

Chemoselective Reduction of Olefin by Mixed "Pd" Catalyst

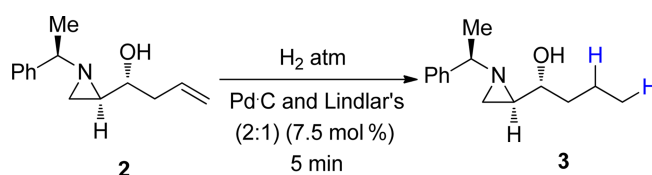
Mi-Kyung Ji, Doo-Ha Yoon, Hyun-Joon Ha,* Philjun Kang,[†] and Won Koo Lee^{†,*}

Department of Chemistry and Protein Research Centre for Bio-Industry, Hankuk University of Foreign Studies, Yongin 449-719, Korea. *E-mail: hjha@hufs.ac.kr

[†]Department of Chemistry, Sogang University, Seoul 121-742, Korea. *E-mail: wonkoo@sogang.ac.kr
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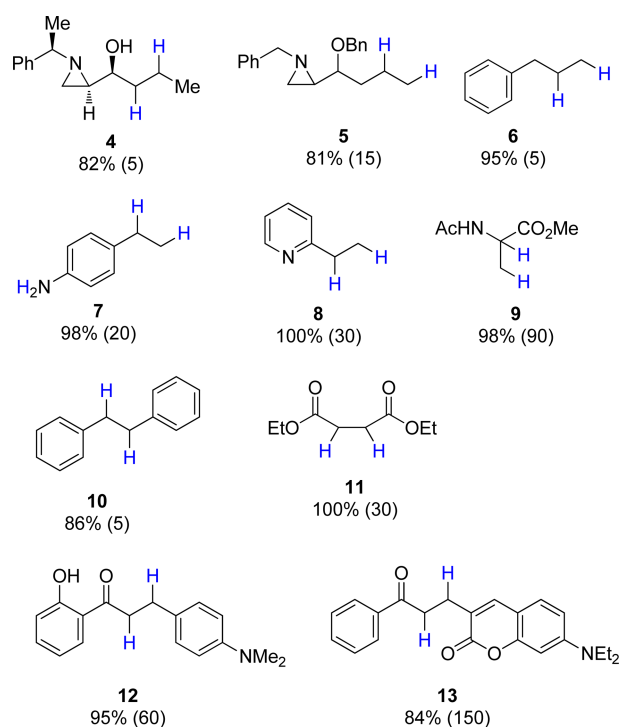
Over the last several years, we have shown that the 2-substituted aziridine (**1**) is a good starting material for the preparation of various amines with synthetic strategies, including functional group manipulation and the ring opening reaction of the aziridine.^{1,2}

To enrich the functionality bearing the aziridine ring, the chemoselective reduction of olefin is required without jeopardizing other functional groups, including phenylethyl or aziridine ring itself. Recently, we discovered a method for the selective reduction of the double bond in 2-vinylaziridines with *o*-nitrobenzenesulfonyl hydrazide (NBSH) in good yield. This protocol worked for most olefins attached to the aziridine ring, which was exemplified in the compound **2**.³ However, there are some drawbacks in using this protocol for general purposes. The reagent NBSH should be prepared prior to use from the corresponding *o*-nitrobenzenesulfonyl chloride and hydrazine.^{3,4} Also, the procedure requires quite an excessive amount of reagent and bases, which are normally four equivalents of NBSH and eight equivalent of Et₃N. Most of these should be removed after finishing the reaction. To avoid these drawbacks, a better method with the hydrogen gas in the presence of metal catalyst is needed. It is quite well known that the aziridine ring may not survive any catalytic hydrogenation conditions.⁵ We decided to find out a way to achieve a reductive hydrogenation method to saturate the olefin in the aziridine ring by the proper control of the reactivity with careful selection of a metal catalyst. We already know that the aziridine ring is opened easily under the hydrogenation condition with any palladium catalysts, including Pd(II) or Pd(0). We thereby decided to reduce the reactivity by adding Lindlar catalyst. Lindlar catalyst consists of 5 wt % palladium supported on porous calcium carbonate with the treatment of various forms of lead and quinoline, *i.e.* a properly deactivated "Pd" catalyst.⁶ With 7.5 mol % of the two mixed catalysts including Pd-C and Lindlar catalyst (2:1 ratio), we obtained the expected

**Scheme 1.** A selective reduction of olefin in **2**.

reaction product in 75% yield without breakage of the aziridine ring (Scheme 1).⁷

This protocol worked well for the reduction of internal olefin in aziridine **4** to yield the expected product in 82%. The chemoselectivity was extended to compound **5** for selective olefin reduction without harming the aziridine and benzyl group attached to the nitrogen and oxygen. This

**Figure 2.** The scope of alkene substrates using the reduction protocol (atmospheric H₂, 7.5 mol % of the mixed catalysts consisted of commercial Pd-C and Lindlar catalyst). Transferred hydrogens are shown in blue. Numbers in parentheses are the reaction times in min.**Figure 1.** Synthetic strategies to utilize 2-substituted aziridine (**1**) for the preparation of various cyclic and acyclic amines.

protocol worked for the olefin as shown in substrate **6** to afford the saturated product in quantitative yield. This hydrogenation method also had the power to reduce the nitro group, showing the conversion of *p*-vinylnitrobenzene to *p*-ethylaniline (**7**) in 98% yield. The reactions worked well, including internal and external olefin with great tolerance of amide and esters in almost quantitative yield within 30 min, exemplified in the compounds **8**, **9**, **10** and **11**. In case of the α,β -unsaturated ketone with aryl group, the reduction occurred selectively at the olefin to afford the product **12** in 95% yield. This protocol is highlighted by the selective reduction of olefin in the compound **13** to yield the product without jeopardizing any possible reduction sites, including the endocyclic olefin. At this moment, we are not aware of the origin of this unusual selectivity without full understanding of the "Mystic" Lindlar catalyst.⁸ We just guess that this successful catalytic hydrogenation was achieved by the proper control of the reactivity in the metal catalyst "Pd" existing by mixing the Pd-C and Lindlar catalysts (2:1 ratio).

In conclusion, the reduction of olefins free from debenzoylation or aziridine ring-opening was achieved by hydrogenation in the presence of mixed commercial catalysts Pd-C and Lindlar catalyst in high yield.

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References and Notes

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7. To a solution of (*R*)-1-[(*R*)-1-(*R*)-1-phenylethyl]aziridin-2-yl]but-3-en-1-ol (**2**) (0.723 g, 0.333 mmol) in EtOH (1.6 mL, 0.2 M) was added Pd-C (17.8 mg, 10 wt % of Pd supported activated carbon, 5 mol % of "Pd") and Lindlar catalyst (17.7 mg, 5 wt % of Pd on calcium carbonate, poisoned with lead 2.5 mol % of "Pd") at rt. The reaction mixture was stirred at rt under atmospheric hydrogen gas. This reaction mixture filtered and washed by extra EtOH (10 mL) and concentrated under *vacuo*. The crude reaction product was purified by silica gel chromatography (EA:HEX = 1:4) to provide the expected product (**3**).
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