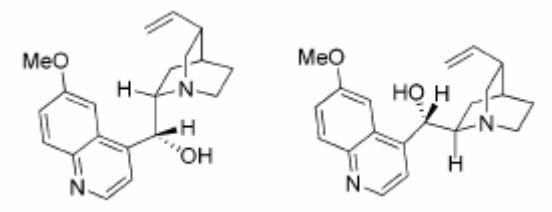
University of Massachusetts Boston
Department of Chemistry
Chemistry Doctoral Program
Green Chemistry Track
Written Qualifying Exam
June 18, 2007

Organic Chemistry I

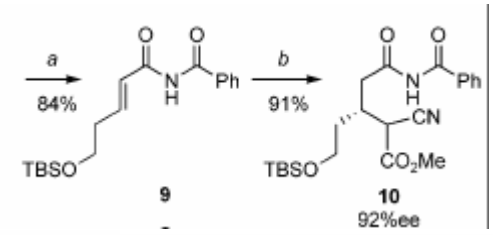
Questions are based on the following article:

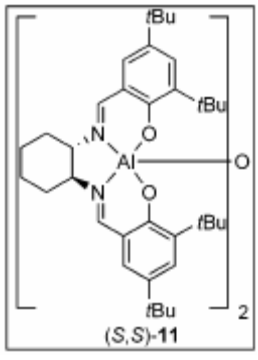
> "Catalytic Asymmetric Total Synthesis of Quinine and Quinidine" Izzat T. Raheem, Steven N. Goodman, and Eric N. Jacobsen. *Journal of the American Chemical Society*, **2004**, 126(3), 706-707.

(1) The final products are chiral compounds.
(**a**) Discuss the basic ways (and illustrate them with at least one example) of the preparation of chiral compounds, and, **(3 points)**
(**b**) Identify the two products by their names and determine the number of chiral centers and their absolute configuration in both structures. **(3 points)**



(2) Propose a *reasonable* mechanism for the following reaction. : **(4 points)**

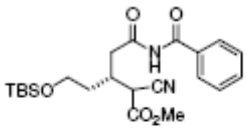




(b) methyl cyanoacetate, (*S*,*S*)-**11** (5 mol %), *t*-BuOH, C_6H_{12}, rt;

Green Chemistry: **(2 points)**

Please, analyze why the above reaction (Question 2) do/do not conform to the principles of green chemistry. The detailed experimental procedure is as follows:



(3*R*)-5-Benzoylamino-3-[2-(tert-butyl-dimethyl-silanyloxy)-ethyl]-2-cyano-5-oxo-pentanoic acid methyl ester (10)[3] Unsaturated imide **9** (12.0 g, 36.0 mmol) was placed in a 500 mL flame-dried round-bottom flask equipped with stirbar, followed by cyclohexane (undistilled, 170 mL), methyl cyanoacetate (7.92 mL, 90 mmol), and (*S,S*)-[(salen)Al]$_2$O ((*S,S*)-**11**, 2.1 g, 1.8 mmol).[3] To this rapidly stirred yellow mixture was added *t*BuOH (undistilled, 4.13 mL, 43.2 mmol) at 23°C. After approximately 48 h, the reaction was judged complete by TLC. The reaction mixture was concentrated, and pumped on high vacuum for 6 h to remove excess methyl cyanoacetate. Flash chromatography (10:1 to 5:1 hexanes : EtOAc) afforded the desired adduct (14.2 g, 91%) as a yellowish oil, which solidified under high vacuum. This material was determined to be 92% ee (Chiralcel OD, 1.5 mL/min, 235 nm, 10%