Integrating the visual arts and inorganic chemistry

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Introduction

- APSU is a regional university in Clarksville, TN with 9,200 students
- Chemistry department has 8 faculty and graduates 10-15 majors per year
- One semester Inorganic Chemistry class for juniors and seniors.
- Experiments from the Chemistry in Art workshop were adapted for inclusion into Inorganic lecture and lab.

Purpose

- Share experience with integration of art concepts into Inorganic lecture and lab
- Discuss two main modules used in lecture and lab during past 3 classes.
  - Inorganic Pigments
  - Chemistry of Photography
- Highlight connections between inorganic chemistry and these art related topics.

Brief course outline

- Topics covered in 1-semester Inorganic Chemistry class at APSU
  - Atomic Structure
  - *Inorganic Pigments*
  - Simple Bonding Models
  - Symmetry
  - Molecular Orbitals
  - Acid/Base Chemistry
  - *Chemistry of Photography*
  - Coordination Chemistry
- Art topics promote connections to real-world applications

Inorganic Pigments: Lecture

- Colorants: Inorganic Pigments and Indigo
  - Definitions
  - Brief history of colorants
  - Highlight chemical reactions of synthetic pigments
  - What causes color in inorganic pigments?
  - Ideal properties of pigments
    - Lightfast, inert, insoluble, high opacity, uniform particle size

Inorganic Pigments: Lab Experiment #1

- Synthesis of inorganic pigments
  - Barium white ($BaSO_4$)
    - $BaCl_2\ (aq) + Na_2SO_4\ (aq) \rightarrow BaSO_4\ (s) + 2\ NaCl$
  - Synthetic malachite ($CuCO_3 \bullet Cu(OH)_2$)
    - $CuSO_4\ (aq) + NaHCO_3 (s) \rightarrow CuCO_3 \bullet Cu(OH)_2 (s) + 2Na_2SO_4 + 3CO_2 + H_2O$
  - Chrome yellow ($ZnCrO_4 \bullet Zn(OH)_2$)
    - $K_2CrO_4\ (aq) + 2\ ZnCl_2 + 2\ NaOH \rightarrow ZnCrO_4 \bullet Zn(OH)_2\ (s) + 2\ NaCl + 2\ KCl$
  - Chrome Oxide Green (Cr_2O_3)
    - $Na_2Cr_2O_7\ (s) + S_8\ (s) + O_2 + \text{heat} \rightarrow Cr_2O_3\ (s) + SO_2\ (g)$

Inorganic Pigments

Barium White

Synthetic Malachite

Chrome Yellow

Chrome Oxide Green

Inorganic Pigments: Lab Experiment #2

- White Pigment Analysis
- Student driven qualitative analysis experiment
  - Microscopic and macroscopic observations to identify an unknown pigment
  - Pigment samples
    - Chalk or whiting ($CaCO_3$)
    - Lead White ($2\ PbCO_3 \cdot Pb(OH)_2$)
    - Zinc White (ZnO)
    - Gypsum ($CaSO_4$)
    - Titanium White (TiO_2)
    - Barium White ($BaSO_4$)
  - Available reagents such as 3M HNO_3 and KI and a polarizing light microscope are used in analysis

Chemistry of Photography: Lecture

- Photographic Chemistry
  - Brief History
  - Salted Paper Prints
    - William Henry Fox Talbot - 1840
    - Connected to acid/base chemistry
    - Sensitizing Paper
      - $NH_4Cl\ (aq) + AgNO_3\ (aq) \rightarrow\ AgCl\ (s) + NH_4NO_3\ (aq)$
    - Development
      - $3\ AgCl\ (s) + light \rightarrow\ 2\ Ag\ (s) + Cl_2\ + AgCl\ (s)$
    - Fixing image
      - $AgCl\ (s)\ + 2\ Na_2S_2O_3\ (aq) \rightarrow\ Na_3[Ag(S_2O_3)_2]\ (aq)\ + NaCl\ (aq)$

Chemistry of Photography: Lecture

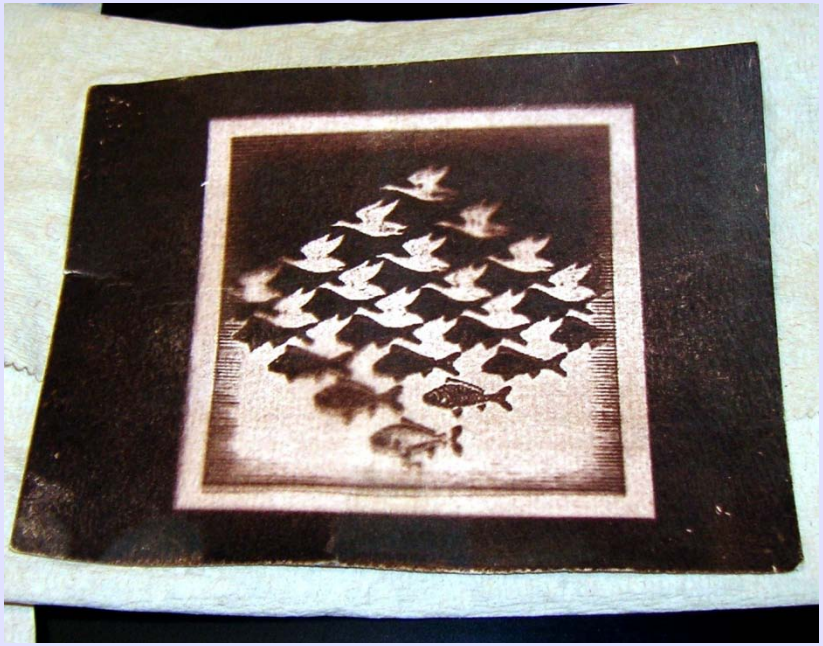
- Photographic Chemistry
  - Cyanotypes
    - Sir John Herschel - 1842
    - $K_3Fe(CN)_6 + C_6H_8O_7 \cdot nFe \cdot nNH_3 \rightarrow Fe[Fe(CN)_6]$
      - Light sensitive $Fe[Fe(CN)_6]$ absorbs into the support
    - $Fe^{3+} + light \rightarrow Fe^{2+}$
    - $Fe^{2+} + [Fe(CN)_6]^{3-} \rightarrow KFe[Fe(CN)_6] \cdot 5\ H_2O\ (s)$
      - $KFe[Fe(CN)_6] \cdot 5\ H_2O\ (s)$ is Prussian Blue
  - Alternative processes and toning
  - Color and instant photography

Chemistry of Photography: Labs

- General Supplies
  - Clip frames and binder clips
  - Support (watercolor paper or cotton)
  - Paint trays and foam brushes
  - Photographic negatives or transparencies
  - Sunlight or Blacklight

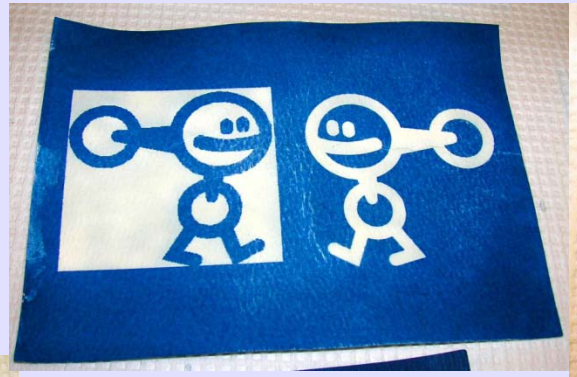
Chemistry of Photography: Lab #1

- Silver Salted Prints
  - Students compare different binder, starch or gelatin



Chemistry of Photography: Lab #2

- Cyanotypes
  - Students compare different supports, paper or cloth


Chemistry of Photography: Lab #3

- Design Your Own Photography Experiment
  - Students plan and carry out individual experiments related to the past weeks of photography experiments
  - Topics studied have included
    - What light sources work for cyanotypes?
    - What exposure times are required for silver salted prints?
    - How does wash temperature affect image quality?
    - What stoichiometric ratio of reagents give the best print?
    - Do other silver halides work as well as AgCl?
    - Can silver halide chemistry be used on cloth?
  - The experiment concludes with a formal report

Student Comments

- *"I really liked developing my own lab experiment. The photography experiment was definitely my favorite."*
- *"This lab was one of my favorites...I really enjoyed the photography experiments and am actually interested in doing some alternative photography on my own time."*
- *"The pigment labs were interesting. I learn best by seeing processes step by step."*
- *"The labs applied new perspectives of chemistry which were both interesting and informative."*

Conclusions

- Student response has been overwhelming positive, even from those who do not normally enjoy lab or consider themselves creative.
- Enjoyable and interesting topics hold student attention and are useful for elucidating concepts like acid/base chemistry and synthetic methods.
- Design Your Own Experiment requires independent scientific thought
- The integration of experiments learned from the Chemistry in Art Workshop into my inorganic classes has been very successful.

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