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<< back

Science Scope

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Feature

Putting Nano-Tex to the Test

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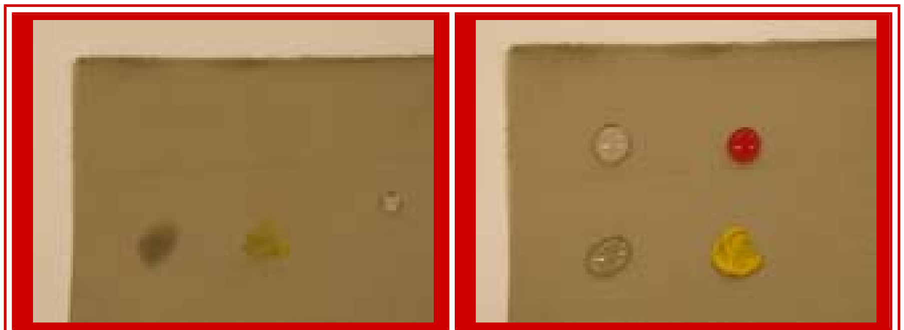

NANO-CARE fabric swatches with (clockwise from top right) water, cranberry juice, mustard, and vegetable oil as they appear after remaining on the fabric for 30 minutes (right) and the same fabrics after the stains have been wiped off with a wet paper towel (left).

Most middle-level students are very appearance-conscious, and an accidental spill in the cafeteria can result in a daylong struggle to cover an embarrassing stain. Thanks to the science of nanotechnology, now students can enjoy a slice of pizza without worrying about their wardrobe.

Nanotechnology deals with machines, materials, and structures and their behaviors at the scale of atoms and molecules, or the *nanoscale*. By working on this scale, scientists are able to create enhanced materials with desirable properties, such as stain-resistance. We developed this activity to introduce middle school students to the everyday applications of nanotechnology, and to give them an opportunity to be real scientists conducting scientific research. The activity challenges students to evaluate a product using detailed observations and experimentation and addresses content from the National Science Education Standards on science inquiry, including designing and conducting a scientific investigation and developing predictions using evidence (NRC 1996).

Students should have a basic understanding of science inquiry and of atoms and molecules before beginning this activity. This activity will fit into any unit about atoms and molecules, the nature of science, or inquiry. Although this activity can be completed in one class period, students may learn more from the activity if it is split into two lab days. On the first day, students would perform the initial observation and design their experiments. On the second day, students would carry out their experiments and present their results.

If you are interested in an interdisciplinary approach, this activity could also be combined with a social studies class studying advertising or mass communication.

Activity materials

Each group of two to four students should have the following at their workstation:

- six swatches of stain-resistant fabric. You can go to a local department store and purchase and cut up a pair of pants or a shirt ($30–$40) made from the fabric. A medium-sized pair of women's pants can yield approximately 80 3" × 3" swatches. A medium women's shirt can yield approximately 100 3" × 3" swatches.

The brands listed on the Nano-Tex website (www.nano-tex.com/products/where.htm) all carry items made from NANO-CARE fabric. To be sure, just look for "nano" someplace on the label. Depending on how vigorously your students test them, swatches may be able to be washed clean and reused—simply follow the care instructions on the original garment.

- three swatches each of two or three other fabrics. You can use 100% cotton, a synthetic fabric such as polyester, and/or a cotton/poly blend. Your school's home economics department may be able to provide these, otherwise remnants can be purchased inexpensively from a fabric or craft store.
- a cafeteria tray or a pan with low sides to put materials in when conducting experiments
- paper towels
- a stopwatch
- sandpaper (optional)
- scissors (optional)
- one large sheet of paper or poster board
- markers

The following materials can be put in a central supply area, but we have found that putting teams at individual workstations stocked with all needed supplies worked best:

- a small amount of several stain agents (see below)
- beakers or cups to hold water and stain agents
- eyedroppers for applying liquid stain agents
- plastic knives or spoons for applying other stain agents
- one fairly large and fairly deep container such as a dishpan or bucket to hold detergent and water for washing fabrics—students may be able to bring suitable items from home, otherwise dishpans are available at many discount stores
- water for washing fabrics—students should only need to fill their buckets with 1–2 inches of water
- a small amount of laundry or dish detergent—it may be easier for the entire class to share one small bottle
- microscopes (optional)

Teacher preparation

Cut the fabric so there are enough swatches for each group to test, per the materials requirements. Each swatch should be no smaller than 3 inches (75 mm) square.

This can be a messy activity, so ask students to move books and other items out of the work zone. Covering the work surface with newspaper or conducting the experiments in a large washtub makes cleanup easier.

Each individual student should have the following:

- a lab notebook or loose-leaf paper and a pen or pencil for recording observations
- a lab coat, a smock, or an apron
- safety goggles

Stain agents

It is important to have a wide variety of stain agents (a few from each category), as the stain-resistant fabrics are designed to repel some and not others.

Liquids

- water
- grape juice or fruit punch
- cooking oil

Given that each group only needs a few teaspoons of each liquid they choose to use, one cup total of each liquid is probably sufficient for a class of 30 students.

Condiments

- ketchup
- mustard
- grape jelly

The small individual packets of ketchup, mustard, and other condiments often found in cafeterias work well for this activity. Each group should only need one packet of each condiment they choose to use.

Others

- acrylic paint
- fabric dye, like that used in tie-dyeing, available from craft and grocery stores
- writing utensils like markers, pens, pencils, or chalk
- dirt or potting soil

Again, only small amounts of each stain agent will be needed.

Observation and investigation

Begin by explaining to students that a new fabric has come onto the market that claims to be extremely stain-resistant. Today, they are going to be teams of researchers and put the claims to the test to see if this special material really is different from fabrics that we already wear every day. Is it really more stain-resistant? Do other properties suffer as a trade-off?

Students should collect three swatches of each fabric, small amounts of several stain agents, and a bucket containing water and detergent for their groups. Teachers should make sure that students don't take more of the stain agents than they need to test the fabric—around a teaspoon—in order to minimize the mess. Students should spend 10 minutes investigating properties of the three different types of fabrics. In addition to investigating stain resistance, students should also test at least one other property, such as water resistance, wrinkle resistance, or durability, as well as examine the general feel and texture of the fabrics. Students should record detailed observations in a laboratory notebook, including variables such as the amount of stain agent they used and the length of time the stain agent stayed on the fabric before they attempted to remove it (Figure 1).

Figure 1. Observing properties of three different fabrics.

The property we are testing is ____

We are using the following procedures to test this property:
____
____
____

Here are our results:

Fabric A	Fabric B	Fabric C
Observations ____________________ ____________________ ____________________ ____________________ ____________________ ____________________	Observations ____________________ ____________________ ____________________ ____________________ ____________________ ___________________	Observations ____________________ ____________________ ____________________ ____________________ ____________________ ____________________
Drawing	Drawing	Drawing

Students usually do not require much guidance for this portion of the activity. However, they tend to be fascinated by the liquid-repellent properties of the Nano-Tex fabrics and may need to be prompted to turn their attention to the other tests.

After 10 minutes, ask students if the claims of extraordinary stain resistance are true. Was the fabric particularly good at repelling certain stains but not others? How did the Nano-Tex fabric compare to the other fabrics, not just in terms of stain resistance, but other properties as well? Students should be able to support their statements with data collected during the observation period. Now would also be a good time to ask if students have additional questions about the fabric. Students' observations and follow-up questions can be collected on the blackboard.

Hypothesis formation and experimentation

The class has just performed a cursory investigation, but careful experimentation is often necessary to determine a material's true properties. This portion of the activity can be started with a discussion of what makes a good scientific experiment. Explain that scientists often first develop a hypothesis—an idea of why things behave the way they do—that is both specific and able to be proven false. This hypothesis is based on existing observations and investigations like the ones students made in the first part of the activity. Once scientists have a hypothesis, they design an experiment to test it.

Characteristics of good experimental design can be discussed, emphasizing the importance of having a control condition in order to assess baseline behavior. The relationship between dependent and independent variables and why it is important to modify only one independent variable at a time should be addressed. Students should have a fairly solid understanding of these ideas before moving onto the group work.

Group work

Figure 2. Nano-Tex fabric experiment: experimental outline.

Our hypothesis is:
____

We are using this base procedure to test our hypothesis:
____
____
____

Our independent variable is
____

Here is how we are going to change the independent variable for each condition:

Control ___________________________________

Condition A _______________________________

Condition B _______________________________

Our dependent variable is ________________________

Here is how we are going to measure the dependent variable:
____
____

Students start by considering the data and observations the class collected earlier and their general experience with fabrics and stains. With this in mind, they should create a hypothesis about what will and will not cause stains on the Nano-Tex fabric. Students then design a simple experiment to test this hypothesis. Students' experiments should contain a control condition and one or two experimental conditions that focus on one independent variable and one dependent variable (Figure 2).

Students often come up with a wide variety of hypotheses and experimental conditions. They may hypothesize that the fabric contains a special coating and they will want to attempt to remove the coating with sandpaper or through repeated washings before staining. Students may want to let a particular stain agent remain on the fabric for varying lengths of time before trying to wash it off. Or they may want to try different classes of stain agents (e.g., water-based substances vs. oily substances) to see if the fabric is more vulnerable to a particular kind of stain. Groups should be encouraged to consult and collaborate with each other throughout the entire process like real researchers (Harwood 2004). It's also important to let students explore their ideas as much as the classroom allows without trying to guide them toward a "right" answer. Teachers should help students improve the quality of their experimental designs, but not hint at the possible outcomes. Some student ideas may require supplies that might not be readily available, such as a microscope. If you can devote more than one class period to this activity, have students design their experiment on one day and perform their experiment on a subsequent day in order to make sure you have all the supplies on hand.

When students have finished designing their experimental procedure, they should gather the supplies they need and carry out the tests. As in the first part of the activity, students should record detailed observations.

Once students have completed their experiment, each group should clean up their work area and prepare and present a poster as part of a scientific presentation. Teachers should stress that the posters/presentations should include enough detail such that another group could duplicate their experiment from what they present.

Students should explain their hypothesis, describe their experimental procedure and their variables of interest, and discuss their results. Students should also address any possible sources of error and suggest future directions for research (Figure 3). Again, other students can be encouraged to ask questions and give feedback to facilitate a real scientific dialogue. Teachers should point out the collaborative nature of the scientific process. For example, one group's findings may supplement another group's findings such that a stronger conclusion can be made. Each presentation/poster should be judged on clarity, amount of detail (i.e., could another group reproduce their experiment?), and quality of arguments (i.e., did they use evidence?).

Figure 3. Nano-Tex experiment: experimental results sheet.

Our hypothesis was:

Here are our results:

Control	Condition A	Condition B
Dependent variable ____________	Dependent variable ____________	Dependent variable ____________
Other observations ____________ ____________	Other observations ____________ ____________	Other observations ____________ ____________
Drawing	Drawing	Drawing

These results
____ support our hypothesis
____ do not support our hypothesis

We think these things might have been sources of error:
____
____

We have these ideas for future research:
____
____

Wrap-up discussion

Begin by leading the class in a discussion on the nature of science and the impact students' research could have on the production and use of this fabric. Address conflicting results by stressing that this is the nature of science—scientists continually refine their experimental designs and methods to get the best data possible and then draw inferences from those. Discuss situations where it would be appropriate to accept one set of results over another (when they conflict, for example, due to error).

This module can be wrapped up by explaining that the Nano-Tex fabric gets its stain-resistant properties from an example of nanotechnology. The fabric is dipped in a solution of "nanowhiskers"—tiny fibers that are 1/1000th the width of a normal cotton fiber. These fibers attach to the fabric like peach fuzz and create a cushion of air around the fabric. This makes the fabric more wrinkle-resistant and causes liquids to bead up and roll off. Because the fibers are on the nanoscale, they are invisible to the naked eye and do not affect the feel or breathability of the fabric (Maney 2001).

Conclusion

Students should come away from this activity with a basic understanding of the nature of scientific research and its progression from observation to experimentation. Although in this case there is an established mechanism to explain why Nano-Tex fabric behaves the way it does—nanoscale fibers that repel water and stains—in science we must develop theories about an underlying mechanism based on the results of many past experiments. It takes many years to begin to understand what the "right" answer is, and in some cases, we may never know.

Students enjoy this activity because it is extremely hands-on. They experience a new perspective on a familiar item and can immediately see possible effects of this technology on their daily lives. In addition, students learn a little about the cutting-edge field of nanotechnology—a field that has already made inroads into society and that holds the potential to revolutionize our lives in the future.

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Resources

Nano-Tex, LLC—http://www.nano-tex.com/

University of Wisconsin–Madison Materials Research Science and Engineering Center Interdisciplinary Education Group. "Exploring the nanoworld." Available online at www.mrsec.wisc.edu/edetc/index.html.

Reuters. Get ready for new "nano" products. *Wired*. Available online at www.wired.com/news/technology/0,1282,59742,00.html.