Creating QuickTime Movies to Demonstrate Lab Experiments

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Creating QuickTime Movies to Demonstrate Lab Experiments

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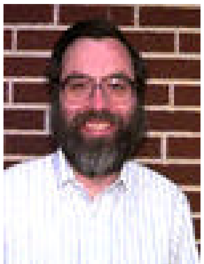

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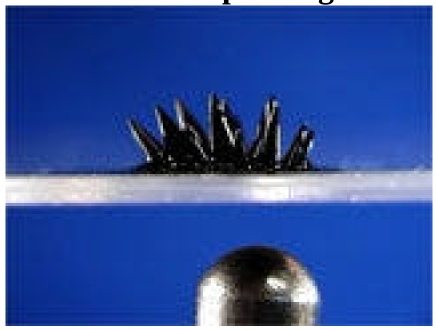
Why use technology?
The use of QuickTime web-accessible videos helped us to demonstrate visually to our students (and other instructors) how to set up a particularly difficult-to-explain lab experiment on ferrofluids. The methodology can readily be extended to other labs.

Originally developed by NASA, a ferrofluid consists of magnetic nanoparticles suspended in a liquid. Ferrofluids have a very captivating property: when you bring a magnet close to them, you see spikes created as the particles attempt to order themselves in the magnetic field, as shown in Figure 1 below.

Figure 1: A ferrofluid responding to a cow magnet



"Ferrofluid synthesis and properties" is an engaging, thought-provoking lab experiment. Students start with two colored solutions that show no visible response to a magnet whatsoever. They mix them together to cause a chemical reaction, apply a few lab procedures, and then, voila, they have this remarkable black liquid that responds to a magnet.

However, some students became frustrated in trying to follow the text-only descriptions and too often did not succeed in producing the ferrofluid. In addition, some of our colleagues had difficulty doing the lab based on an article we wrote about it in the Journal of Chemical Education.

To address these problems, we filmed all the steps of the lab, converted them to QuickTime movies, added written explanations, and made these web-accessible. This conversion into video reduced several paragraphs of dense text to a sequence of easy-to-follow steps. Students really liked the videos describing the process; the videos helped them to understand each step of the lab and to know whether they were on the right track in creating the ferrofluid. The videos also made a difference in their success in the lab: we could tell which students had watched the videos by the ease with which they did the experiment.

In addition to the ferrofluids lab, we have created movies to demonstrate other lab experiments, such as the preparation of colloidal gold particles. These are available at the Materials Research Science and Engineering Center on Nanostructured Materials and Interfaces (MRSEC) website. The MRSEC is generously supported by the National Science Foundation (NSF), where Art is the director of the education and outreach component. These lab experiments and the movies have been created for the purpose of bringing the excitement and results of research on nanoscale science and technology to students, teachers and the general public.

The strategy

The process

Our process was to dissect the lab into a sequence of steps, with written directions. George and Jonathan filmed the stages of the experiments and George formatted them for the web.

For example, the steps that have been filmed for the ferrofluid lab are:

Step 1: Visually checking that the solutions are properly prepared.
Step 2: Mixing and stirring the iron solutions.
Step 3: Precipitating magnetite by slowly adding an ammonium hydroxide solution using a burette.

Step 4: Separating the magnetic stir bar from the product with minimal loss of material. This process is hard to describe in words.

Steps 5-7: Decanting and washing the ferrofluid. Manipulations involving magnets are not common procedures in chemistry laboratories.

Step 8: Adding and mixing the surfactant.

Step 9: Demonstrating the response of the ferrofluid to a magnet, an indication that the preparation was successful.

Using QuickTime

We chose to use QuickTime rather than alternative video players for several reasons. First, QuickTime is popular and easily-accessible: it comes as a standard plug-in with many browsers.

Second, QuickTime can be stopped in the middle of a running movie and advanced frame by frame using the arrow keys. This transforms a "passive" video into an interactive piece of software, enabling students to make more detailed observations of the lab. For example, we have developed another module on amorphous metals in which we do a comparison of an amorphous metal (i.e., one that has tightly-packed atoms but no pattern of packing) to a typical metal like steel (i.e., one that is crystalline with a patterned packing arrangement). The video demonstrates that a bouncing steel ball loses comparatively little energy to the amorphous metal relative to the crystalline metal. Students can use the feature of stopping the video to measure the height of the "bouncing" ball on each bounce to make quantitative comparisons as a function of time for the two surfaces.

Lessons learned along the way

We learned a few things through the process of creating these videos. It is trickier than it looks to decrease the file size while maintaining high quality. Some suggestions:

- Spend time obtaining a good quality movie, because better quality images compress to a smaller size. Use a digital video camera, a tripod, and a plain background. Pay attention to the lighting so that it really highlights the lab.
- Use a good compression algorithm. A minute-long movie can be 100 megabytes to a gigabyte of data and it will need to be reduced to 1-2 megabytes. We use Sorenson compression software and two-pass encoding that is used by graphics professionals.
- We have decided that a reasonable video size is 320 x 240 pixels and a reasonable file size is 1-2 megabytes. This is already a large file -- especially for modem users -- and we do not plan to create larger files or movies sizes in the near future because of the potentially long download time.

Project Support

Funding has come through the NSF-funded Materials Research Science and Engineering Center on Nanostructured Materials and Interfaces (MRSEC). The MRSEC is an interdisciplinary research center based at the University of Wisconsin-Madison that brings dozens of researchers together to conduct cutting-edge research related to nanoscale science and technology. As part of the MRSEC's education component, we try to find effective ways to communicate to different audiences, including students and the public, what the nanoworld is all about, why it is exciting, and why it will have technological and economic impact.

The MRSEC website has many instructional resources that can be drawn upon. In addition to the ferrofluids lab, we have many other experiments that highlight scientific and engineering principles. All of the labs and demonstrations are connected to papers we and others have published. The website also has information about where to purchase the materials needed to do the experiments.

The learning technology

The QuickTime videos that describe the lab setups and experiments involving nanotechnology are available at the MRSEC website.

We started this work before the network connections were fast enough to run these pictures. Originally, we put movies like these along with other materials (animations, text) on solid-state chemistry on a compact disc and distributed them through the Journal of Chemical Education.

The courses

All three of us use the ferrofluid lab in our general chemistry courses. We have done this for several years and have found it successful. One of the things we both try to do in our introductory courses is make chemistry a lot more exciting, by bringing in a connections to high-tech materials and devices. Ferrofluids are a good example: we make clear to students that ferrofluids are used in all kinds of high-tech applications, including disk drives and loudspeakers, and they may have medical applications in the area of drug delivery.

Art's class

I teach a 600-student general chemistry course for science and engineering majors. Many of these students do not plan to become chemistry majors. Jonathan has helped me with the labs to ensure that they ran smoothly. This was the first year (Fall, 2000) that I have used the movies describing the lab process, and I found that the lab required considerably less oversight.

In addition to the QuickTime movies, I use WebCT, which is a type of class management software that the UW-Madison has purchased. I like WebCT because it organizes the course information, including syllabus, lecture notes, announcements and grades, in one place. I have used WebCT to give pre-lab quizzes, in which I ask students questions about the movie to encourage them to watch it prior to the lab. A graduate student teaching assistant, Cindy Widstrand, has helped me to work effectively with WebCT.

George's class

We have much smaller classes at Beloit and have several instructors, who will teach different sections of the same course. During the semester prior to our filming of the ferrofluid lab, only a few students succeeded in the synthesis. I persuaded the other instructors to try again with the videos as a pre-lab assignment. This time, almost all the students were successful in creating the ferrorfluid. I do not believe this means that all the students carefully studied the video before lab, but enough students did so that they could serve as models for others.

Our students are accustomed to accessing web sites and video as part of the course because we use computer-based Wiley ChemConnections modules in this class. These modules center around a particular science-based issue, like the ozone layer or water quality, and were created by the ChemLinks chemistry consortium here at Beloit Colleges and published by John Wiley & Sons.

Student responses

We have found the pre-lab movies to be helpful to many of our students. In fact, in Art's class, 61% of the students who responded to his survey (N=300) found the movies to be useful in their execution of the lab. A few commented on technical difficulties (e.g., unable to get the movie to run), but most students appeared to enjoy the pre-lab movie and found it helpful.

> ***That [the pre-lab] helped out a lot. I knew exactly what I had to do before the lab. It cleared up all the questions I had about the experiment prior to watching the movie. You should do this for all the labs!!!***
>
> ***It helped our group a lot because then we had a better idea of what to do. Sometimes just reading it doesn't give a good enough picture of the lab procedure.***
>
> ***I always learn better when I see something happen first. Also, it cleared up some things in the lab that were described, but I didn't quite completely grasp. At the very least, no one was at a disadvantage of not knowing how the ferrofluid was supposed to work if theirs didn't turn out in lab.***

If you have any questions about the videos or the labs, you can contact Art Ellis at ellis@chem.wisc.edu or George Lisensky at lisensky@beloit.edu.

LINKS
Materials Research Science and Engineering Center Education and Outreach: http://www.mrsec.wisc.edu/edetc
Nanoworld Cineplex: http://www.mrsec.wisc.edu/EDETC/cineplex/index.html
Materials Research Science and Engineering Center: http://www.mrsec.wisc.edu/
Art Ellis' home page: http://www.chem.wisc.edu/~ellis
George Lisensky's home page: http://www.beloit.edu/~chem/lisensky/
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