Procedure for synthesising a red dye

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I. Introduction

The last year has brought very particular challenges to teaching institutions. At the Department of History of Art at University College London, we were keen to continue to provide hands-on experience to students on the BA programme in History of Art, Materials and Technology. Building on existing sources and studies, we designed two experiments that could be performed at home to develop both manual and critical skills. This document aims to serve as a resource for teaching and academic staff involved in teaching subjects at the intersection of art and science, such as technical art history, introductory chemistry, materials and techniques of artists, and conservation. It highlights the source materials used for designing those experiments, describes the experimental procedure and the quantities used for the home kits that were sent to students all over the world, and indicates possible pedagogical uses for this procedure.

One of the challenges encountered when developing these at-home experimental procedures was related to the diverse geographic locations of the students and concomitant challenges. For example, many of the medieval recipes for the manufacture of red or pink dyes from Brazilwood used ingredients that were unsuitable for shipping, such as highly toxic lead white or urine. This led us to develop these procedures with natural ingredients or materials that could be sourced locally. As a fundamental step in the design of our experiments and assembly of the home kits, we researched methods that had been used and published by others. The resources used in developing this procedure can be found in the *Resources* section below.

II. Source materials

The recipe comes from a medieval Portuguese manuscript called *The book on how to make all the colour paints for illuminating books*, dating back to at least the 13th century, written in Hebrew characters. The transliteration and translation are taken from a recent, critical edition by Devon Strolovitch (In: L. U. Afonso (ed.), *As Matérias da Imagem*, Lisboa: Campo da Comunicação, (2010)).

Source: The 'book on how to make colours', *O livro de como se fazem as cores das tintas todas*: medieval colours for practitioners, edited by researchers at Departamento de Conservacao e Restauro (NOVA University of Lisbon). Available at: https://www.dcr.fct.unl.pt/LivComoFazemCores

English

*Chapter 44. Making and tempering another brazil. '*If you wish to make good rose-colour, take brazil-wood and grind it in a mortar, until it is well ground. Sift it, and take a little virgin lime and place it in a glazed earthenware bowl with water until the water becomes clear, and with this water grind the brazil-wood, and put in it a little alum, temper it with gum, and write with it'.

Portuguese transliteration (from the original Hebrew characters)

kapitulo 44 si kiseres fazer | boah roseta toma o | brasil e mole-o no almofaris ke sega been moído | penye rao e toma uah poka h de kal virgen e | pona nuah altamiah kon aguah ates ke se faça | a aguah krara h e kon akela h aguah moy o brasil e lançalye un pekeno de pedra ume e destenpera | kon goma e eskrebe kon el

III. List of materials and equipment

Equipment

- 1 plastic funnel
- 2 round filter papers
- 4 small squares of aluminium foil
- 3 pH paper sticks (pH 0-14)
- 2-3 small glass bottles (30 mL)
- 2 wooden stirring sticks
- 1 sheet (A4) of black cardboard paper
- 2-3 pairs of examination gloves

Materials

- 0.5 g Brazilwood powder
- 3 g Calcium hydroxide
- Pre-mordanted yarn
- Natural yarn
- 0.3 g Potassium alum

IV. Experimental Procedure

1. Pour app. 15 mL water into one of the provided 30 mL-glass bottles and add the calcium hydroxide to make lime water.

   NOTE: do not add all the calcium hydroxide provided at once. Add it little by little until the solution is saturated (i.e. it stops dissolving).

   Any leftover calcium hydroxide can be left in the bag and disposed of alongside any other leftover materials.
2. Filtrate the solution using the plastic funnel and a filter paper. Use one of the pH strips to measure the pH of the lime water.
3. Add the brazilwood powder to the lime water. Let the solution stand for three to five hours. Measure the pH with one of the pH strips after this time.
4. Filtrate the solution into another glass bottle using the plastic funnel and another filter paper.
5. Put some of the provided natural yarn aside and immerse the rest in the solution for at least three hours. Remove the yarn and let it dry.
6. Immerse the pre-mordanted yarn in the solution for at least three hours.

   NOTE 1: If you still have two unused glass bottles at this point, you can divide the solution into two and add the natural and pre-mordanted yarn separately.

   NOTE 2: You can use wooden sticks to move the yarn around inside the bottle.
7. If you have any solution left at theis point (which is unlikely), add the alum to it. Measure the pH and add the remaining natural yarns to the solution, leaving them there for three hours.

<u>Additional experiment</u> (to test the lightfastness of the dye)

1. Cut the black cardboard paper in half, creating two A5-sized sheets of paper.
2. Fold both A5 sheets in half lengthwise.
3. With tape, stick the dyed pre-mordanted yarn on one of the inner sides of one of the A5-sized sheets of paper, so that you can cover half of the length of the yarn, and leave half of it exposed to light.
4. Do the same with both versions of the dyed natural yarn. Don’t forget to label your yarns so that you will be able to distinguish between the yarn dyed with an alum-rich solution and the one dyed in a solution with no alum.
5. You will now have your dyed yarns half-exposed and half-covered with thick black paper. Put them next to a window that catches direct sunlight (and does not have UV filters).
6. Compare the yarns after several days of exposure to sunlight to observe a fading of the colour in the exposed threads.

V. Resources

- Melo, M.J., Castro, R., Nabais, P. et al. 'The book on how to make all the colour paints for illuminating books: unravelling a Portuguese Hebrew illuminators' manual'. *Herit Sci* 6, 44 (2018). https://doi.org/10.1186/s40494-018-0208-z
- Afonso, L. U., J. Cruz, A., and Matos, D. 'O livro de como se fazem as cores or a medieval Portuguese text on the colours for illumination: a review'. In: *Craft Treatises and Handbooks*, 93-105 (2013). https://doi.org/10.1484/M.DDA-EB.5.102148
- Tatiana Vitorino, Maria João Melo, Leslie Carlyle & Vanessa Otero. 'New insights into brazilwood lake pigments manufacture through the use of historically accurate reconstructions', *Studies in Conservation*, 61:5, 255-273 (2016). https://doi.org/10.1179/2047058415Y.0000000006
- 'O livro de como se fazem as cores': medieval colours for practitioners, developed by researchers at Departamento de Conservacao e Restauro (NOVA University of Lisbon). Available at: https://www.dcr.fct.unl.pt/LivComoFazemCores
- Strolovitch, D. 'O libro de komo se fazen as kores das tintas todas (Transliteration)'. In: L. U. Afonso (ed.), *As Matérias da Imagem*, Lisboa: Campo da Comunicação. 213-236 (2010).

VI. Teaching subjects

Under the remit of history of art, technical art history, and conservation, this procedure can be used to discuss themes such as: interpretation of historical sources, understanding of the materials of art, issues of degradation and conservation.

In the area of chemistry, this procedure can be used to discuss issues pertaining to organic chemistry, acids and bases, and chemical reactions. Depending on the depth of analysis, this experiment can fit the curriculum of GCSE and A-level chemistry.

VII. Activities

Various activities can be developed from this experiment. Here, we highlight three of the many pedagogical pathways that can be explored in class:

- ***Interpreting historical sources***
  Students are asked to interpret the recipe – i.e. understand how to successfully replicate it – over the course of several weeks, paying particular attention to the terms used in reference to materials and quantities. This will allow students to develop their own theoretical models on how one could replicate this recipe, confirming or refuting their expectations through this experiment. This activity can also take place in groups.

- ***From the lab to the home***
  NOTE: This activity requires access to analytical data.
  The activity starts with students looking at FT-IR spectra of a sample brazilwood dye or pigment. Ideally, these spectra would have been produced in the laboratory, using a sample from a specific object. Students try to recognise and label the different IR peaks of

the spectra to develop theoretical models on what one should expect the molecule to be. Then they proceed with the experiment and see if they can confirm their expectations.

- ***Comparing historical sources***
  NOTE: This activity takes more than ten weeks to be developed in the context of remote teaching.
  Students are asked to analyse two different historical recipes for producing brazilwood pigments and dyes. They develop the experimental procedure based on their expectations and interpretations of the historical sources. Students are then given access to the materials they need (and home kits are sent to them if the experiment happens remotely). They try both recipes and discuss the results both in terms of the chemical reactions that took place and the useability of the materials. This experiment can be complemented with FT-IR analysis to confirm the results obtained.

- ***Raw materials***
  Students interpret the recipe by tracing back the origin of the mentioned raw materials. This activity will allow students to explore various issues: from trade routes to knowledge exchange, to the material conditions needed to create these materials.

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List of Contributors

Tobias Preuten and Hélia Marçal: development and testing of the experiments, authors of the first version of this document.

Tobias Preuten: risk assessment, procurement, assembly, packing, and posting of the home kits during the academic year 2020-2021.

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