Radical research with magnetic molecules

by Dana Coddington and Monique Jacobs

UVic researchers are now able to “see” the magnetic properties of molecules, gathering information useful in a wide range of fields, from creating advanced magnetic materials to developing novel cancer treatments.

This new line of research is being pursued by a team of UVic scientists headed by chemistry professor Robin Hicks using an electron paramagnetic resonance (EPR) spectrometer purchased with a grant from the Natural Sciences and Engineering Research Council of Canada (NSERC).

The EPR spectrometer is designed to detect radicals, which are molecules that have unpaired electrons. Electrons, which are small spinning electrical charges, usually travel in pairs. In radicals, the lone electron creates a magnetic force as it moves around the molecule. By applying a field of electromagnetic energy to a very small sample of material, the EPR spectrometer can produce a “spectrum” which is unique for every kind of radical and provides information on the location of the unpaired electrons within the molecule and the magnetic properties of molecules or solids.

The new spectrometer replaces two 20- to 25-year-old spectrometers made obsolete by advances in computer technology. “Unlike the older models, the new EPR spectrometer has a computer and analytical software built-in, which will let us run much faster and more accurate experiments,” Hicks explains. The new spectrometer is also much more sensitive, allowing even smaller quantities of material to be studied than before.

Hicks and his three graduate students study stable radicals. Normally, radicals are so reactive they can’t be captured before they disappear, but certain kinds — called “stable radicals” — can actually be put in bottles and stored. The spectrometer is leading Hicks to new insights into why they are so stable.

Hicks and his students are making new kinds of stable radicals and studying their EPR spectra at different temperatures. These may be prototypes for new kinds of large molecules, or polymers, with many unpaired electrons that have novel magnetic properties.

Another UVic scientist who will benefit from the new EPR spectrometer is biochemistry and manufacturers use EPR spectrometers to track their movements as the proteins group together. The movements of the radicals tell him how the proteins join and how they puncture the membrane of the cell. Once scientists know how and why the proteins group, they can use this information in designing proteins for specific applications, such as killing cancer cells or preventing the spread of HIV.

“We don’t really know a lot about the basic properties of stable radicals,” Hicks said. “We’re trying to find out what happens to their properties when a small change is made to the structure of the molecule.”

EPR spectrometers like the one at UVic have been enlisted recently in monitoring flavor stability in beer and other foods.

“The foul odor and taste of stale beer comes from chemical reactions that produce radicals,” says UVic chemistry professor Robin Hicks. He explains that the disagreeable flavor and smell is caused by the compounds formed when these radicals decompose. Part of the reason beer should be refrigerated is because the rate that radicals decompose depends on the temperature at which the beer is stored. Often, additives in the beer are used to slow down the radical-generating reactions, explains Hicks.

Beer manufacturers use EPR spectrometry to detect radicals and monitor the process of decaying flavor. This enables brewers and other food manufacturers to predict the expiration date of the product and how long it will last on the shelf or in a refrigerator.

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For further information, visit the online events calendar at www.uvic.ca/events

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