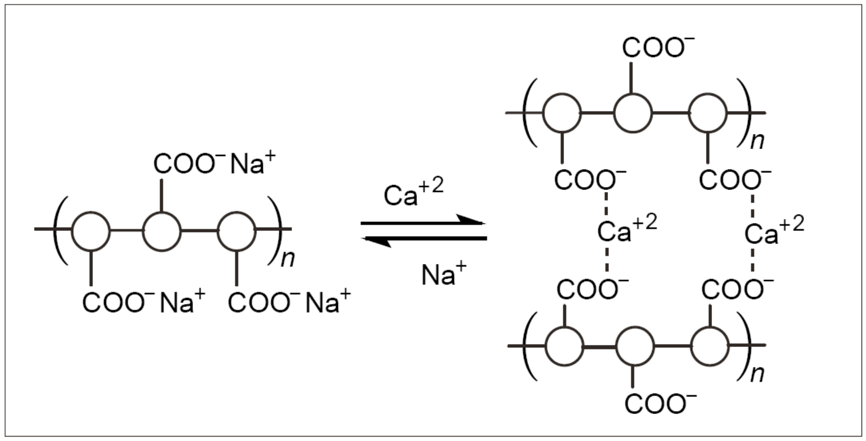
Nanotechnology Research Experience for Teachers

Rice University
Summer 2010

ENCAPSULATION ACTIVITY	**Created by: Michelle Black/Hitesh Bagaria**
Subject	Chemistry
Grade Levels	11-12
Essential Question	Is there a type of bonding that is present in nature that is not your typical ionic or covalent bonding?
Science Objectives	• Know that physical and chemical properties can be used to describe and classify matter. • Recognize and classify pure substances and mixtures. • Classify chemical reactions. Describe the evidence that a chemical reaction has occurred. • Understand chemical kinetics. • Describe intermolecular forces. • Basic structure and function of biological molecules.

Lesson Activities

Engage	Students see a video presentation or have a discussion on encapsulation. They are asked what are the common links between all kinds of encapsulation. What does encapsulation mean? How does it affect us? How is it used in everyday life?
Explore	Students will make capsules that are made of a calcium chloride solution and a sodium alginate solution. The two solutions will bond using electrostatic forces (calcium = pos. and alginate = neg.) Using this model, students discover the intricacies of intermolecular forces. Students then quantify the kinetics of the release rate of the dye in the capsules they have made using the UV/Vis Spectrophotometer. Absorbance indicates release rate (kinetic activity) of the capsules.
Explain	Students answer a variety of questions to tie the model capsule to the typical bonding model and to describe the intermolecular forces in place during the making of the capsules. Students will quantify the release rate using absorbance indicators through UV/Vis spectroscopy.



The negative oxygen ions found in sodium alginic acid (polymer) on left reacts with positive calcium ions. This electronegative bonding forms the structure of the capsules.

Elaborate

Students will collect samples from their supernatant at differing times and take absorbance readings on the UV/Vis Spectrophotometer. After collecting data for four different time intervals, students will graph this data.

Students will work in small groups to predict how this technique could be used in other applications. Students form hypotheses indicating their prior knowledge of bonding/kinetics to apply to our laboratory investigation.

Evaluate

Students are evaluated on their laboratory technique, ability to distinguish and use the proper chemistry lab equipment and on their ability to correlate this new information to existing knowledge.

Students will be evaluated on their ability to correctly make a line graph from the absorbance data collected.

Materials

- UV/Vis Spectrophotometer (Spec 20)
- 4 UV/Vis cuvettes or test tubes per group + 1 blank cuvette or test tube
- Food dye-liquid (commonly found at grocery stores)
- Alginic acid sodium salt-low viscosity - Sigma Aldrich #A2158
- Calcium chloride - Sigma-Aldrich #223506
- Beral Pipets, Thin Stem (1 per group)- Flinn Scientific #AP1444
- Beral Pipets, Extra-Large Bulb (1 per group) - Flinn Scientific #AP1445
- Laboratory timers – any (1 per group)

Solutions to be prepared

Solutions should be made prior to class, as the alginate solution must be stirred an extended period.

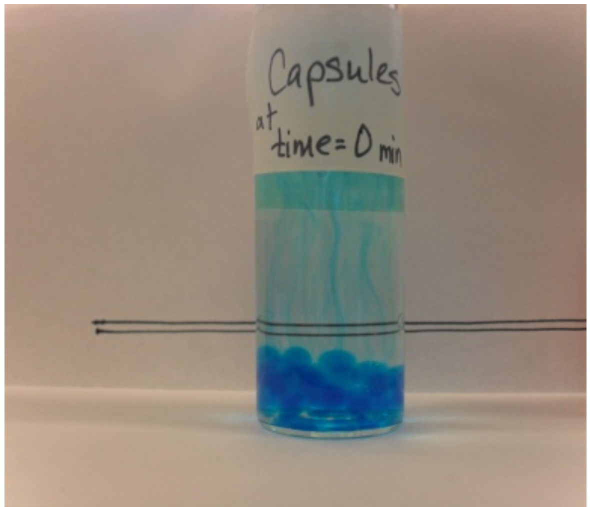
Calcium chloride solution → Dissolve 1.0gram $CaCl_2$ in 100mL distilled water.

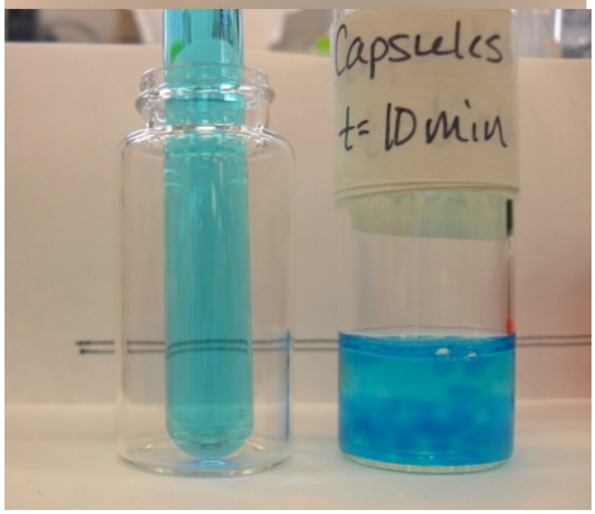
This is enough for one group.

Alginic acid sodium salt (alginate solution) → Dissolve 2.0grams alginic acid sodium salt (low viscosity) in 100mL distilled water with stirring on a magnetic stir plate (set on 7) for 15 to 20 minutes. After all solids have dissolved, add 5 drops of food coloring. This is enough for 20 groups.

Photographs

The following are pictures taken during the course of the laboratory experiment.


Capsules
at time = 0 min


Capsules
t= 10 min

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Information for Teachers

Standards	• CRS Chemistry VII E-6 • CRS Chemistry VII I-7 • CRS Chemistry VII J-1
Prior Student Learning	Students should have a working knowledge of how chemical reactions occur. They should understand that there are intermolecular forces working to "pull" atoms together and/or "push" atoms apart during a reaction. Students should be able to make a graph from data they have collected. As an extension, students should have some understanding of how this relates to enzymes.
Possible Prior Misconceptions	Students may think that all bonds are either ionic (metal to nonmetal) or covalent (nonmetal to nonmetal) and may not truly understand the other intermolecular forces that are present in reactions. Also, students may think that they are just dropping "drops" of the alginic acid solutions (alginate) and not that they are actually making capsules. For this reason, teachers should be sure to include #7 on the lesson sequence. Number 7 clearly shows that when the alginate is dropped into water, no capsules are formed and the blue alginate solution just dissipates.
Lesson Sequence	**1.** Brief overview by teacher regarding how bonding via electrostatic interaction (The positive charge on one molecule is electrostatically attracted the negative charge on a neighboring molecule) works. **2.** Discussion held regarding the new advances in technology, specifically those in the field of nanotechnology. There is more and more research done in the field on nanoencapsulation. That is, encapsulating something at the very small scale (10^{-9}) for a myriad of uses. **3.** Activity making capsules from polymer and citrate solutions. 4. Students take samples of the supernatant at four different time intervals and check for kinetic activity, using UV/Vis Spectrophotometer (Spec 20). 5. Students make a line graph using absorbance data obtained. 6. Small group discussion to predict how the capsules were actually made and how this encapsulation process could be used in other applications. 7. Afterward, teacher should demonstrate dropping the colored alginate solution into a beaker or other container of *distilled water* using the same method that the students used to create the capsules. This will show that the capsules are NOT made unless the positive ions needed in the calcium chloride are available to help bind the capsule. It is truly the cross-linking interaction between the two reactants that yield the capsule product. **<u>NOTE:</u>** Be sure to use distilled water and **not** water from the faucet, as there may be a calcium presence that will give unfavorable results.
Adaptations for Special Learners	Low-level and ESL learners can be given the absorbance data and the line graph

associated with the data and be asked to indicate what is happening.

Extensions A discussion of polymers could also be introduced here, since the capsule is made of a polymer. The demo “Nylon Rope Trick” found in several literature sources could be done followed by a discussion of the discovery and uses of nylon or polymers in society today. Students could also be given instruction on the idea of “self-assembly”, as our capsules are formed via self-assembly.

Resources Photographs- D. Michelle Black, Conroe High School, Conroe, Texas

Friedli, A.C. *J. Chem.Educ*. **2005**, *82*, 1017-1020. (including chemical reaction figure.)

STUDENT HANDOUT

Name ____

Date:_________________________ Period:__________________

Encapsulation Activity

Did you know that Scratch 'N Sniff™ uses encapsulation technology? Sure does!
In Scratch 'N Sniff™, a special kind of scent is enclosed in tiny capsules, which are broken open by friction to release the scent. The capsules are made out of gelatin or plastic and are too tiny to be seen with the naked eye. These tiny capsules are then added to a backing paper using a special printing technique. The scent enclosed in the capsule is not released until the capsule is broken open by the friction of the scratching.

Essential Question: Is there a type of bonding that is present in nature that is not your typical ionic or covalent bonding?

Prelab Questions:

1. How do you think capsules are made?

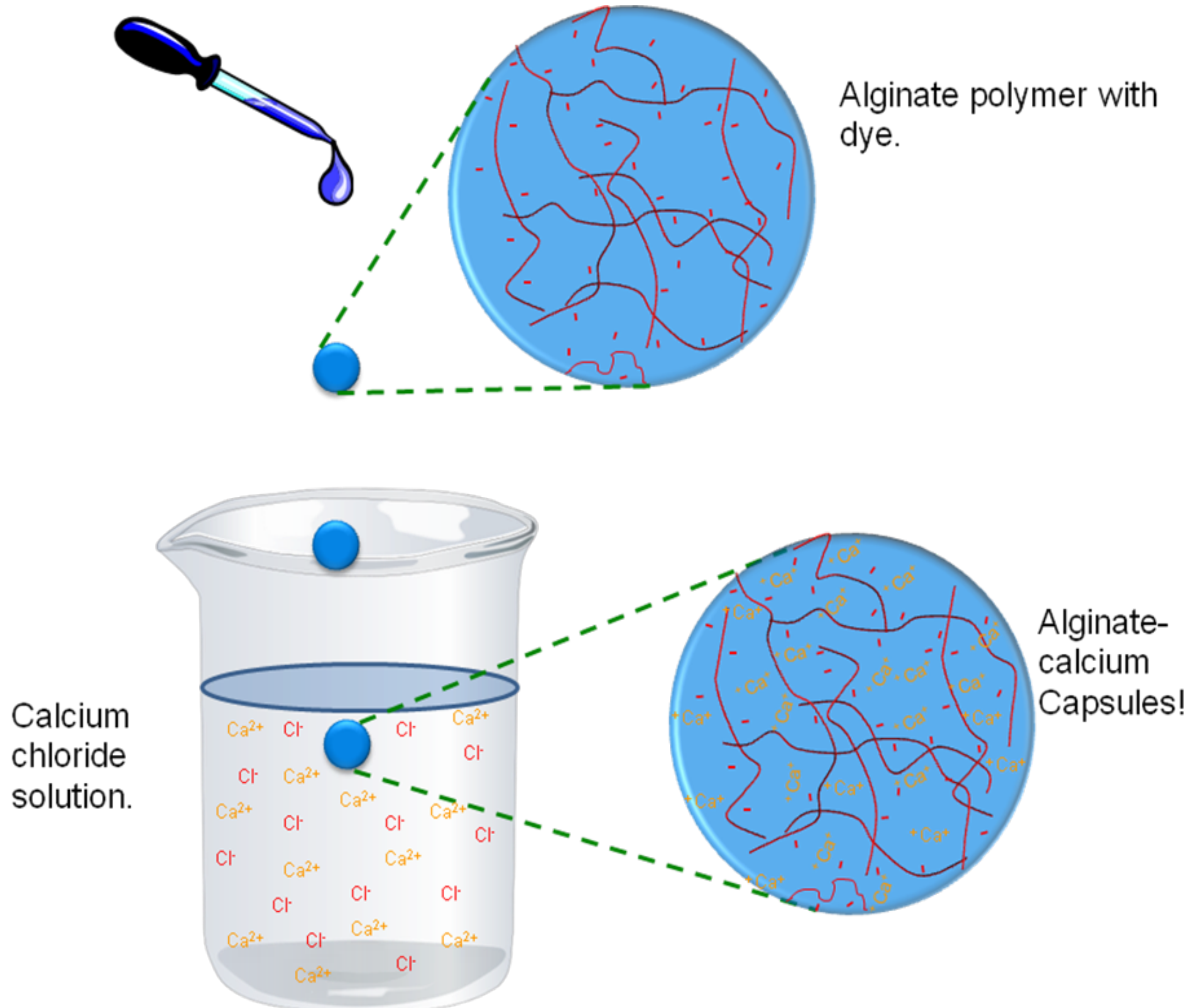
2. Capsules are used today in many ways, some of which are pharmaceuticals and material science. Can you give examples of some of these and describe why they are so useful?

3. Other than ionic and covalent bonds, what other kinds of bonds do you think are possible?

4. How do different types of bonds affect the way different chemical elements or compounds come together?

5. Do you expect the release rate of the dye from the capsule to increase, decrease or remain the same as time goes by?

Explore: Students will make capsules that are made of a calcium chloride solution and an alginate solution. The two solutions will bond using electrostatic forces (calcium = pos. and alginate = neg.) Using this model, students discover the intricacies of intermolecular forces.



Students then discover the kinetics of the release rates of the dye in the capsules they have made using the UV/Vis Spectrophotometer. Remember, a *supernatant* is the liquid floating on the surface above the solid or precipitate. Absorbance indicates release rate (kinetic activity) of the capsules.

Absorbance is a measure of the quantity of light absorbed (at a particular wavelength) by a sample. *Release rate*, in this case, is the speed at which the dye leaves the capsule.

Materials: UV/Vis Spectrophotometer (Spec 20)
Food dye-liquid (commonly found at grocery stores)
Alginic acid sodium salt solution (Alginate--colored)
Calcium chloride solution
Beral Pipets, Thin Stem (1 per group)
Beral Pipets, Extra-Large Bulb (1 per group)
Timer (1 per group)

Procedure:

1. Each group should get one 100mL $CaCl_2$ sample and one 5mL alginate solution sample from the stock solutions. Each solution should be placed in separate beakers.
2. Using the thin stem pipets, drop 50 drops of the colored alginate solution into the $CaCl_2$ solution. You have made 50 capsules!
3. As soon as the last capsule (drop) is made, begin timer.
4. After two minutes, swirl the capsule solution gently to mix. Using the extra-large bulb pipet, draw enough supernatant to fill the test tube or cuvette to the proper height.
5. Take an absorbance reading using the UV/Vis Spectrophotometer (Spec. 20) set at 630nm(for blue food dye) and record in Data Table 1.
6. Dispose of the supernatant by pouring into the sink with lots of water.
7. Take additional absorbance readings using the method in #4 at four, six and ten minute intervals, remembering to swirl the sample prior to taking out the supernatant. Record the absorbance readings in Data Table 1.

Data Table 1:

Sample #	Time (sec.)	Absorbance
1		
2		
3		
4		

8. Make a line graph using your data from Data Table 1. The independent variable is the time (seconds) and the dependent variable is the absorbance reading.

Post Lab Questions:

1. How do you think the capsules formed? Was the alginate solution just a solution ready to be capsules, just made by dropping by a dropper into any solution?

2. Describe the process both in words and in a picture of how you think the capsules are bonding together.

3. What do your data points on your line graph indicate about the release of the dye from the capsules?

4. Describe the term *reaction rate*. Can the way compounds bond affect the rate in which the reaction takes place?

5. This activity used a polymer when bonding. What do you know about polymers and how are they helpful in the chemical industry?

6. Now that you are more familiar with encapsulation, what other uses do you think could be made?