13.9: ^{13}C NMR SPECTROSCOPY - SIGNAL AVERAGING AND FT-NMR

OBJECTIVES

After completing this section, you should be able to

- Understand why the nuclei C NMR looks at is ^{13}C and not ^{12}C.
- Know why more scans are needed in ^{13}C NMR than ^{1}H NMR.

Most of what we have learned about ^{1}H-NMR spectroscopy also applies to ^{13}C-NMR, although there are several important differences.

SIGNAL STRENGTH IN ^{13}C-NMR SPECTROSCOPY

The ^{12}C isotope of carbon - which accounts for more than 98% of the carbons in organic molecules - does not have a nuclear magnetic moment, and thus is NMR-inactive. Fortunately for organic chemists, however, the ^{13}C isotope, which accounts for 1.1% of the remaining carbon atoms in nature, has a magnetic moment just like protons.

The magnetic moment of a ^{13}C nucleus is much weaker than that of a proton, meaning that NMR signals from ^{13}C nuclei are inherently much weaker than proton signals. This, combined with the low natural abundance of ^{13}C, means that it is much more difficult to observe carbon signals and there is a much lower signal-to-noise ratio than in ^{1}H NMR. Therefore, more concentrated samples are required to generate a useful spectrum, and often the data from hundreds of scans must be averaged in order to bring the signal-to-noise ratio down to acceptable levels. This type of **signal averaging** works since background noise in a spectrum is typically random while the signal caused by the ^{13}C nuclei is not. Therefore if the spectra from multiple scans is averaged, the noise gets closer to 0 while the signal stays the same, increasing the signal-to-noise ratio.

FOURIER TRANSFORM (FT) NMR

Earlier versions of NMR instruments used variable magnetic fields which required recording of each signal in the spectrum sequentially which is called continuous wave (CW) NMR. The **Fourier Transform** allows recording of all signals simultaneously by introducing a short pulse of all RF frequencies that cause resonance for a given nucleus. This complex signal is then manipulated through complex mathematical processing that creates an NMR spectrum that looks similar to a CW spectrum, but in much less time.