Using Photos in Lab

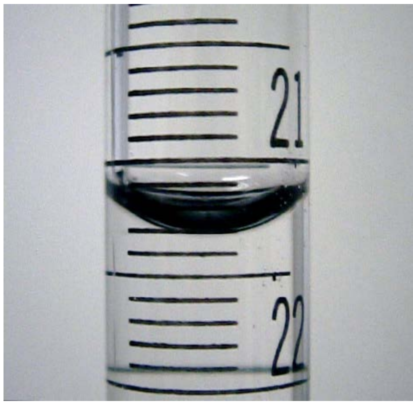
Most of us have our freshmen using graduated cylinders and burets in the lab, and getting students to consistently use correct technique and get accurate readings is a bit of a challenge. I first improved the situation by showing Powerpoint slides of liquids in graduated cylinders and burets. I showed a buret reading card behind the buret. I was doing this in lecture since we didn't have an easy way to show slides in lab. At first I would discuss proper technique and get a bit of feedback from the more active members of the class. This wasn't effective in determining how the weaker students were understanding. Next I used slides with superimposed choices of possible answers of the liquid level and had students choose the correct answer by holding up a card (A,B,C,D) with their choice. Usually after 3-4 examples all of the class was getting it.

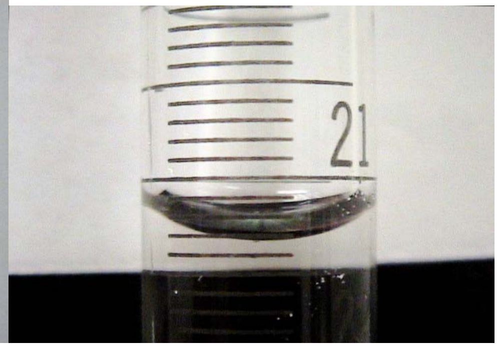
This helped but it is hard to show parallax with photos, and under our system I don't have all the lab students in my lecture, nor do we have an easy method to show Powerpoint slides in lab. I decided to make a tape recording to play on the lab VCR showing how to read the meniscus, and additionally the effect of parallax on the correct reading, lining up exactly parallel to get the correct reading. I currently pause the tape and have students in my lab read the level. One of the problems with this is that the paused image on the screen is sometimes hard to read to the desired accuracy, since it is blurry. Also with over 20 students I have no way of telling how many are getting it till I check their actual readings during their experiment.

Overall the 5-7 minutes spent showing the technique has resulted in significantly fewer mistakes made by students and better overall results from the labs using these techniques. As an additional check of the effectiveness I have a buret and graduated cylinder setup as a practicum during their written final exam. The vast majority of students show correct technique and get an acceptable answer, so there is a long term affect on learning the technique.

Although I have found good improvement I think a still better method with more feedback will be to include high resolution pictures of water levels in the buret and graduated cylinder with the video. If I move to a DVD I could then pause on a sharp easy to read image with choices of possible answers of the water level. Students would then hold up a number of fingers showing their choice. This would allow me to see who is understanding how to read correctly, let them get started, and continue to practice with the students who need more help. This would be useful since we have students clean their equipment before beginning the experiment and with only 3 big sinks available not having everyone start at once would be good.

These two photos were taken with a Nikon Coolpix P3 8.1 M. The one on the right a buret reading card is being used.





These two were taken with a Canon Elura 2 MC digital video camcorder, the video was converted to a photo. My eye doesn’t show the meniscus as sharp as the photo on the left, but using the card gives me better contrast than shown in the photo on the right using a buret reading card.

Does anyone have any suggestions that would make this more useful?

Links:

Oliver Seely

http://www.csudh.edu/oliver/demos/buretuse/buretuse.htm

http://jchemed.chem.wisc.edu/jcesoft/CCA/CCA6/MAIN/1ChemLabMenu/Measuring/Volume/bret_menu/ReadingBuret/MENU.HTM

Book Reviews

With the increased emphasis on our environmental and energy problems I have been including examples of how chemistry can help understand the problems, and find solutions in my lectures. Below are two of the best sources that I use for my own information and creating my Keynote (similar to PowerPoint) presentations. I also have student study groups do semester long projects. Students frequently choose projects with environmental and energy overtones, both of these books are excellent resources for the motivated students working on a project that interests them,

Review of 'Chemistry of the Environment', Thomas Spiro, William Stigliani 2003

I found the first edition of this book very useful for myself and my students as a reference and the second edition is even more useful. The book is excellent in covering thoroughly the chemical aspects of energy and environmental problems. The book is divided into four parts: Energy, Atmosphere, Hydrosphere/Lithosphere, Biosphere.

The authors discuss the advantages and disadvantages of petroleum, natural gas, coal and the ways of handling the emission of CO_2. They include chapters on nuclear, renewable energy, and energy utilization.

I'm particularly impressed with the use of figures which show the many aspects of a system being discussed,with the different contributions from different sources happening at the same time. For instance what happens to the energy annually on earth, organic carbon changing to fossil fuels, energy storage in photosynthesis, maximum work, and systems efficiency, etc. These are great for understanding how many aspects there are to a process.

The section on the atmosphere has chapters that covers air pollution, ozone, climate changes, nitrogen and oxygen chemistry. The section on the hydrosphere covers water resources from a global perspective, properties of water, the importance of acids-bases, solubility, redox reactions, the chemistry of nitrogen and phosphorous. Water quality pollution and its treatment are covered in detail. The section on the biosphere covers toxic materials, the nitrogen cycle in food production use of fertilizers and insecticides.

Dimensional analysis is used extensively throughout and in assigned problems. For instance they calculate an estimate of the energy in a moderate rainstorm to be over a million tons of TNT. They actually show the calculations for other interesting problems such as the increase in energy used in the future with even a small 2.5% annual increase.

You won't find a better or more even-handed exposition of the natural cycles on the Earth emphasizing the importance of understanding the chemistry involved, and our options to keep us and the Earth healthy.

Further information

Review of 'Beyond Oil and Gas: The Methanol Economy'

George Olah (1994 Nobel laureate c*arbocation chemistry,* director of the Loker Hydrocarbon Research Institute), Alain Goeppert, GK Prakash. 2006

Olah and his coauthors do an excellent job going over fossil fuel (coal, natural gas, oil) resources, how close we are to running out of each, the vast number of uses for these resources, and the likelihood of climate change due to their burning. It is assumed that in the future we will have abundant energy available from nuclear and alternative sources. Methanol would then be one of the prime carriers of this energy, and an alternate source for all petrochemicals.

They also cover alternative renewable energy sources, compare using hydrogen versus methanol as a carrier of energy from new renewable energy sources and nuclear energy plants. The authors do a thorough job pointing out the enormous use of hydrocarbons throughout the industrial world for a huge array of products. Not only do we need vast new renewable sources of energy we also need to be able to use this energy to change new carbon sources into useful products. The new source of carbon, methanol from CO_2 and H_2! Olah, et al. shows in great detail how methanol can be changed chemically into the precursors for just about anything and at very high efficiencies. We would use energy from nuclear and new renewable energy sources directly where we can, such as powering our factories and homes' electrical systems. We would use some of this new energy to change CO_2 from emissions and hydrogen from electrolysis of water, into methanol to run our cars, trucks, etc., and provide feedstock for all the products now produced from petroleum. Note that methanol formed this way adds no new CO_2 since CO_2 from the surroundings is used to make it. This is very similar to using ethanol produced from corn or other biomass, except it involves more chemistry.

The new process involves using electrochemical or photochemical reduction of CO_2, which forms methanol, formic acid and formaldehyde, $CO_2 + 2H_2 \rightarrow CH_3OH$ with additional products which are also changed to CH_3OH,

$HCHO + HCO_2H \rightarrow CH_3OH + CO_2$

They don't give a lot of details, because they have a patent pending on the process.

In the interim, while we are developing and building alternative renewable energy sources, we can change coal, natural gas, biomass, etc., into methanol. This is already done to a small degree and existing infrastructure for gas and oil can be used with small adjustments. The authors also compare using hydrogen and methanol, as storage and transport media.

It was a surprise to me that there is more hydrogen in a liter of liquid methanol (98.8 g of hydrogen) than in a liter of liquid hydrogen (70.8 g at -253˚C), water for comparison has 111g of hydrogen. Methanol would store and transport much more easily than liquid hydrogen.

The first sources of CO_2 would be exhaust gas from utilities and big factories, which generate a lot of CO_2, hydrogen would come from water being electrolyzed, $CO_2 + 3H_2 \rightarrow CH_3OH + H_2O$. Then as our CO_2 capture methods get better it would be captured directly from the air. Anyone in the world would with access to energy, would then have a source for a vast array of chemicals! Note that if CO_2 becomes a useful commodity people and nations will compete to pull it out of the atmosphere, and prevent it from being released since it has value. This has much greater appeal than other proposals such as sequestering of the CO_2. A lot would depend on how efficient the process is. It would be useful if they would give some information on this, but Olah replied to me that "...we have of course extensive patent coverage filed for and in process. For obvious reasons in our book we could not go into any details."

The driving force for the Methanol Economy is new energy from nuclear and alternative renewable energy sources, which we don't have yet, replacing hydrocarbons as fuel. Olah, et al. has great confidence that the many problems facing these new energy sources are solvable. The authors are quite negative on the safety of hydrogen, but don't seem to see a major difficult problems with nuclear. Nuclear as we know certainly has its problems, and most of us are wary of nuclear. Scientific American had an article (**December 2005 issue)** on the latest nuclear plant design which uses 99% of the fuel rather than 1% in current plants. It would also have proportionally less radioactive waste, with a much shorter halflife. One of the hookers is using two separate liquid Na (at 600æC) loops as a coolant. Not a minor engineering feat. Another recent Scientific American article Sept 2006, instead sings the praises for 3rd generation nukes with improved technology, but with the same problems we currently have.

A fuel cell is being developed which uses methanol directly.

Anode: $CH_3OH + H_2O \rightarrow CO_2 + 6H^+ + 6e^-$

Cathode: $1.5O_2 + 6H^+ + 6e^- \rightarrow 3H_2O$

Overall: $CH_3OH + 1.5O_2 \rightarrow CO_2 + 2H_2O$

It has a theoretical efficiency of 97%, so far 34% has been achieved, while using H_2 and O_2 in a fuel cell has a theoretical efficiency of 83%. Of course methanol produces CO_2 (which would eventually be used as feedstock) as compared to H_2 which just produces water, a great advantage for hydrogen.

Anytime we contemplate huge installations for generating energy, whether they are nuclear or renewable we face the problem of transporting the energy to the user. Methanol, since it can use existing infrastructure of pipelines, trucks, gas stations with few changes would appear to be far cheaper than hydrogen,. A July 2006 article in Scientific American 'A Power Grid for the Hydrogen Economy' pointed out that our nation's electrical grid is experiencing problems and a possible solution would be to create a new national grid which would carry electricity from distant plants-renewable, nuclear, coal fired etc., by a superconductor cooled by liquid hydrogen. You would have the electricity almost resistance free (about 10% is currently lost in transmission) and the hydrogen for chemical uses. The economics of all these proposals is very hazy.

Some further food for thought is a 1998 study that indicates that the unsubsidized price of gasoline was between $6- 15/gal. A number of other studies place it at $3-11. If their methodology is close to correct then the current subsidy is much higher now, and if this subsidy were available to alternative energy sources they would be much more competitive.

World Primary Energy Production by Source, 1970-2004

Olah, et al., also discuss problems with using concentrated energy sources such as LNG (liquified natural gas) as being a target for terrorists. This is of course true for any concentration of energy or energy production and argues strongly for homes and factories to have energy generating capability, such as solar panels, on their own, energy independence and greater national security.

This is an excellent book and a good source for lecture material, and student projects.

Further

Bookmarks cost of gas

http://72.14.235.104/search?q=cache:PudY29JVPI0J:www.senate.gov/~foreign/testimony/2006/CopulosTestimony060330.pdf

http://www.icta.org/doc/RPG%20security%20update.pdf

http://www.distributiondrive.com/Article4.html

http://www.icta.org/press/release.cfm?news_id=12

Reactions of hydrogen