# A Polymer Analysis Laboratory at Rose-Hulman Institute

**Jerry A. Caskey, Professor**
**Department of Chemical Engineering**
**Rose-Hulman Institute of Technology**

## Abstract

The production and processing of materials into finished goods constitutes a large part of our present economy. A significant portion of new products are developed from polymeric materials. The chemical engineering department at Rose-Hulman introduced an elective course in Polymer Engineering some years ago. In keeping with our belief that the student understands and appreciates science and engineering principles best after applying them in a laboratory experience, we have made a laboratory an integral part of the course. Through the National Science Foundation ILI program, two analytical tools have been obtained to allow students to perform compositional analysis and some structural analysis on polymeric materials. These tools are a Fourier Transform Infrared Spectrometer(FTIR) and a Thermal Analyzer. The thermal analysis equipment will perform Differential Scanning Calorimetry(DSC) and Thermogravimetric Analysis(TGA). Several projects have been used in class using plastic components from the automotive industry. Projects are also assigned which require student groups to choose a manufactured object and identify the material(s) used in the object. Each group then writes a report summarizing their opinion of the manufacturers choice of material(s) used and suggests alternate materials. Since there are some 12,000 commercially available plastic materials they soon find almost every part has more than one suitable material and in most cases there is no "single" most appropriate material. Several recent student projects will be presented to illustrate the range of materials studied.

## In-Class Demonstrations

In order to help the students obtain familiarity with the equipment and analysis procedures, several manufactured parts from the automotive industry are picked as in-class examples. These are highlighted below.

**Ford Ranger Door Panels.** Shenandoah Plastics in Greencastle, IN has injected molded Ford Ranger door panels for several years. They have provided us with finished and unfinished doors from the 1989-91 model and the 1992-94 model. FTIR, DSC, and TGA analyses are performed each year on the injected molded door panels. The students are asked to identify the materials. Then in class we discuss their findings. The 1989-91 model uses an alloy of polyethylene and polypropylene, commonly referred to as thermoplastic elastomer(TPO). The 1992-94 model door uses an ABS polymer. Several questions are discussed in class. Why change materials? Why was the cheaper TPO replaced by a more expensive ABS? What

other materials could have been used? What mechanical properties are important? The students are asked to examine the design changes in the door and comment on reasons for changes.

**Isuzu Rodeo Air Distribution Ducts.** Arkay Plastics in Paris, IL injection molds the air distribution ducts used in the instrument panel on the Isuzu Rodeo. Arkay has supplied parts for our use. Each year FTIR, DSC, and TGA analyses are performed and the students discuss the results in class. The TGA clearly shows the presence of an inorganic filler at 20 weight per cent. The DSC and FTIR confirm the material used is polypropylene(PP). Among the questions discussed in class are: Why was PP used? Why the filler? Wouldn't PP work well without a filler? Is the filler used to reduce the cost? If so, why not add 30% or 40%? What alternate materials could be used? Discussion follows easily, but students are often frustrated because answers are not easy to come by. After a period of discussion, I point out that the filler is used to reduce flammability to meet government regulations This is a good introduction to reinforce the point that regulations are an important part of design decisions. I then move on to point out that these parts are manufactured and assembled in a just-in-time(JIT) manufacturing facility. This leads to discussion on advantages and disadvantages of JIT manufacturing.

**Isuzu Rodeo Tachometer Cover.** Arkay Plastics in Paris, IL also injection molds the tachometer cover for the Isuzu Rodeo. From parts provided by Arkay, FTIR, DSC and TGA analyses have been performed for the past three years. The FTIR analysis shows the presence of polystyrene(PS) and polyphenylene oxide(PPO). The TGA gives relative percentages of the two polymers. Students then are generally able to identify this material as a common alloy produced by General Electric among other companies. Lots of questions flow naturally from analyses on this manufactured component. Why an alloy? Why this particular alloy? What properties do each of the component polymers bring to bear on the mechanical properties of the part? This opens up discussion on alloy polymers in general. How does one know what polymers are miscible? How can one predict interactions between the two polymers? This discussion makes studying polymer alloys more relevant.

**Kenworth Bumper.** Hoosier Fiberglass in Terre Haute, IN thermoforms the plastic bumpers and side panels used in several models of Kenworth semi-tractors. Hoosier Fiberglass has provided us with samples of both the starting extruded sheet and the final thermoformed bumper. Each year FTIR, DSC and TGA analyses are made. In this case the analyses show that the starting sheet is a coextruded sheet of styrene/acrylonitrile polymer (SAN) on one side and a styrene/butadiene/acrylonitrile polymer(ABS) on the other side. Most of the questions listed above are discussed in class with the additional question of why use a coextruded material? After a period of frustration, I point out that the bumpers are black and owners of the semi-tractors don't want the exposed part to fade to a gray over the next few years. This requires

special additives and inhibitors, general expensive, but not needed throughout the entire part. This introduces the topic of additives of all types.

**GM Automatic Transmission Part.** General Motors has graciously provided us with samples of plastic parts used in several models of their automatic transmission. These manufactured components are good ones to use for in-class discussion, because most students don't think of plastic parts in transmissions. One part that has been used for the past three years is a governor gear. The FTIR, DSC and TGA analyses show this part is a filled nylon with an inorganic filler level at 45%. Several questions naturally arise from the above analyses. Why nylon? What other materials could work? Why the high level of filler? If 45% is good why not 55%? What filler is used? Then another obvious question is asked--what advantages does the filled nylon have over metal? What about resistance to solvents?

The above five manufactured parts have been used as in-class examples to stimulate student interest in the use of plastics as well as learning about polymer analysis techniques. Groups of three are then asked to pick a plastic manufactured part of interest to them and perform the FTIR, DSC and TGA analyses. Each group is asked to write a report summarizing what material or materials were used in the part, what alternate materials could have been used and to discuss the manufacturing technique used. A partial list of manufactured parts chosen and analyzed by the last three classes is given below.

## Parts Chosen by Student Groups.

The parts chosen by student groups tend to be as diverse as the students. Groups with athletic interests have chosen football helmets, pole vaulting poles, roller blade wheels, golf balls and tennis rackets. Other groups have tended to stick to the more academic components like plastic in pens, pencils, calculators, laptop computer covers, floppy disks, notebooks and erasers. Each year there have been groups that want to analyze cassette tape, audio cassette cases, audio CD's, CD-ROM's and other plastic items used in the music area. Silly putty and plastics used in the Glock pistol have been among the most diverse. In some cases the student groups don't seem to have any particular interest. For those groups I have gone to a local lawnmower dealer and obtained a scrap Echo chainsaw, Echo weedeater and Lawnboy lawnmower. These all have numerous interesting plastic components. Whatever manufactured component the students choose, the goal is the same. The students analyze the part, identify the material(s) used, pick an alternate choice of material(s) and discuss the appropriateness of the material and the manufacturing technology.

## Summary

The goal of this NSF sponsored project was to give students exposure to modern analytical techniques used in the plastics industry and to provide laboratory experiences that encourage learning about polymeric materials. The hands-on experiences have certainly been appreciated by the students. In several cases students

have come to me during a subsequent term with with some part or component they have become interested in and want to analyze and study. This is an indication of continued interest in Polymer Engineering.

## Acknowledgments

The author wishes to acknowledge the support of the National Science Foundation through ILI grant DUE-9152044. Appreciation is also expressed to the following companies for supplying manufactured components used as in-class projects: Arkay Plastics, General Motors, Hoosier Fiberglass, Shenandoah Plastics and SIA Automotive.

### Dr. Jerry A. Caskey

Dr. Caskey received his Ph.D. from Clemson University in 1965. Upon graduation from Clemson he worked 2 years as a research engineer for the Dow Chemical Co. From 1967-71 Dr. Caskey taught at Virginia Polytechnic Institute and State University. Dr. Caskey spent 1972 as a research professor at the Israel Institute of Technology. Since 1973 he has taught at Rose-Hulman Institute of Technology.