

# Communications

## AuCl<sub>3</sub>-Catalyzed Propargylation of Arenes with *N*-Tosylpropargyl Amine: Synthesis of 1,3-Diarylpropynes

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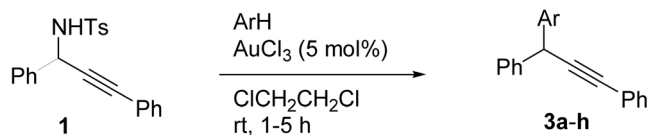
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1,3-Diarylpropynes are an important class of building blocks in organic synthesis.<sup>1,2</sup> One of the most useful methods for these compounds is a transition metal-catalyzed propargylation of electron-rich aromatics with propargyl alcohols.<sup>1</sup> The use of (dppm)Re(O)Cl<sub>3</sub>/AgPF<sub>6</sub>,<sup>1a</sup> [Cp\*<sub>2</sub>RuCl-(μ<sub>2</sub>-SMe)<sub>2</sub>RuCp\*(OH<sub>2</sub>)]OTf,<sup>1b</sup> NaAuCl<sub>4</sub>·2H<sub>2</sub>O,<sup>1c</sup> AuCl<sub>3</sub>,<sup>1d</sup> BF<sub>3</sub>·OEt<sub>2</sub>,<sup>1d</sup> FeCl<sub>3</sub>,<sup>1e</sup> BiCl<sub>3</sub>,<sup>1f</sup> *p*-TsOH,<sup>1g</sup> TiCl<sub>4</sub>/Et<sub>3</sub>N,<sup>1h</sup> and iodine<sup>1i</sup> has been reported. As the precursors of the corresponding propargyl cations, the use of propargyl alcohol is the most popular<sup>1a-i</sup> and the acetate of propargyl alcohol<sup>1j,k</sup> or *O*-propargyl trichloroacetimidate<sup>2</sup> 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.<sup>3</sup> 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),<sup>4b</sup> sulfonamide and some amide derivatives.<sup>4a,c-e</sup> 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<sup>5</sup> 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<sub>3</sub>,<sup>6</sup> FeCl<sub>3</sub>, InCl<sub>3</sub>, *p*-TsOH and montmorillonite K10 was examined and the results are summarized in Table 1.<sup>7</sup> The use



Scheme 1

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

Entry	Conditions	Results
1	FeCl <sub>3</sub> (10 mol%), ClCH <sub>2</sub> CH <sub>2</sub> Cl, rt, 5 h	78%
2	InCl <sub>3</sub> (10 mol%), ClCH <sub>2</sub> CH <sub>2</sub> Cl, rt, 2 h	no reaction
3	InCl <sub>3</sub> (10 mol%), ClCH <sub>2</sub> CH <sub>2</sub> Cl, reflux, 2 h	70%
4	AuCl <sub>3</sub> (5 mol%), ClCH <sub>2</sub> CH <sub>2</sub> Cl, rt, 1 h	89%
5	<i>p</i> -TsOH (10 mol%), ClCH <sub>2</sub> CH <sub>2</sub> Cl, rt, 2 h	no reaction
6	<i>p</i> -TsOH (10 mol%), ClCH <sub>2</sub> CH <sub>2</sub> Cl, reflux, 1 h	83%
7	Montmorillonite K10 (100 w/w%), ClCH <sub>2</sub> CH <sub>2</sub> Cl, rt, 2 h	no reaction
8	Montmorillonite K10 (100 w/w%), ClCH <sub>2</sub> CH <sub>2</sub> Cl, reflux, 2 h	69%

of InCl<sub>3</sub>, *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<sub>3</sub> and AuCl<sub>3</sub> 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<sub>3</sub> is the best choice among the trials.

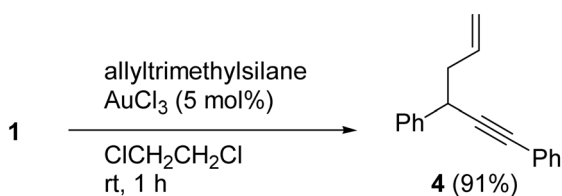
With this optimized conditions we examined the reaction of **1** and various arene nucleophiles including anisole (**2a**), 1,2,3-trimethoxybenzene (**2c**), furan (**2d**), 2-methylfuran (**2e**), pyrrole (**2f**), phenol (**2g**), and 2-naphthol (**2h**). The corresponding 1,3-diarylpropynes **3a-h** 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<sub>3</sub>, refluxing, 5 h).<sup>8</sup> Besides of electron-rich arenes, allyltrimethylsilane can also be used in the reaction efficiently and we obtained compound **4** in 91% yield (Scheme 2).<sup>1c,e-g</sup>

In summary, we disclosed an efficient AuCl<sub>3</sub>-catalyzed synthesis of 1,3-diarylpropynes from *N*-tosylpropargylamine with electron-rich arenes under mild conditions.

**Table 2.** AuCl<sub>3</sub>-catalyzed C-N bond cleavage of *N*-tosylpropargylamine **1**<sup>a</sup>

Entry	NuH	Time (h)	Product (%)	Entry	NuH	Time (h)	Product (%)
1		1	 3a (92)	5		3	 3e (91)
2		1	 3b (89)	6		5 <sup>b</sup>	 3f (41)
3		1	 3c (90)	7		1	 3g (82)
4		2	 3d (83)	8		1	 3h (75)

<sup>a</sup>Conditions: Compound **1** (1.0 mmol), nucleophile (3.0 mmol), ClCH<sub>2</sub>CH<sub>2</sub>Cl (5 mL), AuCl<sub>3</sub> (0.05 mmol), rt. <sup>b</sup>The reaction was carried out at refluxing temperature with 10 mol% AuCl<sub>3</sub> for 5 h.



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- 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<sub>3</sub> (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<sub>2</sub>Cl<sub>2</sub>, 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.<sup>1a-l</sup>
- The reaction with *m*-xylene or *p*-xylene also showed sluggish reaction even under the optimized conditions.