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Laboratories and Demonstrations

"Do-It-Yourself" Attenuated Total Reflectance Cell Designed and Constructed in a Laboratory Course: A Versatile and Economical Alternative to Commercial Designs

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An innovator must be able to identify new opportunities, explore the boundaries of technology, and develop and implement technologies.

An attenuated total internal reflectance (ATR) cell has been designed and constructed by a group of four undergraduate and graduate students during an advanced laboratory course in the School of Chemical Engineering at Purdue University. Details for the assembly, which utilizes commercially available optical components, are given in this paper. The cell employs a 45-degree trapezoidal ZnSe crystal as the ATR element. Both spherical and flat gold-coated mirrors are used to focus and align the IR beam.

The cell design presented here not only provides practical instrumentation design and implementation experience for students, it also has four major advantages important for teaching purposes: a) It can be ported between different FTIR spectrometers with similar sample-compartment sizes; b) it provides an economical means for ATR spectroscopy in laboratory courses as the cost of this cell is less than half the price of similar commercial cells; c) all optical parts of the cell

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are easily accessible and visible for demonstration and adjustment purposes; and d) it can serve as a starting point for a variety of student experiments.

Introduction

Innovation in a fast-changing technological world requires new skills from young scientists and engineers that go far beyond traditional expertise. An innovator must be able to identify new opportunities, explore the boundaries of technology, and develop and implement technologies. Therefore, it is one of the most important educational tasks of a modern university, in combination with a strong theoretical foundation, to challenge students in laboratory courses to think, explore, hypothesize, plan, solve, and evaluate their experiments. The typical sequence of development of laboratory skills often stops short of introducing students to these critical aspects of experimental work. In many undergraduate chemistry laboratory courses, experiments are closely managed. Students follow instructions and learn by observing the results with equipment that was already set up for them. More and more, students are also taught how new experiments are designed, and hence to have a good appreciation of what care, planning, design, and testing are required to produce equipment that will give reliable and useful results. All these skills require more freedom than is usually allowed to undergraduate students in well-structured laboratory courses.

The opportunity for students to discover and develop experimental skills is expensive in terms of both hardware and the recurring costs associated with the freedom to make mistakes. Therefore, it is important to carefully use the available equipment resources. In addition, equipment design and experiments should be planned so that future generations of students will be able to benefit from the instrumentation. In this paper, we report a student design of an ATR cell from an advanced laboratory course at Purdue University. This cell design can be easily adapted by other laboratory courses. While the first part of the paper describes the technical design, the last part describes some of the learning experiences the students had while designing the ATR cell.

Introduction to ATR Spectroscopy

ATR spectroscopy is a versatile and effective infrared sampling method widely used in industry. This spectroscopy requires little or no sample preparation for rapid analysis;