New chemistry of aryl(2,2,2-trifluoroethyl)iodonium triflates

Fluorine-containing organic compounds have found wide applications in the areas of chemistry, biology, and materials science over the past several decades. Since only a few naturally-occurring organofluorides have been discovered, fluorinated organic compounds including CF_3CH_2-substituted compounds have to be manually synthesized. Although the direct 2,2,2-trifluoroethylation reactions with CF_3CH_2X (X = Br, I), CF_3CHCl_2, $CF_3CH_2SO_2Y$ (Y = Na, Cl), CF_3CH_2OTs, and $CF_3CH_2NH_2$ have been extensively investigated, the incorporation of CF_3CH_2 functionality by transition metal-mediated/catalyzed direct 2,2,2-trifluoroethylation is still much less developed, owing to the disadvantages of those reagents. Thus, the exploitation of effective catalytic trifluoroethylation systems and the design of versatile trifluoroethylation reagents would become hot topics in the coming years.

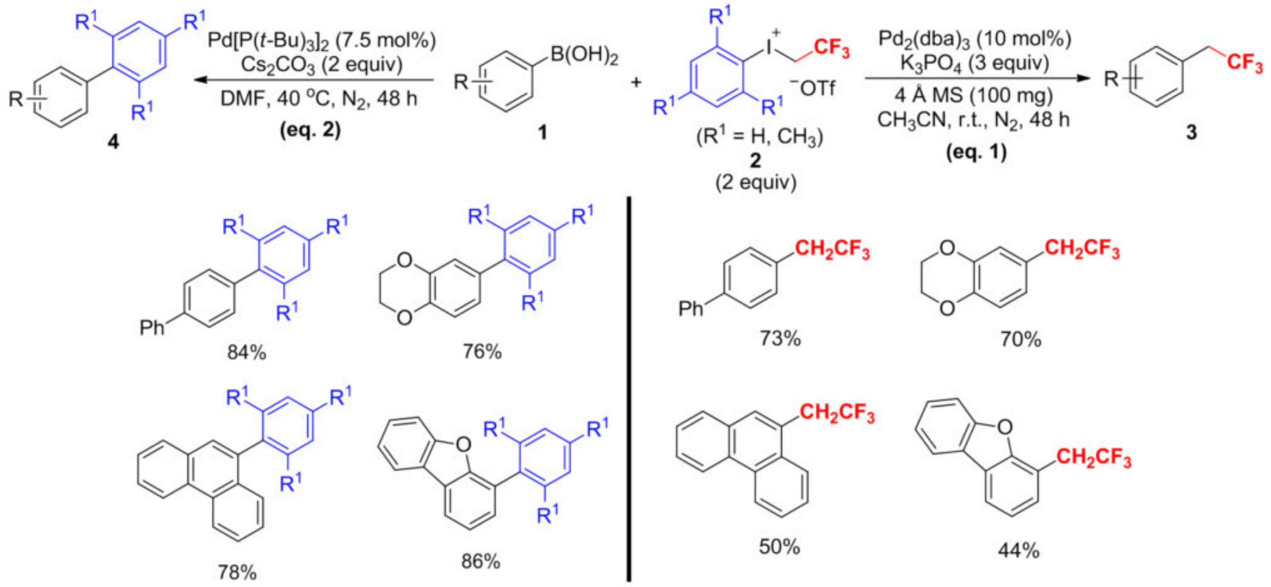

Fig. 1. Pd-catalyzed divergent trifluoroethylation and arylation of arylboronic acids by [ArICH2CF3][OTf]

Aryl(2,2,2-trifluoroethyl)iodoniums have been demonstrated to be powerful electrophilic trifluoroethylation reagents for heteroatom and soft carbon nucleophiles. There are a large number of electrophilic substitution reactions reported using aryl(2,2,2-trifluoroethyl)iodonium salts. Transitional-metal mediated/catalyzed cross-couplings with these reagents, however, are rarely known. Inspired by our previous work, we imagined that aryl(2,2,2-trifluoroethyl)iodoniums might also be good participants in transition metal-catalyzed reactions. To our delight, a variety of arylboronic acids could be efficiently trifluoroethylated by aryl(2,2,2-trifluoroethyl)iodonium triflates in the presence of Pd catalysts under mild reaction conditions. Electron-rich arylboronic acids reacted with $[ArICH_2CF_3][OTf]$, $Pd_2(dba)_3$ (10 mol%), and K_3PO_4 in CH_3CN at room temperature to provide trifluoroethyl arenes in up to 82% yield (Fig. 1 eq. 1).

Interestingly, if $Pd[P(t\text{-}Bu)_3]_2$, Cs_2CO_3, and DMF were used instead of $Pd_2(dba)_3$, K_3PO_4, and CH_3CN, respectively, arylation rather than trifluoroethylation of arylboronic acids by $[ArICH_2CF_3][OTf]$ was observed. The reactions of both electron-rich and -poor arylboronic acids with $[ArICH_2CF_3][OTf]$ in DMF in the presence of $Pd[P(t\text{-}Bu)_3]_2$ and Cs_2CO_3 at 40 °C afforded arylated products in good to high yield (Fig. 1 eq. 2). Mechanistic studies showed that the cleavage of the C_{Ar}–I bond of $[ArICH_2CF_3][OTf]$ ought to be involved in the conversion. However, arylation of arylboronic acids by aryl iodide, generated from the decomposition of $[ArICH_2CF_3][OTf]$ in the reaction, cannot be excluded.

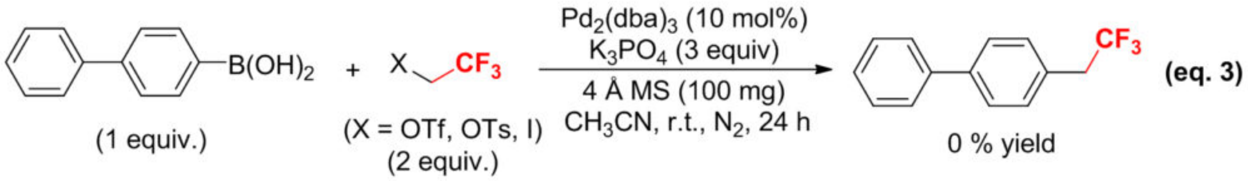

Fig. 2. The failure of Pd-catalyzed trifluoroethylation with CF3CH2X (X = I, OTf, OTs) under the standard conditions.

Furthermore, upon treatment of 1,1'-biphenyl-4-ylboronic acid (1a) with CF_3CH_2X (X = I, OTf, OTs) under the standard reaction conditions, no desired product was obtained (Fig. 2 eq. 3), suggesting that aryl(2,2,2-trifluoroethyl)iodoniums are much more effective cross-coupling partners than trifluoroethyl iodide and sulfonates in Pd-catalyzed trifluoroethylation of arylboronic acids. In conclusion, this tunable protocol provides access to trifluoroethyl arenes and biaryls under mild conditions and without additional ligands, and represents the first use of aryl(2,2,2-trifluoroethyl)iodoniums as both trifluoroethylation and arylation reagents in the presence of Pd-catalysts.

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