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Activity

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Chemistry and Art in a Bag: An Easy-To-Implement Outreach Activity Making and Painting with a Copper-Based Pigment

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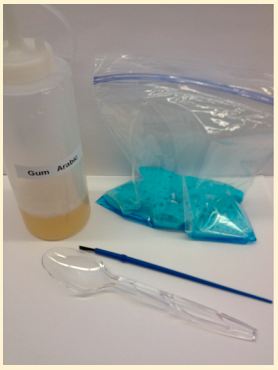
Supporting Information

ABSTRACT: An easy-to-implement outreach chemistry activity showing the synthesis, isolation, and use of a copper-based pigment, malachite, with three paint binders is described. This activity is adapted from a traditional chemistry laboratory experiment and can be performed in a sandwich bag using plastic utensils within a 15 min time frame. Student group size is kept at five students maximum, allowing interaction between a large number of students over the course of a 3 h outreach event. This Science Technology Engineering Arts and Mathematics (STEAM) experiment combining chemistry with art has the advantage of demonstrating a chemical reaction by the observation of a precipitate and evolution of a gas, which most students find highly intriguing. Discussions about chemical reactions, physical and chemical changes observed, and the interplay of chemistry and art took place between the authors and the students, who were highly engaged.



KEYWORDS: *General Public, Public Understanding/Outreach, Hands-On Learning/Manipulatives, Aqueous Solution Chemistry, Dyes/Pigments, Applications of Chemistry, Precipitation/Solubility*

INTRODUCTION

In recent years increased emphasis has been placed on interdisciplinary activities that aim at engaging students by making the scientific activities exciting and relevant to their everyday life. Although many college curricula have been enhanced by contextualizing chemistry with art and many STEAM (Science Technology Engineering Arts and Mathematics) activities have been developed, it has not yet translated into outreach activities for the general public and younger audiences. This outreach activity is designed for the young audience of elementary and middle-school age students. This activity has many advantages: first, it combines chemistry and art, as students prepare a pigment and try it with various paint binders; second, it offers a historical prospective about paint binders; third, it is easily implemented in informal settings since the reaction takes place in a sandwich bag; and finally, it uses relatively inexpensive materials.

THE ACTIVITY

Students are prompted to think about paint and its components and the fact that the chemistry of paint has evolved through time, following chemical, technological, and artistic changes. After a brief conversation about pigments and paint binders, students are directed to start the experiment, which consists of making their own paint. Students start by synthesizing a green copper-based pigment, copper(II) carbonate hydroxide, also called malachite, according to the following chemical reaction:

$$CuSO_4(aq) + NaHCO_3(s) \rightarrow CuCO_3{\cdot}Cu(OH)_2(s) + 3CO_2(g) + H_2O(l) + Na_2SO_4(aq)$$

This reaction can lead to discussions on the different types of chemical reactions, solubility rules, physical state of chemical compounds, and nomenclature of inorganic compounds, according to the level of interest and age of the audience. This synthesis has been described as a traditional chemistry laboratory activity where students may also create their own paint by mixing malachite with egg yolk.[1] Malachite has also been used as a starting material for an undergraduate chemistry laboratory where it is reduced in the presence of charcoal and heated to yield metallic copper, in a consistent way with copper age techniques.[2] In our modified activity, the malachite is mixed with three different paint binders of historical importance: gum Arabic, egg yolk, and linseed oil.[3−5] Also, since no traditional chemistry equipment is necessary and the chemicals used are nonhazardous, classifying this as a green reaction,[1] this experiment can be done in any setting, like at a booth at a science festival, or a school science night event, thus, making it a great outreach activity. It is advised that one adult supervise no more than five students at one time, depending on the student age and the presence of the students' parents.

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PREPARATION OF MALACHITE AND THREE DIFFERENT PAINTS

Materials for the Activity

Copper(II) sulfate was purchased from Fisher Scientific, and a 1.0 M solution was prepared. Baking soda and eggs were purchased from the grocery store, and linseed oil, gum Arabic solution, and turpentine were purchased from a local art supply store. The linseed oil binder was prepared by combining 10.0 mL of linseed oil and 20.0 mL of turpentine. The egg yolk binder was prepared as described previously.[1] Each binder is stored in a clearly labeled plastic squirt bottle that is easy to use for young students. Each student is provided with a handout that briefly describes malachite as a pigment and several binders and provides the chemical reaction for the experiment, a detailed procedure, and a space where the students can test and compare their paints.

Procedure

Students are provided with a sandwich bag, a plastic cup, a plastic spoon, and three paintbrushes. Using the plastic cup, the facilitator measures approximately 20.0 mL of 1.0 M copper(II) sulfate solution, which is then poured into the student's sandwich bag. A tablespoon of baking soda is then carefully added by the student, and the bag is massaged in order to mix the contents as carbon dioxide evolves and copper(II) carbonate hydroxide precipitates. These physical changes are subject to lots of discussion by and with the students. Additional baking soda is added after the reaction stops to ensure that the reaction goes to completion. Once fizzing has ceased, the precipitate is placed using the plastic spoons on several pieces of paper towel to dry. The solid, malachite, is then separated into three portions on a new piece of paper towel. The paint binders, stored in plastic squirt bottles, are then added to each malachite stack dropwise. Each malachite−binder combination is thoroughly mixed using a different paintbrush for each. If necessary, more paint binder is added, until the texture of the mixture is similar to that of regular paint. Students can then paint onto a piece of paper or a small canvas and observe the differences between the different paints. Because the malachite is not completely dry, the paint obtained by mixing it with the linseed oil binder is clumpy, leading to a discussion about hydrophobic interaction. Alternatively a premade dry sample of malachite can be made available to the students to examine the effect of the presence of water when using non-water-based binders.

SAFETY AND HAZARDS

Safety goggles and gloves should be worn during the entire activity. All copper compounds are irritant to skin, respiratory tract, and eyes. Participants allergic to eggs should use only the linseed oil and gum Arabic binders.

RESULTS

This activity has been tested with over 100 students, at a middle school science night event and at the Atlanta Science Festival as part of their STEAM program. The outcomes are qualitative since the activity was performed in informal settings where signing of consent forms was not practical. However, the authors can report that students and parents were highly positive about the activity. Many parents requested ideas on how to perform a similar experiment at home. Students were highly engaged and autonomous as the experiment uses easy-to-handle materials such as plastic spoons, cups, and bags. All students were given a choice to keep or leave the paper on which they painted, and all younger students of elementary school age kept their paper whereas about two-thirds of the middle school age students kept theirs. Moreover this activity involves chemical and physical changes that are quite captivating for a young mind and that led to discussions about gases, precipitates, and solutions with the students. In addition, many discussions about art-related chemistry activities took place with the parents while the students were painting.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.5b00364.

Student handout (PDF, DOCX)

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Notes

The authors declare no competing financial interest.

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REFERENCES

(1) Solomon, S.; Rutkowsky, S.; Mahon, M.; Halpern, E. Synthesis of Copper Pigments, Malachite and Verdigris: Making Tempera Paint. *J. Chem. Educ.* **2011**, *88*, 1694−1697.

(2) Johnson, C. E.; Yee, G. T.; Eddleton, J. E. Copper Metal from Malachite circa 4000 B.C.E. *J. Chem. Educ.* **2004**, *81*, 1777−1779.

(3) Wells, G.; Haaf, M. Investigating Art Objects through Collaborative Student Research Projects in an Undergraduate Chemistry and Art Course. *J. Chem. Educ.* **2013**, *90*, 1616−1621.

(4) Daines, T. L.; Morse, K. W. The Chemistry Involved in the Preparation of a Paint Pigment. *J. Chem. Educ.* **1976**, *53*, 117−118.

(5) Mayer, R. *The Artist's Handbook of Materials and Techniques*, 5th ed.; Viking: New-York, 1991.

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