



# Enol ether–olefin ring closing metathesis using the Grubbs ruthenium imidazole catalyst

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Received 5 October 2000; accepted 2 November 2000

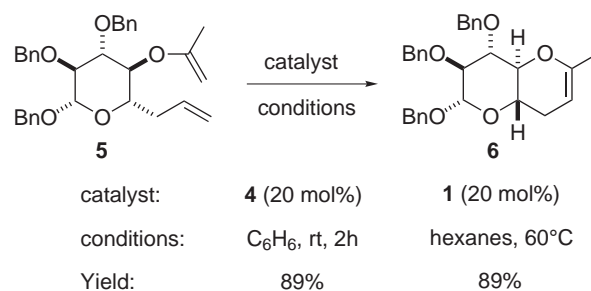
**Abstract**—This letter reports our successful use of the Grubbs ruthenium imidazole alkylidene catalyst in enol ether–olefin ring closing metathesis reactions. © 2000 Published by Elsevier Science Ltd.

In a relatively short period of time since its discovery, the olefin–olefin ring closing metathesis (RCM) reaction has become an integral synthetic tool in organic chemistry.<sup>1</sup> This has largely been due to the discovery of well defined catalysts that are remarkably stable while still demonstrating high reactivity. The evolution of catalysts capable of carrying out olefin–olefin RCM has proceeded from highly reactive yet relatively unstable W and Mo alkylidenes (e.g. **1** and **2**)<sup>2</sup> to less reactive, yet highly stable, Ru alkylidenes (e.g. **3**)<sup>3</sup> to the more recently developed highly reactive and highly stable Ru imidazole catalysts (e.g. **4**) (Fig. 1).<sup>4</sup>

A number of research groups, including ours, have been interested in the use of enol ether–olefin RCM reactions.<sup>5–7</sup> This reaction provides high yields of cyclic enol ethers when the Schrock molybdenum catalyst **1**<sup>8</sup> is used but does not generally work with the more robust Grubbs catalyst **3**.<sup>9–11</sup> Out of an interest in using catalysts more robust than **1** in enol ether–olefin RCM chemistry, we have recently explored the use of the ruthenium imidazole catalyst **4** in these reactions and report the results of this study herein.

We isolated bicyclic enol ether **6**<sup>7a</sup> in an 89% yield when  $\beta$ -C-glycoside **5** was treated with 20 mol% of **4** at rt for 2 h. Impressively, **4** worked as well as the more sensitive catalyst **1** with this substrate (Scheme 1).

We have also investigated the enol ether–olefin RCM reaction of an intermediate on route to the marine ladder toxin gambierol. In a similar fashion to **5**, when **7**<sup>12</sup> was exposed to **4** at rt for 5 h, we were able to isolate an 83% yield of the corresponding bicyclic enol ether (e.g. **8**) (Scheme 2).



Scheme 1.

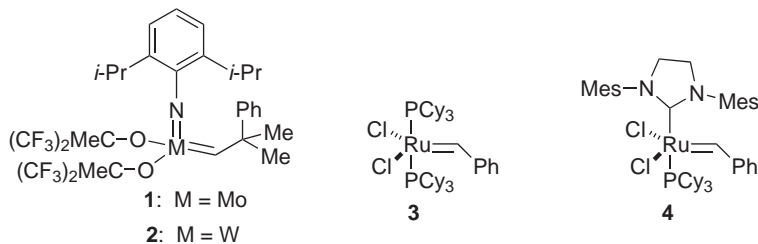
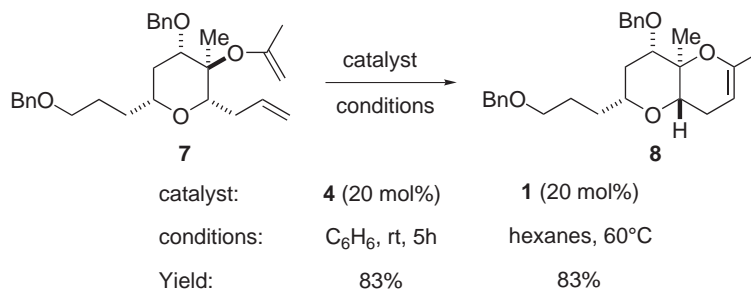
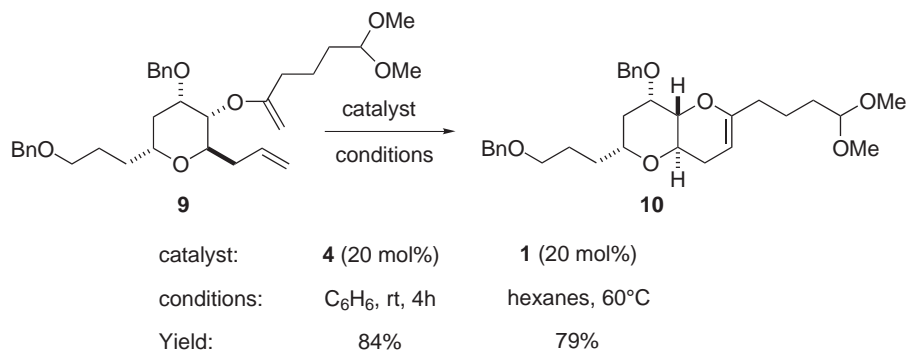


Figure 1.

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Scheme 2.



Scheme 3.

Lastly, we have examined the RCM reaction of an intermediate that was used in our synthesis of hemibrevetoxin B,<sup>13</sup> enol ether **9**. We considered this reaction to be a test of the ability of **4** to carry out enol ether–olefin RCM as the cyclized compound places the two substituents on the pyran in a 1,3-diaxial relationship to one another. In the event, the reaction of **9** proceeded at rt to give an 84% yield of bicycle **10**. This result clearly demonstrates the utility of **4** in enol ether–olefin RCM (Scheme 3).

These results indicate that the robust and mild Grubbs' imidazole catalyst **4**<sup>14</sup> can be used in enol ether–olefin RCM reactions. Undoubtedly, this catalyst will enable a number of highly substituted and sensitive cyclic enol ethers to be synthesized.

#### Acknowledgements

We are grateful to the National Institutes of Health, General Medical Sciences (GM56677) and Research Corporation for the generous support of this work.

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11. While the use of **1** requires the use of a glove box in the transfer of the catalyst, **3** and **4** can be transferred in the atmosphere without any adverse effects.
  12. Rainier, J. D.; Cox, J. M. unpublished results.
  13. See Reference 7b and Rainier, J. D.; Allwein, S. P.; Cox, J. M. manuscript submitted.
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