Heterogeneous Aquacatalysis Toward Ideal Organic Synthesis

Yasuhiro Uozumi Institute for Molecular Science and CREST, Okazaki 444-8787, JAPAN

We have recently developed palladium and rhodium complexes of amphiphilic polystyrenepoly(ethylene glycol) (PS-PEG) resin-supported phosphine ligands (Figure 1) which promote various catalytic transformations smoothly in water under heterogeneous conditions. The palladium-catalyzed π -allylic substitution, carbonylation, Heck reaction, Suzuki-Miyaura coupling, Sonogashira coupling, cycloisomerization, and rhodium-catalyzed alkyne-cyclotrimerization, hydroformylation, and Michael addition are representatives where the advantages of both aqueousand heterogeneous-switching were combined in one system to achieve high level of chemical greenness.



Figure 1. A typical structures of PS-PEG resin (left top) and the polymer-supported phosphines (A and B), and a SEM image of PS-PEG resin beads (right).

A fully environmentally benign multi-step asymmetric organic synthesis of a hydrindane framework was achieved in water under mild conditions with recyclable polymeric catalysts to represent what may be considered an ideal chemical process. Here we report the development of fully environmentally benign heterogeneous aquacatalytic multi-step asymmetric organic synthesis. Asymmetric synthesis of the hydrindane (3aR,7aS)-4 was achieved in water with recyclable catalysts. The racemic cyclohexenyl ester rac-1 reacted with diethyl malonate in water with a PS-PEG resin-supported chiral imidazoindole phosphine-Pd complex A (10 mol%) to give 90% ee of 2. The polymeric chiral palladium complex was reused three times without any loss of

stereoselectivity. Propargylation of the cyclohexenylmalonate 2 was performed with PS-PEGimmobilized PTC base **B** to give a quantitative yield of the 1,6-enyne (S)-3. The enyne (S)-3 underwent cycloisomerization with the amphiphilic polymeric palladium **C** to afford hydrindane (3aR,7aS)-4 in 94% yield.



[selected recent reference papers reported from the author's group]

(a) Uozumi, Y. Top. Curr. Chem. 2004, 242, 7 (review). (b) Yamada, Y. M. A.; Arakawa, T.; Hocke, H.; Uozumi, Y. Angew. Chem. Int. Ed. 2007, 46, 704 (catalytic oxidation). (c) Uozumi, Y.; Yamada, Y. M. A.; Beppu, T.; Fukuyama, N.; Ueno, M.; Kitamori, T. J. Am. Chem. Soc. 2006, 128, 15994 (catalytic membrane). (d) Yamada, Y. M. A.; Maeda, Y.; Uozumi, Y. Org. Lett. 2006, 8, 4259 (network polymeric complex). (e) Uozumi, Y.; Suzuka, T. J. Org. Chem. 2006, 71, 8644 (asymmetric C1 substitution). (f) Uozumi, Y.; Suzuka, T.; Kawade, R.; Takenaka, H. Synlett 2006, 2109 (allylic azidation). (g) Kobayashi, Y.; Tanaka, D.; Danjo, H.; Uozumi, Y. Adv. Synth. Catal. 2006, 348, 1561 (combinatorial catalyst). (h) Nakai, Y.; Kimura, T.; Uozumi, Y. Synlett 2006, 3065 (alkylative cyclization). (i) Uozumi, Y.; Kimura, M. Tetrahedron Asymmetry 2006, 17, 161 (asymmetric etherification). (j) Yamada, Y. M. A.; Uozumi, Y. Org.Lett. 2006, 8, 1375 (viologen polymer). (k) Nakai, Y.; Uozumi, Y. Org. Lett. 2005, 7, 291 (multi-step synthesis). (l) Nakao, R.; Rhee, H.; Uozumi, Y. Org. Lett. 2005, 7, 163 (nano-Pd catalysis). (m) Uozumi, Y.; Tanaka, H.; Shibatom, K. Org. Lett. 2004, 6, 281 (asymmetric amination). (n) Uozumi, Y.; Nakao, R. Angew. Chem., Int. Ed. 2003, 115, 204 (nano-Pd catalysis). (o) Uozumi, Y.; Nakai, Y. Org. Lett. 2002, 4, 2997 (HTS coupling). (p) Uozumi, Y.; Shibatom, K. J. Am. Chem. Soc. 2001, 123, 2919 (asymmetric alkylation).