Materials Science- A Continuing Frontier

Background

The search for new materials provides one of the most dynamic frontiers of science. Chemists in diverse fields of science explore novel materials for fuel, construction, manufacturing, and consumption. Every week, amazing new substances are discovered: metals that behave like glass, plastics that conduct electricity, shatterproof windows, and hundreds of products find application at home, work, and school. Many times in the past, new materials have set the stage fo major cultural and technological advances. With natural resources dwindling, the search for new materials has intensified.

In many cases scientists design new materials atom by atom much as an architect designs buildings by assembling wooden frames, windows, and doors. Scientists have learned that certain arrangements of atoms produce materials with predictable properties: groups of metal atoms provide good electrical conductivity; chains of carbon atoms create strong flexible fibers. Many useful materials from plywood to superglue were designed and developed by "material architects." Chemists transform our lives with new discoveries that are both simple and practical.

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A New York chemist intrigued by a gummy substance on drilling equipment experimented many months to produce a pure form of a substance marketed as petroleum jelly. Then, as today, this product is a popular summer and winter product for protecting against chapped lips and wind burns. All drugs on the market undergo testing by chemists. Some drugs, such as aspirin, were derived many decades ago from common plants. Other drugs require more testing and are developed over many years of experimentation.

Chemists often search for materials out of special need, but they often discover new compounds by chance. The search for synthetic rubber led to several fascinating substances, such as "Silly Putty," which eventually led to a million-dollar novelty industry.

Synthesizing of new materials has created entire new industries and helped build some of the world's leading industrial corporations. Chemists at DuPont for instance, working with organic molecules called polymers, discovered that thin strands of the material could be pulled to the thickness of a silky thread, resulting in a man-made textile, Dacron polyester. While investigating the strength of this new material, they invented yet another clear polymer film they called Mylar. Compact audio and video discs are made of Mylar.

Clear tough materials used in the production of windshields and scuba diving masks are examples of the rapidly growing plastics industry. As a material, plastics are used in an amazing array of products. From juice bottles to car bumpers, new frontiers continue to exist for the development and recycling of plastics.

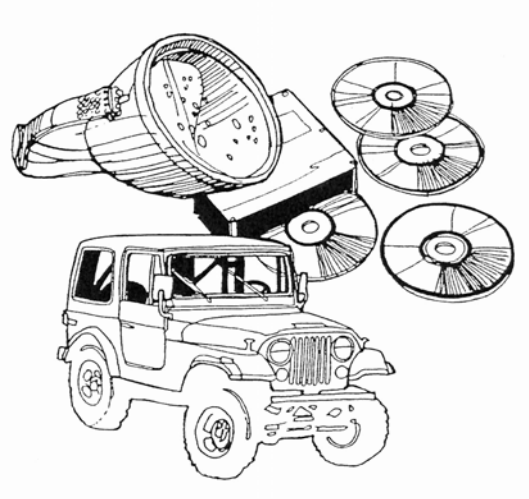
All around you are a remarkable variety of useful material-chemical compounds created to improve our lives. Development of new materials, better use of our raw resources and thoughtful appraisal of how we use and recycle these materials will continue to provide one of the most exciting frontiers in science.

References

Panati, Charles *Extraordinary Origins of Everyday Things* Perennial, Dim York: 1987

Roberts, Reystea *Serendipity* Wiley & Sons Inc.: 1989

Fitzgerald, J.A., Phillips, B.R.,and Tanner, D. The Kevlar Story. *Advanced Materials*. 1989, p. 151-156.



Activity

Here is a unique opportunity for students to compare three unique substances commonly known as Glurch, Oobleck and Slime. Using the following recipes, students can try their own variations of each recipe and record their results.

Classroom Organization/Planning

Divide the class into small working groups of four to five students each. Allow 10- 15 minutes for each group to "manufacture" a sample of each mystery material. This can be done at a central mixing table or individually at each group’s workplace. In the first round of experimentation, have students follow the recipes carefully, since comparison of the three substances by the whole class is the initial objective. This first phase should take at least 45 minutes to allow plenty of time for each group to complete a series of tests on their materials. Group consensus on the outcome of each experiment should be obtained before recording their results. A compilation of the

entire class results can be made at the end of the 45 minute period or used as the initial step in an extension of the activity the next day.

Clean-up of the materials is an important aspect of any science exploration. In all cases these materials should not be poured down sink drains. Have students dispose of their substances in the trash and wash any reusable containers and mixing utensils in soap and water. Although the substances are nontoxic, students should wash their hands at the end of the activity. Oobleck has a tendency to “spread" throughout the entire school if it is not disposed of and cleaned up properly. Also, covering the entire student workspace (desk, countertop) with newspaper or butcher paper at the beginning will help contain the materials during experimentation and assist in the cleanup process at the end. Try not to inhibit the “messing around" that will naturally be a part of this activity. Simply prepare for the mess in advance and have the students help in cleaning up the room at the end of the exploration.

Recipes for Materials

The following recipes and directions for materials "manufacture" are for each group of four to five students. Plastic cottage cheese/margarine containers can serve as mixing bowls and, if necessary, storage containers over a two/three-day period. All of these materials will dry out over time with exposure to air.

I. Glurch

- 1/2 cup of liquid laundry starch or high quality laundry detergent
- 1/4 cup of white glue
- 1/2 teaspoon of salt

Mix the laundry starch and salt first, then add glue, stirring continually. Once a lump of material forms (making it difficult to stir), squeeze remaining liquid from the lump and dispose of this liquid in the trash or a separate "waste sludge" container. The rubbery material that remains is your Glurch.

II. Oobleck

- 1/2 cup of dry cornstarch
- 1/4 cup water

Add water slowly to the cornstarch mixing with fingers until all the powder is wet. It may take a little less or a little more than 1/4 cup of water to get the right consistency. The material should be liquid enough to drip slowly from your fingers, yet feel solid when pressed on the surface (in your container).

Ill. Slime

- 1/2 cup polyvinyl alcohol or guar gum
- 3 tablespoons sodium borate solution

Add all three tablespoons of sodium borate at once to the alcohol, stirring constantly with another spoon or your finger. Once material thickens, stir a little longer, until you get a thick gelatin-like material which can be removed from your container and handled.

Materials for this activity can be purchased through
Flinn Scientific Inc.,
131 Flinn Street,
Batavia, Illinois 60510
(708) 879-6900.

Questioning

Once all of the materials have been manufactured, have students play with them a little in order to become familiar with their unique properties and how best to handle them. Then have each group discuss the unique properties of their mysterious materials, agree upon a one-line description of the material and record these descriptions on a sheet of paper.

Next, have the student groups answer the following questions by conducting comparative tests on these materials and recording their results.

Questions

- Which substance holds its shape the best?
- Which substance bounces the best?
- Which substances leave a mark on your hand?
- Which substance stretches the farthest?
- Which substance flows faster when cooled?
- Which substance changes the most over a period of time?

Once the students have compiled their own group data, have them share their results with the entire class. This can be done both orally and by using a larger, classroom recording chart on the chalkboard. Discuss any variations between group results and have students suggest possible explanations for those variations.

Remember to leave adequate time for classroom clean-up and disposing of the materials properly.

Extensions

Extensions to this activity can be scheduled as small group, individual or full classroom explorations. In any case, remember to allow the necessary time to mix the materials, set up an orderly workspace, and clean-up afterwards.

1. Compare and analyze the effect of different ingredients on the final product. How does each ingredient affect the resulting material?

2. After making the recommended materials, give each group a ball of "Silly Putty." Students can compare the properties of their material with that of a commercial material.

3. Form a "Materials Olympics" where one or several characteristics (bounce, flow, or stretch) are tested between groups that have varied the recipe

Create

Advertise one of your materials on a poster, or in a radio announcement, to describe its special uses and unique characteristics.

Classroom Resources

0obleck. What Do Scientists Do? Lawrence Hall of Science. Great Explorations in Math and Science, University of California, Berkeley, 1985.

Shakhashiri, Bassam. *Chemical Demonstrations, Volume 3*. Wisconsin: University of Wisconsin Press. 1989