Visualizing Chemistry for Online College Learning: An Introduction to the Hybridization of Atomic Orbitals

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Abstract

This project is designed to help undergraduate organic chemistry students better understand the concept of atomic orbital hybridization. Atomic and hybrid orbitals are mathematical equations that predict the location of electrons in simple atomic molecular models. The concepts of atomic and hybrid orbitals are typically introduced to students early in the first semester and then used extensively throughout both semesters of an organic chemistry course. Traditionally, the basic shapes of atomic orbitals are introduced, followed by possible combinations of the atomic orbitals to form hybrid orbitals. The process of combining atomic orbitals is called hybridization. The hybrid orbitals are used to explain bonding behavior in organic compounds.

These topics tend to be difficult for beginning organic chemistry students to comprehend due to the three-dimensional nature of the orbital shapes. To better conceptualize the hybridization process, animations may be useful.

Development of the Prototype

A prototype has been developed that animates the process of atomic orbitals combining to form hybrid orbitals. Mathematical modeling software, MAPLE 8, was utilized in the development of this prototype. Atomic orbitals are essentially mathematical equations. Just as the expression “y = x” can be represented as a line on a graph, atomic orbitals are representations of equations. These equations provide an indication of the location of electron density in atoms, an important concept to consider in chemical reactivity. Although these equations are fairly complex, they can be shown in a graphical form in MAPLE, allowing students to focus on the shapes and characteristics of the orbitals rather than the equations. Also, these equations can be added in various combinations, producing hybrid orbitals. The hybrid orbitals, also equations, can be represented in MAPLE.

In this project the atomic orbitals are added incrementally to animate the hybridization process. It is hoped that this type of visualization will help chemistry students to better understand this important process.

Implementation and Formative Evaluation

The goal of this project is to adapt the prototype for use as both a lecture aid and a stand-alone instructional module. It has great advantages as a lecture aid in that the various shapes can be rotated and
seen from different views. The animation of the process will also be a useful supplement to the various three-dimensional physical models and static images that are often used in chemistry classes. As a stand-alone instructional module the animations and rotations can be controlled directly by the student.

The prototype has been completed and is being delivered using PowerPoint with animations. It has been used as a lecture aid during the spring of 2003 in a large-lecture Organic Chemistry class at a major southwestern university and also in fall 2003 in a smaller Organic Chemistry class at a community college.

It is planned that the module will also be implemented early in the spring of 2004 as stand-alone instruction in undergraduate chemistry classes, both in campus computer labs and via a course management system, such as Blackboard.

Formative evaluation data will be collected to determine how effective the online module is for student learning, as well as student satisfaction and motivation regarding the module. Measures will include a concept-level quiz about the atomic orbital content, and an attitude survey that includes both Likert-type questions and open-ended questions to determine students' attitudes toward the software, and their motivation about the topic and the online mode of delivery. Students will also be observed using the online module in the labs to determine ease of use and navigability.