Studying Synthetic Polymers in the Undergraduate Chemistry Curriculum

A Review of the Educational Literature

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The Importance of Polymer Education

Synthetic polymers account for a significant proportion of activity in the commercial chemical world and play an important role in modern society. It is estimated that approximately 50% of all professional chemists work within the area of polymer chemistry. Hence, it is important that chemistry students become familiar with polymeric materials as part of their education. Although the foundations of polymer chemistry date back to the 1800s it was not until the 1940s that polymer-related instruction was offered within the university. Since then there has been increased activity in the teaching of polymer chemistry, but the amount of educational material in this important area remains disproportional to that which has been generated in other areas of chemical education.

We reviewed the mainstream literature in the area of polymer education. This review, which appears online, contains 339 references. It is offered to polymer educators as a resource in which the educational literature in polymer chemistry is extensively cited and conveniently classified. It presents an updated account of (i) the scope of polymer chemistry in education, (ii) the educational literature itself, (iii) course modules that may be used for instruction in polymer chemistry, and (iv) polymer experiments for the teaching laboratory. A selection of simple experiments that involve everyday polymers is recommended to encourage the wider inclusion of polymers in the undergraduate chemistry curriculum. A summary of the review is presented here.

Polymers in Chemical Education

Shown in Figure 1a is a plot of the total number of publications devoted to polymers that appear in the mainstream literature on chemical education (viz., the Journal of Chemical Education and Education in Chemistry) versus the year of publication since 1938. It is interesting that a considerable number of these papers were presented in 1981 in response to an American Chemical Society (ACS) symposium that identified the need for further polymer-related instruction in the undergraduate chemistry curriculum and that no similar “burst” of activity has occurred since. A comparison of the cumulative total number of papers in the mainstream educational literature with the cumulative total number of papers that deal in some way with polymer science reveals that there has always been a disproportionate, arguably negligible, growth in the latter compared with the former. Indeed, the under-representation of polymer chemistry in many educational resources has been recognized within the educational literature itself.

The educational literature relating to polymers can be broadly classified into five categories: synthesis, properties, characterization, reactions, and “miscellaneous”; polymer instruction is included in the last category. The percentage of educational literature devoted to each category is displayed in Figure 1b. Excluding the “miscellaneous” category, which as a whole constitutes the largest proportion of the literature (25.4%), the majority of studies focus on the synthesis (23.5%) and properties (18.9%) of polymers; the topics of polymer characterization (14.8%), instruction (10.3%) and reactions (7.1%) are represented to a lesser extent.

In a random survey of 24 textbooks on general chemistry we also obtained an indication of the extent to which polymer chemistry is represented in undergraduate textbooks. Of the texts surveyed, only five contained chapters or sections devoted...
exclusively to polymer chemistry. The others typically included a limited discussion of polymer chemistry in the sections on organic chemistry. Overall, the survey indicated that the topic of polymers is given not only variable treatment (from a few pages in many cases to an entire chapter in a few cases), but insufficient attention overall. Moreover, a close inspection of the textbooks revealed that very little attention is devoted to specific aspects of polymer science such as the chemistry of polymer stability and degradation—an important consideration for the successful commercial and appropriate environmental application of polymers.

Polymers in the Undergraduate Chemistry Curriculum

While it is preferable to incorporate a unit on polymers in an undergraduate chemistry course, this is not always practical. Thus, for students to have sufficient exposure to polymers, this topic must be successfully integrated more widely into the general chemistry curriculum. To achieve this, one useful approach is for teachers to use polymer-related examples to illustrate chemical principles that have traditionally been illustrated with examples that are not related to polymers. The ability of educators to incorporate practical exercises that demonstrate theoretical principles relating to polymer chemistry is also advantageous to student learning. To facilitate this, some laboratory experiments can be designed in a modular way so that various principles and techniques may be adapted to suit a typical chemistry curriculum. To stimulate student interest, particularly when introducing polymers to undergraduate chemistry students, it is recommended that commodity polymers such as poly(ethene), poly(vinyl chloride) (PVC), and poly(styrene) be chosen as examples. These polymers are, of course, very familiar to students in their everyday lives. A number of polymer-based experiments that do not require specialized materials or sophisticated instrumentation may be readily conducted in a general chemistry laboratory. For example, simple chemical reactions, such as the synthesis of Nylon and the “zip” dehydrochlorination of PVC that results in the yellowing of the polymer, may be discussed within the context of reaction chemistry in an undergraduate chemistry course.

The Future Challenge

The continued growth of the polymer field in the chemical world has meant that educators are now faced with the challenge of finding innovative ways to introduce these materials within the context of the undergraduate chemistry curriculum. Despite the commonplace use of polymers in most modern societies, polymer education as an academic subject is widely acknowledged to have lagged behind other areas. As a consequence, there is an immediate need for modern instructional material in polymer science to stimulate and capture the imaginations of undergraduate chemistry students. The review article to which this summary relates is intended to be used as a starting point for the process of developing new and suitable educational material.

Supplemental Material

A comprehensive list of polymer references in the education literature is available in this issue of JCE Online.