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PRELIMINARY NOTE

Palladium Catalyzed Coupling of F-Vinyl Zinc Reagents With Aryl Iodides. An Improved Synthesis of α,β,β-Trifluorostyrenes and The Stereospecific Preparation of 1-Phenyl-F-Propenes

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SUMMARY

Palladium catalyzed coupling of trifluorovinyl zinc reagents with substituted aryl iodides provides a practical high yield route to α,β,β-trifluorostyrenes. Ortho, meta, and para substituted aryl iodides all work equally well. Similar coupling with _E_- and _Z_-1-iodo-_F_-propenes outlines the first stereospecific preparative route to 1-aryl-_F_-olefins. This approach provides a rapid, easily scaled-up synthesis _via_ a one pot procedure to these valuable styrenes from commercially available precursors without recourse to low temperature processes or the use of unstable reaction intermediates.

Recent work from our laboratory has demonstrated the stereospecific preparation of _F_-vinyl organocadmium, zinc, and copper reagents _via_ direct reaction of 1-bromo-_F_-olefins or 1-iodo-_F_-olefins and metal powders or _via_ metathesis reactions of _F_-alkenyl cadmium and/or zinc reagents with metal salts [1]. Subsequently, Sauvetre and co-workers have reported analogous organozinc reagents _via_ _in_ _situ_ low temperature capture of fluorovinyl lithium reagents with zinc chloride [2]. Palladium catalyzed cross-coupling of these organic zinc reagents with vinylic iodides or iodo heterocycles gave partially fluorinated dienes or heterocycles [3].

These recent reports by Sauvetre _et_ _al_. prompt us to report related palladium catalyzed coupling processes of our _F_-vinyl zinc reagents described earlier [1]. Our initial work has focused on the development of a practical synthesis of α,β,β-trifluorostyrenes which avoids the low yields, side products, and multi-step procedures that have plagued earlier preparation of these important olefins [4].

Our method involves the room temperature preparation of the *F*-vinyl zinc reagents from either bromotrifluoroethene [5,6] or iodotrifluoroethene [6] followed by subsequent coupling of the zinc reagent with aryl iodides in the presence of 1-2 mole percent of $(Ph_3P)_4Pd$ (eqn. 1).

$$\begin{tikzcd}[column sep=large] CF_2{=}CFX + Zn \arrow[r, "\text{DMF,}", "\text{THF, or TG}"'] & CF_2{=}CFZnX + (CF_2{=}CF)_2Zn \arrow[d, "\begin{array}{l}\text{ArI, Pd}^\circ\\ 60\text{-}80^\circ\text{C}\\ 1\text{-}8\ \text{hours}\end{array}"] \\ X = Br,\ I & F_2C{=}CFAr \end{tikzcd} \tag{1}$$

A wide variety of substituted aryl iodides readily participate in the coupling process (*cf.* Table I). The coupling reaction occurs most readily for aromatics substituted with electron-releasing groups (reaction times < 1 hr.) and less readily for aromatics substituted with electron-withdrawing substituents (reaction times 4-8 hrs.). Even bulky ortho substituents such as $(CH_3)_2CH$-, CF_3-, C_6H_5-, Br-, and NO_2- give excellent yields of styrene. Table I summarizes a survey of the scope of this coupling process. Substituents such as -OH and -COOH hydrolyze the zinc reagent and fail to produce styrene.

The reaction proceeds equally well in DMF, triglyme (TG), or THF. Choice of solvent is made to facilitate isolation of the product. Reaction temperatures below 80°C preclude or minimize dimerization of the trifluorostyrenes. At long reaction times the trifluorostyrenes containing electron-releasing substituents (such as p-Me, p-OMe) readily form head to head dimers [7]; however, the rapid coupling reaction (< 1 hr.) of aryl iodides with such substituents easily circumvents this problem.

Extension of this methodology to *E*- and *Z*-1-iodo-*F*-propenes stereospecifically produces the *Z*- and *E*-1-phenyl-*F*-propenes. In contrast to earlier routes [8] this coupling method cleanly gives only one geometrical isomer.

$$\underline{Z}\text{-}CF_3CF{=}CFI \xrightarrow[\text{2) } C_6H_5I]{\text{1) Zn/TG}} \underline{E}\text{-}CF_3CF{=}CFC_6H_5$$

$$\text{Pd}^\circ,\ 80^\circ\text{C} \qquad 80\%\ (100\%\ \underline{E})$$

$$\underline{E}\text{-}CF_3CF{=}CFI \xrightarrow[\text{2) } C_6H_5I]{\text{1) Zn/TG}} \underline{Z}\text{-}CF_3CF{=}CFC_6H_5$$

$$\text{Pd}^\circ,\ 80^\circ \qquad 100\%\ (^{19}\text{F NMR, [9]})\ (100\%\ \underline{Z})$$

Table I

Coupling of Trifluorovinyl zinc reagents with aryl iodides

$$CF_2{=}CFZnX \;+\; Y\text{-}ArI \xrightarrow{Pd^\circ} F_2C{=}CFAr\text{-}Y$$

Y	Solvent	Yield[a,b]
H	DMF	80(74)
p-MeO	DMF	88(61)
m-NO_2	THF	94
m-NO_2	DMF	100
o-NO_2	DMF	100(73)[c]
m-CF_3	THF	89
o-C_6H_5	THF	82
m-CH_3	THF	85
o-$CH(CH_3)_2$	THF	87(70)
o-Br	THF	76
2,5-diCl	THF	75
o-I	THF	90[d]
o-CF_3	TG	-(73)
o-CF_3	THF	76

[a] ^{19}F NMR yield of trifluorostyrene *vs*. $PhCF_3$; yield in parenthesis is isolated yield.

[b] All styrene products exhibited ^{19}F NMR spectra consistent with assigned structure.

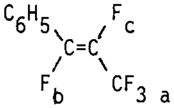
[c] Isolated *via* flash chromatography.

[d] 79:21 ratio of mono: bis coupled product.

A preliminary survey of substituted aryl iodides (with similar substituents illustrated in Table I) with the *E*- and *Z*-1-iodo-*F*-propenes indicates that ortho, meta, and para-substituted aryl iodides readily participate in this stereospecific coupling reaction. With ortho substituted precursors, the zinc reagent from the *E*-1-iodo-*F*-propene reacts much more rapidly than the analogous zinc reagent from the *Z*-1-iodo-*F*-propene; suggesting that in the reaction complex there may be steric hindrance between the trifluoromethyl group *trans* to the zinc and the ortho substituent on the aromatic ring. However, additional work is needed to elucidate this effect.

The operational details of a typical experimental procedure are outlined below for the coupling reaction of *Z*-1-iodo-*F*-propene.

A one-necked round-bottom flask fitted with a condenser and magnetic stir bar was charged with 5.0 grams of acid-washed zinc powder and 40 mL of dry triglyme and the apparatus maintained under a nitrogen atmosphere. To this mixture was added 12.7 g, 6.7 mL (50 mmoles) of *Z*-1-iodo-*F*-propene and the reaction mixture was stirred for one hour at room temperature. The excess zinc was allowed to settle and the supernatant liquid was removed *via* syringe and added to a new reaction apparatus of the same configuration. Iodobenzene (8.2 grams, 40 mmoles) and 0.3 grams of tetrakis (triphenylphosphine) palladium (0.2 mmoles, 0.5 mole%) were then sequentially added to the zinc reagent. The reaction mixture was then heated to 75-80°C for four hours, then flash distilled. The flash distillate was poured into 200 mL of ice-water; the organic layer washed twice with ice-water, and dried over P_2O_5. Distillation (Vigreaux column) gave 6.6 grams (80%) of clear liquid boiling at 52-53°C/15 mm with GLPC purity > 98%. The ^{19}F NMR (d-6 acetone) of the distillate exhibited the following absorptions, consistent with previous reports [8].



a -67.8 ppm (dd)
b -145.6 ppm (dq)
c -174.0 ppm (dq)

J_{ab} = 22.0 Hz
J_{ac} = 10.2 Hz
J_{bc} = 131.9 Hz

In conclusion, a simple, mild, high yield preparation of substituted α,β,β-trifluorostyrenes *via* Pd° catalyzed coupling of *F*-vinyl zinc reagents with aryl iodides is described. The olefinic precursors are commercially available and the zinc reagents are readily prepared at room temperature - no low temperature preparation of unstable intermediates [2] is required. Extension of this methodology to 1-iodo-*F*-propenes outlines stereospecific preparative routes to 1-aryl-*F*-olefins. This mild, high yield process provides a practical entry to substituted *F*-olefins previously available only *via* tedious low yield procedures or *via* methodology that gave mixtures of isomeric olefins. We recommend this catalyzed coupling process to researchers interested in such substituted F-olefins.

Our work continues to explore these interesting reagents and future reports will detail other applications of these organometallic intermediates.

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1 Presented in part at the 10th International Symposium on Fluorine Chemistry, Vancouver, Canada, August 1982, Abstract I-31; PAC Chem Conference, Honolulu, Hawaii, December 1984, Abstract 10F21, Chemical and Engineering News, January 7, 1985, p. 41; 11th International Symposium on Fluorine Chemistry, East Berlin, Germany, August 1985, Abstract B-4.

2 J.P. Gillet, R. Sauvetre, and J.F. Normant, Tetrahedron Letters, (1985) 3999.

3 F. Tellier, R. Sauvetre, and J.F. Normant, J. Organometallic Chemistry, 292 (1985) 19.

4 S.G. Cohen, H.T. Wolosinski, and P.J. Scheuer, J. Am. Chem. Soc., 71 (1949) 3439; 72 (1950) 3953; M. Prober, J. Am. Chem. Soc., 75 (1953) 968; S. Dixon, J. Organic Chem., 21 (1956) 400; J.M. Antonucci and L.A. Wall, SPE Trans, 3 (1963) 225; G.V. Kazenikova, T.V. Talalaeva, A.V. Zimin, A.P. Simonov, and K.A. Kocheshkov, Izv. Akad. Nauk SSSR, (1961) 1063; R.B. Hogdon and D.I. MacDonald, J. Polymer Science (Pt.A), 6 (1968) 711.

5 Available from Halocarbon Chemical.

6 Available from PCR and Fluorochem Limited.

7 P.D. Bartlett and G.M. Cohen, J. Am. Chem. Soc., 95 (1973) 7923.

8 W. Dmowski, J. Fluorine Chem., 18 (1981 25; 29 (1985) 273 and references therein.

9 Z-$CF_3{}^aCF^b=CF^cPh$ exhibits resonances at -66.9 ppm (dd) CF_3; -108.1 ppm (dq) F_c; and -157.0 ppm (dq) F_b; J_{ab} 7.8 Hz; J_{ac} 13.2 Hz; J_{bc} 10.5 Hz; consistent with previous reports [8].