)