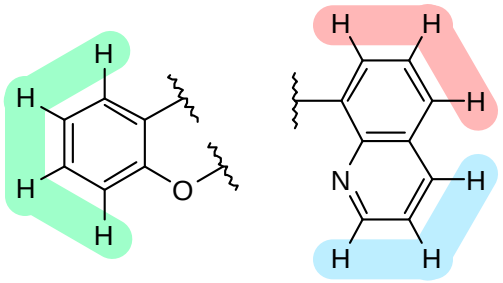
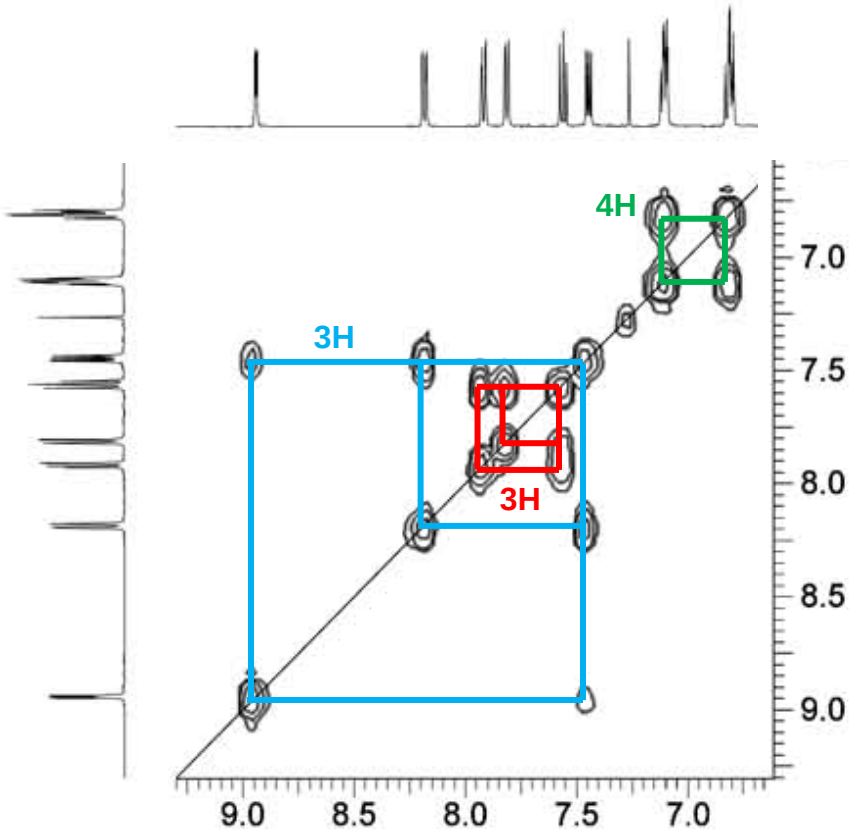
Chemistry 4361/8361 Friday, October 19

Workshop 4 Solutions
Heteronuclear Correlations

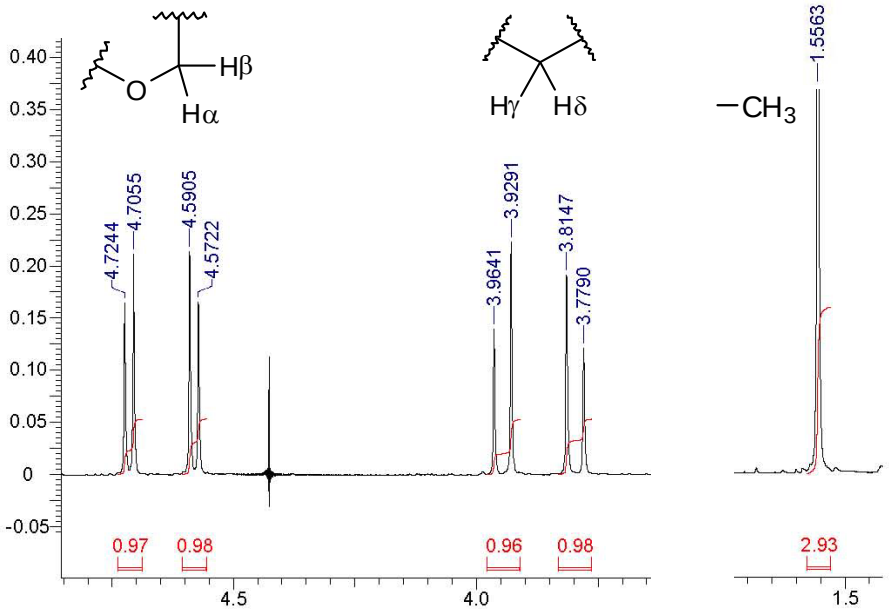
a. All of the protons in the substructures at right are aromatic protons. There are ten protons total, and yay for us, the total intensity of peaks above 6.5 ppm is 10H. But which proton is associated with which substructure? Although we might be able to figure this out from coupling constants, the easier way is to look for coupled proton sets in the COSY spectrum. The aromatic region shows one set of four protons and two sets of three:



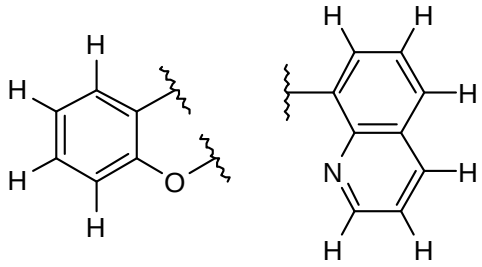


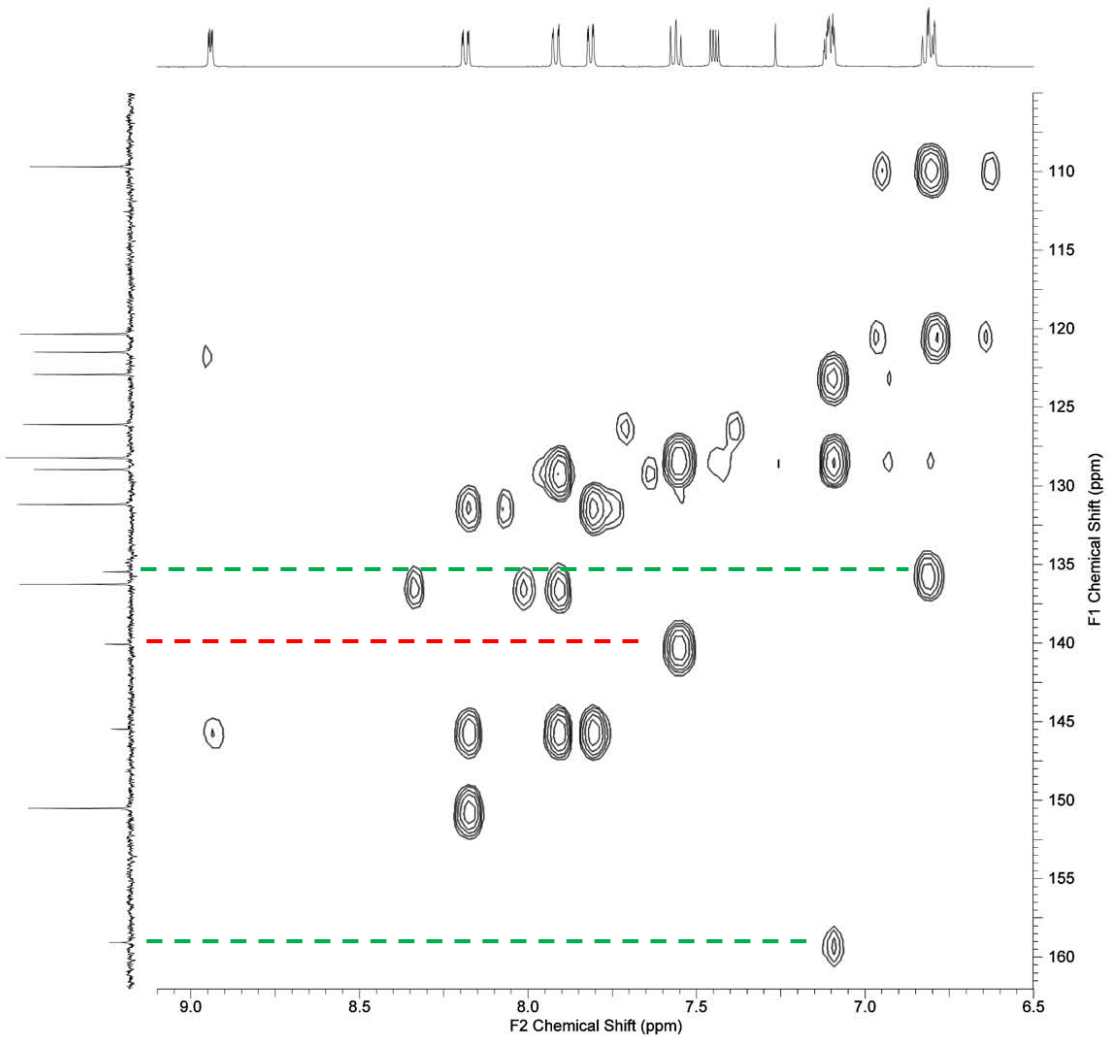
The set of 4H protons is easy to assign to the phenoxy ring. The 3H set with the proton farthest downfield probably belongs to the heteroatom-containing ring of the quinoline (because N is more electronegative than C), and that downfield proton must be the one closest to the nitrogen atom.

Before leaving the topic of proton assignments, it's probably useful to explain what is going on in the remainder of the ^{1}H spectrum. Each of the prospective structures has in the center a carbonyl group, two -CH_2- groups, and a -CH_3 group. For each structure, the individual protons of the -CH_2- groups are inequivalent, which is why there are distorted doublets in the ^{1}H NMR closeup:



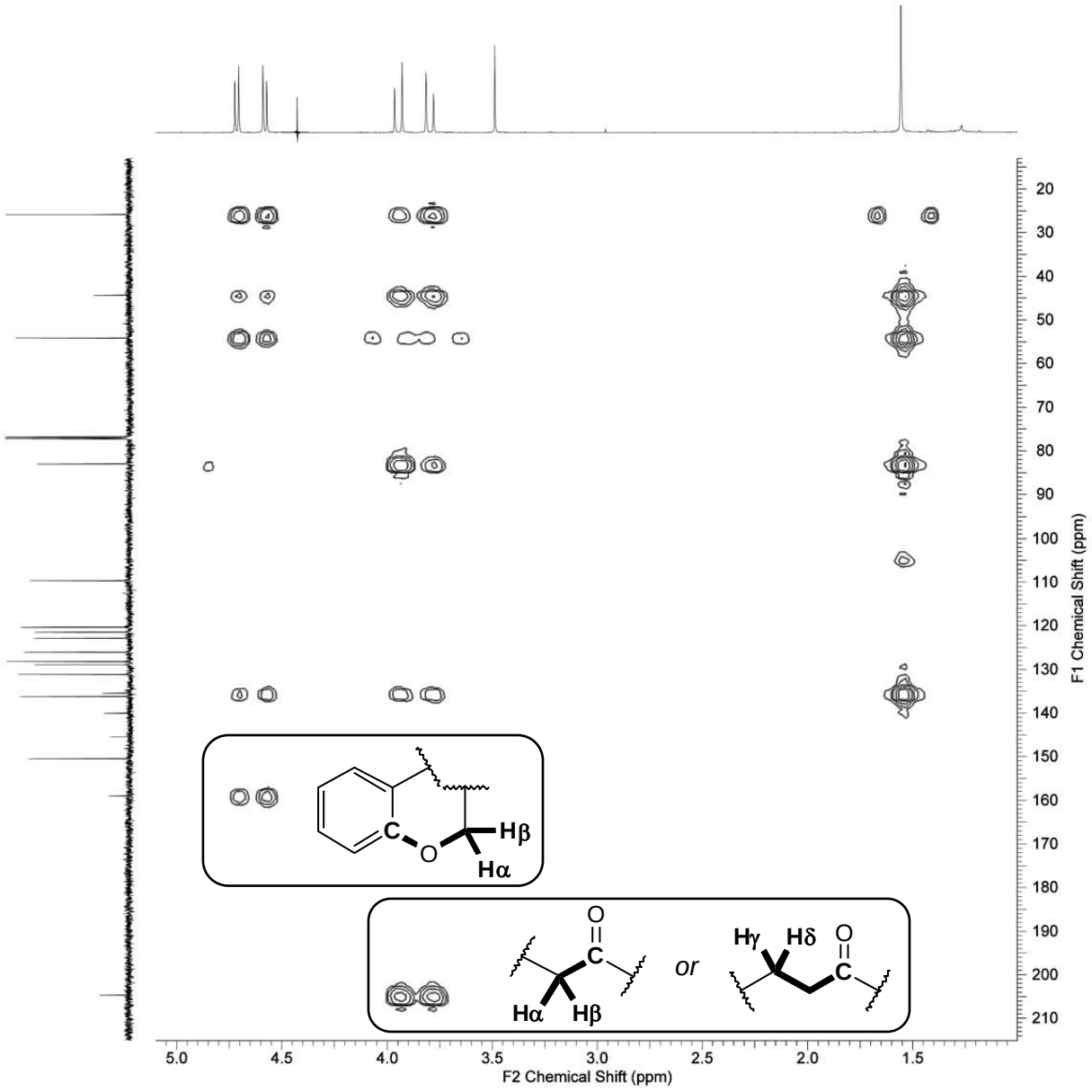
b. The main reason I suggested starting with the aromatic rings was to try to determine which carbons might be closest to which functional groups in the center. That means it might be helpful to determine the chemical shifts of the three carbons next to the squiggles in the drawing on the right. The aromatic rings have only five carbons with no attached protons, and it is pretty easy to distinguish these from the other carbons in the ^{13}C spectrum—they are the five really short peaks. But which peak goes with which carbon? For this, we need HMBC. Which short peak shows long-range coupling to which proton?



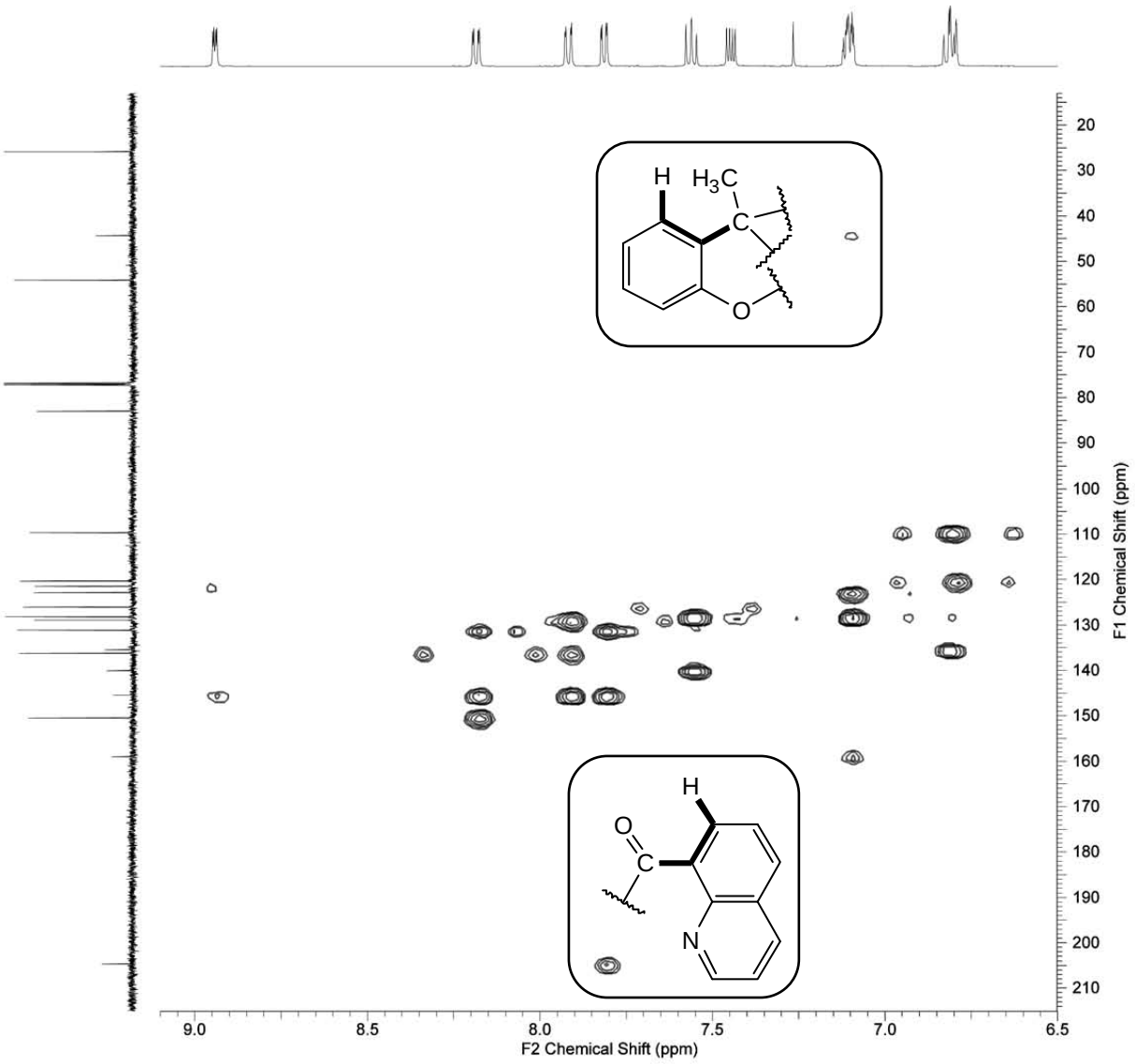


Three ^{13}C peaks stand out because they exhibit J_{HC} with only one partner ^{1}H. Two of them (marked in green) partner with the set of four phenoxy protons; the one farthest downfield must be the oxygen-substituted carbon, and the other one must be, well, the other one. The carbon marked in red must partner with a quinoline set of three, and must be the attachment-site carbon.

The next challenge is to find correlations between these aromatic atoms and the functional groups in the middle of the molecule. What other correlations can we find? Looking at the other HMBC close-ups,



This HMBC closeup wasn't so helpful. Most of the correlations in the top of the spectrum show that the -CH_2- groups and the -CH_3 group are close to each other, which we already know. The first correlation I circled shows that the phenoxy carbon is near the oxygen-substituted -CH_2- group, but that's true by definition, so not so helpful. The second correlation shows that the carbonyl group is 2 or 3 bonds away from the other -CH_2- group. This is actually true for all four structures, so again not so helpful. I will say that it would be unusual for the carbonyl to show three-bond coupling ($^3J_{CH}$) with the -CH_2- group but not the -CH_3 group, and that suggests to me that this is actually a $^2J_{CH}$ (as I've drawn above). If that were true, it would narrow the set of potential structures to two. But it's not conclusive, so I'll hold off from making that judgment.



I thought this closeup was more conclusive. The carbon involved in the crosspeak at the top of the spectrum must be the quaternary carbon; its ^{13}C NMR intensity is low, and it doesn't couple to any protons in the HMQC. The crosspeak shows that this carbon must be close to the phenoxy group, coupling with one of the phenoxy group protons. The carbon at the bottom of the spectrum is the carbonyl, and the crosspeak shows that the carbonyl is adjacent to the quinoline group.

The only structure that meets these criteria is