

Preliminary communication

Directing effect of functional groups in ruthenium-catalyzed addition of substituted acetophenones to an olefin

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Abstract

Ruthenium-catalyzed addition of 3'-methyl-, 3'-trifluoromethyl-, and 3'-*N,N*-dimethylaminoacetophenones to an olefin proceeds site selectively at 6' C–H bonds to give the 1:1 C–H/olefin addition products in high yields. In contrast, the addition of 3'-methoxyacetophenone takes place preferentially at the C–H bond at the more congested 2' position.

Keywords: Ruthenium; Catalytic C–H/olefin coupling; Acetophenone; Carbon–hydrogen bond cleavage; Catalysis; Ketone

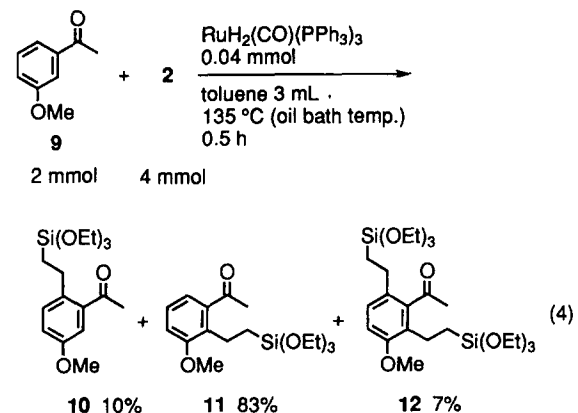
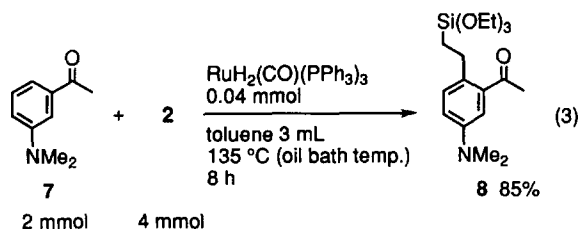
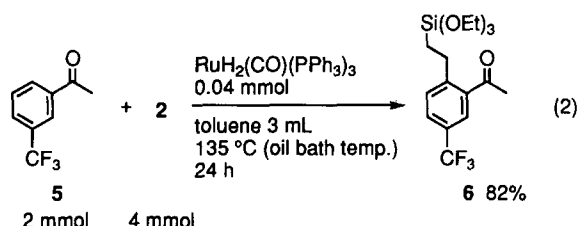
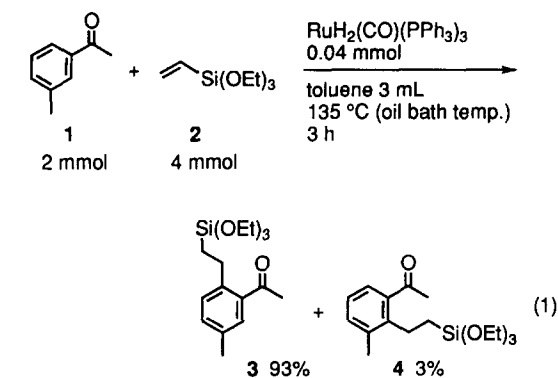
We have recently reported the ruthenium-catalyzed addition of C–H bonds in aromatic ketones to olefins [1–4]. This catalytic C–H/olefin coupling reaction has opened a new possibility for the direct manipulation of unreactive C–H bonds in organic synthesis. Although the basic feature of the catalytic reaction has been studied in some detail, further extensive study should be conducted to clarify the applicable range and enhance the utility of the new reaction, especially for synthetic purposes. To begin with, we have initiated a systematic study of the effect of substituents in the aromatic ring of the ketones and have found interesting directing effects of the substituents at the *meta* position. The present paper reports the preliminary results of the study of the functional group compatibility of the C–H/olefin coupling and directing effects of some substituents.

The catalytic reaction was carried out under the reaction conditions described below. A substituted acetophenone (2 mmol), triethoxyvinylsilane (**2**) (4 mmol), and $\text{RuH}_2(\text{CO})(\text{PPh}_3)_3$ (0.04 mmol) were dissolved in toluene (3 ml) and the solution was refluxed vigorously at 135 °C (oil bath temperature) for an appropriate reaction period. In the case of the reaction of 3'-methylacetophenone (**1**), two regioisomers, **3** and **4**, were obtained in 93% and 3% yields based on the ketone, respectively (Eq. (1)). The coupling took place at the

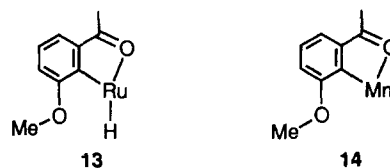
less congested position (6' position) to give **3** as the major product. Similar selectivities were observed in the cases of 3'-trifluoromethyl- and 3'-*N,N*-dimethylaminoacetophenones (**5** in Eq. (2) and **7** in Eq. 3, respectively). In these two cases, **6** (Eq. (2)) and **8** (Eq. (3)) were obtained as the sole products in 82% and 85% yields, respectively. Thus, in these reactions, the C–C bond formation occurred exclusively at the 6' position. Both electron-withdrawing (CF_3) and electron-releasing (Me and Me_2N) groups showed the same directing effect for the C–C bond formation. These results suggest that steric effects mainly control the site selectivity. On the other hand, 3'-methoxyacetophenone (**9**) showed an entirely different site selectivity, giving three products, **10–12**, in 10%, 83%, and 7% yields, respectively (Eq. (4)). In this case, the C–C bond formation occurred preferentially at the 2' position to give the sterically less favorable coupling product **11** as the principal product.

The results shown in Eqs. (1)–(4) indicate some important features of the C–H/olefin coupling. First, some functional groups containing oxygen, nitrogen, and fluorine atoms are tolerant of the catalytic reactions. This is important from a synthetic point of view. Secondly, the catalytic reaction proceeds smoothly irrespective of the electronic properties of the substituents. Both electron-withdrawing and -releasing groups can be attached to the aromatic ring. Thirdly, the selection of the C–H coupling site is determined primarily by steric factors. The methoxy substituent in Eq. (4) showed a

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different, rather exceptional directing effect, which could be attributed to the coordinating ability of the methoxy oxygen to the ruthenium in the intermediate **13**. A similar directing effect of a methoxy group is known in stoichiometric reactions using manganese carbonyls such as **14** [6–9].



Encouraged by these observations, we are now studying intensively the directing effect of various substituents. The systematic study is hoped to result in the development of a highly selective method of C–H/olefin coupling of aromatic ketones having various functional groups.

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Note added in proof

After submission of this paper, several relating works have been published. (a) Y.-G. Lim, Y.H. Kim, and J.-B. Kang, *J. Chem. Soc., Chem. Commun.*, (1994) 2267; (b) H. Guo, and W.P. Weber, *Polymer Bull.*, **32** (1994) 525; (c) H. Guo, M.A. Tapsak, and W.P. Weber, *Polymer Bull.*, **33** (1994) 417; (d) B.M. Trost, K. Imi, and I.W. Davies, *J. Am. Chem. Soc.*, **117** (1995) 5371; (e) F. Kakiuchi, Y. Tanaka, T. Sato, N. Chatani, and S. Murai, *Chem. Lett.*, (1995) 679; (f) F. Kakiuchi, Y. Yamamoto, N. Chatani, and S. Murai, *Chem. Lett.*, (1995) 681.