

## Influence of the Nature of the Lewis Acid on the Rearrangement of 1-Phenyl-7-oxanorbornadiene Derivatives

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**Abstract** : 1-phenyl-7-oxanorbornadiene derivatives are rearranged into 6-hydroxyfulvenes or 4-phenylphenols derivatives when they are reacted with Lewis acids. The course of the reaction, which is highly selective, depends exclusively on the nature of the Lewis acid used.

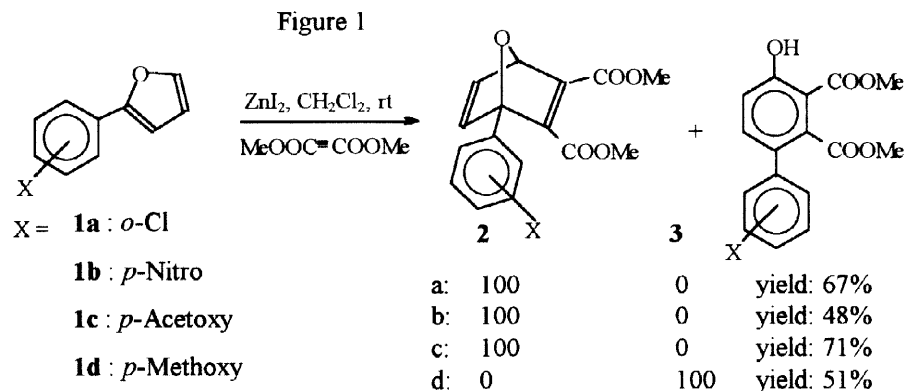
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During the course of our investigations concerning the synthesis of a large variety of polysubstituted arylphenols,<sup>1</sup> we were interested by the reactivity of 7-oxabicyclo[2.2.1]heptadienes. This class of highly reactive molecules is frequently encountered as synthons in the synthesis of natural products,<sup>2,3</sup> polymers<sup>4</sup> and drugs.<sup>5</sup>

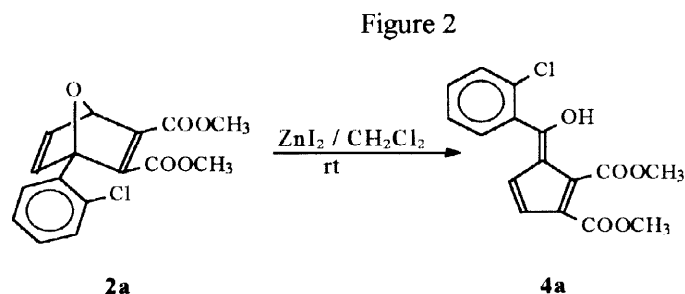
We have shown that these compounds are interesting precursors for the synthesis of polyarylphenols.<sup>1</sup> They can also be converted to hydroxyfulvenes and to oxepines.<sup>6</sup> Stusche and Prinzbach have reported that 6-hydroxyfulvenes are formed under direct or sensitized irradiation of oxanorbornadienes (5-50%), or by Cu<sup>+</sup> or Ag<sup>+</sup> catalyzed isomerization of the corresponding oxaquadricyclanes (40-50%).<sup>7</sup> When the last approach is applied to oxabicycloheptadienes no hydroxyfulvenes are formed. However the direct conversion of 1,4-dialkyl oxabicyclo[2.2.1]heptadienes to 6-hydroxyfulvenes can be realized under the influence of [Rh(CO)<sub>2</sub>Cl]<sub>2</sub><sup>8</sup> or by reaction with iodine.<sup>9</sup> In this last case, a radical pathway was proposed in order to explain the isomerization process.

We report here the results we have obtained when a series of aryl substituted oxabicyclo[2.2.1]heptadiene derivatives were reacted with various Lewis acids.

The required oxabicycloheptadienes were readily prepared by a Lewis acid catalyzed Diels-Alder reaction between arylfurans **1** and dimethylacetylene dicarboxylate. As expected, some arylfurans afforded the oxabicycloheptadienes **2** while other ones, especially those bearing an electrodonating group located in the para position, were directly converted to arylphenols **3**, in the reaction conditions<sup>1</sup> (Figure 1).



The isomerization of the so-obtained oxabicycloheptadienes was studied. In preliminary experiments 1-[2-chlorophenyl]-2,3-dicarbomethoxy-7-oxabicyclo[2.2.1]heptadiene **2a** led to the corresponding 6-hydroxyfulvene **4a** quantitatively, when treated with ZnI<sub>2</sub> (4 equivalents), in dichloromethane (Figure 2).



However, other conditions and especially other Lewis acids allowed for the alternative reaction to proceed. Our results are reported in Table 1.

**Table 1.** Reaction of **2a** with various Lewis acids


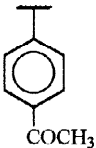
Lewis acid	Entries	Ratio equivalents	Time (h)	6-hydroxyfulvene <b>4a</b> <sup>a</sup>	4-arylphenol <b>3a</b> <sup>a</sup>
ZnI <sub>2</sub>	1	0.1	48	90	0
"	2	1	48	86	0
"	3	2	48	91	0
"	4	3	48	95	0
"	5	4	48	100	0
ZnBr <sub>2</sub>	6	4	48	0	100
ZnCl <sub>2</sub>	7	4	48	0	100
AlCl <sub>3</sub>	8	4	48	0	100
CuCl	9	4	48	0	0
CuI	10	4	48	0	0

<sup>a</sup>: Yields of isolated products

As it can be seen, the nature of the Lewis acid has a spectacular effect on the issue of the reaction; in most cases (entries 6 to 8), only phenol **3a** was obtained except when ZnI<sub>2</sub> was used (entries 1 to 5).

Furthermore in all cases the selectivity of the reaction was excellent. Other substituted phenyloxanorbornadienes **2b-2c**, were studied under the same conditions. They similarly afforded 6-hydroxyfulvenes in quantitative yields when  $\text{ZnI}_2$  was used and 4-hydroxyphenyl benzene derivatives in all other cases (Table 2). All the compounds described here were fully characterized by NMR ( $^1\text{H}$  and  $^{13}\text{C}$ ), IR and elemental analysis.

**Table 2.** Rearrangement reaction of various substituted oxanorbornadienes

Substrate	Lewis acid (4 equiv.)	Time	Yield	
			<b>4</b>	<b>3</b>
<b>2b</b> 	$\text{ZnI}_2$	48h	90	0
	$\text{ZnBr}_2$	48h	0	100
<b>2c</b> 	$\text{ZnI}_2$	48h	100	0
	$\text{ZnBr}_2$	48h	0	92

It can be seen from Table 1 that the isomerization of oxanorbornadienes into fulvenes is a catalyzed reaction but the best results were obtained when 4 equivalents of  $\text{ZnI}_2$  were used. In fact, under these conditions, the 6-hydroxyfulvene is formed in almost quantitative yield and can thus be easily purified, without noticeable degradation.

Although the synthesis of oxabicyclonorbornadienes is catalyzed by 0.1 equivalent of  $\text{ZnI}_2$  we never observed the catalyzed formation of 6-hydroxyfulvenes during the cycloaddition step, even when longer reaction times were used (up to 150 hours). Furthermore, it has to be noted that **1a** (bearing an electrodonating chlorine atom) can be converted to the hydroxyfulvene **4a** via **2a** contrary to **1d** which, under the same conditions, yields directly **3d** (**2d** was never isolated in our conditions). In fact, calculations indicate that, in **2a**, the positive charge density on C-1 is the same as the one calculated with a non-substituted aromatic ring and is smaller than the one determined for **2d**.<sup>10</sup>

Since it has been reported that such an isomerization can also be performed with divalent iodine<sup>9</sup>; we repeated that reaction in the conditions described for comparison purposes. Using 1 equivalent of molecular iodine, 6-hydroxyfulvene was indeed formed along with many unidentified by-products. Clearly the use of  $\text{ZnI}_2$  gives a cleaner reaction and much better yields. We then checked that the reaction was not due to traces of  $\text{I}_2$  contaminating the catalyst. The Zn iodide was heated at  $150^\circ\text{C}$  for 48h under vacuum (0.5 mm Hg) prior to use. No modification was observed on the course of the reaction. We also performed the reaction with iodine in

the presence of sodium thiosulfate; the isomerization process was inhibited. In the same conditions but with  $ZnI_2$ , the isomerization took place without any significant kinetic modifications. Finally in the presence of a radical trap, namely *N*-*t*-butyl- $\alpha$ -phenylnitron<sup>11</sup>, 6-hydroxyfulvene was formed in the presence of iodine or  $ZnI_2$  excluding thus a radical pathway for this rearrangement. It has also to be noted that the reaction exhibits a total regioselectivity as 6-hydroxy-3-aryl-1,2-dicarbomethoxy fulvenes are never formed. This implies that in the mechanism of the formation of 6-hydroxyfulvenes the O-C4 bond is broken. It seems thus that a somewhat concerted or ionic mechanism has to be considered in the observed rearrangement of oxanorbornadiene into 6-hydroxyfulvene.

This work shows the dramatic effect of the Lewis acid nature on the rearrangement of oxabicyclo[2.2.1]norbornadienes. The use of  $ZnI_2$  gives high yield of 6-hydroxyfulvenes derivatives without formation of side products. Further work is presently in progress to establish the precise mechanism of this rearrangement.

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