NATURAL INDICATORS: HOW DO THEY WORK?

By Gayathri Withers, GIPSE, 2001

Unit Objective: Describe characteristics and common uses of acids and bases

PA STATE SCIENCE AND TECHNOLOGY STANDARDS:

3.4.10.A Explain concepts about the structure and properties of matter.
- **Explain the formation of compounds and the resulting properties using bonding theories.**

3.4.12.A Apply concepts about the structure and properties of matter.
- **Characterize and identify important classes of compounds.**

3.1.12.C Assess and apply patterns in science and technology.
- **Compare and contrast structure and function relationships as they relate to patterns.**

3.2.12.B Evaluate experimental information for appropriateness and adherence to relevant scientific processes.
- **Evaluate experimental data correctly within experimental limits.**

3.2.12 C Apply the elements of scientific inquiry to solve multi-step problems.
- **Evaluate the significance of experimental information in answering the question.**

B A C K G R O U N D:

We know the color changes that we see in the nature all around us. We also notice the color changes in iced tea when lemon juice is added. In the study of acid-base chemistry we use litmus paper to indicate if a solution is acidic, basic, or neutral based on the color changes. Is there a common chemical process occurring in all the above phenomena? Can we know the 'mystery' of the acid-base indicators, like litmus paper, by carefully examining the change in color of some natural dyes?

The substances in plant products such as tea, red cabbage or grapes react with acids(or bases), resulting in changes at the molecular level which causes their colors to be different at different pH levels. All pH indicators, such as litmus paper, change colors depending upon whether they donate or accept protons, (acids are proton donors and bases are proton acceptors). Therefore, pH indicators are themselves acids or bases!!!!! Chemists pick selective natural dyes to indicate specific pH levels based on their color changes.

For example, a commonly used acid-base indicator, named Bromthymol Blue, is yellow in acid and blue in base and intermediate in between at pH 7. Yellow form of Bromthymol Blue, (acid-form, HBb) when donates a proton to OH^- ions at higher pH changes to anion, (base-form, Bb-) which is blue. The point at which the color changes from intermediate to blue gives information on the acid strength of the acid-form, HBb. Chemists test various indicators for their acid strength and choose an indicator for specific pH levels.

LESSON PLAN

TITLE: Natural Indicators: How do they work?

OBJECTIVES: Ss are to describe the role of natural indicators in the chemistry of acids and bases after testing and making observations on a variety plant extracts.

- **Dyes from plants have distinct physical and chemical properties**
- **Dyes change colors in solutions of different pH levels.**

Resources: Chemistry by Addison-Wesley Publishing
Hands-on Chemistry by William Metz, GIPSE, 2001

Materials:
For demo: red cabbage leaves, vinegar, ammonia, 0.1 M HCl solution, O.1 M NH_3
3- 25 mL beakers, stirring rods
For lab : blueberries, grapes, cherries, tomatoes, Red and Violet Petunia flowers, 6 known pH solutions, micro-analysis trays, droppers, crayons

Teacher Doing	Student Doing
PRE-LAB Demonstration	Write down the observations, then share
Exploratory questions	Answer questions in groups of 4 (worksheet1)
Share, Worksheet1 Response	whole-class discussion
Signals to proceed to test	Ss test plant samples in groups, Observe and record the data individual groups
Monitors the Ss progress	Complete the Whole Class Table (on the board) Clean up
Wrap-up / Conclusion	whole-class discussion Complete the Mystery Report!

EVALUATION:

LESSON: **WORKSHEET 1**
The Mystery Report
Informal assessment during the procedure

CHAPTER: **Quizzes**
Chapter test on Acids and Bases
(Chemistry by Addison-Wesley Publishing)

REMARKS:

THE 'MYSTERY' REPORT:

Students will receive this part at the pre-lab and the background during the wrap-up discussion after the lab (before they write the report).

The mystery report consists of:

The Task
The Procedure
The Worksheet 1
Individual data table (Table 1)
Class data table (Table 2)
Consider this to wrap-up

THE TASK:

In this lesson, you will extract and test dyes from various plant samples in solutions with different pH levels. Using these observations, they are to:

- **Solve the identity of a mystery dye,**
- **Write a brief report on their conclusions, using appropriate science concepts.**

THE PROCEDURE: (to be completed for each plant sample tested)

1. **Place a sample of plant material in a 250 mL beaker with enough distilled water to cover the plant material.**
2. **Stir occasionally while heating this solution.**
3. **Bring to a boil, remove from heat, check the color of the solution, If the solution is not a medium to strong color continue boiling.**
4. **When the solution has obtained a relatively a strong color, use caution to carefully decant the liquid into an appropriately labeled beaker and discard the plant material.**
5. **Before testing the extracted dye use your pH meter to determine the pH of each pH solution (Be sure to clean meter before and after each use).**
6. **Place 4-6 drops of each pH solution in a separate depression of the clear testing tray.**
7. **Add the extracted vegetable dye, drop by drop, to each test solution until an obvious color change occurs.**
8. **Fill out your individual data table and the class data table with your findings.**
9. **Obtain a 'mystery' dye from your teacher and solve the 'mystery' by testing and comparing with the whole class data.**
10. **CLEAN UP**

WORKSHEET 1

<u>Directions</u>: Work in your lab groups and answer the following questions. After a few minutes, we will share the answers with the whole class. Submit this worksheet along with your lab report at the end of the lab.

1. **Is vinegar acidic or basic? Why? How can you test your answer?**

2. **Is ammonia acidic or basic? Why? How can you test your answer?**

3. **What did you observe in the demonstration?**

4. **Based on your knowledge of vinegar and ammonia, in terms of protons and OH- ions, explain your observations.**

5. **What is an indicator? Give an example.**

CONSIDER THIS: In your brief report, you must

- **Identify which of the natural dyes is the 'mystery' dye.**
- **Explain your justification for the identity of the mystery dye, use the concepts we discussed in the pre-lab worksheet**
- **Characterize any similarities and differences you observed in your study of plant materials and pH solutions and the red cabbage demo**
- **Can all plant materials be used as effective pH indicators? Why or why not?**

Assessment:

Checklists for: Marked on the scale of 5 to 1 (5 excellent, 1 poor)

Pre-lab inquiry

Attempts to give explanation	**5/4/3/2/1**
Attempts to make predictions	**5/4/3/2/1**
Attempts to raise questions	**5/4/3/2/1**

Lab participation

Observing the changes	**5/4/3/2/1**
Taking steps to ensure accuracy	**5/4/3/2/1**
Recording the data tables	**5/4/3/2/1**

Post-lab discussion

Attempts to explain things in terms of relevant concepts	**5/4/3/2/1**
Explains how evidence has been used in making predictions	**5/4/3/2/1**
Discusses what is found in relation to the initial question	**5/4/3/2/1**
Identifies patterns or trends in the results	**5/4/3/2/1**
Listens to others' ideas and look at their results	**5/4/3/2/1**

Grading for the written report:

Report complete	**10 points**
Data Tables complete	**20 points**
Explanation Scientific	**15 points**

Maximum points earned: 100

REFERENCES:

Chemistry: textbook by Addison-Wesley Publishing

GIPSE, 2001 materials:

- **PA Standards handout**
- **STEEP lesson handout**
- **Hands-on Chemistry session and handout**
- **Levels of Inquiry sessions and handout**

WEB sources: ***www.chem4kids.com/reactions/acidbase.html***

http://library.thinkquest.org/2690/exper/exp14.htm