

A Polymer-supported Iridium Catalyst for the Stereoselective Isomerisation of Double Bonds

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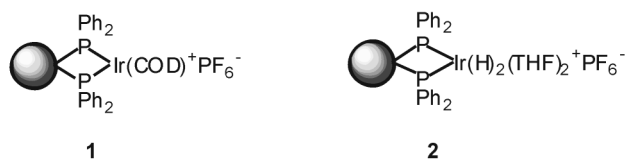
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Abstract: A polymer-supported iridium catalyst has been prepared and used in the isomerisation of the double bonds in aryl allylic derivatives with excellent *trans* selectivity and without the need for conventional work-up procedures.

Key words: iridium, isomerisation, polymer-supported reagents

The use of solid-supported reagents, catalysts and scavengers is becoming increasingly important for the assembly of organic compound libraries.¹ In the case of transition metal catalysts, attachment to a solid-support often offers the additional advantages of reduced toxicity and air-sensitivity of the species as well as the possibility of recycling the catalyst.



Figure

We became interested in the mild and selective *trans* isomerisation of aryl allylic derivatives during the synthesis of the natural product carpanone.² A polymer-supported iridium isomerisation catalyst was developed based on Felkin's iridium catalyst.³ A 6:1 molar ratio of polymer-supported triphenylphosphine⁴ and [(COD)IrCl]₂ [LG1] was agitated in THF at room temperature for 24 h. Addition of ammonium hexafluorophosphate as a solution in THF and agitation for a further 24 h produced a red polymer with the proposed structure **1** (Figure).⁵ Elemental analysis indicated 12.5% Ir, corresponding to a theoretical loading of 0.65 mmol/g. Hydrogen activation of catalyst **1** produces a chrome yellow polymer with suggested structure **2** (Figure) which is used to isomerise various aryl allylic derivatives (Table).⁶ The reactions proceed smoothly in THF at ambient temperature requiring only gentle agitation, work-up is then achieved by simple filtration and solvent evaporation to yield the isomerised products.

In general the isomerisation of electron-rich aromatic compounds by catalyst **2** results in products with predominantly the *trans* alkene geometry (entries 1–7; Table). However, electron-poor derivatives (entries 13 and 14) are substantially less prone to rearrangement. In fact entry 13 was recovered unchanged from the reaction after 12 h. The iridium catalyst **2** was also examined with various allyl ether derivatives (Table, entries 9–12). Although the isomerisations proceeded smoothly, these were not *trans* selective. However, catalyst **2** may still find an application in allyl ether deprotections where the *trans* selectivity is not relevant.⁷

In another experiment we determined whether the isomerisations were solely due to **2** or due to a species that may have leached into the solution from the support during the course of the reaction. To test this, the reaction with dillapiolone (Table, entry 6) was stopped after 15 minutes reaction time by filtration, when analysis showed a 60% conversion to the desired product. The filtrate was then allowed to stir for a further 12 hours. No further reaction was observed, suggesting that the active catalyst remains bound on the support during the reaction.

In an attempt to show that **2** can be recycled, we carried out a sequence of reactions on allyl benzene. The recovered polymer from the first conversion was reactivated with hydrogen and reused for a further three runs.⁸ The conversion dropped from quantitative to 95%, 91% and 75% in each subsequent run, suggesting some degradation of the catalyst (the *cis:trans* ratio remained constant).⁹

As a further investigation the catalytic potential of **2** was tested using the dimethoxy substrate entry 2 (Table). Employing catalyst **2** (2 mol%) for the isomerisation of 800 mg of the substrate resulted in 77% conversion after 24 h. Subsequent monitoring over an additional 3 day period showed a slow but steady progression to 84% conversion (day 2: 80%; day 3: 82%). The addition of a further batch of freshly prepared catalyst (1 mol%) allowed the reaction to proceed to completion over a further 48 h period.

We believe that the new polymer-supported catalyst **1** will add to the rapidly expanding armoury of immobilised reagents for use in organic synthesis programmes.

Table Isomerisations using Polymer-Supported Iridium Catalyst 2

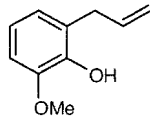
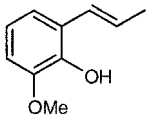
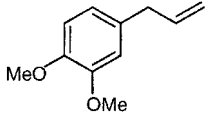
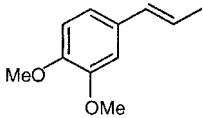
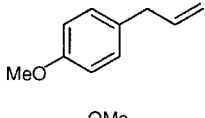
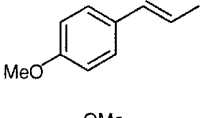
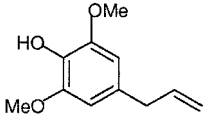
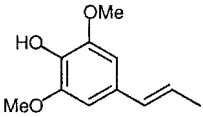
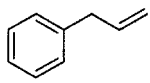
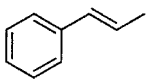
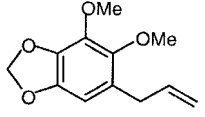
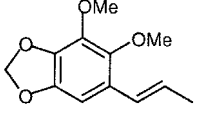
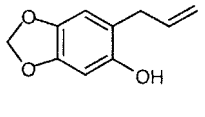
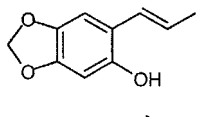
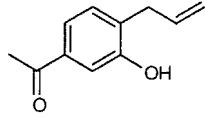
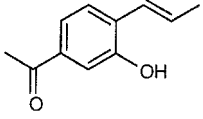
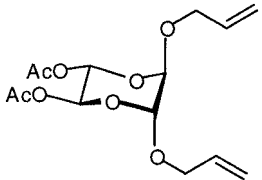
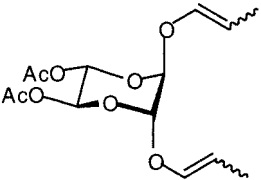
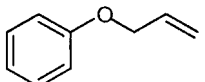
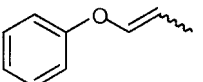
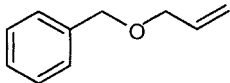
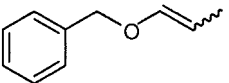
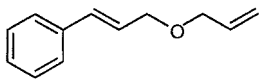
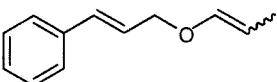
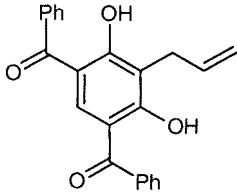
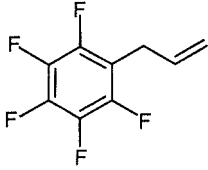
Entry	Substrate	Product ^a	<i>Trans:cis</i> ratio ^b
1			>95% <i>Trans</i>
2			>95% <i>Trans</i>
3			>97% <i>Trans</i>
4			>96% <i>Trans</i>
5			<i>Trans</i> only
6			>98% <i>Trans</i>
7			~92% <i>Trans</i>
8			~92% <i>Trans</i>
9			2:1
10			1:1
11			1:1
12			1:1

Table Isomerisations using Polymer-Supported Iridium Catalyst **2** (continued)

Entry	Substrate	Product ^a	<i>Trans:cis</i> ratio ^b
13		Recovered starting material	-
14		50 % conversion	-

^a Recovered yields are essentially quantitative although ¹H NMR analysis indicate up to 4% of the hydrogenated alkene product present in small scale reactions.

^b Determined by ¹H NMR

Acknowledgement

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References

- (1) Ley, S. V.; Baxendale, I. R.; Bream, R. N.; Jackson, P. S.; Leach, A. G.; Longbottom, D. A.; Nesi, M.; Scott, J. S.; Storer, I.; Taylor, S. J. *J. Chem. Soc., Perkin Trans. 1* **2000**, 3815.
- (2) Baxendale, I. R.; Lee, A.-L.; Ley, S. V. *Synlett* **2001**, 1482.
- (3) (a) Yamamoto, R.; Fujikawa, N.; Miyanra, N. *Synth. Commun.* **2000**, *30*, 2383. (b) Baudry, D.; Ephritikhine, M.; Felkin, H. *J. Chem. Soc., Chem. Commun.* **1978**, 694. (c) Crabtree, R. H.; Felkin, H.; Morris, G. E. *J. Chem. Soc., Chem. Commun.* **1976**, 716.
- (4) Triphenylphosphine on polymer-support had a loading of 3 mmol/g and was purchased from Fluka.
- (5) Proposed structure of the active species **1** and **2** is based on the solution-phase analogue: (a) Haines, L. M.; Singleton, E. *J. Chem. Soc., Dalton Trans.* **1972**, 1891. (b) See ref. 3a.
- (6) General Experimental Procedure: A suspension of the polymer **1** (150 mg) in THF (2.5 mL) was activated by bubbling hydrogen through the suspension until the red polymer turned chrome yellow. The reaction flask was then evacuated and filled with argon before a solution of the aryl allylic derivative (0.25 mmol) in THF (2.5 mL) was cannulated into it. The resulting suspension was agitated at room temperature for 2 h to 15 h. The polymer was removed by filtration and washed with CH₂Cl₂ and THF. The filtrate was concentrated in vacuo and filtered through a plug of silica to yield the isomerised product.
- (7) (a) Kloosterman, J. H.; Van Boom, J. H.; Chatelard, P.; Boullanger, P.; Descotes, G. *Tetrahedron Lett.* **1985**, 5045. (b) Oltroovt, J. J.; van Boeckel, C. A. A.; de Koning, J. H.; Van Boom, J. H. *Synthesis* **1981**, 305.
- (8) All reactions were stopped after 1.5 h and the reaction mixture analysed directly.
- (9) In a similar manner dillapiole (Table, entry 6) proceeded from quantitative to 91% to 70% (1.5 h reaction runs). The reaction did however proceed to completion when extended reaction times were used (15 h).