

# Colored Pencils: Composition, Solubility, and Lightfastness

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## Introduction

Colored pencils are a medium used by both artists and conservators, but their material properties have not been widely studied. The aim of this research was to identify the composition, solubility, and lightfastness of water-insoluble colored pencils. Both artist-grade and student-grade colored pencils were tested so there was representation of media that would be used for inpainting and fine arts, as well as by amateur artists.

## Experimental

Two artist-grade colored pencil sets (Caran d'Ache LUMINANCE 6901 [CDLum] and Faber-Castell Polychromos [FCPoly]) and two student-grade pencils sets (Caran d'Ache School Line (Swisscolor) [CDSchool] and Faber-Castell Classic Colour [FCClassic]) were utilized. The primary colors from each set were chosen for experimentation and are pictured in Figure 1.



Figure 1: The colored pencils analyzed, from top to bottom: CDLum, CDSchool, FCPoly, FCClassic

## Analytical Techniques

- XRF of the pencil leads
- ATR-FTIR of the pencil leads
- Samples of each lead were solubilized in distilled water, ethanol, acetone, ethyl acetate, and toluene. The resulting films formed after evaporation were analyzed with microspectroscopy
- Three drawn samples for each colored pencil were light aged approximately following ASTM D6901, *Standard Specification for Artists' Colored Pencils*

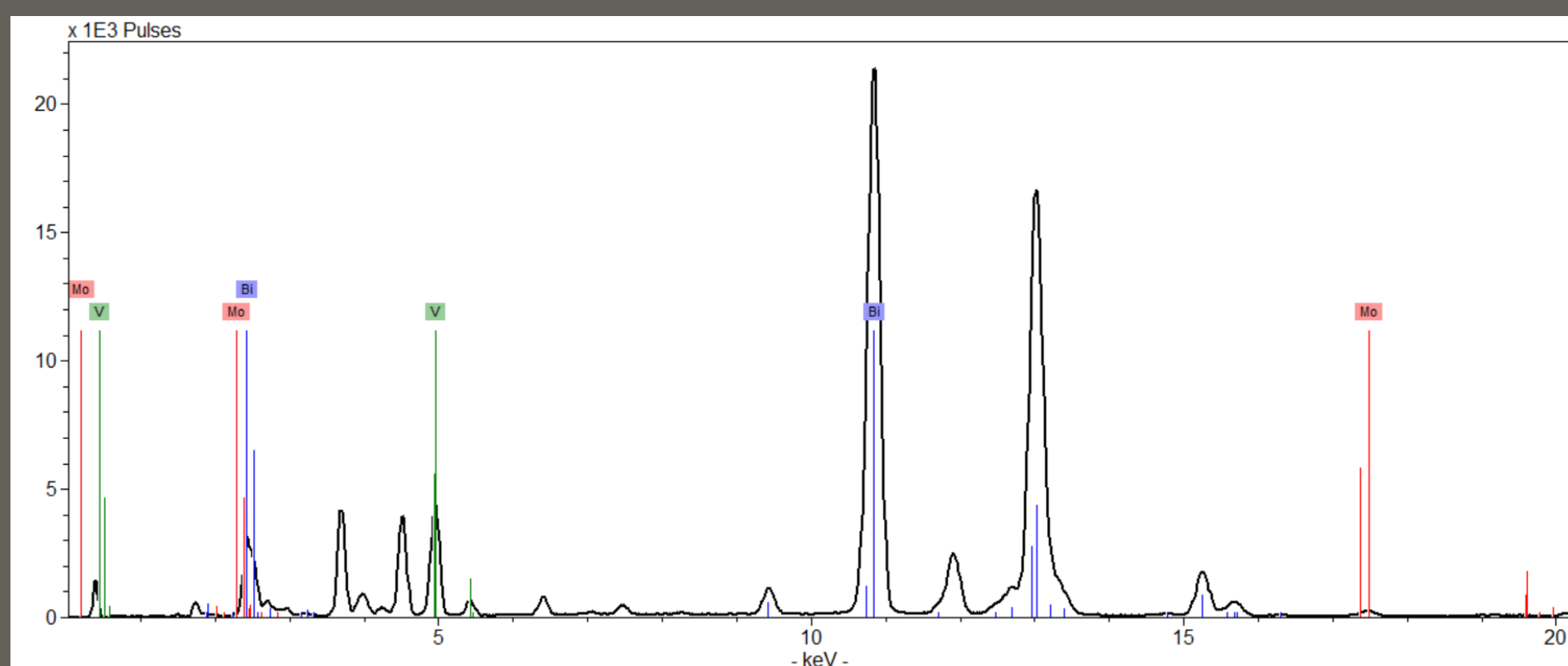


Figure 2: The XRF spectrum for the yellow CDLum colored pencil, highlighting the peaks for bismuth, vanadium, and molybdenum

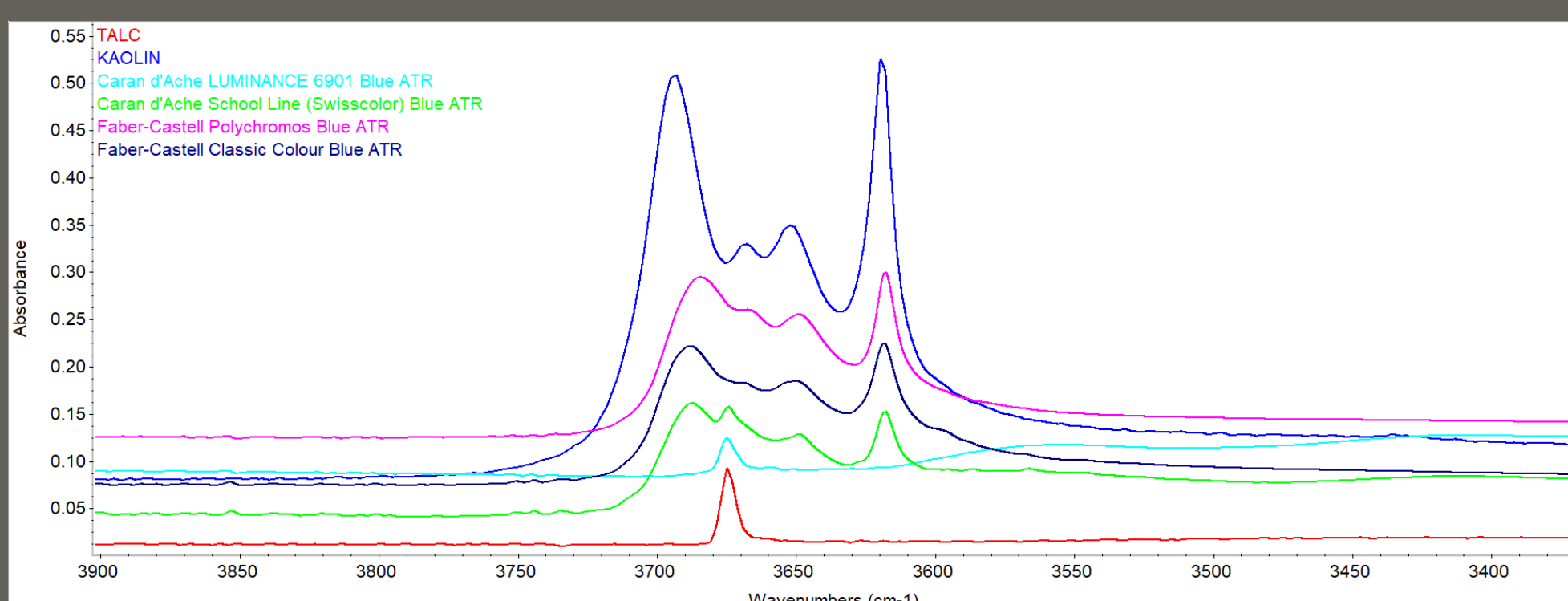


Figure 3: The 3900-3400 cm<sup>-1</sup> region of the ATR-FTIR spectra comparing the blue colored pencils from each brand with talc and kaolin

## Composition

- The yellow CDLum pencil contains bismuth vanadate yellow,  $\text{BiVO}_4 \cdot n\text{Bi}_2\text{MoO}_6$ , as seen in Figure 2
- The blue CDSchool pencil and both blue FC pencils have an iron-based colorant component, with low concentrations of PB15, copper phthalocyanine
- Table 1 exemplifies some compositional similarities and differences between pencils
  - Figure 3 shows the FTIR spectra for talc and kaolin
  - Instead of a wax, the CDLum pencils contain dicarboxylic acids of saturated fatty alcohols, an industrial slip agent

	CDLum	CDSchool	FCPoly	FCClassic
Stearic Acid		X	X	
Talc	X	X		
Kaolin		X	X	X
Paraffin/ester wax		X	X	X

Table 1: Some compositional elements of the four colored pencils

## Lightfastness

- All drawn samples exhibited some color change
- The CDLum pencils were the most lightfast
- The yellow samples showed the least color change
- All the blue samples, illustrated in Figure 5, had a visible color change after aging
  - They became less blue and more green



Figure 5: Visual representations of the blue drawn samples before after light aging

## Solubility

- Soluble components in each pencil could be noted visually under magnification, as seen in Figure 4, and identified with microspectroscopy
- None of the colorants themselves were soluble in the organic solvents tested

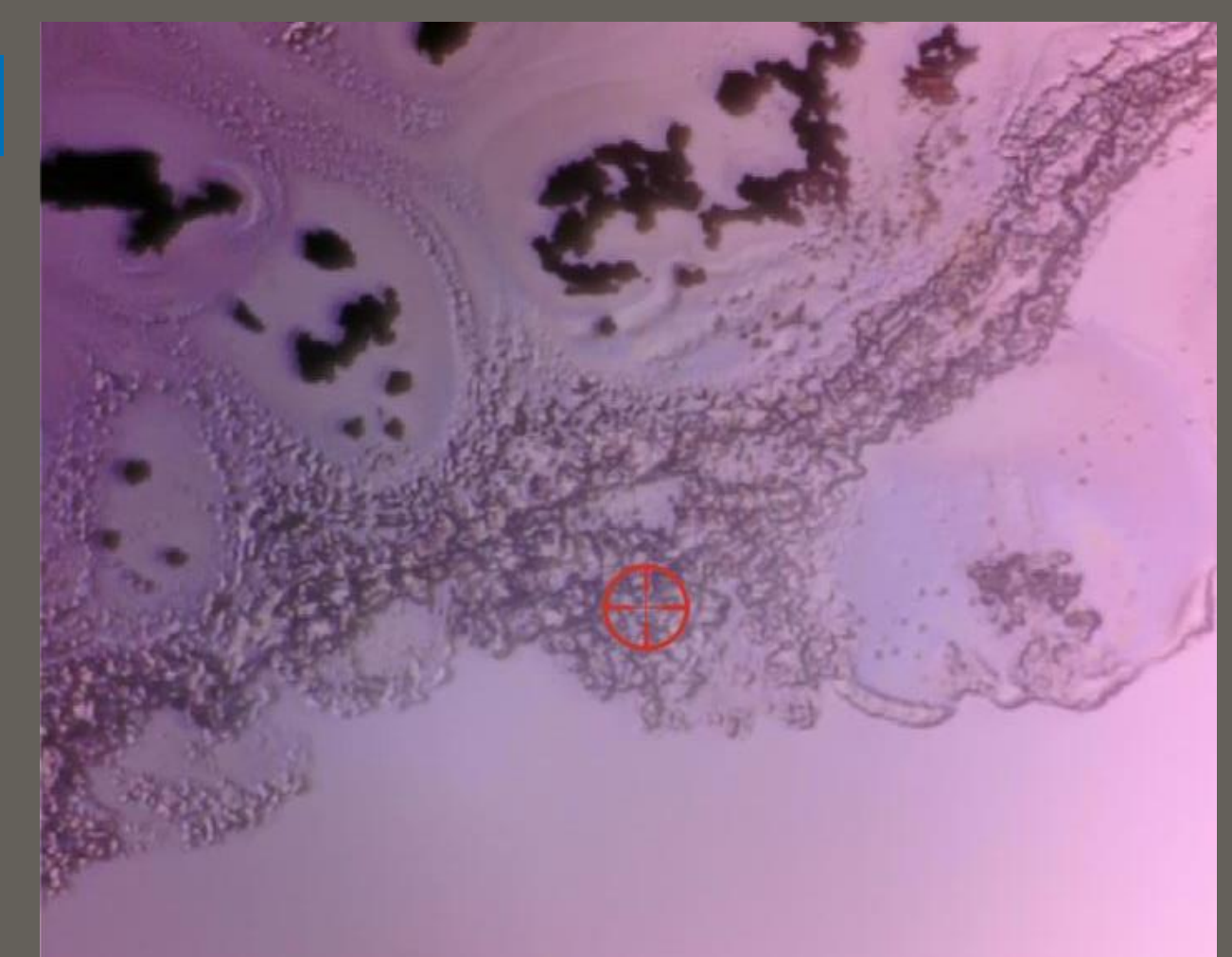


Figure 4: The material within the red FCClassic pencil that was solubilized in ethyl acetate and analyzed with FTIR

## Selected References

- ASTM International. *Standard Specification for Artists' Colored Pencils*. D6901-15. ASTM International. 2015.
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## Conclusions

- The general pencil composition included at least one colorant (organic and/or inorganic), long-chain fatty acid, and a filler material
- There were colorless components in each pencil that were soluble in organic solvents, though the colorants themselves were not soluble
- Artist-grade colored pencils were more lightfast than student-grade
- The blue colored pencils were the least lightfast and the yellow colored pencils were the most lightfast