# Communications

## $AuCl_3$-Catalyzed Propargylation of Arenes with *N*-Tosylpropargyl Amine: Synthesis of 1,3-Diarylpropynes

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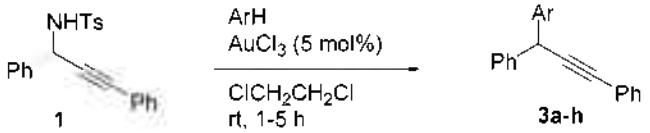
1,3-Diarylpropynes are an important class of building blocks in organic synthesis.[1,2] One of the most useful method for these compounds is a transition metal-catalyzed propargylation of electron-rich aromatics with propargyl alcohols.[1] The use of (dppm)$Re(O)Cl_3/AgPF_6$,[1a] [Cp*RuCl-($\mu_2$-SMe)$_2$RuCp*$(OH_2)$]OTf,[1b] $NaAuCl_4{\cdot}2H_2O$,[1c] $AuCl_3$,[1d] $BF_3{\cdot}OEt_2$,[1d] $FeCl_3$,[1e] $BiCl_3$,[1f] *p*-TsOH[1g] $TiCl_4/Et_3N$,[1h] and iodine[1i] has been reported. As the precursors of the corresponding propargyl cations, the use of propargyl alcohol is the most popular[1a-j] and the acetate of propargyl alcohol[1j,k] or *O*-propargyl trichloroacetimidate[2] were also examined very recently. To the best of knowledge, synthesis of 1,3-diarylpropynes has not been examined starting from propargylic amine derivatives.

Generation of carbocationic species by C-O bond cleavage have been studied and used extensively in the Friedel-Crafts chemistry.[3] However, limited number of papers has been reported on the generation of carbocation by C-N bond cleavage, which involved the cases of DCC (1,3-dicyclohexylcarbodiimide),[4b] sulfonamide and some amide derivatives.[4a,c-e] In these respects, we reasoned that the reaction of *N*-tosyl derivative of propargyl amine and arenes could provide another useful method of 1,3-diarylpropynes (Scheme 1).

Thus we prepared *N*-tosylpropargyl amine **1**, as the representative example, by the reaction of *N*-tosylimine and phenylacetylene as reported[5] and examined the feasibility for the synthesis of 1,3-diarylpropynes **3**. Initially, we examined the reaction of **1** and 1,3-dimethoxybenzene (**2b**) under various conditions (Table 1). The use of $AuCl_3$,[6] $FeCl_3$, $InCl_3$, *p*-TsOH and montmorillonite K10 was examined and the results are summarized in Table 1.[7] The use




**Scheme 1**

**Table 1**. Optimization of reaction conditions between the reaction of **1** and **2b**

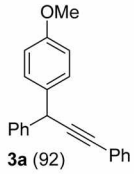
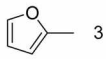
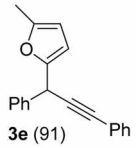
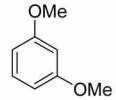
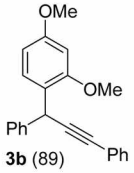
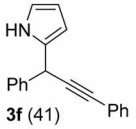
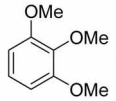
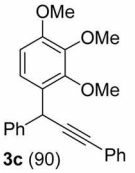
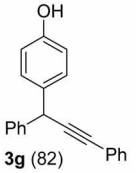
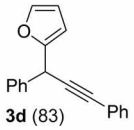
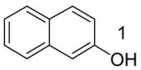
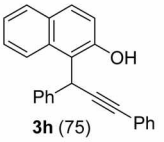
| Entry | Conditions | Results |
|---|---|---|
| 1 | $FeCl_3$ (10 mol%), $ClCH_2CH_2Cl$, rt, 5 h | 78% |
| 2 | $InCl_3$ (10 mol%), $ClCH_2CH_2Cl$, rt, 2 h | no reaction |
| 3 | $InCl_3$ (10 mol%), $ClCH_2CH_2Cl$, reflux, 2 h | 70% |
| 4 | $AuCl_3$ (5 mol%), $ClCH_2CH_2Cl$, rt, 1 h | 89% |
| 5 | *p*-TsOH (10 mol%), $ClCH_2CH_2Cl$, rt, 2 h | no reaction |
| 6 | *p*-TsOH (10 mol%), $ClCH_2CH_2Cl$, reflux, 1 h | 83% |
| 7 | Montmorillonite K10 (100 w/w%), $ClCH_2CH_2Cl$, rt, 2 h | no reaction |
| 8 | Montmorillonite K10 (100 w/w%), $ClCH_2CH_2Cl$, reflux, 2 h | 69% |

of $InCl_3$, *p*-TsOH and montmorillonite K10 at room temperature was completely ineffective (entries 2, 5, and 7). When the reaction mixture was heated to reflux we could isolate desired product **3b** in moderate yields (70-83%, entries 3, 6, and 8). The use of $FeCl_3$ and $AuCl_3$ were all efficient at room temperature (entries 1 and 4). Based on mildness, reaction time, the amount of used catalyst, and the yield of **3b**, we thought $AuCl_3$ is the best choice among the trials.

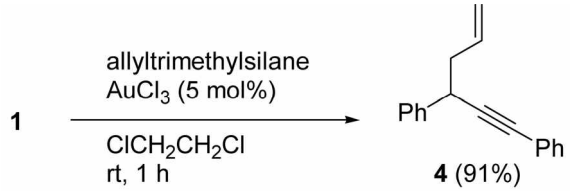
With this optimized conditions we examined the reaction of **1** and various arene nucleophiles including anisole (**2a**), 1,2,3-trimethoxybenzene (**2c**), furan (**2d**), 2-methylfuran (**2e**), pyrrole (**2f**), phenol (**2g**), and 2-naphthol (**2h**). The corresponding 1,3-diarylpropynes **3a-h** were isolated in good to excellent yields except for the case of pyrrole (entry 6). The reaction of **1** and pyrrole produced **3f** in only 41% (10 mol% $AuCl_3$, refluxing, 5 h).[8] Besides of electron-rich arenes, allyltrimethylsilane can also be used in the reaction efficiently and we obtained compound **4** in 91% yield (Scheme 2).[1c,e-g]

In summary, we disclosed an efficient $AuCl_3$-catalyzed synthesis of 1,3-diarylpropynes from *N*-tosylpropargylamine with electron-rich arenes under mild conditions.

**Table 2**. $AuCl_3$-catalyzed C-N bond cleavage of *N*-tosylpropargylamine **1**[a]

| Entry | NuH | Time (h) | Product (%) | Entry | NuH | Time (h) | Product (%) |
|---|---|---|---|---|---|---|---|
| 1 |  | 1 |  **3a** (92) | 5 |  | 3 |  **3e** (91) |
| | **2a** | | | | **2e** | | |
| 2 |  | 1 |  **3b** (89) | 6 |  | 5[b] |  **3f** (41) |
| | **2b** | | | | **2f** | | |
| 3 |  | 1 |  **3c** (90) | 7 |  | 1 |  **3g** (82) |
| | **2c** | | | | **2g** | | |
| 4 |  | 2 |  **3d** (83) | 8 |  | 1 |  **3h** (75) |
| | **2d** | | | | **2h** | | |

[a]Conditions: Compound **1** (1.0 mmol), nucleophile (3.0 mmol), $ClCH_2CH_2Cl$ (5 mL), $AuCl_3$ (0.05 mmol), rt. [b]The reaction was carried out at refluxing temperature with 10 mol% $AuCl_3$ for 5 h.




**Scheme 2**

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7. General procedure for the preparation of compound **3a**: To a stirred solution of **1** (361 mg, 1.0 mmol) and **2a** (325 mg, 3.0 mmol) in 1,2-dichloroethane (5.0 mL) was added $AuCl_3$ (15 mg, 5 mol%) at room temperature and stirred for 1 h. After reducing the amount of solvent, pure product **3a** was obtained by column chromatography (hexanes:$CH_2Cl_2$, 8:1), 275 mg (92%) as a colorless oil. Other compounds were synthesized similarly and the structures of **3a-h** and **4** were confirmed by comparison with the reported spectroscopic data.[1a-l]
8. The reaction with *m*-xylene or *p*-xylene also showed sluggish reaction even under the optimized conditions.