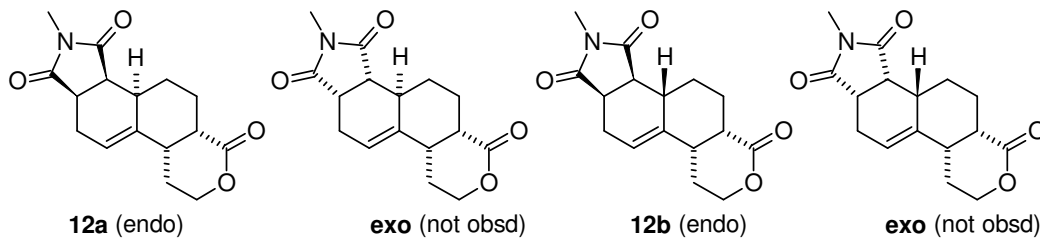


Exam 1 – Selected Answers

1. This problem contained several interesting challenges.

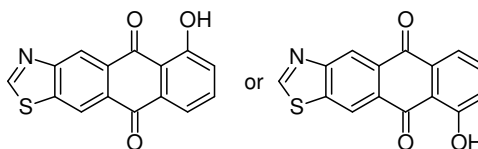
Since compound **12a** contains five stereogenic carbons, there are several ways to create diastereomers of **12a**. I accepted two different answers (there was even a third possibility) since there is no way to decide which one was meant by *dr* without having access to the experimental data. The possible diastereomers and their *exo/endo* labels are provided below:



Several kinds of selectivity operate in this reaction. In order:

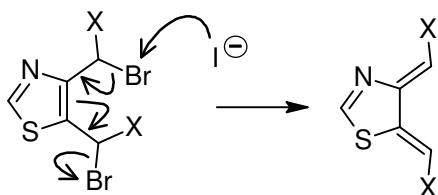
- Diene selectivity. The alcohol contains a six carbon pi system and you can find *two* dienes in this pi system. Undoubtedly the reaction involves the diene that can more easily adopt an *s-cis* conformation.
- Regioselectivity. The formation of **7** is regioselective. You might try to explain this using FMO theory.
- Facial selectivity (one aspect of stereoselectivity). Compounds **12a/b** appear when the dienophile attacks different faces of the diene in **7**. Note that both **12a/b** are both *endo*. Facial selectivity is probably the result of differential steric hindrance/strain effects in the competing transition states.
- *Endo/exo* selectivity (another aspect of stereoselectivity). In the drawing above, the two compounds on the left are *endo/exo* stereoisomers derived from attack of the dienophile on the same face. The same applies to the two stereoisomers on the right. Therefore, each stereoisomer can be distinguished from the other three by 1) choosing the diene face and 2) choosing *endo* or *exo*. We have not examine the basis for *endo/exo* selectivity mainly because I have yet to see a completely convincing explanation for it.

2.



Alternative products are regioisomers:

The mechanism for making the unstable diene can be drawn in a couple of different ways. You should incorporate iodide ion into your mechanism since that was used as a reagent. Iodide might initiate the reaction this way:



Or, another possibility (not shown) is to have bromide ion dissociate from the molecule leaving a carbocation. The resulting cation might be regarded variously as a heterocyclic “benzylic” cation, an “allylic” cation, or a distorted cyclic bromonium ion. Regardless of your point of view, the iodide would attack the electrophilic bromine atom and produce a neutral diene. (Notice that the loss of Br_2 is effectively the reverse of 1,4-addition of Br_2 to a diene.)

The frontier MO analysis involved one trick, but first you had to build useful models of the diene and dienophile. The modeling method and procedure are effectively described by stating “HF/3-21G(*) equilibrium geometry.” There was more than one way to build the dienophile because the OH group can freely rotate around the CO bond. The most stable orientation is the one that produces an intramolecular hydrogen bond.

The next step is to identify the dominant FMO interaction. This involves looking at the MOs of each reagent and finding MOs that have appropriate shapes. This means the correct symmetry and a significant presence on the reacting atoms. The key MOs on the diene are the HOMO and LUMO. The key MOs on the dienophile are HOMO-2 and LUMO. The rest of the analysis was straightforward. The energy gap between HOMO(diene)-LUMO(dienophile) is smaller so this is the dominant interaction. The MOs are nearly symmetric, but the AO orbital coefficients are slightly larger on the starred atoms and these should become bonded together preferentially.

