Emission Spectroscopy of C2 Produced in a Hydrocarbon/Oxygen Flame

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Practical:

Summary: Spectroscopy provides a means to examine places and things that are not readily accessible. For example, spectroscopy is the tool with which we can determine the composition of stars. It also tells us which species in Earth’s atmosphere protect us from UV radiation, or contribute to the greenhouse effect.

Spectroscopy also provides us a window to examine the microscopic world of atoms and molecules. Measurement of spectra and knowledge of spectroscopic theory provides us with the shape and size of molecules, the bonds that hold them together and their reactivity. In this experiment students use spectroscopy to examine both of these applications: they measure the free radical species present in a flame and use this information to enquire into the chemistry of combustion. Detailed analysis of the C2 spectrum by the students, using quantum theory that is taught in most undergraduate physical chemistry syllabi, allows the structure and bonding of this free radical to be inferred.

In this experiment, the electronic emission spectra of small, diatomic, radicals produced in a hydrocarbon/oxygen flame are recorded and the C2 spectrum is analysed. The experiment begins by having the students observe the emission spectra of atomic species generated in relatively intense discharge lamps. In this way, they become familiar with data collection and interpretation strategies in a relatively straightforward manner. They then move on to study emission spectra of less luminous species present in a flame where they identify common radical species such as C2, CH and/or OH.

The experiment is designed to be run in one afternoon (4-6 hours) for Level II or Level III undergraduates (depending upon individual curriculum requirements).

The aims of the practical are:

To develop competency in the measurement of emission spectra;

To measure and record the discrete molecular transitions in C2, CH and OH from a mixed hydrocarbon/oxygen flame;

To explore the chemistry by which these species are produced;

To analyse the spectrum of C2 in terms of quantum theory of electrons and vibrations of a diatomic molecule;

To use the parameters of the analysis to provide the force constant of C2 in both ground and excited state, and hence infer the bond order of C2 in each state;

To relate the bond order of C2 to theories of bonding, e.g. molecular orbital theory, valence bond theory.

Abstract

The experiment develops practical skills related to the underlying principles of atomic and molecular spectroscopy that is presented in most second and third year lecture courses and extends the application of these principles to combustion chemistry. Students should have a basic knowledge of quantised energy levels in atoms (electronic) and molecules (rotational, vibrational and electronic). Ideally, students should also have an understanding of the spectroscopic concepts of transitions between these levels and the relationship with the electromagnetic spectrum. However, this is not considered essential as students can learn these concepts as part of the experiment.

Duration

Prior to Lab	1 hour
In Laboratory	4-6 hours
After Laboratory	1-2 hours

Further comments

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