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Baking Cakes: A Novel Method for Illustrating Processing-Structure-Property Relationships in Materials

Objectives

The primary objective of this exercise is to use the baking of cakes, a commonly recognized process, to illustrate the effects of processing methodology on the resulting structure and properties of materials.

Activity Description

The students bake cakes from scratch. In class, their cakes are examined for surface structure and texture artifacts, cross-sectional morphology, pore size and pore size distribution, and homogeneity. For each observation, a relationship is drawn between the process used to construct the final product and the resulting properties. Relevant processing parameters include raw materials, mixing, forming/casting, and heat treatment.

Grade Levels Intended

This activity has been used in a college level materials processing laboratory course. The students baked cakes at the beginning of the semester and studied them as an introduction to the course. The activity was repeated at the end of the semester after the students had learned processing and characterization techniques. However, this activity can be used with students as early as first grade, but the discussion of the relationships resulting from the activity and the engineering applications must be geared specifically to the audience.

Time Required

The time to make the products ranges from 1.5 to 3.0 hours, depending on the type of recipes attempted and the cooking time for each. The discussion revolving around the final product can take from 0.5 to 1.0 hours. Again, this time is dependent on the audience. We must include an additional 0.5 hours for final characterization – eating the cakes!

Equipment and Supplies

Measuring and mixing implements, pans, ovens and cooling racks are required to prepare the cakes. Wax paper and a cutting implement are required for characterization. A magnifying glass or sheet also can be helpful.

Material Selection for Sustainable Product

This paper will examine materials selection from an eco-efficiency perspective. Typical accounting practices and subsequent management practices have typically placed heavy emphasis on cost reduction via labor rate reduction. However, as automation increases particularly for high volume commodity products the cost of raw materials is becoming the predominant cost factor for most durable goods. Designers need to consider many aspects as they prepare to develop their ideas. Selection of an appropriate material is traditionally made by service demands like: environmental stability, strength of material, density, and manufacturability. The material chosen must also take into account customer satisfaction by providing value at a competitive cost. As raw material costs and concern for the environment increase the selection of appropriate materials is becoming more involved. Sustainability concepts like product take back needs to become a central consideration for designers and managers. Raw material selection based on, life cycle assessment, dematerialization, material input per units of service, and eco-design will be explored in an effort to provide a framework for material selection that mitigates environmental impact and conserves energy.

Basics of Polymer Science and Engineering:

New Modules covering Plastics Characterization and Selection

Objectives

For a number of years I've been assembling a collection of animations that cover basic concepts in Polymer Science Engineering and Technology. Approximately 50 modules are freely available for viewing at www.plastics-elearning.com. This presentation introduces two new modules for the site. One module allows students to analyze an unknown polymer using a variety of virtual characterization tools primarily oriented towards measuring physical properties. Students gain experience making basic measurement and with the analysis of calculated results. The second module serves as an introduction to the selection of the appropriate plastic for a particular application. The module is in two parts; initially we cover basic concepts behind those polymer characteristics that generally dominate physical properties. Polymers are still used primarily, but certainly not exclusively for the wide range of mechanical properties that they exhibit. In this case we have initially limited ourselves to polyethylene type materials for reasons that will become clear.

Activity

The characterization module currently contains nine virtual tools including: -

Differential Scanning	Fourier Transform InfraRed
Calorimetry	Wide Angle X-ray
Thermogravimetric Analysis	Scattering
Gel Permeation	Small Angle X-ray
Chromatography	Scattering
Density by Titration	Instron
Solution Viscosity	

Examples for two of these tools namely Solution Viscosity and Thermogravimetric Analysis are shown below. In all cases it is assumed that the student is familiar with basic concepts behind the tool in question. If not these concepts are covered in other modules on the site.

DSC
TGA
GPC
Density
Soln Visc
FTIR
WAXS
SAXS
Instron



c = 0.10 g/dl
c = 0.15 g/dl
c = 0.20 g/dl

Flow OFF

Timer OFF

0

Note: flow times through narrow and wide portions of this schematic viscometer are NOT adjusted to scale.

Solution Viscosity

Plot specific viscosity and/or inherent viscosity vs. polymer concentration to find intrinsic viscosity $[\eta]$. Remember $[\eta] = K \cdot M^a$. In this system assume $K = 0.002$ and $a = 0.7$ and pure solvent takes exactly 10 seconds to flow between etch marks. Calculate M - viscosity average mol. wt. from the above equation.

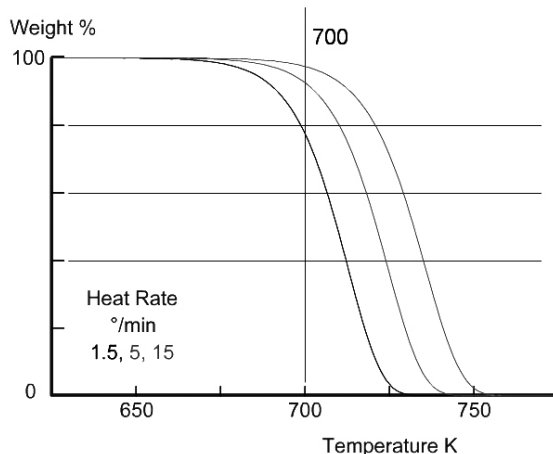
- Select polymer solution concentration before starting flow - and again to repeat expt.
- Turn ON flow with the Flow ON/OFF switch, once flow is started it will run to completion.
- Record the time between etch marks using the Timer ON/OFF switch. Repeat if needed.

Visc. average Mol Wt $M / 1,000 =$

Press to check results; three tries only!

For solution viscosity measurements (a screen capture is shown above) the student is supplied with virtual viscometer filled with a solution of selectable concentration. The student starts solution flowing, and starts and stops a timer as the solution passes fiduciary marks. All runs can be repeated to improve averages. Given times for pure solvent and the value of certain constants it is possible to calculate the viscosity average molecular weight for the polymer. This value is entered into the appropriate box and is checked by the computer based on the sample's randomly selected reference number.

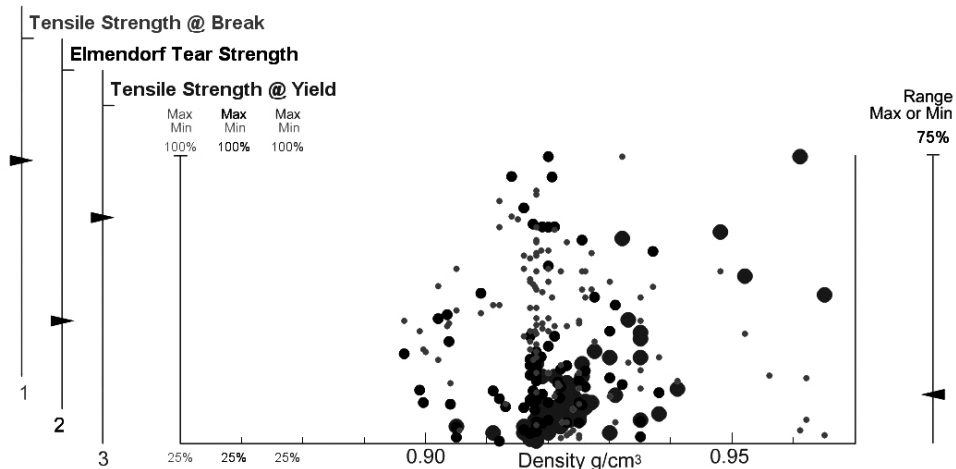
DSC
TGA
GPC
Density
Soln Visc
FTIR
WAXS
SAXS
Instron



E_a (kJ/mole) =

Press to check results;
three tries only!

For TGA above, a sample is assumed to decompose on heating and weight change versus temperature is recorded as a function of heating rate. The temperature at which equivalent weight loss occurs at various heating rates is used to determine the activation energy for this particular sample.



The data set shown above as a screen capture from the Selection module is a collection of PE data available from industry web sites. Users can select resins using the sliders on the left to have three criteria. The primary criterion, in this particular example is that the polymer has a certain Tensile Strength at Break (TSB). Those plastics that have these TSB values are then tested to see if they pass the second test namely they have a certain Elmendorf Tear Strength (ETS). Finally, do they possess a specified Tensile Strength at Yield? The slider at the right establishes the range of acceptable values based on the total range in the database. As noted earlier in addition to the data-base this module contains a separate section covering those parameters that have a major influence on polymer physical properties; mainly mechanical properties in this case.

The modules above are suitable for post high-school students; little or no prior knowledge is assumed although modules build on each other. Since these are all self-paced learning modules it is difficult to specify a time required. The Characterization module would be given as a weeklong homework project, assuming students have already covered the basics of various techniques used; the Selection module would probably be similarly employed. Free web access with a Flash Player is currently employed although students can if they wish download any module for a small fee. Momentum Press will shortly offer an audio enhanced movie version of what are currently non-audio .swf files. These movies are designed with special fonts to play on iPhones[®], iTouch[®] and other smart phones as well as on larger screens.

Defining Sustainability via ISO 14000

What Educators Need to Know

The issue of sustainability is becoming more critical as finite resources become depleted and pollution destroys our habitat. This paper will examine the basic concepts around ISO 14000. As an international standard ISO 14000 encourages corporations to develop environmental management systems (EMS) to support systematic efforts to prevent pollution. This paper will examine ISO 14000's evolution as a "sister" specification to ISO 9000 designed to support quality control. Educators need to understand the fundamental benefits as well as limitations of ISO 14000 certification in order to properly present it to their students within a sustainability construct. This paper will provide educators with the basic concepts that are at the core of an effective EMS such as audits, life cycle analysis, product take-back, and continuous improvement to name a few. Finally, this paper will explore some of the myths and misconception around ISO 14000 as well as the number of ISO 14000 certifications in the United States compared to other developing nations.

Crystal Growth in a Cu-Al alloy

Objective: Provide a visual demonstration of the growth of crystals in metal alloys. We combine this demonstration with a very typical Epsom Salts crystal growing activity to show students the physical structure of metal alloys. Because the crystals of this particular alloy grow very large, and relatively slowly the demonstration provides a real 'gee whiz' impact on the subject. It also leads to meaningful discussion into the effect of eutectics, and the usefulness of binary phase diagrams.

Activity Description: If an alloy of two metals forms a eutectic and a solid solution (or intermetallic compound) on cooling, the eutectic can be poured off and crystals formed by the solid solution will be exposed. An alloy has been prepared by melting equal weights of pure copper and aluminum in one crucible, and holding the materials overnight in the furnace. An intermetallic compound, Al_2Cu and a eutectic are formed. The compound takes the form of large needles if slowly cooled from the molten phase.

1. Heat the Copper-Aluminum alloy up to approximately 700°C and pour it into a hollowed out firebrick resting on a metal surface or a hollow made in dry sand contained in a metal tray.
2. As the liquid cools, you will first observe small bubbles on the surface. Next, you may be able to see a hint of motion just under the surface, as the crystals of metal are forming. Tilt the pan slightly to see this structure. When there seems to be some rigidity or structure inside the liquid, tip the pan to pour off the liquid eutectic phase. Depending on when you decide to tip the pan, you will see large crystals that have formed throughout the system. Note the size of the crystals in the liquid that was poured out as compared to those left behind.

Grade levels intended: High school AP level science class, or undergraduate materials science course.

Time required: About 45 minutes

Equipment and supplies needed: Furnace, crucible, sand in a tray, tongs, safety glasses and gloves. 50% Aluminum – 50% Copper alloy (previously alloyed). (I can bring everything except the furnace)

Project Based Learning for Technology Programs

RapidTech the national center for rapid technologies team will present a classroom demonstration on project based learning for Rapid Digital Manufacturing (RDM) and Rapid Prototyping. Ken Patton, Ed Tackett and Ben Dolan will make up a panel to present teaching methodologies for team approach to project based learning where the attendees will learn the methodology and methods used for team selection. Course and certificate program structure and curriculum will be shared with all attendees. The information and examples provided will assist the instructor in developing a project based approach for their technology discipline. Examples will be provided of student projects with outcomes.

Objectives

1. Provide attendees with a pedagogical approach to project based learning in technology programs.
2. Provide certificate structure for Rapid Digital Manufacturing.
3. Provide methods for establishing balanced teams for technical courses.
4. Provide project team components for a comprehensive approach.
5. Give examples of student projects and outcomes utilizing this approach.
6. Provide Curriculum for RDM courses.

Activity Description

A panel of three from RapidTech will deliver a power point presentation on the above with hand-outs and time for question and answer. There will be time allowed for exchange of ideas and group discussion on approaches to project based learning.

Grade Levels

High school through college will find value in adopting this approach.

Time Required

One hour to 1&1/2 hours

Equipment & Supplies Needed

Projector and screen for power point presentation

Composite Clipboards

Objectives:

- To introduce students to the world of composites and some small finishing operations
- To introduce composite constituents, challenges, and benefits
- To gain a respect for safety and chemicals

Activity Description:

Students are brought into the classroom and a discussion is held about composites. What are they? How are they made? What types of things can be made out of composites?

Before beginning in the lab, while they're still in the classroom, the students get a safety briefing. The chemicals used in this process can be hazardous if not properly handled. Explaining the MSDS sheets is also helpful.

Once in the lab, each student is given a metal plate to clean with acetone. The cleaned plate is then coated with a release agent.

At this stage the students can cut up decorative items to become imbedded into their clipboards. I usually have items made from plastic, such as stickers or sayings, that the students can cut up. I get these items from craft stores. Paper items seem to become saturated with the resin and turn cloudy.

Once the items are cut out, I have the students mix their resin. I use steel cans from soup, chili, and the like. Each can must be labeled with the student's name, the date, and the material that will go into it.

I pre-cut the fibers for the exercise. Any fibers work, it's up to you. The students weigh the fibers and record it. The students will then use the same amount of resin as fibers. I use polyester resin for this activity for safety reasons. It is important to make sure that the resin does not have an air inhibited cure or you will end up with a sticky mess in the morning. Boating resin works well for this exercise.

The students pour the resin into the can and then add 1% MEKP to start the curing process. The resin is thoroughly mixed. At this point, the students only have about 30 minutes to complete the lay-up.

The students then brush a layer of resin onto the release coated area of their plate. Once this initial layer of resin is in place, they can add their decorative items. Then they brush another light layer of resin over the items and place the first layer of fabric down. Any number of plies and orientations can be used and experimented with. Sometimes it's good to have students use different amounts of fiber and then compare the boards once their complete. Add resin in between each layer to fully saturate the layer. If the students run out of resin, they can get more. Try to encourage them to use the least amount of resin needed to saturate all of the fibers. They will get the strongest parts with as little resin as possible but enough resin to coat each fiber thoroughly.

Once all the plies have been used, you can let the resin cure overnight. Be sure to have each laminate labeled. Any extra resin should go into a water bath to cure in the can before disposing it in the garbage.

The next day, remove the lay-up from the plate. Clean the plate and remove any release agent still on the panel.

Trim the edges of the panel using a band saw fit with a very abrasive blade (sometimes called a composite blade). If necessary, file the edges smooth with a file or sandpaper.

Have the students mark the holes for the clip on their board using a permanent marker. Drill the holes using a drill press. Be sure to have a block of wood under the laminate to keep the hole from fracturing the back side of the composite.

Using a pop rivet gun and pop rivets, rivet the clip onto the board.

Grade Levels: 3-10 (3rd grade with more help, especially with the math)

Time Requirement: 2 hours day 1 (not including prep time), 1 hour day 2

Equipment & Supplies:

Band saw with composite blade, acetone, chip brushes, tin/steel cans, stir sticks, nitrile gloves, rags, polyester resin (not air inhibited), MEKP (usually comes with the resin), safety glasses, metal flat plates, pop rivets, pop rivet gun, drill press, drill bit, clipboard clips, sandpaper &/or file, release agent (such as PVA or wax), permanent marker, tape for labeling, MSDS sheets for all chemicals, fibers (any will work)

Abstract submitted to National Educators Workshop in Materials Science, Engineering and Technology

Date submitted: Mon 13 July 2008

Title: Incorporation of a Podcast Contest in Materials Engineering Course for Undergraduates

Objectives:

- a) Show how a nationally-sponsored podcast contest is used in a Materials Engineering course,
- b) Play audio files of materials-based podcasts as examples.

Activity description:

A laptop or other media player(s) will be set up to demonstrate how a podcast contest is incorporated into an undergraduate materials course. Several examples of student-produced materials podcasts will be available for participants to listen to. The podcasts are produced by undergraduates, and are intended to be listened to by middle schoolers and high schoolers in a science curriculum. The podcast contest is administered by ASM International and is open to collegiate Material Advantage chapter members at any university. Three contests have been run since Fall 2007, and a fourth contest will be started in Fall 2008.

Grade levels intended:

Undergraduate engineering students (to produce the podcasts)

Middle-school and high school students (the intended target audience for the podcast)

Time required:

1-2 hours (or less, depending on available time)

Equipment and supplies needed:

Laptop or other audio media player

Speakers and/or headphones