Case File 5

The Ink Is Still Wet: Using colorimetry to identify an unknown ink

Identify the ink on the ransom note to narrow down the suspects.

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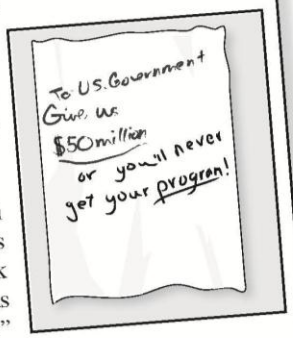
TrueMind AI Kidnapping Case Solved!
Mystery ink proves key to case

SPRINGFIELD, September 10: Science has proven indispensable in solving yet another kidnapping case. This time, a special kind of fingerprint—a chemical fingerprint—proved to be the crucial clue in recovering the victim, 22-year-old Shawn Morgan, unharmed.

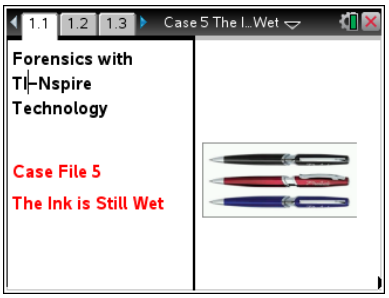
It was only in the last month that Morgan sold his design for the TrueMind artificial intelligence system to the United States government for $100 million. As fate would have it, a day later, Morgan vanished. When investigators forcibly entered Mr. Morgan's apartment, they found it empty except for a ransom note written on a piece of computer paper. The note was written in black ink, and the handwriting varied in style, so police handwriting experts were at a loss to come up with a profile.



Using advanced chemical analysis, investigators determined that the ink used to write the infamous "To US Government" ransom note came from a specialized marker used in photo retouching. These pens are unusual and unusually expensive, and investigators found one at the apartment of one of the prime suspects, Tamyra Elliot, 32. Ms. Elliot is currently being held without bail.

continued on p. C4

About the Lesson



- This lab utilizes colorimetry to identify inks as unique mixtures of pigments.
- Teaching time: one 45 class period

Science Objectives

- Identify an unknown ink by its light absorbance characteristics.
- Measure a solution's absorbance of different colors (wavelengths) of light.

Activity Materials

- TI-Nspire™ technology
- *Case 5 The Ink is Still Wet.tns* file
- *Case_5_The_Ink_Is_Still_Wet_Student.doc* student activity sheet
- Vernier EasyLink™ or TI-Nspire Lab Cradle
- Vernier Colorimeter
- colored wax pencil
- distilled water
- lint-free tissues
- 6 cuvettes
- 5 dropper bottles, with 10 mL samples of different diluted black inks
- 1 dropper bottle, with 10 mL of diluted unknown black ink

TI-Nspire™ Navigator™

- Send out *Case 5 The Ink is Still Wet.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.

Background Information

The Colorimeter works by passing a beam of a single wavelength of light through the sample and then measuring how much of that light is transmitted. The Colorimeter can then calculate how much of that wavelength was absorbed by the sample. This technique can help identify materials because different materials absorb different amounts of light at different wavelengths.

Most inks are mixtures of different-colored pigments. When we separate those mixtures, we can define their parts, and the percentages of the parts allow us to identify the original ink. Many companies have their own formulas for the inks that they use. Each pigment has distinctive spectral properties. We can see those properties when we examine the solutions in light of different wavelengths.

Teacher Notes and Teaching Tips

- The student activity sheet and .tns file contain the complete instructions for data collection. All assessment questions are also included in both places giving you the flexibility to either collect the .tns files with student data/answers (using TI-Nspire Navigator) or the student activity sheet.
- **Make sure that all solution preparation is done before having students begin the experiment**.
- Before assigning the lab, you may want to review the spectrum of visible light and the concept of absorbance of light. Remind students that different colors are actually different wavelengths in the spectrum and that an object appears to be a specific color because it absorbs all wavelengths of light except that specific color. It may also be helpful to review the difference between colors of light (white light is a combination of all wavelengths, and darkness is the absence of all wavelengths) and colors of pigment (white pigment reflects all wavelengths, and black pigment absorbs all wavelengths).
- Use of the Colorimeter with the handheld is extremely battery intensive. It is recommended to keep handhelds charging between classes or using the lab cradle to minimize battery drain.
- The cuvette must be from 55% to 100% full in order to get a valid absorbance reading. If students fill the cuvette 3/4 full, as described in the procedure, they should easily be in this range. To avoid spilling solution in the cuvette slot, remind students not to fill the cuvette to the brim.
- The following Web site contains information about the properties of different inks: http://chemistry.about.com/library/weekly/aa121602a.htm
- If using TI-Navigator, collect all data and aggregate it and redistribute it to the class.
- More advanced students may want to explore the absorbance of different-colored inks (red, blue, green) to see if the variations in absorbance pattern are as great as they are for black inks.

Allow students to read the forensics scenario on the first page of their student activity sheet.

Procedure

Teacher Preparation of Solutions (Prior to the Lab)

1. Use rubber gloves to prepare all the ink solutions.
2. Use five different brands of pens (e.g., Pilot, Bic, Zebra) and/or different types of pens (e.g., erasable ink, archival ink) for the known solutions. Use one of the same five for the unknown solution.

3. To prepare each ink solution, disassemble the pen (or purchase a refill ink cartridge), cut the ink cylinder, and put the cylinder parts into 300 mL of Isopropyl alcohol (rubbing alcohol) and allow the ink to dissolve in it. Each ink will dissolve at a different rate, so the soak times will vary.
4. To prepare each of your final ink solutions, add 100 mL of the ink/alcohol solution to 400 mL of distilled water. Mix the solution thoroughly before adding to each of the dropper bottles. Repeat for each of the ink solutions that will be tested. The six different diluted samples should look similar. Of the black inks used to obtain the sample data, the Bic, Pentel, and Zebra had a purplish hue and were indistinguishable from one another when diluted; the Pilot ink was black in dilution; ink from the erasable Paper Mate was blue in dilution.
5. You may get better results even if you make up the samples using gel food dyes; the mixtures will also last for years!

Part 1 –Preparing for Analysis

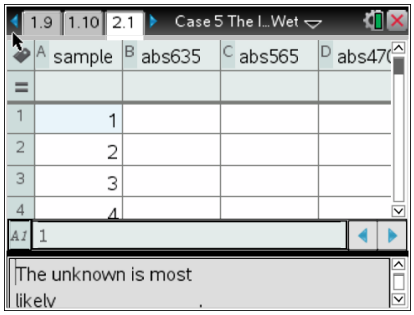
Move to page 1.2-1.6

Students will need to follow the directions on how to prepare the samples for analysis and also to calibrate the colorimeter. Have students move to page 1.5 before attaching the colorimeter to the TI-Nspire using EasyLink or the Lab Cradle.

Part 2 – Collecting Data

Move to page 1.7-2.1

Students will need to follow the directions on the student worksheet or the .tns file to collect and record the data on the Evidence Record. Students may also record data on page 2.1 in the .tns file, if you plan to collect the student .tns files.



Part 3 –Analyzing the Data

Students will measure the absorbance of each solution at the three other wavelengths (or colors) that the Colorimeter can measure. Remind students to store their run by clicking on the file cabinet near the collect button.

Evidence Record

SAMPLE DATA

Sample	Type of Ink; Appearance in Alcohol	Absorbance at 635 nm	Absorbance at 565 nm	Absorbance at 470 nm	Absorbance at 430 nm
1	Pilot gel ink; black	0.408	0.498	0.539	0.492
2	Paper Mate erasable; blue	0.951	0.986	0.958	0.926
3	Bic; purple	0.278	0.681	0.433	0.402
4	Pentel; purple	0.111	0.355	0.217	0.182
5	Zebra; purple	0.181	0.379	0.262	0.241
6	Unknown; purple	0.288	0.673	0.437	0.395

Unknown is most likely 3 Bic

Case Analysis

Have students answer the following questions on the handheld, on their activity sheet, or both.

Q1. How did you identify the unknown?

Answer: Find the set of absorbencies that most closely matched those of the unknown.

Q2. Why did the inks show different absorbance patterns if they all appeared to be the same color?

Answer: Even though the inks are the same color, the amount of colorant(s) and the kind of colorant(s) present may vary, causing the absorbance readings to vary.

Q3. Do you think you would have seen the same large variations in absorbance if all the samples had been red ink or all the samples had been blue ink instead of black? Why or why not?

Answer: The variations in absorbance patterns would probably have been smaller if we had used red or blue ink because those inks tend to be mixtures of fewer pigments.