

# An efficient and inexpensive scavenger resin for Grubbs' catalyst

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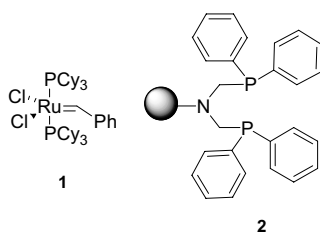
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**Abstract**—Addition of the inexpensive polymer-bound chelate phosphine **2** to ring-closing metathesis reaction mixtures effectively removes coloured impurities and delivers ruthenium-free (>95%) reaction products.

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During the last decade the olefin-metathesis reaction has achieved the status of a 'strategy-level' reaction. The generality and versatility associated with this reaction in organic synthesis has been the subject of excellent reviews and was highlighted by its application in the synthesis of complex natural products.<sup>1</sup> Grubbs' ruthenium catalyst **1** is the most widely used catalyst for ring-closing metathesis (RCM) reactions. Removal of the dark coloured, metal-containing by-products upon completion of the metathesis reaction turns out to be a serious experimental drawback of this reaction, as it might effect subsequent synthetic reactions or obscure biological screening results.



Recently several groups have introduced olefin-metathesis catalysts, which are bound to polymeric or inorganic supports and can be easily removed from the reaction mixture by filtration.<sup>2</sup> Although such immobilised versions of RCM-catalysts can be regarded as an elegant solution to the problem of metal impurities, their cost, lack of commercial availability and inferior catalytic perfor-

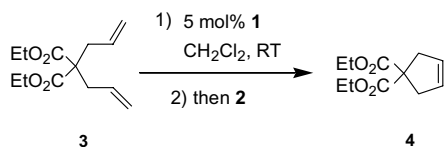
mance have been an obstacle for their application in organic synthesis by a wider community of organic chemists.

As homogeneous catalysts still represent the most effective reagents for performing an olefin-metathesis reaction, ideas have been proposed to destroy the catalyst after the reaction and convert it in a form, which will allow its removal by conventional methods such as flash chromatography or extraction with water-soluble phosphine ligands.<sup>3</sup> Paquette et al. have demonstrated that the addition of a slight excess of  $\text{Pb}(\text{OAc})_4$  to the reaction mixture effectively reduces the Ru-level after filtration through a pad of silica.<sup>4</sup> The high oxidising power and considerable toxicity of this reagent impose serious limitations to the use of this method. Recently the group of Georg demonstrated that the addition of a 50-fold excess of  $\text{Ph}_3\text{P}=\text{O}$  or DMSO to a RCM reaction mixture decomposed the catalyst, allowing its removal after flash chromatography.<sup>5</sup> Recent progress in the design and use of scavenging resins as an experimentally simple way of removal of unwanted reagents, side-products and catalysts have inspired us to design an inexpensive scavenger resin for Grubbs' catalyst, which enables the removal of metal impurities by addition of an easily filterable reagent.<sup>6</sup> We and others introduced resin-bound phosphine **2** as a readily accessible chelate P-ligand for the design of immobilised transition metal catalysts in organic synthesis,<sup>7</sup> which can be stored at room temperature under air for >6 months without any formation of P(V)-species.<sup>7a</sup>

In order to evaluate the efficiency of **2** in removal of **1** from reaction mixtures, we investigated the RCM of bis(allyl)malonate **3** and measured the Ru content in its reaction product **4** (Scheme 1, Table 1).<sup>8</sup>

**Keywords:** Polymer support; Supported reagents; Metathesis; Ruthenium; Phosphines.

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Scheme 1.

**Table 1.** Removal efficiency of Ru in the RCM pictured in Scheme 1

Entry	<b>2</b> (equiv)	Conditions	Yield <b>4</b> (%)	Ru content <sup>8</sup> [µg Ru/5 mg <b>4</b> ]	Ru removal (%)
1	—	—	99	108	4
2	20	17 h	99	12	90
3	5	17 h + SiO <sub>2</sub> <sup>a</sup>	88	8.3	94
4	5	17 h + C <sup>b</sup>	81	5.6	96

<sup>a</sup>The reaction mixture was filtered through a plug of SiO<sub>2</sub>.

<sup>b</sup>The solution was treated with charcoal and filtered.

After complete conversion of **3** 20 equiv (referred to catalyst) of **2** were added to the purple reaction mixture. Within 30 min the solution decolourised into a slightly yellow solution, whereas the originally off-white beads of **2** had accepted a green-brownish colour. Determination of residual Ru-content after an exposure time of 17 h showed that 90% of the Ru had been removed (Table 1, entry 2). This value could be improved by treatment of the reaction mixture with 5 equiv of **2** followed by either filtering the solution through a short plug of silica or addition of charcoal (entries 3 and 4). The removal efficiency improved then to 94% (resp. 96%). These values compare very well for those achieved by the homogenous methods mentioned above.

In conclusion, by introducing readily available **2** as a scavenger resin, we have presented an efficient method for the removal of Grubbs' catalyst from reaction mixtures using easily filterable heterogeneous reagents, which offer the advantage of experimental simplicity compared to other procedures reported in the literature.

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