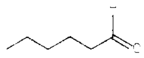
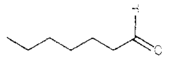
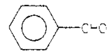
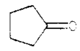
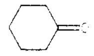
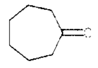
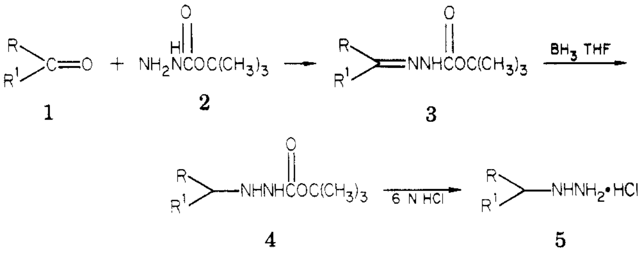
Table I. Preparation of Monoalkylhydrazines 5 and Intermediate Alkylidinecarbazates 3[a]

carbonyl compd 1		3		5	
		mp, °C	% yield	mp	% yield[b]
a		86-87	96	50-51	92
b		71-72	95	49-50	93
c		176-177[c]	96	110-111	95[d]
d		124-125	96	131-132	90[e]
e		134-135	96	112-113	93[f]
f		121-122	97	80-81	90

[a] Reactions were carried out on a 10-mmol scale as described in the text. [b] Isolated, overall yield of analytical sample from carbonyl compound. [c] Lit.[9] mp 185-187 °C. [d] Lit.[10] mp 109-111 °C. [e] Lit.[11] mp 132-134 °C. [f] Lit.[12] mp 112-113 °C. Spectral data (NMR, MS) for all compounds were consistent with the assigned structures. All new compounds and compound **3c** gave satisfactory analysis (C, H, N).

We now report a modification of the ethyl carbazate procedure in which analytically pure monoalkylhydrazine hydrochlorides were isolated in greater than 90% yield, starting from a ketone or aldehyde (Table I).[9-12] The present procedure avoids formation of the dialkylated carbazate side product and harsh hydrolysis conditions previously reported[7,8] by the use of *tert*-butyl carbazate (**2**) instead of ethyl carbazate with a ketone or aldehyde **1**. Reduction of the resulting *tert*-butyl alkylidinecarbazate **3** with diborane in tetrahydrofuran (BH_3·THF) under anhydrous conditions avoids hydrolysis of the alkylidinecarbazate, which is believed to give rise to the dialkylated carbazate side product when catalytic hydrogenation is used. In addition, use of the commercially available *tert*-butyl carbazate (**2**) in place of the ethyl carbazate greatly facilitates hydrolysis of the intermediate carbazate **4**, giving direct in situ formation of the hydrazine hydrochloride salts **5** under mild conditions.



R = alkyl, aryl; R¹ = H, alkyl

Experimental Section

A hexane solution containing the carbonyl compound (10 mmol) and *tert*-butyl carbazate (10 mmol) was heated to reflux for 20 min. When the solution cooled, the *tert*-butyl alkylidinecarbazate **3** crystallized and was filtered (85%). Further concentration of the mother liquor separated the remainder of **3** (10%). The combined products had essentially the same melting point as that of the analytical samples prepared by a single recrystallization from ether/methanol. BH_3·THF (10 mL of a 1 M solution, 10 mmol) was added to the solid *tert*-butyl alkylidinecarbazate **3** (10 mmol), which was allowed to stir for 10 min at room temperature. HCl (6 N, 5 mL) was then added dropwise to the reaction mixture. The reaction became vigorous with the evolution of isobutylene and carbon dioxide. The reaction mixture was heated for 10 min on the steam bath and then taken to dryness under reduced pressure. The residue was treated with tetrahydrofuran (20 mL) and boric acid was removed by filtration. Removal of the solvent under reduced pressure and a single crystallization from tetrahydrofuran/ether gave the hydrazines as their hydrochloride salts (Table I).

Acknowledgment. This investigation was supported by Grant No. R01 HL24530.

Registry No. 1a, 66-25-1; **1b**, 111-71-7; **1c**, 100-52-7; **1d**, 120-92-3; **1e**, 108-94-1; **1f**, 502-42-1; **2**, 870-46-2; **3a**, 79201-37-9; **3b**, 79201-38-0; **3c**, 24469-50-9; **3d**, 79201-39-1; **3e**, 60295-11-6; **3f**, 79201-40-4; **5a**·HCl, 79201-41-5; **5b**·HCl, 79201-42-6; **5c**·HCl, 1073-62-7; **5d**·HCl, 24214-72-0; **5e**·HCl, 24214-73-1; **5f**·HCl, 79201-43-7.

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(9) Carpino, L. A.; Santilli, A. A.; Murry, R. W. *J. Am. Chem. Soc.* **1960**, *82*, 2728–31.

(10) Kline, G. B.; Cox, S. H. *J. Org. Chem.* **1961**, *26*, 1854–6.

(11) Seidlova, V.; Vejdelek, Z. J.; Rajsner, M.; Jirkovsky, I.; Protiva, M. *Cesk. Farm.* **1969**, *18*, 190–7.

(12) Druey, J.; Schmidt, P; Eichenberger, K. U.S. Patent 3098075, 1963.

Palladium-Catalyzed Arylation of Methyl Vinyl Ether

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Recently Tsuji reported in a review[1] that palladium-catalyzed reaction of iodobenzene with ethyl vinyl ether had been largely unsuccessful. The reaction exhibited little regioselectivity and produced low yields of (1-ethoxyethenyl)benzene and (*E*)- and (*Z*)-(2-ethoxyethenyl)benzene.[2] Double bonds substituted with electron-donating substituents tend to produce significant amounts of 2-aryl adducts in addition to the major 1-aryl isomers.[3-5] This is further exemplified in the reaction between bromobenzene and vinylpyrrolidinone producing both the isomers in comparably high yields, 40% and 60%, respectively. A dimethylamino group in the 4-position increased the addition on the internal carbon of the double bond while a 4-nitro group had the opposite effect.[6] These results prompted us to study the palladium-catalyzed reaction between 4-nitrohalobenzenes and methyl vinyl ether with the intention of obtaining the 1-aryl isomer in high yield.

Results and Discussion

We found that among the 4-nitrohalobenzenes, the iodo and bromo compounds were superior to the chloro compound. Starting from 4-bromonitrobenzene (or from 4-chloro), we noticed a comparably higher yield when triphenylphosphine, commonly used as ligand, was absent (Scheme I).

The total yield of 1-aryl adducts from 4-bromonitrobenzene in a preparative run was 52% compared to 25% with triphenylphosphine present. Small-scale reactions

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(1) J. Tsuji, "Organic Synthesis with Palladium Compounds", Springer-Verlag, New York 1980, p 142.

(2) I. Arai and G. D. Daves, Jr., *J. Org. Chem.*, **44**, 21 (1979).

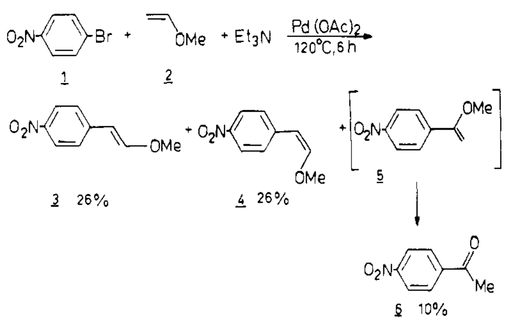
(3) H. A. Dieck and R. F. Heck, *J. Am. Chem. Soc.*, **96**, 1133 (1974).

(4) C. B. Ziegler, Jr., and R. F. Heck, *J. Org. Chem.*, **43**, 2941 (1978).

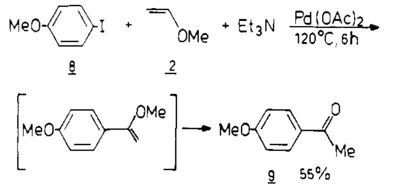
(5) J. B. Melpolder and R. F. Heck, *J. Org. Chem.*, **41**, 265 (1976).

(6) C. B. Ziegler, Jr., and R. F. Heck, *J. Org. Chem.*, **43**, 2949 (1978).

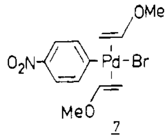
Scheme I



Scheme II



in sealed tubes after 6 h showed the same ratio according to GLC analysis. The content of starting material in the crude product was the same regardless of scale, but in the case where triphenylphosphine was present, a considerable amount of unidentified high-molecular-weight compounds had been formed. These results could best be interpreted by the assumption that the aryl vinyl ethers **3** and **4** are more easily further arylated, leading to diarylvinyl compounds when triphenylphosphine is involved. We presume that a species of type **7** lies on the reaction coordinate and plays an important role in the absence of a phosphine ligand.



7

The 1-aryl/2-aryl ratio (5.2:1) was approximately the same by starting from either the chloro-, bromo-, or iodonitrobenzene. An addition of 20% trifluoroacetate in order to substitute the halogen in the oxidative addition complex neither changed this ratio nor the yield of the reaction. The only isolated product on starting from 4-iodoanisole was 4-methoxyacetophenone (55%). It is not known whether the other isomer was formed but had decomposed or had escaped detection (see Scheme II).

Thus, the 2-aryl adduct was the major product in this case in comparison to the formation of the high yield of 1-aryl adduct on starting from 4-bromonitrobenzene. This shows that the electron density on the carbon atom bonded to palladium plays a significant role in the regioselectivity of the reaction. Among the reaction conditions, so far only the influence of temperature on the regioselectivity has been studied. It was found that reaction at 100 °C for 16 h gave a higher 1-aryl/2-aryl ratio (6.2:1). *E* to *Z* ratios were approximately constant (ca. 1:1) regardless of the conditions and substrates used.

As indicated by GLC, the crude reaction mixture contained the 2-aryl adduct **5** in addition to the derived acetophenone **6**. Hydrolysis of the reaction mixture by brief shaking with 10% hydrochloric acid at room temperature resulted in complete conversion of the vinyl ether **5** to the acetophenone **6**. This is in accord with the well-known sensitivity of vinyl ethers to acid hydrolysis. However, it is noteworthy that the 1-aryl adducts **3** and **4** were intact even after 2 h of aqueous acid treatment. The stability of the vinyl ether linkages in **3** and **4** may be due to the ability of the 4-nitrophenyl group to delocalize not only the π electrons of the double bond but also the nonbonding electrons of the ether oxygen, thus counteracting protonation. In the vinyl ether **5** the nonbonding electrons of the ether oxygen cannot be involved in conjugation with the 4-nitrophenyl ring. Recently, cleavage of aryl vinyl ethers has been studied in detail.[7-9]

The results reported in this paper show that methyl vinyl ether may give fair yields of 1-aryl-2-methoxyethenes in palladium-catalyzed reactions with halobenzenes provided these contain a 4-nitro group.

Experimental Section

General Comments. NMR spectra were recorded on a Varian T-60 spectrometer. Mass spectra were obtained by using a Finnigan 4021 (Data System Incos 2100) gas chromatograph–mass spectrometer at the Chemical Centre, University of Lund, Lund, Sweden. Quantitative gas chromatographic analyses were obtained on a Perkin-Elmer Sigma 1 (Sigma 10 data system) gas chromatograph equipped with a 2-m column of 10% OV-101 on Chromosorb WHP (80–100 mesh) and a flame-ionization detector. Phenanthrene was used as an internal standard. The compounds, 4-chloronitrobenzene from KEBO, 4-bromonitrobenzene, and 4-iodonitrobenzene and 4-iodoanisole from Fluka AG, were used as received. Palladium acetate was received from Fluka AG, and triphenylphosphine and methyl vinyl ether were received from Merck and were used without purification.

General Procedure for Palladium-Catalyzed Arylation of Methyl Vinyl Ether. (A) Sealed-Tube Experiments. A mixture consisting of 5.0 mmol of 4-halonitrobenzene, 5.5 mmol (0.76 mL) of triethylamine, 0.05 mmol (11.2 mg) of palladium acetate, 0.10 mmol (26.2 mg) of triphenylphosphine (when present), and 2.0 mL of acetonitrile in a glass tube was cooled below 0 °C. Methyl vinyl ether (5.0 mmol, 0.38 mL) was added and the tube sealed. After being heated, the mixture was diluted with methylene chloride and analyzed by gas chromatography.

(B) Autoclave Experiments. 4-Halonitrobenzene or 4-iodoanisole (40 mmol), 44 mmol (6.10 mL) of triethylamine, 0.40 mmol (90 mg) of palladium acetate, 0.80 mmol (210 mg) of triphenylphospine (when present), and 15 mL of acetonitrile were added to an ice-cold autoclave (Parr, 250 mL, Hastelloy B). After addition of 40 mmol (3.0 mL) of methyl vinyl ether the autoclave was closed and heated to 120 °C. After reaction with stirring for 6 h and cooling, a small sample for GLC analysis was taken out. The main part of the reaction mixture was evaporated. To the semisolid residue were added methylene chloride and 10% aqueous hydrochloric acid, and the mixture was shaken for 3 min. The aqueous phase was extracted twice with methylene chloride and the combined organic phases were washed once with water. The organic phase was dried (sodium sulfate), and the yields were estimated by gas chromatography.

Isolation and Characterization. Compounds **3**, **4**, **6**, and **9** were isolated by column chromatography on silica gel by using methylene chloride for elution. (*E*)-1-(2-Methoxyethenyl)-4-nitrobenzene (**3**):[10] NMR ($CDCl_3$) δ 3.74 (3 H, s), 5.81 (1 H, d, J = 13 Hz), 7.13 (1 H, d, J = 13 Hz), 7.18–8.10 (4 H, AA′XX′); mass spectrum, *m/e* 179. (*Z*)-1-(2-Methoxyethenyl)-4-nitrobenzene (**4**):[9] NMR ($CDCl_3$) δ 3.87 (3 H, s), 5.30 (1 H, d, J = 8 Hz), 6.35 (1 H, d, J = 8 Hz), 7.60–8.10 (4 H, AA′XX′); mass spectrum, *m/e* 179. Kresge et al.[9] reported vinyl proton signals from the *Z* isomer at δ 6.7 and 7.9 which is not in accordance with our results.

Registry No. 1, 586-78-7; 2, 107-25-5; 3, 66821-16-7; 4, 66821-15-6; 5, 3440-23-1; 6, 100-19-6; 8, 696-62-8; 9, 100-06-1; 4-iodonitrobenzene, 636-98-6; 4-chloronitrobenzene, 100-00-5; palladium acetate, 3375-31-3.

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[7] G. M. Loudon, C. K. Smith, and S. E. Zimmerman, *J. Am. Chem. Soc.*, **96**, 465 (1974).

[8] G. M. Loudon and C. Berke, *J. Am. Chem. Soc.*, **96**, 4508 (1974).

[9] Y. Chiang, A. J. Kresge, and C. I. Young, *Can. J. Chem.*, **56**, 461 (1978).

[10] G. Marchese, F. Naso, and G. Modena, *J. Chem. Soc. B*, 290 (1969).