GC/MS on the crude reaction mixtures. Stereochemistry determination and all other experimental procedures are given in the Supporting Information.

Received: July 6, 2001
Revised: September 24, 2001 [Z17449]

[1] C. Fehr, *Angew. Chem.* **1998**, *110*, 2509; *Angew. Chem. Int. Ed.* **1998**, *37*, 2407.
[2] For a review on substrate-directed epoxidations see: a) A. H. Hoveyda, *Chem. Rev.* **1993**, *93*, 1307.
[3] a) M. Freccero, R. Gandolfi, M. S. Amade, A. Rastelli, *J. Org. Chem.* **1999**, *64*, 3853; b) R. D. Bach, C. M. Estezez, J. E. Winter, M. N. Glukhovtsev, *J. Am. Chem. Soc.* **1998**, *120*, 680.
[4] A. Hasegawa, H. Z. Sable, *J. Org. Chem.* **1966**, *31*, 4154.
[5] a) B. Zipperer, K. H. Muller, B. Gallenkamp, R. Hildebrand, M. Fletschinger, D. Burger, M. Philat, D. Hunkler, L. Knothe, H. Fritz, H. Prinzbach, *Chem. Ber.* **1988**, *121*, 757; b) H. E. Schink, H. Pettersson, J. E. Backvall, *J. Org. Chem.* **1991**, *56*, 2769.
[6] a) A. Jenmalm, W. Berts, K. Luthman, I. Csoregh, U. Hacksell, *J. Org. Chem.* **1995**, *60*, 1026; b) P. Kococovsky, I. Stary, *J. Org. Chem.* **1990**, *55*, 3226.
[7] a) S. Winstein, R. Boschan, *J. Am. Chem. Soc.* **1950**, *72*, 4669; b) J. Joska, F. Sorm, Collect. Czech. *Chem. Commun*. **1995**, *21*, 745; c) L. Goodman, S. Wienstein, R. Boschan, *J. Am. Chem. Soc*. **1958**, *80*, 4312; d) K. Ponsold, W. Preibach, *J. Prakt. Chem.* **1964**, *25*, 26; e) K. Ponsold, *J. Prakt. Chem*. **1964**, *25*, 32; f) A. Hasegawa, H. Z. Sable, *J. Org. Chem.* **1966**, *31*, 4154; g) G. Lukacs, D. K. Fukushima, *J. Org. Chem*. **1969**, *34*, 2707.
[8] a) W. R. Roush, J. A. Straub, R. Brown, *J. Org. Chem.* **1987**, *52*, 5127; b) H. Kogen, T. Nishi, J. *Chem. Soc. Chem. Commun.* **1987**, 311; c) J. R. Luly, J. F. Dellaria, J. J. Plattner, N. Y. Soderquist, *J. Org. Chem.* **1987**, *52*, 1486; d) K. Hori, Y. Ohfune, *J. Org. Chem.* **1988**, *53*, 3886; e) M. M. Campbell, A. J. Floyd, T. Lewis, M. F. Mahon, R. J. Oglivie, *Tetrahedron Lett.* **1989**, *30*, 1993; f) D. P. Rotella, *Tetrahedron Lett*. **1989**, *30*, 1913; g) S. Julia, B. Furer, *Bull. Soc. Chim. Fr.* **1966**, 1106.
[9] D. K. Fukushima, M.Smulowitz, J. S. Liang, G. Lukacs, *J. Org. Chem.* **1969**, 34, 2702.
[10] I. Honda, A. Ori, G. Tsuchihashi, *Chem. Lett*. **1986**, 1417.
[11] S. A. Hardinger, P. L. Fuchs, *J. Org. Chem.* **1987**, *52*, 2739.
[12] R. P. Joyce, J. A. Galnor, S. M. Weinreb, *J. Org. Chem.* **1987**, *52*, 1177.
[13] J. Clayden, E. W. Collington, E. Egert, A. B. McElroy, S. Warren, *J. Chem. Soc. Perkin Trans. 1* **1994**, 2801.
[14] G. Asensio, C. B. Bernardini, C. Andreu, M. E. G. Nunez, R. Mello, J. O. Edwards, B. Carpenter, *J. Org. Chem.* **1999**, *64*, 4705.
[15] a) M. Freccero, R. Gandolfi, M. S. Amade, *Tetrahedron* **1999**, *55*, 11309; b) R. W. Murray, M. Singh, B. L. Williams, H. M. Moncrieff, *J. Org. Chem*. **1996**, *61*, 1830.
[16] Studies of performic acid, dioxirane, peroxynitrous acid, and oxiziridine epoxidations have shown that B3LYP/6-31G(d) calculations provide transition structure and energies in accord with available experimental data and quadratic configuration interaction (QCI) calculations see: a) K. N. Houk, J. Liu, N. C. DeMello, K. R. Condroski, *J. Am. Chem. Soc.* **1997**, *119*, 10147; b) C. Jenson, J. Liu, K. N. Houk, W. L. Jorgensen, *J. Am. Chem. Soc.* **1997**, *119*, 12982; c) R. D. Bach, M. N. Glukhovtsev, C. Gonzalez, *J. Am. Chem. Soc*. **1998**, *120*, 9902.
[17] Gaussian 98 (Revision A.7), M. J. Frisch, G. W. Trucks, H. B. Schlegel, G. E. Scuseria, M. A. Robb, J. R. Cheeseman, V. G. Zakrzewski, J. A. Montgomery, R. E. Stratmann, J. C. Burant, S. Dapprich, J. M. Millam, A. D. Daniels, K. N. Kudin, M. C. Strain, O. Farkas, J. Tomasi, V. Barone, M. Cossi, R. Cammi, B. Mennucci, C. Pomelli, C. Adamo, S. Clifford, J. Ochterski, G. A. Petersson, P. Y. Ayala, Q. Cui, K. Morokuma, D. K. Malick, A. D. Rabuck, K. Raghavachari, J. B. Foresman, J. Cioslowski, J. V. Ortiz, B. B. Stefanov, G. Liu, A. Liashenko, P. Piskorz, I. Komaromi, R. Gomperts, R. L. Martin, D. J. Fox, T. Keith, M. A. Al-Laham, C. Y. Peng, A. Nanayakkara, C. Gonzalez, M. Challacombe, P. M. W. Gill, B. G. Johnson, W. Chen, M. W. Wong, J. L. Andres, M. Head-Gordon, E. S. Replogle, J. A. Pople, Gaussian, Inc., Pittsburgh, PA, **1998**.
[18] All activation energies were calculated relative to separated reactants in their lowest energy conformations. Zero-point corrections calculated for epoxidation of 3-methylcyclohexene did not change relative energies of the four transition states and are not included in any reported activation energies.
[19] M. J. Lucero, K. N. Houk, *J. Org. Chem*. **1998**, *63*, 6973, and references therein.
[20] Y. Gu, T. Kar, S. Scheiner, *J. Am. Chem. Soc.* **1999**, *121*, 9411.
[21] Studies on epoxidation of allylic alcohols have shown that the B3LYP/6-31G(d) level accurately reproduces structure and energies in accord with available experimental data.[2] Studies show that the B3LYP/6-31+G(d,p) level accurately describes F_nCH_{3-n} interactions with water, methanol, and formaldehyde.[20]
[22] a) J. J. Nova, F. Mota, *Chem. Phys. Lett.* **1997**, *266*, 23; b) D. E. Woon, P. Zeng, D. R. Beck, *J. Chem. Phys.* **1990**, *93*, 7808; c) M. M. Szczesniak, G. Chalasinski, S. M. Cybulski, P. Cieplak, *J. Chem. Phys.* **1993**, *98*, 3078; d) J. J. Novoa, P. Lafuente, F. Mota, *Chem. Phys. Lett.* **1998**, *290*, 519.
[23] G. Bellucci, G. Berti, M. Ferrett, G. Ingrosso, E. Mastoroilli, *J. Org. Chem.* **1978**, *43*, 422.
[24] For 4-fluoro-1-butene the addition of another fluorine atom (4,4-difluorobutene) did not increase the *syn* preference; this is probably due to electrostatic repulsion in the *syn* transition state, between the oxygen atoms of the peracid and the two fluorine atoms.
[25] M. Freccero, R. Gandolfi, M. Sarzi-Amade, A. Rastelli, *J. Org. Chem.* **2000**, *65*, 8948.
[26] M. Chini, P. Crotti, F. A. Lee, C. Gardelli, M. Franco, *J. Org. Chem.* **1992**, *57*, 1713, and references therein.
[27] F. Camps, J. Coll, A. Messeguer, F. Pujol, *J. Org. Chem.* **1982**, *47*, 5402.

Use of a Perfluoroalkylsulfonyl (PFS) Linker in a "Traceless" Synthesis of Biaryls through Suzuki Cleavage

Yijun Pan, Beatrice Ruhland, and Christopher P. Holmes*

Solid-phase synthesis has attracted increasing attention from the scientific community and particularly from the pharmaceutical industry in an effort to speed up drug discovery.[1] A key component in solid-phase synthesis is the linker that is used to attach the molecules to the solid support. There has been significant interest in recent years to develop "traceless" linkers[2] which afford compounds suitable for biological assays lacking any extraneous functionality that may limit their usefulness as drug leads.

We recently reported the preparation of a perfluoroalkylsulfonyl (PFS) fluoride resin, **1** (see Scheme 1, in essence a triflate resin), and its application for the traceless synthesis of arenes using a palladium-mediated reductive deoxygenation.[3] We sought to extend application of this linker to a

[*] Dr. C. P. Holmes, Dr. Y. Pan, Dr. B. Ruhland
Department of Chemistry, Affymax Research Institute
4001 Miranda Avenue, Palo Alto, CA 94304 (USA)
Fax: (+1) 650-424-9860
E-mail: chris_holmes@affymax.com

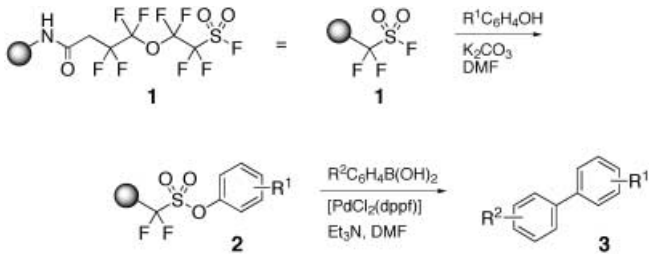
Supporting information for this article is available on the WWW under http://www.angewandte.com or from the author.

  0044-8249/01/11323-4620 $ 17.50+.50/0

cross-coupling strategy whereby additional functionality could be appended to the aryl ring during the cleavage step. Several methods describing the formation of new C–C and C–N bonds upon cleavage of products from the resin have been reported. Recently, an elegant approach to biarylmethanes derived from polymer-supported benzylsulfonium salts was reported by Mioskowski et al.[4] Bräse and Schroen created several types of molecules starting with a resin-bound triazene formed by coupling diazonium salts to an amine resin,[5] whereas separately the research groups led by Carboni[6] and Burgess[7] have treated immobilized boronic acids with various electrophilic species. Reitz et al. reported the preparation of phenethylamines by means of a C–N bond forming reaction by displacing a resin-bound alkylsulfonate with amines.[8]

Our strategy of coupling phenols to the electrophilic sulfonyl fluoride resin **1** to create an aryltriflate species avoids the limitations of the existing methods, which rely on relatively uncommon starting materials or preactivation steps to prepare a linker–substrate conjugate prior to attachment to the support. Aryl triflates have been widely used as substrates to introduce diverse functionality on an aromatic group through palladium-mediated cross-coupling reactions.[9] The Suzuki, Heck, and Stille reactions are among the most powerful methods for C–C bond formation and have been shown to proceed in excellent yield on solid support.[10] We report herein that a Suzuki cleavage/cross-coupling reaction of perfluoroalkylsulfonate resin **2** (see Scheme 1) affords high yields of biaryls.

A variety of phenols were attached to resin **1**[11] through the formation of the polymer-bound perfluoroalkylsulfonates **2**, by using K_2CO_3 as base in dimethylformamide (DMF) at room temperature (Scheme 1). These conditions are very mild



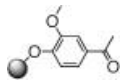
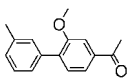
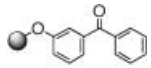
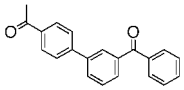
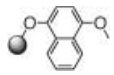
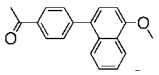
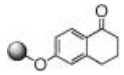
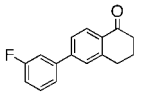
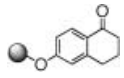
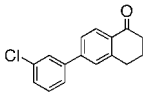
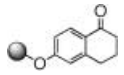
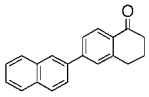
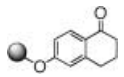
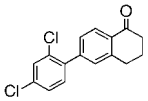
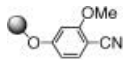
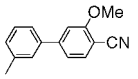
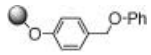
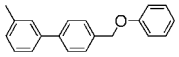
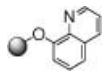
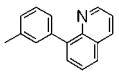
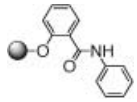
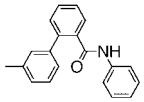
Scheme 1. Attachment and subsequent Suzuki cleavage/cross-coupling reaction of phenols bound to the PFS linker **1** as "aryl triflates" **2** to generate biaryls **3**.

and compatible with a wide range of functionalized compounds such as aldehydes, carboxylic acids, alcohols, and ketones without the need for protecting groups. Loading levels were determined by elemental analysis and could be monitored by the disappearance of the SO_2F signal in the gel-phase ^{19}F NMR spectrum.[3] Others have reported the use of gel-phase ^{19}F NMR spectroscopy to monitor reactions and to determine resin loadings.[12] Although several reports have been published on the Suzuki coupling of aryl triflates, these methods require different sets of conditions (catalyst, base, solvent) depending on the substrates. Our objective was to identify mild reaction conditions employing a single catalyst system that would be suitable for the synthesis of a wide range of biaryl compounds. In our initial studies we tested a variety of catalyst systems including $[Pd_2(dba)_3(PtBu_3)]$ (dba = dibenzylideneacetone), $[Pd(PPh_3)_4]$, and $[Pd(OAc)_2(PCy_3)]$ with different bases (K_3PO_4, K_2CO_3, KF), by varying the solvent and the temperature. However, none of those catalyst systems was of broad applicability, giving inconsistent yields of the desired biaryl products and often considerable amounts of reduction products.[13] We were pleased to discover that our original conditions for the resin-based Suzuki coupling of aromatic iodides proved to be the most general.[14] Treating the polymer-supported aryl perfluoroalkylsulfonate species **2** with a variety of arylboronic acids in the presence of $[PdCl_2(dppf)]$ (dppf = 1,1′-bis(dipenylphosphanyl)ferrocene) and Et_3N in DMF at 80 °C for 8 h afforded the biaryl compounds **3** in good yield and purity (Scheme 1). The desired products were easily isolated by two-phase extraction and purified to homogeneity by preparative thin-layer chromatography. Based on the initial loading of the resin, the biaryl products were isolated in yields of 62–89 %. As shown in Table 1, arylboronic acids and phenols containing both electron-poor and electron-rich substituents participated effectively. Phenols with *ortho* substituents also reacted effectively (entries 1, 10, 11). More remarkably, the *ortho*-substituted and somewhat electron-deficient 2,4-dichlorophenylboronic acid coupled very efficiently giving the biaryl product in 82 % yield (entry 7). It appears that the linker **1** behaves as a polymer-supported triflate species as desired.

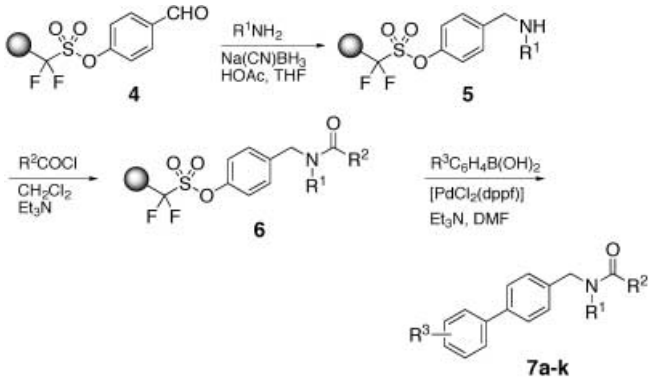
Next, we further explored the generality of the traceless Suzuki cleavage/cross-coupling strategy by synthesizing a small library of eleven biarylamides **7** employing reductive amination and acylation steps (Scheme 2). Thus, 4-hydroxybenzaldehyde was tethered to PFS support **1** to generate the resin-bound sulfonate **4**. Aldehyde **4** was split into three aliquots, which were separately subjected to reductive amination with isobutylamine, furfurylamine, and isopropyl amine in the presence of $Na(CN)BH_3$ and HOAc in THF. The resulting benzylamines **5** were further partitioned into aliquots and separately treated with four acid chlorides (benzoyl chloride, *p*-toluoyl chloride, isobutyryl chloride, and 2-furoyl chloride) to give the N-acylated products **6**. Each resin was then individually cleaved as described above with an arylboronic acid to liberate the biarylamides **7a–k** (Scheme 3), which would have been difficult to prepare with other reported solid-phase linkers. In agreement with our previous results,[3] the compounds were of sufficient purity to be submitted directly to biological screening after filtration through silica gel. After purification, the biaryl compounds **7a–k** were isolated in 65–90 % yield based on the original resin loading. While not extremely diverse, the small library did allow us to demonstrate that the intermediates were stable and could be manipulated without degradation; further exploitation and optimization of this process for the preparation of larger libraries is currently underway.

What is noteworthy is that the PFS linker serves as a linker, a protecting group, and an activating group for phenols. The polymer-supported aryl sulfonates appear to be stable to a variety of reaction conditions common in library synthesis

Table 1. Suzuki cleavage/cross-coupling of resin-bound aryl perfluoroalkylsulfonates **2**.

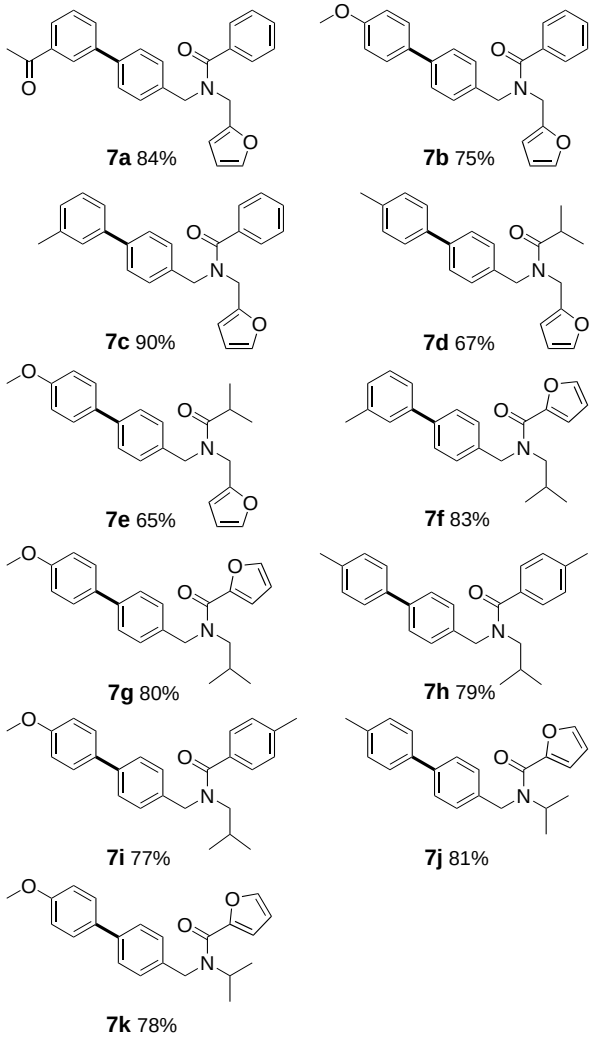
Entry	Resin **2**	$R^2C_6H_4B(OH)_2$[a]	Product **3**	Yield [%][b]
1		A		76
2		B		62
3		B		73
4		C		74
5		D		80
6		E		78
7		F		82
8		A		85
9		A		89
10		A		88
11		A		84

[a] The boronic acids used were A: 3-tolyl-, B: 4-acetylphenyl-, C: 3-fluorophenyl-, D: 3-chlorophenyl-, E: 2-naphthyl-, F: 2,4-dichlorophenylboronic acid. [b] Yields were based on the measured loading of resin **2**.



Scheme 2. Reaction sequence to create a library of biarylamides using **1** as a tethering and activating group.

such as reductive amination and acylation, while affording a high degree of activation in palladium-based reactions. The single-catalyst system $[PdCl_2(dppf)]/Et_3N$ was found to be



Scheme 3. Structures and yields of Suzuki cleavage/cross-coupling products **7** with the newly formed bond in bold.

suitable for the cross-coupling of a variety of substituted phenols and boronic acids. Considering the number of commercially available phenols, the traceless cleavage/cross-coupling strategy using a key Suzuki reaction should serve as a powerful method to generate vast numbers of diverse compounds for drug discovery programs.

Experimental Section

A mixture of polymer-supported aryl perfluoroalkylsulfonate **2** (200 mg, 0.07 mmol), $[PdCl_2(dppf)]$ (7.2 mg), boronic acid (0.26 mmol), and Et_3N (88 μL, 0.62 mmol) in DMF (1.5–2.0 mL) was placed in a vial under an N_2 atmosphere. The vial was sealed and magnetically stirred at 90 °C for 8 h. The resin was filtered and washed with Et_2O, and the combined organic phases were washed with 10 % aqueous Na_2CO_3 and water, and evaporated to dryness. The residue was dissolved in Et_2O and eluted through a short bed of silica gel to removed inorganic residues. The crude products were purified by preparative TLC to give the desired products in > 98 % purity.

Received: July 30, 2001 [Z17624]

[1] a) S. E. Hall, *Annu. Rep. Comb. Chem. Mol. Diversity* **1999**, *2*, 15; b) I. Sucholeiki, *Annu. Rep. Comb. Chem. Mol. Diversity* **1999**, *2*, 9; c) W.-C. Haase, P. H. Seeberger, *Curr. Org. Chem.* **2000**, *4*, 481; d) B. Kundu, S. K. Khare, S. Rastogi, *Prog. Drug Res.* **1999**, *53*, 89; e) A. J.

  0044-8249/01/11323-4622 $ 17.50+.50/0

Mendonca, X.-Y. Xiao, *Med. Res. Rev.* **1999**, *19*, 451; f) K. Gordon, S. Balasubramanian, *Curr. Opin. Drug Discovery Dev.* **1999**, *2*, 342; g) C. Watson, *Angew. Chem.* **1999**, *111*, 2025; *Angew. Chem. Int. Ed.* **1999**, *38*, 1903; h) S. Kobayashi, *Chem. Soc. Rev.* **1999**, *28*, 1; i) S. Booth, P. H. H. Hermkens, H. C. J. Ottenheijm, D. C. Rees, *Tetrahedron* **1998**, *54*, 15385; j) P. Hodge, *Chem. Soc. Rev.* **1997**, *26*, 417.

[2] a) F. Zaragoza, *Angew. Chem.* **2000**, *112*, 2158; *Angew. Chem. Int. Ed.* **2000**, *39*, 2077; b) A. B. Reitz, *Curr. Opin. Drug Discovery Dev.* **1999**, *2*, 358; c) C. J. Andres, D. L. Whitehouse, M. S. Deshpande, *Curr. Opin. Chem. Biol.* **1998**, *2*, 353; d) I. W. James, *Tetrahedron Lett.* **1999**, *55*, 4855.

[3] Y. Pan, C. P. Holmes, *Org. Lett.* **2001**, *3*, 2769.

[4] C. Vanier, F. Lorgé, A. Wagner, C. Mioskowski, *Angew. Chem.* **2000**, *112*, 1745; *Angew. Chem. Int. Ed.* **2000**, *39*, 1679.

[5] S. Bräse, M. Schroen, *Angew. Chem.* **1999**, *111*, 1139; *Angew. Chem. Int. Ed.* **1999**, *38*, 1071.

[6] C. Pourbaix, F. Carreaux, B. Carboni, *Org. Lett.* **2001**, *3*, 803.

[7] W. Li, K. Burgess, *Tetrahedron Lett.* **1999**, *40*, 6527.

[8] J. K. Rueter, S. O. Nortey, E. W. Baxter, G. C. Leo, A. B. Reitz, *Tetrahedron Lett.* **1998**, *39*, 975.

[9] a) K. Ritter, *Synthesis* **1993**, *8*, 735; b) W. J. Scott, J. E. McMurry, *Acc. Chem. Res.* **1988**, *21*, 47; c) I. L. Baraznenok, V. G. Nenajdenko, E. S. Balenkova, *Tetrahedron* **2000**, *56*, 3077.

[10] R. Franzén, *Can. J. Chem.* **2000**, *78*, 957; see also references compiled in F. Zaragoza Dörwald, *Organic Synthesis on Solid Phase*, Chapter 5, Wiley-VCH, Weinheim, **2000**.

[11] Support **1** bearing the PFS linker was prepared from Tentagel-NH_2 resin (RAPP Polymere, loading 0.43 mmol g^{-1}) with the loading measured by elemental analysis being typically 0.33 mmol g^{-1}.

[12] a) D. Stones, D. J. Miller, M. W. Beaton, T. J. Rutherford, D. Gani, *Tetrahedron Lett.* **1998**, *39*, 4875; b) A. Svensson, K.-E. Bergquist, T. Fex, J. Kihlberg, *Tetrahedron Lett.* **1998**, *39*, 7193.

[13] In the absence of a suitable nucleophile, reduction to the parent arene is often observed during palladium-mediated reactions of aryl species.

[14] B. Ruhland, A. Bombrun, M. A. Gallop, *J. Org. Chem.* **1997**, *62*, 7820.

Asymmetric Allylsilane Additions to Enantiopure *N*-Acylhydrazones with Dual Activation by Fluoride and $In(OTf)_3$**

Gregory K. Friestad* and Hui Ding

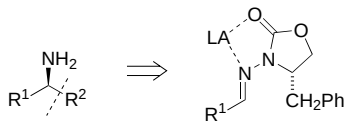
Chiral α-branched amines are common features of biologically active compounds. Direct asymmetric amine synthesis by addition to the C=N bond of carbonyl imino derivatives holds promise for improved access to these substructures by introducing a stereogenic center and a carbon–carbon bond in one step. However, the use of strongly basic organometallic reagents for this purpose[1] can result in competitive metalloenamine formation.[2] Development of alternative milder methods for the construction of C–C bonds is therefore of considerable importance.[3]

[*] Prof. G. K. Friestad, H. Ding
Department of Chemistry, University of Vermont
Burlington, VT 05405 (USA)
Fax: (+1) 802-656-8705
E-mail: gregory.friestad@uvm.edu

[**] We thank the National Science Foundation (Vermont EPSCoR) and the University of Vermont for generous support.

Supporting information for this article is available on the WWW under http://www.angewandte.com or from the author.

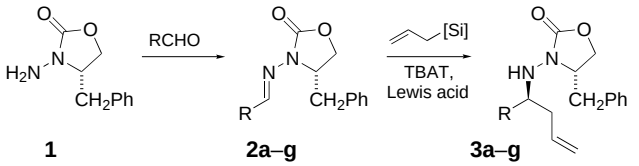
Previously we found that in the presence of Zn^{II} or In^{III} salts, chiral *N*-acylhydrazones (Scheme 1) underwent highly stereoselective radical additions[4] in which Lewis acid activation and restriction of rotamer populations were key design



Scheme 1. Retrosynthetic carbon–carbon bond disconnection of chiral α-branched amines to a Lewis acid activated chiral *N*-acylhydrazone precursor.

elements. We sought to exploit this design further with other reaction types that would broaden the variety of accessible chiral amines. An allyl group is particularly useful for subsequent synthetic manipulations, so extensive efforts have been directed toward the stereoselective allylation of chiral imines, iminium ions, and related C=N electrophiles.[5] We envisioned a novel dual activation protocol in which both the allyl donor and acceptor would be activated in a complementary fashion to promote C–C bond construction under relatively mild conditions. We hypothesized that the fluoride-promoted addition of an allylsilane to *N*-acylhydrazones in the presence of a Lewis acid would achieve this goal with excellent stereocontrol. There are surprisingly few examples of the Sakurai-like fluoride-promoted addition of allylsilanes to C=N bonds,[6] perhaps because of a prevailing perception that allylsilanes are rather unreactive toward imines without the use of strong Lewis acids.[7] We report herein convenient, highly stereoselective additions of allylsilanes to chiral *N*-acylhydrazones at room temperature with dual activation by fluoride and indium(III) trifluoromethanesulfonate.

Our initial studies examined the reaction of allyltrimethylsilane with chiral hydrazone **2a**[4] (Scheme 2). The use of a fluoride ion source required careful consideration of experimental protocols to avoid its potential incompatibility with



Scheme 2. Addition of allylsilanes to enantiopure hydrazones with dual activation by Lewis acid and fluoride ion (**a**: R = Ph; **b**: R = *p*-tolyl; **c**: R = *m*-nitrophenyl; **d**: R = 2-naphthyl; **e**: R = 2-furyl; **f**: R = CH=CHPh; **g**: R = CH_2CH_3; for [Si] see Table 1).

Lewis acids. Eventually, we found that the soluble, air-stable, nonhygroscopic fluoride source tetrabutylammonium triphenyldifluorosilicate (TBAT)[8] could effectively promote allyltrimethylsilane addition to the complex formed by mixing **2a** with a Lewis acid, to provide **3a** [Scheme 2] with good stereoselectivity. The optimal protocol entailed mixing a slight excess of allylsilane with TBAT in CH_2Cl_2 while preparing a mixture of **2a** and a Lewis acid in CH_2Cl_2. After 4 h, these solutions were combined at room temperature, followed by a