Integration of Aerobic Oxidation and Intermolecular Asymmetric Aza-Friedel–Crafts Reactions with a Chiral Bifunctional Heterogeneous Catalyst

Chiral Piperazines by Phosphoric Acid/Metal Nanoparticle Catalysis

**Significance:** Chiral phosphoric acids immobilized on polymer/carbon black-entrapped Au/Pd or Au/Pt nanoparticles (1 and 2, respectively) were prepared according to eq. 1. Catalysts 1 and 2 promoted an aerobic oxidation of benzyl alcohols and subsequent asymmetric aza-Friedel–Crafts reaction with \(N\)-(2-aminoethyl)pyrroles in one pot to give the corresponding chiral piperazines in ≤91% yield and ≤95% ee (eq. 2).

**Comment:** Benzyl methyl sulfide prevents oxidation of the resulting piperazine products to their imine forms. In the sequential reactions of benzyl alcohol and \([2-(1H\text{-pyrrol-1-yl})\text{ethyl}]\)amine, catalyst 1 was recovered by filtration and reused five times without significant loss of its catalytic performance (first run: 92% yield, 89% ee, sixth run: 85% yield, 84% ee).

**Selected examples:**
- 89% yield, 94% ee (with 1)
- 91% yield, 92% ee (with 1)
- 83% yield, 93% ee (with 1)
- 91% yield, 90% ee (with 2)
- 89% yield, 95% ee (with 2)
- 84% yield, 90% ee (with 2)
- 1% yield, 85% ee (with 1)
- 83% yield, 70% ee (with 1)
- 89% yield, 95% ee (with 2)
- 91% yield, 90% ee (with 2)
- 84% yield, 90% ee (with 2)
- 1% yield, 85% ee (with 1)
- 83% yield, 70% ee (with 1)