

# Facile preparation of vinylaziridines by the reaction of *N*-sulfonylimines and cinnamyl bromide mediated by a catalytic amount of dimethyl sulfide

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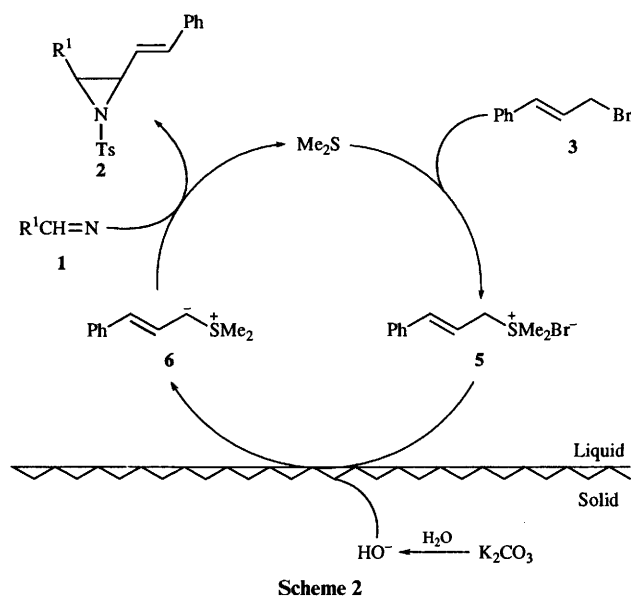
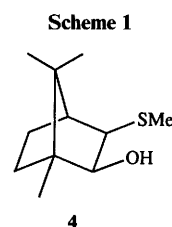
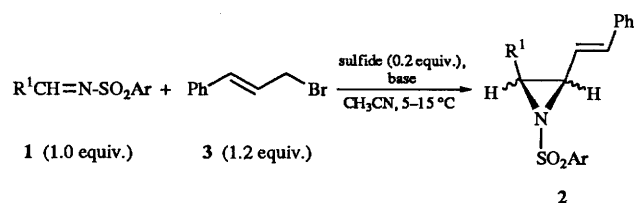
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$\beta$ -Phenylvinylaziridines are prepared in moderate to good yields from the reaction of *N*-sulfonylimines and cinnamyl bromide mediated by a catalytic amount of dimethyl sulfide in the presence of solid  $K_2CO_3$  in acetonitrile at ambient temperature.

Making a stoichiometric reaction catalytic is of practical significance both for laboratory synthesis and for industrial production. This idea has not been ignored by ylide chemists and the report of the first catalytic Wittig-type reaction of arsonium ylides in 1989 is an excellent example.<sup>1</sup> This idea was then applied in olefination,<sup>2</sup> epoxidation<sup>3</sup> and cyclopropanation<sup>4</sup> by way of telluronium or sulfonium ylides. However, it seems that no catalytic aziridination *via* an ylide route has yet appeared in the literature. It is easy to understand considering that there have been only limited reports<sup>5</sup> on stoichiometric aziridination using ylides because of the low reactivity of *N*-alkyl- or -aryl-imines towards the attack of nucleophiles compared with carbonyl compounds and Michael acceptors, and only a methylene group has been successfully transferred to a C=N bond.<sup>6</sup> In our previous publications,<sup>7</sup> we described an efficient reaction of *N*-sulfonyl-activated imines with sulfonium, arsonium or telluronium ylides either under phase-transfer conditions at room temperature or with preformed ylides at low temperature to furnish vinylaziridines, which are very useful synthetic intermediates.<sup>8</sup> The facile reaction of *N*-sulfonylimines with allylic ylides and the fast salt-formation between  $Me_2S$  and cinnamyl bromide† encouraged us to perform the ylide aziridination<sup>7</sup> in a catalytic form. Herein we disclose our results for the preparation of  $\beta$ -phenylvinylaziridines by a catalytic ylide process (Scheme 1).

*N*-sulfonylimines **1** (1.0 equiv.), cinnamyl bromide **3** (1.2 equiv.), dimethyl sulfide (0.2 equiv.) and anhydrous  $K_2CO_3$  (1.2 equiv.) were mixed in acetonitrile (4 cm<sup>3</sup>). After stirring for 1–4 h, the reactions were complete and gave clearly the desired aziridines **2** in moderate to good yields. Results are summarized in Table 1.

The increase in the amount of sulfide resulted in improvement of the yield and reduction of the reaction time (entries 1, 5–7 in Table 1).  $Et_2S$  and sulfide **4**<sup>9</sup> could also mediate this reaction, but  $PhSMe$  and  $Ph_2S$  were ineffective because of difficulties in the salt-formation step.  $K_2CO_3$ ,  $Cs_2CO_3$  and  $KF \cdot Al_2O_3$  could serve as the base, but a strong base like  $KOH$  would clearly cause a different reaction *via* a non-ylide route when the temperature was higher than 25 °C. The addition of  $KI$  to the reaction significantly improved the yield of aziridines due to the production of the more readily salt-forming species cinnamyl iodide from the *in situ* reaction of cinnamyl bromide and  $KI$  (entry 2 in Table 1) and thus



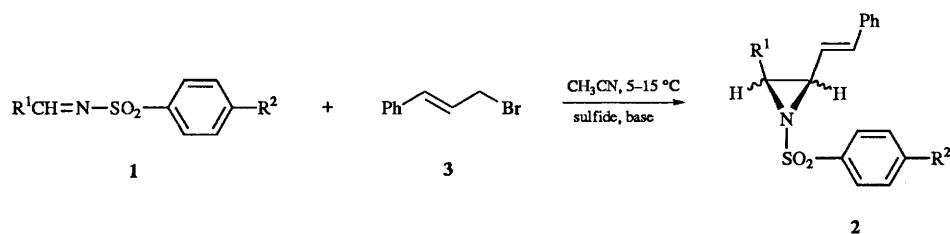
accelerating the salt-formation step in the catalytic cycle (Scheme 2).

This is a one-pot reaction containing three independent processes. The catalytic amount of dimethyl sulfide is initially converted into sulfonium salt **5** by cinnamyl bromide **3**. Subsequently, the salt is deprotonated to give the dimethylsulfonium cinnamyl anion **6**. After the reaction of ylide **6** with *N*-sulfonylimines **1**, dimethyl sulfide is released and allowed to react with cinnamyl bromide to form sulfonium salt **5** again.

Obviously, the hydrolysis of *N*-sulfonylimines to aldehydes and sulfonamides under solid-liquid phase-transfer conditions is a competing reaction. Thus, the key to the success of this reaction is the high reaction rate for all the independent

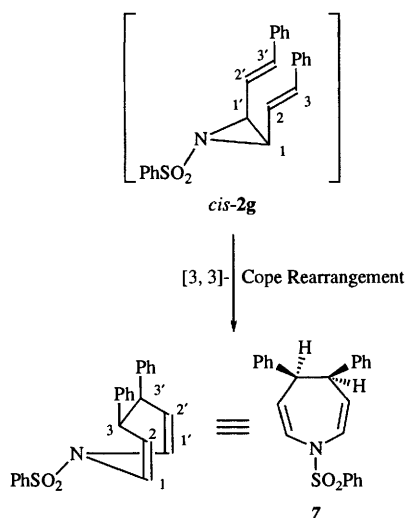
† It was observed that the reaction between cinnamyl bromide and dimethyl sulfide was very fast and this reaction was completed generally within several minutes.

**Table 1** Preparation of  $\beta$ -phenylvinylaziridines **2** by a catalytic aziridination of *N*-sulfonylimines **1** with cinnamyl bromide **3** mediated by sulfide under solid-liquid phase-transfer conditions<sup>a</sup>



Entry	R <sup>1</sup>	R <sup>2</sup>	Sulfide	Amount of sulfide (equiv.)	Base	Reaction time	Yield <b>2</b> , (%) <sup>b</sup>	<i>trans</i> : <i>cis</i> <sup>c</sup> of <b>2</b>
1	<i>p</i> -ClC <sub>6</sub> H <sub>4</sub>	Me	Me <sub>2</sub> S	0.2	K <sub>2</sub> CO <sub>3</sub>	1.5 h	43 ( <b>2a</b> )	43:57
2	<i>p</i> -ClC <sub>6</sub> H <sub>4</sub>	Me	Me <sub>2</sub> S	0.2	K <sub>2</sub> CO <sub>3</sub>	1.5 h	49 <sup>d</sup> ( <b>2a</b> )	53:47
3	<i>p</i> -ClC <sub>6</sub> H <sub>4</sub>	Me	Me <sub>2</sub> S	0.2	CS <sub>2</sub> CO <sub>3</sub>	1.5 h	40 ( <b>2a</b> )	53:47
4	<i>p</i> -ClC <sub>6</sub> H <sub>4</sub>	Me	Me <sub>2</sub> S	0.2	KF·Al <sub>2</sub> O <sub>3</sub>	1.5 h	44 ( <b>2a</b> )	55:45
5	<i>p</i> -ClC <sub>6</sub> H <sub>4</sub>	Me	Me <sub>2</sub> S	0.5	K <sub>2</sub> CO <sub>3</sub>	70 min	54 ( <b>2a</b> )	35:65
6	<i>p</i> -ClC <sub>6</sub> H <sub>4</sub>	Me	Me <sub>2</sub> S	0.7	K <sub>2</sub> CO <sub>3</sub>	55 min	70 ( <b>2a</b> )	38:62
7	<i>p</i> -ClC <sub>6</sub> H <sub>4</sub>	Me	Me <sub>2</sub> S	1.0	K <sub>2</sub> CO <sub>3</sub>	45 min	72 ( <b>2a</b> )	31:69
8	<i>p</i> -CH <sub>3</sub> C <sub>6</sub> H <sub>4</sub>	H	Me <sub>2</sub> S	0.2	K <sub>2</sub> CO <sub>3</sub>	3.0 h	45 ( <b>2b</b> )	32:68
9	<i>o</i> -MeOC <sub>6</sub> H <sub>4</sub>	Me	Me <sub>2</sub> S	0.2	K <sub>2</sub> CO <sub>3</sub>	3.5 h	45 ( <b>2c</b> )	29:71
10	C <sub>6</sub> H <sub>5</sub>	Me	Me <sub>2</sub> S	0.2	K <sub>2</sub> CO <sub>3</sub>	2 h	49 ( <b>2d</b> )	38:62
11	<i>p</i> -O <sub>2</sub> NC <sub>6</sub> H <sub>4</sub>	Me	Me <sub>2</sub> S	0.2	K <sub>2</sub> CO <sub>3</sub>	1.5 h	30 ( <b>2e</b> )	35:65
12	<i>p</i> -MeOC <sub>6</sub> H <sub>4</sub>	H	Me <sub>2</sub> S	0.2	K <sub>2</sub> CO <sub>3</sub>	3.0 h	47 ( <b>2f</b> )	38:62
13	<i>trans</i> -PhCH=CH	H	Me <sub>2</sub> S	0.2	K <sub>2</sub> CO <sub>3</sub>	2 h	38 ( <b>2g</b> )	34:66 <sup>e</sup>
14	<i>p</i> -ClC <sub>6</sub> H <sub>4</sub>	Me	Et <sub>2</sub> S	0.2	K <sub>2</sub> CO <sub>3</sub>	4 h	20 ( <b>2a</b> )	45:55
15	<i>p</i> -ClC <sub>6</sub> H <sub>4</sub>	Me	<b>4</b>	0.2	K <sub>2</sub> CO <sub>3</sub>	1.5 h	23 ( <b>2a</b> )	49:51
16	<i>p</i> -ClC <sub>6</sub> H <sub>4</sub>	Me	PhSMe	0.2	K <sub>2</sub> CO <sub>3</sub>	5 h	0	—
17	<i>p</i> -ClC <sub>6</sub> H <sub>4</sub>	Me	Ph <sub>2</sub> S	0.2	K <sub>2</sub> CO <sub>3</sub>	5 h	0	—

<sup>a</sup> All reactions were carried out in a ratio of imine:sulfide:cinnamyl bromide:base = 1:0.2:1.2:1.2 on a 0.5 mmol scale in CH<sub>3</sub>CN. <sup>b</sup> Isolated yields based on imine. <sup>c</sup> Determined by 300 MHz <sup>1</sup>H NMR analysis. <sup>d</sup> Potassium iodide (1.2 equiv.) was added to the reaction. <sup>e</sup> This ratio refers to that of the *N*-benzenesulfonyl-*trans*-2,3-di( $\beta$ -phenylvinyl)aziridine *trans*-**2g** and the rearranged product *N*-benzenesulfonyl-*cis*-4,5-diphenyl-4,5-dihydroazepine **7**.



Scheme 3

processes. The high reactivity of *N*-sulfonylimines towards allylic ylides<sup>7</sup> just meets this requirement.

The investigation of reaction conditions showed that acetonitrile was the best solvent and solid K<sub>2</sub>CO<sub>3</sub> was the most suitable base for this aziridination. Considering the yields and economy, an acceptable amount of mediator (sulfide) was 20% of the substrates and the ease of its sulfonium salt formation made it the most suitable reagent for this reaction. Any attempts to replace cinnamyl bromide with other allylic halides, like allyl bromide, silylated allyl bromide and crotonyl bromide, were unsuccessful. Under the optimized conditions, a variety of *N*-sulfonyl arylimines gave moderate yields. But, in the case of the *N*-sulfonyl  $\alpha,\beta$ -unsaturated imine (entry 13 in Table 1), we obtained a mixture of *N*-benzenesulfonyl-*trans*-2,3-di( $\beta$ -phenylvinyl)aziridine *trans*-**2g** and *N*-benzenesulfonyl-*cis*-

4,5-diphenyl-4,5-dihydroazepine **7**, which was derived from a rapid room temperature Cope rearrangement of the *cis* isomer (*cis*-**2g**)<sup>10</sup> (Scheme 3).

## Experimental

### Typical procedure for aziridination

A 25 cm<sup>3</sup> flask containing a magnetic stirring bar was charged with imine **1** (1.0 equiv.), cinnamyl bromide **3** (1.2 equiv.), Me<sub>2</sub>S (0.2 equiv.) and anhydrous K<sub>2</sub>CO<sub>3</sub> (1.2 equiv.). Acetonitrile (4 cm<sup>3</sup>, reagent grade, not dried before use) was added and the mixture stirred. After the reaction was complete according to TLC, the mixture was filtered through a short neutral Al<sub>2</sub>O<sub>3</sub> column to remove inorganic salts. The filtrate was concentrated and chromatographed on a neutral Al<sub>2</sub>O<sub>3</sub> column with a mixture of light petroleum (60–90 °C), ethyl acetate and NEt<sub>3</sub> (8:1:1) as the eluent to give the pure product.

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