Chemistry in Art Restoration

In 2012 a visitor to the Tate Museum in London sprayed black ink on the Rothko painting *Black on Maroon*, which is estimated to cost around $80 million. To remove the graffiti from the priceless Rothko mural, the Rothko Conservation Project was started, bringing together art conservationists and chemists with expertise in paints. In order to restore the painting, the chemists and art conservations worked together to test different solvents, to determine which could remove the black graffiti ink from the painting without damaging the painting itself. Rothko was known for using different paint binders (binders are the materials that hold the colored pigments to the surface of the canvas). This made the chemists' job even more difficult, because they did not know what kind of binder Rothko used. Artists use anything from egg yolk to oil as their binder.

In this activity you will act as the chemical consultant for this project. You will need to study the structure of the solvents and the binders to help discover what solvent will remove the black ink without removing the underlying paint layer. You will examine paints made with three different binders (linseed oil, casein, and Gum Arabic).

BEGINNING QUESTIONS

1) In what solvent(s) is/are the black Molotow ink soluble? What does this tell us about the chemical properties of the ink?
2) Which solvents will remove the ink, but not the paint?
3) How does the binder composition affect the results?

TESTS & OBSERVATIONS

Safety. Appropriate personal protective equipment (PPE), including safety goggles and gloves, should be worn at all times. The solvents should be used in the hood, and disposed of in appropriately marked containers.

Part 1 - Solvent Solubility

Test. Using only as much solvent as appropriate, test the solubility of the ink in solvents of two different polarities (see Table 1 for solvents and their structures). What do your results suggest about the polarity of the ink?

Prediction. After determining the solubility of the ink, predict what solvent will be the most effective in removing the black graffiti ink without removing the underlying paint. To aid in your decision making, consider the structures of the solvents shown in Table 1 and the structures of the paint binders shown in Table 2.

Table 1. Solvents available for use in this experiment along with their structures.

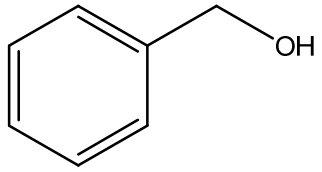
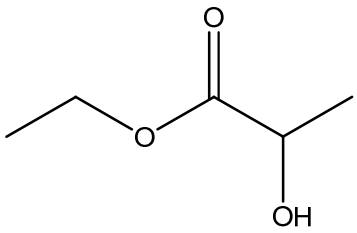
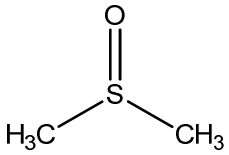
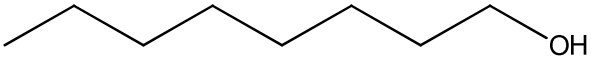
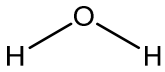
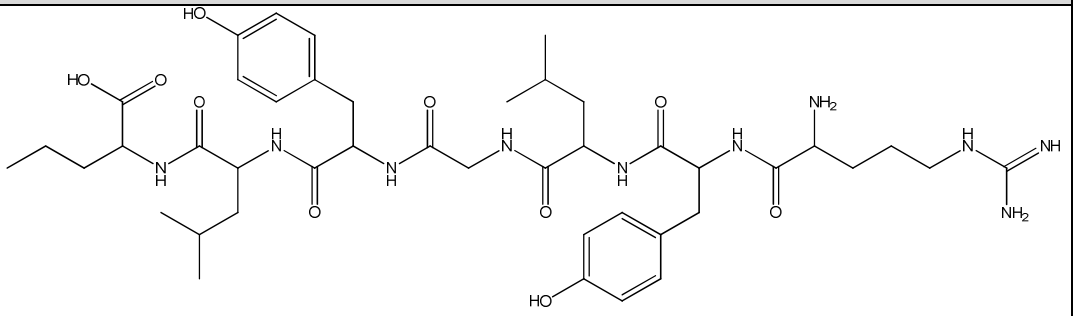
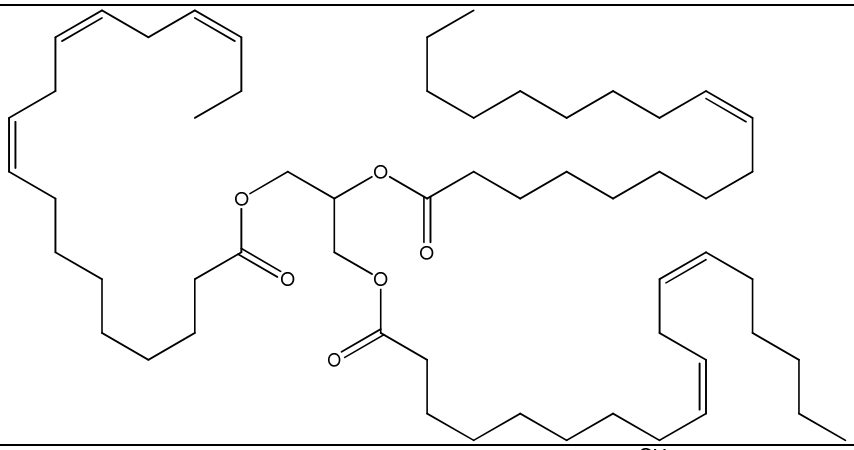
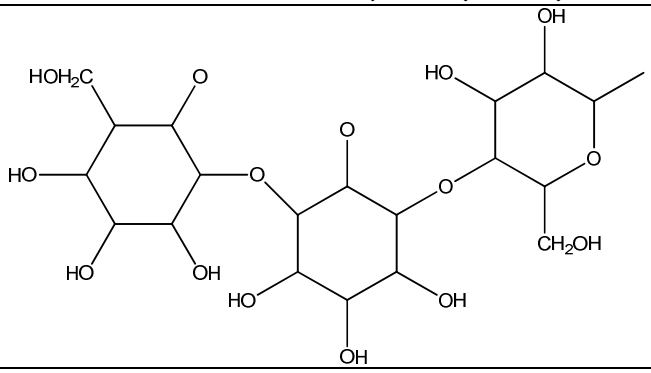
Solvent	Structure
Benzyl alcohol	
Ethyl lactate	
Dimethylsulfoxide (DMSO)	
1-Octanol	
Water	

Table 2. Paint binders available for use in this experiment along with their structures.

Binder	Structure
Casein	
Linseed oil	
Gum Arabic	

Part 2 - Preparation of Binders and Paint Sample

Preparation of binders

A. Casein Binder

- Add 20 mL of skim milk and 5 mL of vinegar into a disposable cup and stir. Let the mixture sit for five minutes (if no solid material is seen, add in 5 mL more vinegar).
- Isolate the solid material by pouring the mixture into a funnel with filter paper into a flask. Blot the extra liquid off with a paper towel.

Gum Arabic Binder

- In a weigh boat, mix 1 part Gum Arabic with 4 parts water (~5 mL). If the solution seems too watery, add another spatula tip of Gum Arabic.

C. Linseed Oil Binder

- This will be provided to you.

Preparation of paint sample

- Mix a small amount of pigment (tip of a spatula) with each binder, and paint thick stripes of each type of paint on a piece of cardstock.
- After the paint dries (~5-20 min), add a small amount of the black ink over each type of paint.

Testing of the solvents

Using water, octanol, and another solvent based on your predictions, determine how effective each is at removing the ink without removing the underlying paint layer. This may be best achieved by dipping a Q-tip in each solvent and rubbing it across the paint sample.

CLAIMS

What can you claim about the beginning questions?

EVIDENCE

How do you know? Why are you making these claims?

COMPARISON TO OTHERS

How do your claims and evidence compare to other groups?

REFLECTION

How have your ideas changed since conducting this activity?
What experimental studies would you do if you had more time? Why?