Total Synthesis of (-)-Vindorosine

1) POCl₃, DMF
2) Boc₂O
3) (S)-tert-butylsulfinamide, Ti(OEt)₄
4) X, LiHMDS, BF₃•OEt₂
5) I₂ (0.2 equiv), THF/H₂O
6) K₂CO₃, NaI, 4-bromo-1-butene

7) TFA
8) CH₂CICOCI
9) NaI
10) AgOTf

step 1: Vilsmeier-Haack reaction

Step 4 involves a named reaction. Which one?
(vinyllogous) Mannich addition

How would you synthesise X from Meldrum's acid? What's the pKₐ of Meldrum's acid?
see below, pKₐ ~ 5

Step 5 involves a named reaction. Please give a plausible mechanism for step 5. See below

Step 10 involves a named reaction. Please provide name and mechanism.
Heathcock-aza-Prins, mechanism see below
11) ClCO₂Me, Na₂CO₃
12) OsO₄, NMO
13) NaIO₄
14) DBU
15) SOCl₂, py, 90 °C
16) NaOMe, MeOH
17) CeCl₃•7H₂O, O₂
18) CeCl₃•7H₂O, NaBH₄

Step 12 involves a named reaction. Please provide the name. Which Nobel prize laureate developed an asymmetric variant? Upjohn dihydroxylation, Barry Sharpless

19) CBr₄, Ph₃P then THF/aq. NaHCO₃
20) m-CPBA, CH₂Cl₂/MeOH
21) HCHO, NaBH₃CN
22) Ac₂O, py, DMAP
23) MeOTf, Y
24) NaBH₄, MeOH

Please provide the name for the reaction used in Step 19. Appel reaction

(−)-Vindorosine
Synthesis of X from Meldrum's acid

Mechanism of step 10

Sulfinamide deprotection