JOURNAL OF CHEMICAL EDUCATION

Activity

pubs.acs.org/jchemeduc

Activities Designed for Fingerprint Dusting and the Chemical Revelation of Latent Fingerprints

J. Brent Friesen*

Physical Sciences Department, Rosary College of Arts and Sciences, Dominican University, River Forest, Illinois 60305, United States

Supporting Information

ABSTRACT: This article describes two different latent fingerprint revelation activities that have similar organization structures and pedagogy methodologies. The two activities feature the use of multiple stations to allow students to test, compare, and contrast different fingerprint revelation techniques. Both activities adopt a structured-inquiry pedagogical methodology that invites students to form their own opinions on the strengths and weaknesses of each technique. Fingerprint dusting techniques are more accessible because there is less need for fume hoods and protective safety equipment. The chemical revelation of latent prints techniques are more suited for a laboratory environment where fume hoods and protective safety equipment are available.

KEYWORDS: *High School/Introductory Chemistry, Organic Chemistry, Inquiry-Based Discovery Learning, Forensic Chemistry*

INTRODUCTION

TV shows that feature teams of forensic scientists who help reveal the truth behind complex and intriguing criminal activities have grown in popularity since "CSI: Crime Scene Investigation" first aired on CBS in 2000.[1] Educational course offerings and science activities have followed this popularity trend at all levels of instruction. The revelation of latent fingerprints is one of few forensic science activities that is unique to forensic science and not an adaptation of common scientific techniques to law enforcement such as the identification and quantitation of illegal substances. This journal has published four articles that describe latent print revelation activities and experiments.[2−5] Individual techniques to reveal latent prints through dusting or chemical revelation are often straightforward activities that can be performed and discussed in a short period time. However, by combining a half-dozen or more of these techniques into stations allows students to experiment and observe individual techniques as well as compare and contrast the strengths and weaknesses of these techniques with each other. In turn, this may engender a deeper discussion of how and why these techniques work (or do not work in some cases) to create a contrast between the latent print residue and the material on which they are deposited. It is not necessary to execute all of the techniques each time the activity is performed. I have tried some techniques in the past that I have found to be less effective and subsequently dropped. Over the years, I have also replaced reagents made from scratch with commercial preparations.

These two activities have been included in the fingerprint unit of both Forensic Science for Non-Science Majors and Forensic Chemistry for Science Majors courses. Both of these courses have been taught as "workshop" courses where the class session takes place in a multiuse organic chemistry laboratory space. To begin the unit, we look at the history of fingerprinting that includes the modern day digital recognition software and databases. This subunit is followed by investigating the physiological phenomena of volar pads and the classification of fingerprint patterns. We perform an inked fingerprint activity where students make their own 10-cards and classify their fingerprints. Next, we study the chemical composition of latent fingerprints and the methods of revealing them. There are two main chemical categories of fingerprint revelation techniques: (1) Revelation techniques that rely on noncovalent interactions such as dusting, gentian violet staining and small particle reagent. (2) Revelation techniques that involve chemical reactions such as ninhydrin, DFO (1,8-diazafluoren-9-one), and silver nitrate. The following activities are included in this subunit.

DESCRIPTIONS OF THE ACTIVITIES

Fingerprint Dusting

Fingerprint dusting is a hands-on activity that can be performed with almost any age group as it does not require specialized chemical safety equipment. It is easily adapted to an structured inquiry format[6,7] where the students test different fingerprint revelation techniques, fingerprint powders and fingerprinted materials to answer the question of which techniques and powders work best with which materials. The question of what chemical interactions are responsible for the "stickiness" of fingerprint powders is a more in-depth question since it

DOI: 10.1021/ed500406v
J. Chem. Educ. XXXX, XXX, XXX−XXX

Table 1. Hazards Associated with the Reagents Used for the Chemical Revelation of Fingerprint Residues

Chemical	Hazards
Iodine crystals	Oxidizer. May be harmful if inhaled, ingested, or contacted by skin or eyes. Respiratory irritant. May be corrosive to skin and eyes.
Ninhydrin solution	Flammable. Harmful vapors. Skin and eye irritant.
DFO (1,8-diazafluoren-9-one) solution	Flammable. May be harmful if inhaled. May be absorbed through the skin. Respiratory and digestive tract irritant. May cause skin and eye irritation.
Silver nitrate solution	Oxidizer. May be harmful if inhaled. Respiratory and digestive tract irritant. May cause skin and eye burns. May cause argyria, a blue-gray discoloration of the skin, eyes, and mucous membranes.
Small particle reagent	Readily absorbed by skin. Respiratory irritant. May irritate skin. May irritate and burn eyes.
Cyanoacrylate glue	Respiratory tract, eye and skin irritant. Bonds skin rapidly and strongly. May cause skin burns.
Gentian violet solution	May be absorbed through the skin. Respiratory and digestive tract irritant. May cause skin and eye irritation.
Sudan black solution	May be absorbed through the skin. Respiratory and digestive tract irritant. May cause skin and eye irritation.
Physical developer	May be harmful if inhaled, ingested, or absorbed by the skin. Respiratory tract irritant. Skin irritant. Severe eye irritant.
Fingerprint dust	Respiratory tract, eye, and skin irritant. Wash thoroughly after handling.

requires knowledge of the chemical composition of both the latent prints and the fingerprint powders.

Fingerprint powders can be purchased from a forensic supply vendor such as Sirchie Fingerprint & Forensic Supplies.[8] It is also possible to prepare fingerprint powders from charcoal powder, starch powder, silica gel, rosin, graphite pencil leads, or various inorganic salts.[4,9] Depending on how many stations are feasible to create, powders should be prepared or purchased from each of five categories: (1) traditional, (2) metallic, (3) fluorescent, (4) magnetic, and (5) sticky-side tape powders. Each category will have several different colors to choose from. To create some variety, powders of different shades and hues should be procured.

The supplies needed to apply the powders are simple brushes in most cases. However, there are several different kinds of brushes to choose from such as fiberglass, feather, animal hair and others. Magnetic powders require a special "wand" for application. It is a good idea to have a shallow container or tray at each dusting station where materials will be dusted. A UV light with a light box is necessary to fully appreciate the contrast created by fluorescent powders. A set of 10 tests may be: regular black, heavy black, white (talc), red, magnetic black, magnetic fluorescent, fluorescent red, fluorescent green, copper metallic, and black sticky side powder.

Common objects composed of different materials may be dusted. I have used empty pop cans, bottle caps, glass vials, glass microscope slides, pennies, tin foil squares, wax paper squares, blocks of wood, cardboard squares, ceramic tiles, plastic spoons, paper squares of different colors, plastic weigh boats, packing tape, duct tape, masking tape, and others. It is important to have a variety of materials and colors. Materials that have been dusted can simply be wiped off and reused except for the sticky side of tape. Dusted fingerprints can be lifted with special lifting tape ("hinges") or any commercial clear tape for preservation.

Students are asked to write down two positive characteristics and two negative characteristics of each powder. The structured inquiry nature of these questions is intended to instigate exploration and experimentation in the context of careful observation. At the end they are asked to rank all of the powders they tested by using their observations to compare and contrast the powders they used. They are also asked to answer a set of in-depth observations for at least two powders. A sample student handout is included in the Supporting Information. A typical set of questions for a specific dusting powder may be: (1) Record two observations on the dusting technique using this dust. (2) Under what conditions and in what circumstances would fingerprint dusting with this powder work well? (3) Under what conditions and in what circumstances would fingerprint dusting with this powder not work well? (4) Compare this dust/technique with other dusts and techniques that you have performed (two points of comparison).

Chemical Revelation of Latent Prints

The chemical revelation of latent prints requires proper ventilation and protective safety equipment. The age appropriateness is dependent on the ability of students to adhere to good safety practices when working in a ventilated hood with hazardous chemicals. It is easily adapted to an structured inquiry format where the students test different fingerprint revelation techniques and fingerprinted materials to answer the question of which techniques work best with which materials. The question of what chemical interactions are responsible for the revelation of fingerprint residues is a more in-depth question since it requires knowledge of both the chemical composition of the latent prints and the fingerprint revelation mechanism.

There are several fingerprint revelation techniques that can be performed with common laboratory equipment and chemicals. Specialty chemical preparations and kits can be purchased from a forensic supply vendor such as Sirchie Fingerprint & Forensic Supplies.[8] Nine of the most accessible techniques are iodine fuming staining, ninhydrin staining, DFO (1,8-diazafluoren-9-one) staining, silver nitrate revelation, superglue fuming revelation, gentian violet staining, Sudan black staining, small particle reagent, and physical developer revelation. However, this list is by no means exhaustive. Basic formulations for common staining techniques can be found online in the U.S. Department of Justice Federal Bureau of Investigation Laboratory Division's "Processing Guide for Developing Latent Prints",[10] and the Chesapeake Bay Division of the International Associate for Identification's "Latent Fingerprint Processing Techniques—Selection & Sequencing Guide."[11]

The supplies needed to apply and develop chemical revelation techniques are quite simple and are described in the Supporting Information.

Common objects composed of different materials that have been described for dusting techniques can be tested. Chemically treated materials cannot usually be reused and need to be disposed of in a hazardous waste container.

The student handout to record observations is very similar to that of the dusting techniques. A sample of the student handout is included in the Supporting Information.

DOI: 10.1021/ed500406v
J. Chem. Educ. XXXX, XXX, XXX−XXX

HAZARDS

Fingerprint dusting is a hands-on activity that can be performed with almost any age group as it does not require specialized chemical safety equipment. It is advisable to inform students not to deliberately inhale, ingest or rub the fingerprint powders into their eyes. The age appropriateness of handling glass objects such as microscope slides should also be considered.

The chemical revelation of latent fingerprints requires student work in a fume hood and/or proper safety equipment. These working conditions are generally available in sophomore organic chemistry laboratories. Iodine and cyanoacrylate glue are used directly in their solid and liquid forms, respectively. Ninhydrin, DFO, silver nitrate, and Sudan black are dissolved in organic solvents before use. Small particle reagent, gentian violet, and physical developer are aqueous solutions. Table 1 summarizes the hazard concerns on the reagents. A more comprehensive table is found in the Supporting Information.

DISCUSSION

The challenge that is presented to the students in these activities is twofold. First, there is a task of creating a clear latent print by following the guidelines presented for each technique. Generally, students find it easy to reveal a print, but the production of a clear fingerprint that gives enough ridge detail for a positive identification is rather challenging. The laboratory discussion should include a line of questioning about how to determine whether a print is "good enough" for further forensic identification. Second, the students are challenged to discover the best combination of technique, material, and conditions to create clearly revealed prints. Some guidance about what certain techniques are typically used for is given in the instructions, but students are also encouraged to experiment with different materials. The activity encourages students to compare and contrast different techniques. Some have inherent limitations and others may present challenges to the student to perform them properly. It is a good idea to have students reflect on what they would do in a real forensic investigation where recovering at least one clean fingerprint from a limited number of objects is critical. There is also the possibility of using two or more methods to reveal the same prints. For example, iodine fumed prints can be revealed with ninhydrin and subsequently with silver nitrate.[12]

It may be useful to discuss what forensic scientists call "the chain of evidence" in regard to fingerprints. What fingerprint revelation techniques could be and should be performed at the crime scene? Which methods require that the object to be fingerprinted undergo transport to a laboratory for analysis? What objects at a crime scene are likely to have latent prints left by the criminal? How should the objects collected at a crime scene be handled in order to preserve the integrity of latent prints?

Another avenue of discussion may be how fingerprints are processed and preserved after they are revealed. There are also ways of processing prints to make the contrast sharper. For example, iodine fumed prints can be treated with a starch solution,[13] water vapor,[14] zinc chloride,[15] 7,8-benzoflavone[16] or brucine.[17] Greater contrast of superglue fumed prints can be achieved with gentian violet or coumarin 540.[18] Digital photography is of great importance for the preservation of revealed fingerprints.[13,19] However, photographing fluorescent prints may require specialized equipment.[5]

Students may be aware that we leave hundreds of latent prints on the objects we handle every day. The prints are a result of endogenous body oils and exogenous substances which coat the volar ridges of our fingertips. Many different revelatory techniques have been developed to create a contrast between the fingerprint and the surrounding material. The basic approach is to employ a colored substance which binds to the fingerprint residue and does not bind to the object. The chemical interactions responsible for revealing latent prints are given a cursory treatment in popular forensic science textbooks.[13,19] The chemical revelation of latent prints is not covered in a popular forensic chemistry textbooks.[20,21] Therefore, one must look to more specialized resources such as Advances in Fingerprint Technology,[22] Fingerprints: Analysis and Understanding[23] and The Fingerprint Sourcebook[24] for a more in-depth consideration of the chemical processes.

CONCLUSION

Fingerprint revelation is a quintessential forensic activity that can be adapted to topics and courses in elementary, secondary, or undergraduate education. Simple materials can be used, especially for dusting fingerprints. In addition to comparing and contrasting the different fingerprint revelation techniques performed by the students, it is also possible to bring in other topics of discussion such as the chain of evidence, processing prints, preserving prints, the chemical composition of fingerprint residue and the molecular interactions responsible for the revelation of latent prints.

ASSOCIATED CONTENT

Supporting Information

Student handouts and instructor prep notes, which include CAS numbers and hazards. This material is available via the Internet at http://pubs.acs.org.

AUTHOR INFORMATION

Corresponding Author

*E-mail: jbfriesen@dom.edu.

Notes

The authors declare no competing financial interest.

ACKNOWLEDGMENTS

I gratefully acknowledge the support of Dominican University's Rosary College of Arts and Sciences for their encouragement and support of faculty scholarship development. I also acknowledge the undergraduate students who have played an important role in the development of these activities.

REFERENCES

(1) Houck, M. M. CSI: Reality. *Sci. Am.* **2006**, *295*, 84−89.
(2) Nikitakis, A.; Lymperopoulou, K. A. Fun with Fingerprints: Cyanoacrylate Fuming. *J. Chem. Educ.* **2008**, *85*, 816A.
(3) Clark, S.; Quigley, M. N.; Tezak, J. Chemical Detection of Latent Fingerprints. *J. Chem. Educ.* **1993**, *70*, 593.
(4) Sodhi, G.; Kaur, J. Chemical Methods for Developing Latent Fingerprints. *J. Chem. Educ.* **1999**, *76*, 488A.
(5) LaFratta, C. N.; Huh, S. P.; Mallillin, A. C.; Riviello, P. J.; Walt, D. R. Visualizing Fluorescence: Using a Homemade Fluorescence "Microscope" To View Latent Fingerprints on Paper. *J. Chem. Educ.* **2010**, *87*, 1105−1107.
(6) Colburn, A. An Inquiry Primer. *Sci. Scope* **2000**, *23*, 42−44.

DOI: 10.1021/ed500406v
J. Chem. Educ. XXXX, XXX, XXX−XXX

(7) Domin, D. S. A Review of Laboratory Instruction Styles. *J. Chem. Educ.* **1999**, *76*, 543.
(8) Sirchie. Fingerprint & Forensic Supplies. https://www.sirchie.com (accessed May 10, 2014).
(9) Oregon Museum of Science and Industry. Latent Prints http://www.omsi.edu/sites/all/FTP/files/chemistry/NH-PDF/NH-G23-LatentPrints.pdf (accessed Aug 14, 2013).
(10) Trozzi, T. A.; Schwartz, R. L.; Hollars, M. L.; Leighton, L. D.; Schehl, S. A.; Trozzi, Y. E.; Wade, C. Processing Guide for Developing Latent Prints. http://www.onin.com/fp/fbi_2000_lp_guide.pdf. U.S. Department of Justice, Federal Bureau of Investigation, Laboratory Division, 2000.
(11) Chesapeake Bay Divison. Latent Fingerprint Processing Techniques—Selection and Sequencing Guide. http://www.cbdiai.org/Reagents/main.html. International Association for Indentification.
(12) Sirchi. Overview of Latent Print Development Techniques. http://d1zh4ok0q8k7dm.cloudfront.net/media/resourcecenter/item/l/p/lp_dev_mt_tech_tb02-102eng-rev5e_9.pdf. TB02-102ENG-REV1, 2009; pp 1−20.
(13) Saferstein, R. *Criminalistics: An Introduction to Forensic Science*; 10th ed.; Prentice Hall: Boston, MA, 2011.
(14) Almog, J.; Sasson, Y.; Anati, A. Chemical Reagents for the Development of Latent Fingerprints. II: Controlled Addition of Water Vapor to Iodine Fumes—A Solution to the Aging Problem. *J. Forensic Sci. 24*, 431−436.
(15) Davies, P. J.; Kobus, H. J.; Taylor, M. R.; Wainwright, K. P. Synthesis and Structure of the Zinc(II) and Cadmium(II) Complexes Produced in the Photoluminescent Enhancement of Ninhydrin Developed Fingerprints Using Group 12 Metal Salts. *J. Forensic Sci.* **1995**, *40*, 565−569.
(16) Haque, F.; Westland, A.; Kerr, F. M. An Improved Non-Destructive Method for Detection of Latent Fingerprints on Documents with Iodine-7,8-Benzoflavone. *Forensic Sci. Int.* **1983**, *21*, 79−83.
(17) Jasuja, O. P.; Kaur, A.; Kumar, P. Fixing Latent Fingermarks Developed by Iodine Fuming: A New Method. *Forensic Sci. Int.* **2012**, *223*, e47−52.
(18) Kobus, H. J.; Warrener, R. N.; Stoilovic, M. Two Simple Staining Procedures Which Improve the Contrast and Ridge Detail of Fingerprints Developed with "Super Glue" (Cyanoacrylate Ester). *Forensic Sci. Int.* **1983**, *23*, 233−240.
(19) Girard, J. E. *Criminalistics: Forensic Science, Crime, and Terrorism*; 3rd ed.; Jones & Bartlett Learning: Sudbury, MA, 2013.
(20) Bell, S. *Forensic Chemistry*; 2nd ed.; Prentice Hall: Hoboken NJ, 2012.
(21) Khan, J.; Christian, D.. *Basic Principles of Forensic Chemistry*; Humana Press: New York, 2012.
(22) Lee, H. C.; Ramotowski, R.; Gaensslen, R. E. *Advances in Fingerprint Technology*, 2nd ed.; CRC Press: Boca Raton, FL, 2001.
(23) Hawthorne, M. *Fingerprints: Analysis and Understanding*; CRC Press: Boca Raton, FL, 2008.
(24) National Institute of Justice. The Fingerprint Sourcebook http://www.nij.gov/pubs-sum/225320.htm (accessed Jan 9, 2013).

DOI: 10.1021/ed500406v
J. Chem. Educ. XXXX, XXX, XXX−XXX