

ALCOM Education Project has new web site

The ALCOM Education Project (AEP) has created a web site to allow students, teachers, and parents to browse through resource materials developed for K-12 science education. The following is an outline of the site and a brief description of the kinds of resources available on these pages.

The URL for the main homepage of the ALCOM Education Project is:
<http://olbers.kent.edu/alcomed/k12.html>

The main page includes the AEP mission statement and hyperlinks to all the AEP online resources. From the main page, all of the following online resources can be accessed:

Newsletters

Online copies of the ALCOM Education newsletters are available for browsing online. A request for an AEP demonstration kit, a package that includes a printed copy of each ALCOM newsletter and the materials necessary to illustrate the science described in the newsletters, can be posted via an online form linked to this page.

Lesson Plans

ALCOM developed the SAM-Net program with support from the National Science Foundation Directorate for Education and Human Resources, the Ohio Board of Regents Dwight D. Eisenhower Mathematics and Science Program, the Martha Holden Jennings Foundation, and the Portage County School District. SAM-Net has involved math and science teachers and school librarians from Northeast Ohio schools in integrating science, mathematics, and information management instruction. Participating students and teachers explored new approaches to education and the use of technology in the classroom through workshops held at Kent State University, visits by ALCOM scientists to the classrooms, and accounts on the

University's computer system. Results of these interactions can be found on these sections of the AEP web-site.

Ask-A-Scientist

The purpose of "Ask-A-Scientist" is to act as a starting point for students and teachers interested in liquid crystals and the science and mathematics from which they arise: physics, chemistry, mathematics, computer science, polymer science, display engineering, and information management. "Ask-A-Scientist" provides global access to ALCOM scientists, mathematicians, and information specialists and allows the user to pose questions to them.

Liquid Crystal References

Listed on these pages are references to popular works, texts, and monographs on liquid crystal science. This bibliography is a starting point for the teacher or student interested in obtaining more detail on the science behind and in the applications of liquid crystalline materials. In addition to print works on liquid crystals, there are links to other sites supporting educational materials.

Library

The Electronic Library Resources Page links the user to a variety of World Wide Web sites which help support science and mathematics education. All sites linked from this page are external to ALCOM, providing access to science and math information that is beneficial to students and others visiting the AEP site. They are offered through this site as general references.

Polymer Tutorial

Polymers & Liquid Crystals is a pilot program produced by a cooperative effort between the departments of Physics, Macromolecular Science and Engineering at Case Western Reserve University and in conjunction with the Center for Advanced Liquid Crystalline Optical Materials (ALCOM). This

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project is intended to demonstrate the advantages and capabilities of the Hypertext medium as an educational tool.

The Virtual Textbook contains many features that cannot be found in a conventional reference. In addition to comprehensive text, 3-D animations help the user to understand complex structures. Video footage from actual experiments provides valuable perspective. In the unique "virtual laboratory" the user is able to perform his or her own experiments in areas such as polymer growth, phase transformations, and crystalline optics. Full color still images and sound complement the program.

The Online Experiment

A pilot experiment that explores the feasibility of conducting experiments at a distance via the World Wide Web (WWW) demonstrates new possibilities in education over the internet. This initiative is part of ALCOM's educational project and is partly sponsored by NSF's educational program.

The "Experiment at a Distance" enables anyone with WWW access to carry out electro-optic measurements on a liquid crystal cell. The experiment is physically located at the NSF Science and Technology Center for Advanced Liquid Crystalline Optical Materials (ALCOM) at Kent State University in Kent, Ohio. Information entered from the user's entry form is sent directly to the experimental instruments. The result of the measurement is returned to the user's web browser and displayed. The instrument panels and their readings are also displayed. The picture on the user's screen is taken by a video camera interfaced to the computer.

The AEP web-site is an ongoing project of the ALCOM Education Program. We invite educators, parents, and students to offer feedback on how we can make the facility a more useful resource for science education.

Soap Films

The unusual properties of soaps have long been known. If a small amount of soap is added carefully to the surface of water, the behavior of the surface changes, becoming calm and less prone to forming wavelets. Small objects, such as a pin, that might have floated on the water's surface are not able to after the soap is added. A fine powder scattered on the water's surface before the soap is added will be swept off of the surface and aggregate on the edges.

Light scattering studies show that little, if any, of the soap enters into solution in the bulk of the liquid. The change in behavior of the surface can be attributed to a change in the surface tension of fluid. The lack of an effect in the bulk of the fluid can be understood if it is assumed that the soap molecules do not enter the fluid bulk, but remain on the surface of the fluid (see Figure 1). For these reasons, soaps are often called surfactants or surface-active agents.

With the addition of more soap, the bulk properties of the water begin to be affected. Unlike other solutes in water such as ordinary table salt, each soap molecule does not appear to be completely surrounded by water molecules except at low concentrations of soap. The soap molecules are found to clump together into spherical structures that are mixed in with the water. These spherical clumps may be composed entirely of soap molecules, in which case they

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ALCOM Education Outreach is a periodic publication of the NSF Science and Technology Center for Advanced Liquid Crystalline Optical Materials.

ALCOM, a consortium of three Northeast Ohio universities, Kent, Case Western Reserve, and Akron, consolidates the expertise of internationally recognized researchers in liquid crystals and polymers. ALCOM's primary and secondary outreach programs provide summer workshops for gifted students, presentations at local schools, tours for students and educational packages for science students.

We invite you to join us in achieving high educational standards using liquid crystals to motivate and teach students basic principles of physics, chemistry, and information management.

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Web sites:
ALCOM Education Home Page
<http://olbers.kent.edu/alcomed/k12.html>

Ask A Scientist
<http://olbers.kent.edu/alcomed/Ask/ask.html>

ALCOM Home Page
<http://www.alcom.kent.edu/ALCOM/ALCOM.html>

On-line Polymer Liquid Crystal Tutorial
<http://abalone.cwru.edu>

are called micelles (see Figure 2). Alternatively, they may have a ball-like structure, with a shell made up of soap molecules that surrounds a small core of water molecules. These structures are called vesicles (see Figure 3).

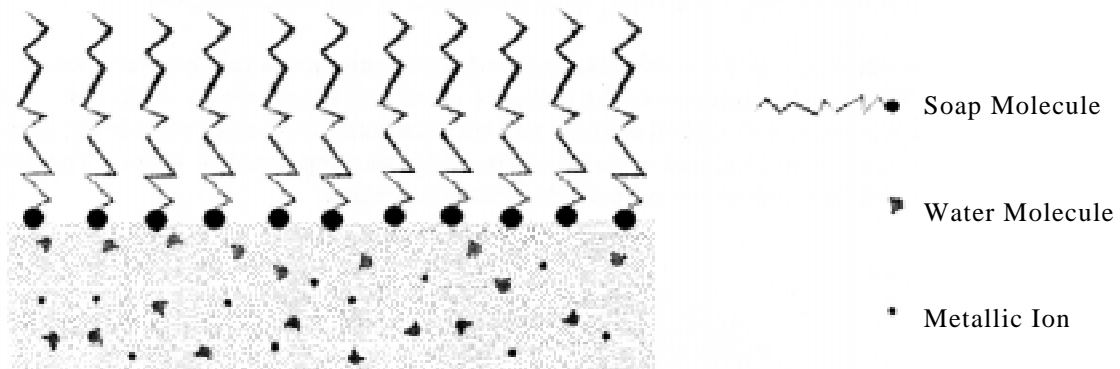


Figure 1. Soap film on water.

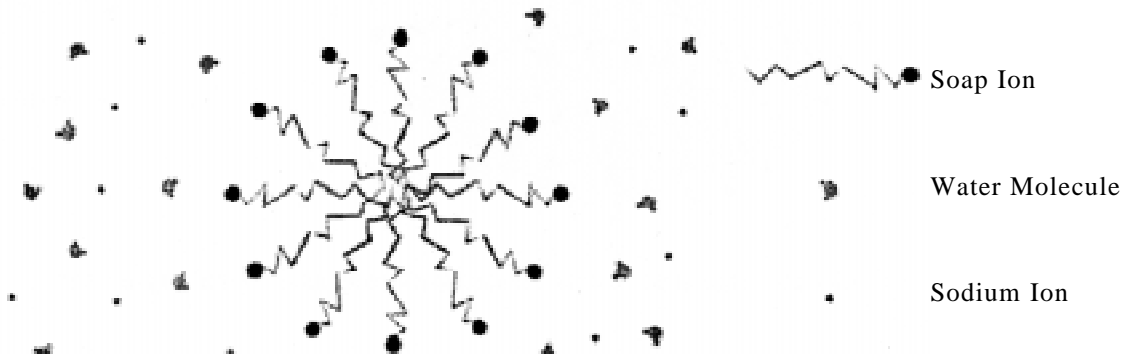


Figure 2. Soap and water micelle structure.

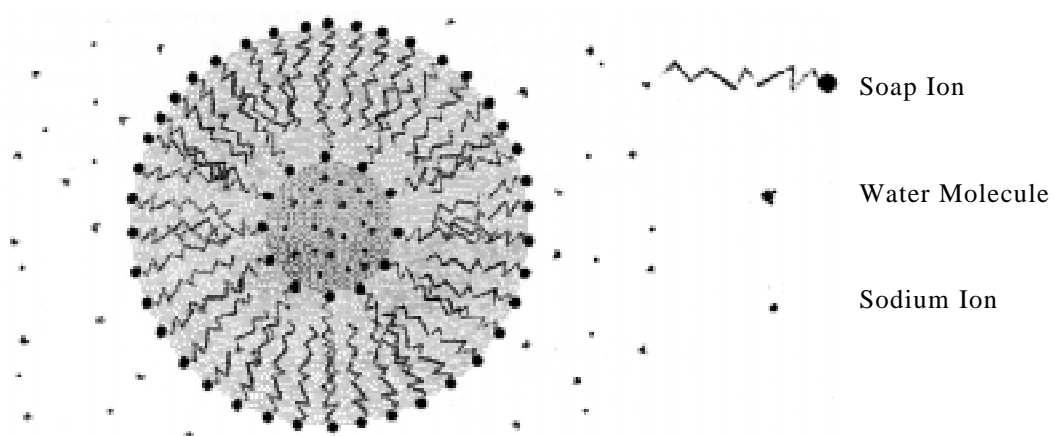


Figure 3. Water and soap vesicle structure.

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Another surprising behavior of soap is that it will also dissolve in nonpolar solvents, such as oil. As a rule of thumb, polar or ionic compounds (table salt, for example) will dissolve in polar solvents (like water) but are insoluble in nonpolar fluids (such as oil), and conversely, nonpolar solutes will dissolve in nonpolar solvents, but not in polar solvents. Soap, dissolvable in both kinds of solvents, is an exception to that rule of thumb.

If one creates a mixture of soap, water, and oil, the soap molecules will migrate to the interface between the oil and water portions of the mix. The micelle structure in the presence of oil and excess water is altered. The core of the micelle will contain oil, surrounded by a thin shell of soap, and with the water molecules outside the shell (see Figure 4). The soap molecules coat the oil droplets and keep them suspended and separated in water. The soap acts as an emulsifying or stabilizing agent, preventing the oil particles from coalescing.

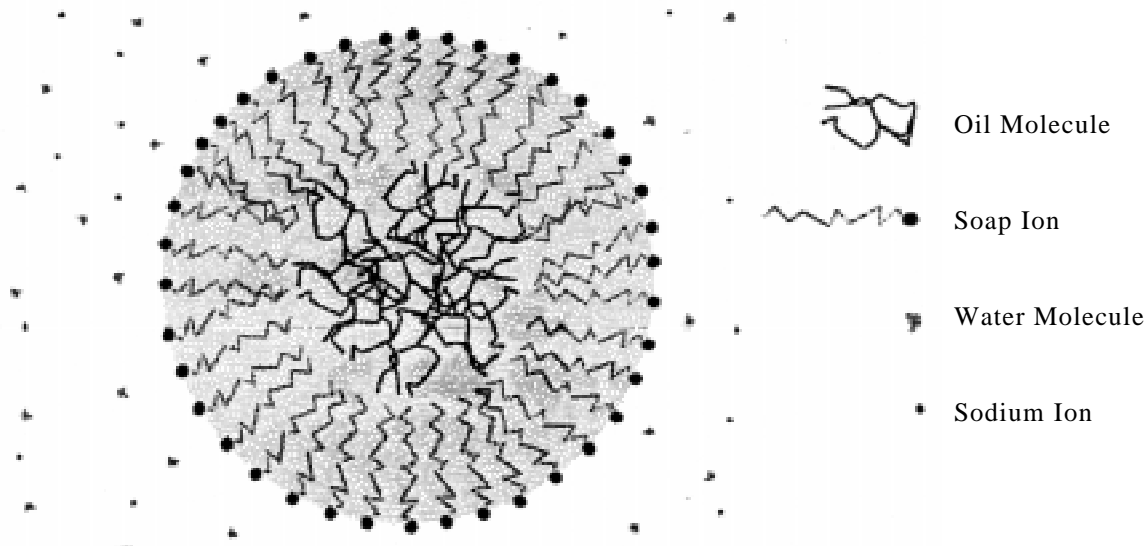


Figure 4. An oil/water emulsion vesicle created with soap as the emulsifying agent.

The soap molecules are seen to

- aggregate on and coat the surface of water
- dissolve in either water or oil
- form micelles in both solvents
- move to the interface between oil and water

These observations suggest that a soap molecule is composed of two parts (see Figure 5). One part, like ordinary table salt, is ionic and will have an affinity for water. The ionic portion of the molecule is termed hydrophilic (“hydro” – Greek meaning “water,” “philo” – meaning “love”). The other end of the molecule is relatively insoluble in water and is termed hydrophobic (“phobic” – meaning “fear”). Other evidence from molecular weight measurements and x-ray diffraction studies indicates that the hydrophilic end of the molecule is a hydrocarbon chain, giving it a tail-like appearance. Molecules such as soap are also called “amphiphilic” because of their nature of migrating to the boundary between oil and water and their ability to dissolve in either polar or nonpolar solvents.

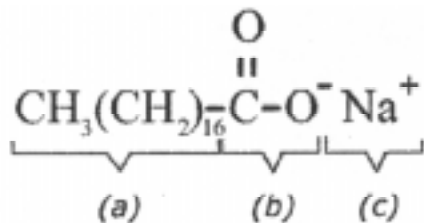


Figure 5. The chemical structure of sodium stearate, a common soap. (a) is the hydrophobic tail, (b) and (c) together represent the hydrophilic head of the molecule. In water, the sodium ion (c) will dissociate from the molecule.

Because of its geometry and its interactions with the solvent, soap molecules will form aggregate, ordered structures in the solvent. The surface film, micelles, and vesicles are examples of such structures. As the concentration of solvent is changed, other structures will form and take the place of the micelles in the bulk of the fluid. For example, at higher soap concentrations, the micelles may coalesce and deform into very long cylinders that pack in the solvent in the form of a two-dimensional hexagonal array, like logs stacked one over the other.

At even higher concentrations, these cylinders may evolve into extended soap bilayers or lamella, with solvent in-between each layer. Increasing the temperature when either the hexagonal or lamellar ordering is present in the soap molecules will reintroduce the micelle ordering.

The aggregate structures that the soap molecules form have different degrees of order than the solvent fluid in which they occur. These aggregates are primarily composed of one constituent, the soap molecules. One can speak of the soap having phases in water in the same sense of a single component system having different phases. These phases of soap in water are called lyotropic phases, and are sensitive to both water concentration and temperature. The lyotropic phases are a type of liquid crystalline ordering.

The lyotropic phases are distinct from the thermotropic liquid crystal phases that have been introduced before in these newsletters. Thermotropic liquid crystal systems consist of only liquid crystalline molecules without any solvent component present. The phases of the thermotropic materials will depend only on temperature. With the presence of two components in the lyotropic systems, soap and water, the soap/water lyotropic phases can depend on both concentration and temperature.

There are two broad categories of liquid crystalline phases - nematic and smectic. In a nematic liquid crystal phase, the rod-like molecules of the material are free to move about, and no long-range order is present in terms of the location of the centers of each of these molecules with respect to the other molecules. However, each of the rod-like molecules will be oriented to point in the same direction as its neighbors. In this way, the nematics show orientational ordering without being spatially ordered.

Layered structures occur in the smectic phases. In the simplest of the smectic phases, the liquid crystal molecules lie parallel to one another, with the long axis of the molecules directed perpendicularly to the plane of the layer in which they are found. Within the plane of the layers, the centers of the molecules are unordered and fluid. The smectics show a degree of ordering between a solid and a nematic. Like a nematic, the molecules lie parallel to one another.

The molecules of a smectic display the spatial ordering of a solid in the one dimension in which the layering forms, but they retain the disordered fluid character of a liquid in the two directions perpendicular to the layering direction. In the plane of the layers, the molecules are free to move. They retain the character of a fluid in the layer.

The root of the word, "smectic" comes from the Greek word for "soap." In fact, the molecules of soap on the free surface of water and in the micelles, lamella, and hexagonal phases are ordered in layer-like structures in the same way as the different smectic phases. The micelles themselves can also form liquid crystalline ordering that is reminiscent of the nematic phase. Under the right conditions, non-spherical micelles can be formed. These micelles can be elongated in the form of rods, or flat in the form of disks, depending on the conditions of their formation. In either case, the micelles' symmetry axis will orient in the same manner as thermotropic nematic phases.

Experiments with Soap Films

(1) Surface Films of Soap on Water

Select a shallow plate (a petri dish works well) and rinse it until you are sure that it is very clean. Fill the plate with cold water and let it stand for a time on a table until the water is still. Sprinkle some talcum powder (finely ground pepper will work as well) lightly over the surface of the water. Wet a piece of soap and touch it to the water near the edge of the petri dish. What happens to the powder? Can you explain why this happens?

(2) Surface Films of Oil on Water.

Repeat the above experiment, but instead of soap, place one drop of cooking oil near the edge of the plate. How does the oil affect the water?

(3) Surface tension and Surface Soap Films.

Set up the plate of water as above. Make a loop with a

fine thread. Open the loop a little, and float it carefully on the water's surface. Touch the surface inside the loop with a bit of soap. What happens? Why?

(4) Soap as an Emulsifier of Oil in Water.

Select a clear glass jar with a lid. The jar should be small but large enough to hold about a half cup of water. Rinse the jar and lid until they are very clean. Partially fill the jar with water, then add a thin layer of cooking oil on top of the water. Cap the jar and shake it well. Set the jar down and let it sit for a time. What do you see? Now add a drop of liquid soap to the jar. Mix the soap, water, and oil well, but not so vigorously as to foam up the oil surface. Let the mixture sit for a time. How does the oil look now? How does the water portion of the mixture look? Add some more soap to the

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jar and mix again. Let the mixture sit for a time again. How does the oil look now? Can you explain what you are seeing?

(5) **Lyotropic Phases of Soap in Water.**

Use the clear glass jar with a lid that was used in the last experiment. Rinse the jar and lid until they are very clean. Partially fill the jar with water. What is the appearance of the water? Now add a little bit of soap and mix it well, but not so vigorously as to foam the solution. What is the appearance of the water? Continue mixing soap into the solution until the soap no longer dissolves. How has the appearance of the solution changed? How can you explain the change in appearance?

(6) **Freely Suspended Films of Soap.**

Create a square frame from a stretch of wire of about two and quarter feet in length. Each edge of the frame will be about six inches in length. Close the square loop by twisting it around the starting end. With the remaining wire, form a small loop from which you may suspend the frame. In a shallow pan, dissolve approximately two tablespoonfuls of soap into two cups of warm water. Let the solution stand for a while (preferably

overnight). For longer lasting films, add a couple of drops of glycerine to the solution. Dip the square frame into the soap solution and observe the films. It is helpful to have a hook by which to suspend the frame from over the pan of soap solution. It is also helpful to have a very dark background behind the frame and a strong, bright light source in front of the frame. What do you observe occurring on the film? What colors do you see, and in what order do they occur? Let the film stand for a time. What do you observe now?

Resources

1. Boys, Charles Vernon. *Soap Bubbles: Their Colors and the Forces Which Mold Them*. New York: Thomas Y. Crowell, 1962.
2. Isenberg, Cyril. *The Science of Soap Films and Soap Bubbles*. Avon, England: Tieto, 1978.
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