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Water Treatment Experiments

David Reckhow
University of Massachusetts - Amherst, reckhow@ecs.umass.edu

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Friday AM

David A. Reckhow
University of Massachusetts

Introduction

- The water industry spends a lot of money and effort on removal of natural organic matter (NOM) from drinking waters
- Problems with NOM (the more NOM the bigger problem)
  - NOM interferes with the ability of water treatment systems to remove substances that cause disease
    - Pathogenic organisms
    - Toxic chemicals
  - NOM reacts with chlorine-based disinfectants forming carcinogenic organic byproducts

Intro (cont.)

- Thinking about removal of NOM, many questions come to mind.
  - Which methods are most effective? Are home treatment systems as good as, better than or worse than community water treatment systems?
  - Will alum, the most common method of treatment in cities, really remove colored organic matter? If so, how much removal occurs?
  - How does alum compare to chlorine and GAC, the other major types of treatment
  - How does chorine compare with the other disinfectants, iodine and chlorine dioxide?
  - How do the various home filtration products compare?
  - Does treatment effectiveness depend on the type of leaves in the watershed?

Materials

- Plant leachate
  - Yours or mine
- Containers for treatment & imaging
  - Plastic Culture Flasks (275 mL),
    - Corning #430720; $3.70 each from Fisher, $2 from Caroline Bio
- Treatment Chemicals & Equipment
  - <u>Coagulation</u>: alum
  - <u>Activated Carbon Adsorption</u>: Aquarium charcoal
  - <u>Disinfection</u>: household bleach, “field” disinfectants
  - <u>Home Treatment Systems</u>: Brita, etc.
  - Filtration apparatus
- Camera, computer & ADI software

What to Do for the Treatment Tests?

- Decide on plant leachate to treat
- Conduct Treatments
  - Bottle 1: Alum coagulation (do this first)
  - Bottle 2: GAC adsorption (two options)
  - Bottle 3: Disinfection/Oxidation (do one or more)
  - Bottle 4: Home Treatment (do one or more)
- Some may require paper filtration
  - If treated waters look cloudy
- Record Images and analyze
  - Collect at least one photographic image of the treated bottles next to a blank (tap water) and an untreated control (leachate)

Alum Coagulation

1. Add about 15-20 drops of the 4% sodium bicarbonate ($NaHCO_3$) solution you'll want to reach a pH of about 7-7.5
2. to your 250 mL sample, add about 1-2 drops of the 6% sodium hydroxide solution (NaOH). Check pH
3. Add a sufficient amount of the 10% alum solution (about 15-20 drops) to initiate floc formation. You will need to gently shake the bottle (slowly invert about 20 times over 60 seconds) and wait for the slow formation of visible and settleable floc. This step is called flocculation.
4. Check pH, add more NaOH if it is below 7, you may need to add 4-8 additional drops. Do this 2 drops at a time, checking pH. Remember your target is pH 7-7.5.
5. Allow the floc to settle for about a half-hour.

Granular Activated Carbon (GAC)

- There are at least two different methods of GAC treatment used in water treatment plants.
  - Both can be simulated in the laboratory, although the first may be easiest. You're welcome to select either one:

1. Filter Bed method: simultaneous contact/filtration
   - Gently pour half of the 250 mL sample into the filter funnel containing a layer of pre-washed GAC[1]. Slowly turn on the vacuum until the level just starts to drop. Once the first have has been received into the filter flask, repeat with the second half. Don't discard the GAC; it can be uaed again. Transfer the filtrate back to your culture bottle for image analysis

or

2. Slurry method : contact then filtration
   - Add a spoonful of GAC directly to the 250 mL bottle, shake and allow it to settle. You may need to filter the sample after it settles

[1]GAC was gently introduced over a sandwich of 2 Whatman #1 filter circles (90mm)

Disinfection & Oxidation

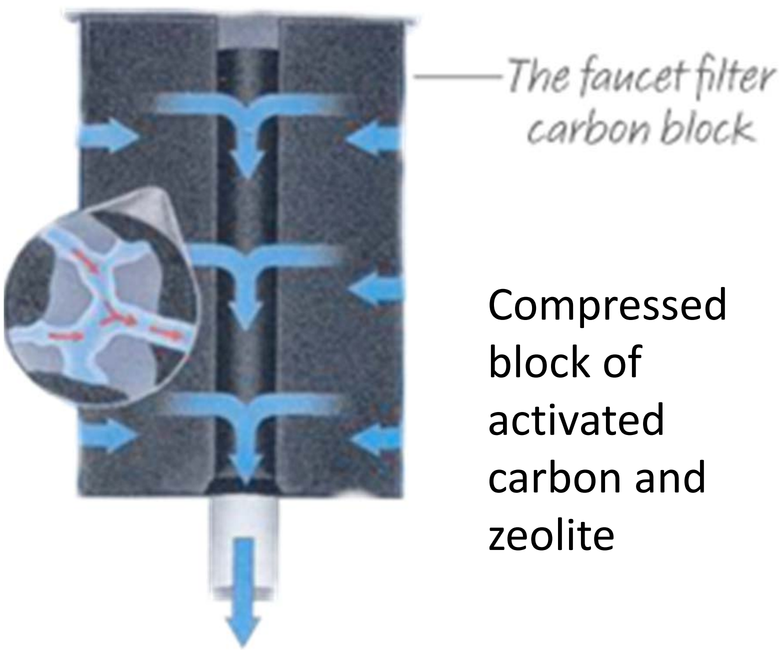
1. Add one of the following:
   - Chlorine or Household Bleach: 10 drops of the 5% chlorine solution (each group has a bottle).
   - Iodine or Potable Aqua: add 1 tablet to the 250 mL sample (only one set of tablet for the class)
   - Chlorine Dioxide or Aquamira: add ½ to 1 tablet to the 250 mL sample (only one set of tablets for the class)
2. Shake and wait about 10 minutes for reactions to occur
3. Collect images and analyze

Home or Point of Use Treatment

1. Select one or more treatment products
   - Brita Bottle
   - Brita Pitcher
   - ZeroWater Pitcher
2. Pour 250 mL sample into reservoir.
3. Allow water to percolate through or squeeze it out (Brita bottle)
4. You may need to filter if the treated water looks cloudy
5. Return it to the culture bottle, image and analyze

Brita: Water Bottle

- GAC/ion exchange
- Replace cartridge every 75L



Compressed block of activated carbon and zeolite

Brita: Pitcher

- Same
  - Activated Carbon and Ion Exchange resin
- 160 L per cartridge

ZeroWater

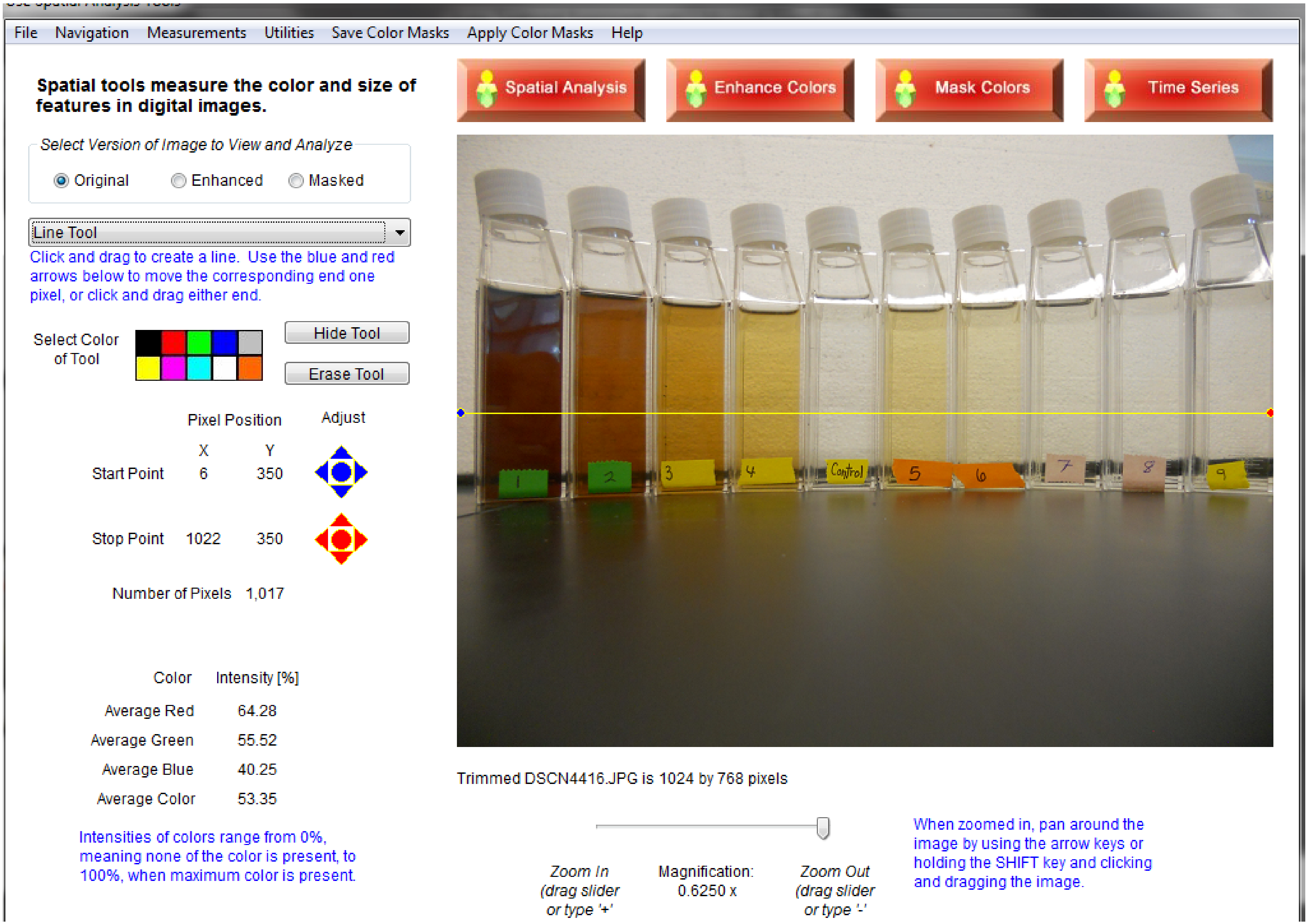
- 5-stage dual Ion Exchange
- Replace cartridge when TDS meter reads 6 ppm
- Capacity depends on TDS of water to be treated

Data Analysis

- Using line or rectangle tool, determine color intensity of red, green & blue
- Tabulate these values and compare with calibration curve
  - This will show the amount of colored organic matter remaining after treatment
  - Comparison with a calibration helps to assign a quantitative "% remaining" or "% removal"

Calibration Curve & Beer's Law

- From a single leachate sample
  - Prepare serial dilutions with each successive sample diluted to half its initial concentration
    - 100%, 50%, 25%, 12.5%, 6.25% etc.
  - Image bottles with a blank (pure dilution water)
  - Prepare plot of color intensity vs % of initial concentration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Measurements
Utilities
Save Color Masks
Apply Color Masks
Help
Spatial tools measure the color and size of features in digital images.
Spatial Analysis
Enhance Colors
Mask Colors
Time Series
Select Version of Image to View and Analyze
Original
Enhanced
Masked
Line Tool
Click and drag to create a line. Use the blue and red arrows below to move the corresponding end one pixel, or click and drag either end.
Select Color of Tool
Hide Tool
Erase Tool
Pixel Position
Adjust
X
Y
Start Point 6 350
Stop Point 1022 350
Number of Pixels 1,017
Color
Intensity [%]
Average Red 64.28
Average Green 55.52
Average Blue 40.25
Average Color 53.35
Intensities of colors range from 0%, meaning none of the color is present, to 100%, when maximum color is present.
1
2
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Control
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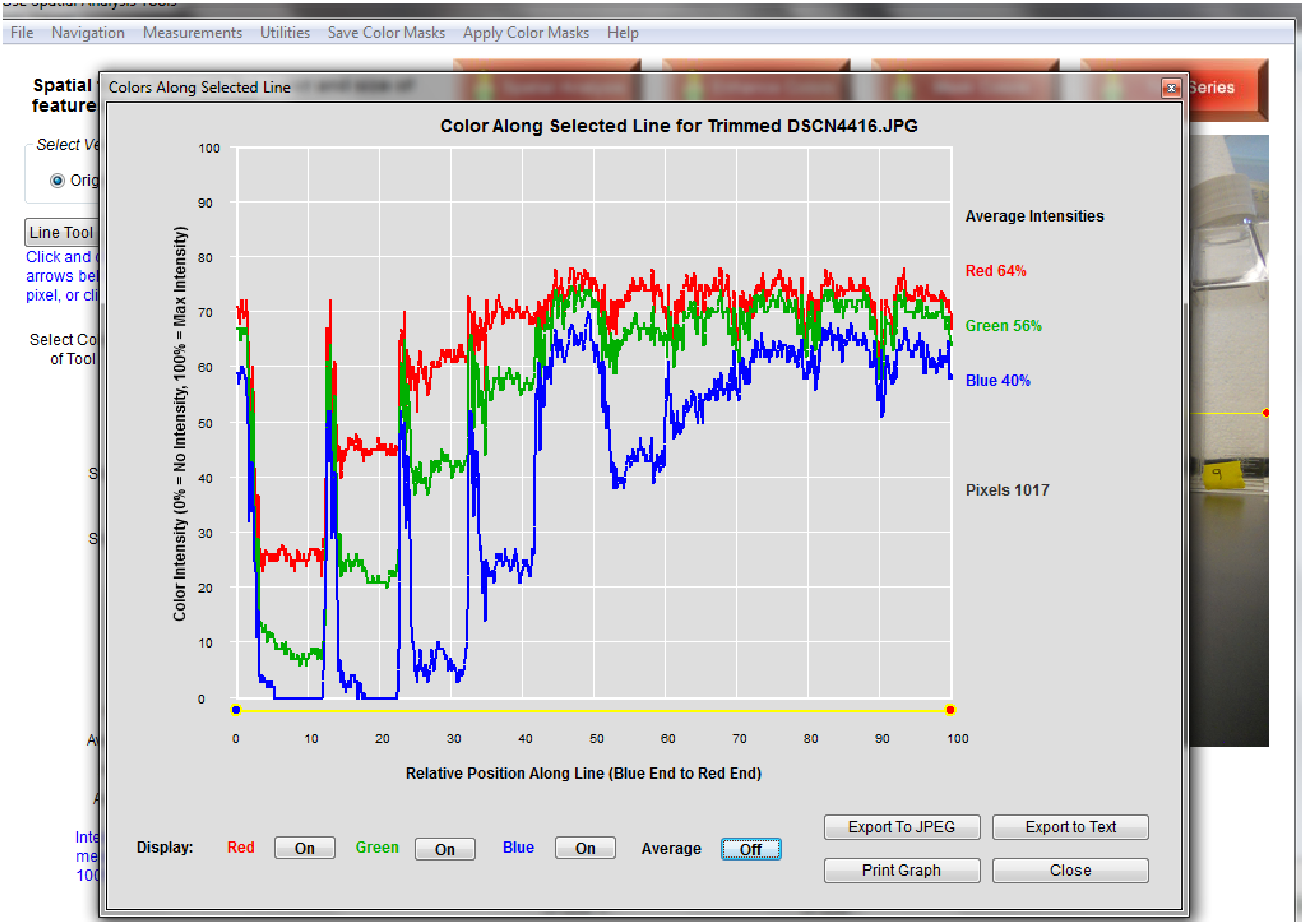
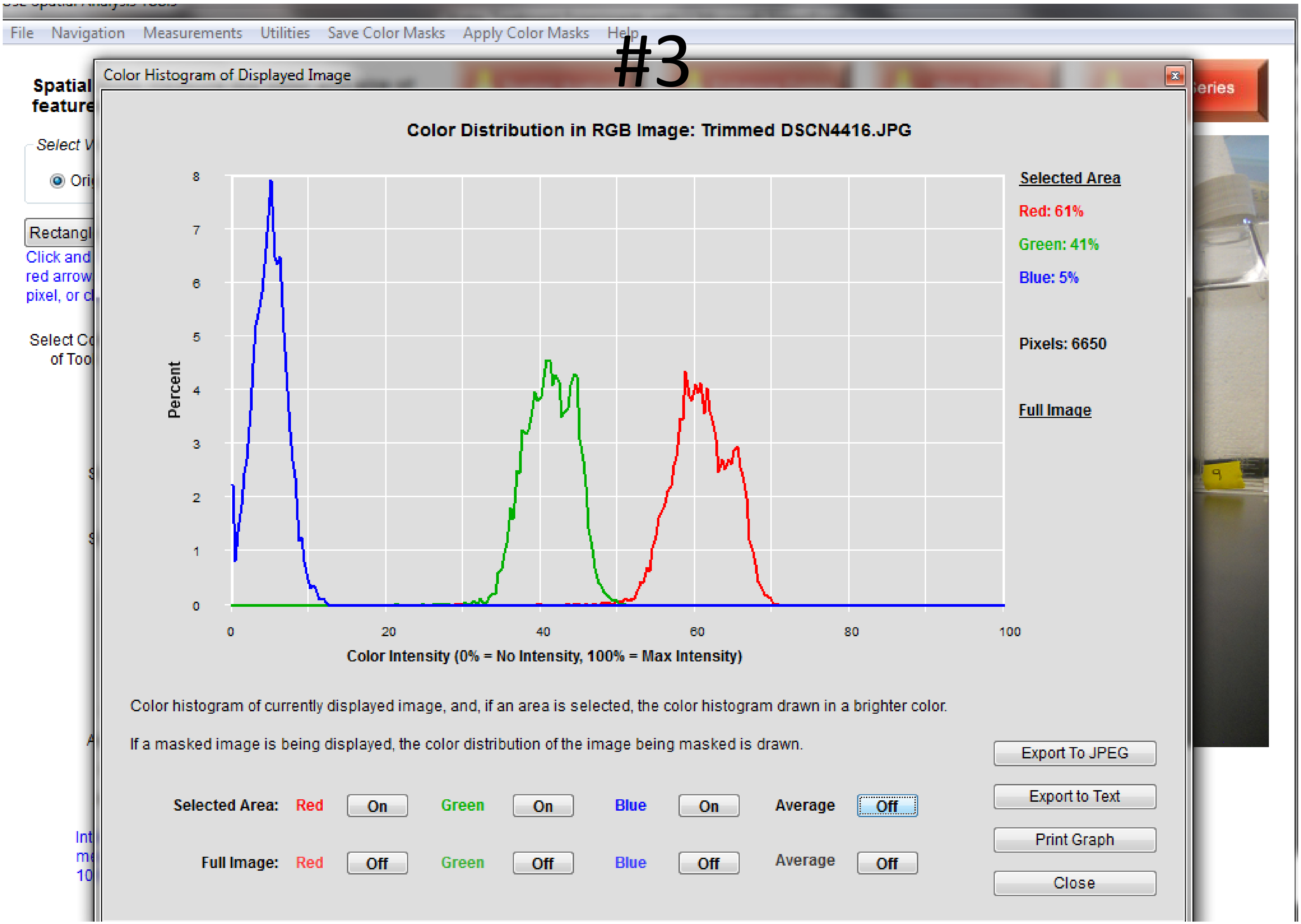
Trimmed DSCN4416.JPG is 1024 by 768 pixels
Zoom In (drag slider or type '+'
Magnification: 0.6250 x
Zoom Out (drag slider or type '-'
When zoomed in, pan around the image by using the arrow keys or holding the SHIFT key and clicking and dragging the image.

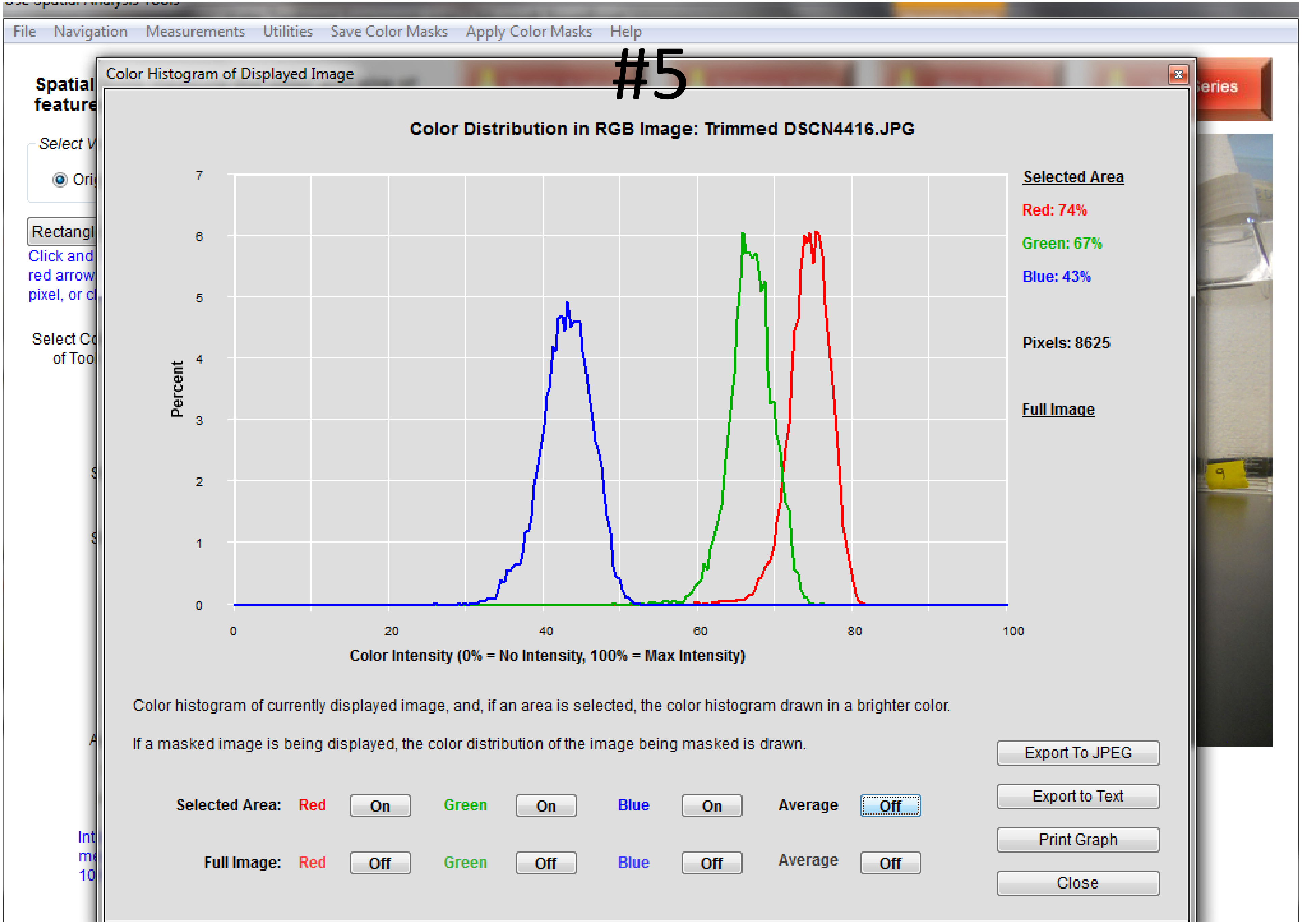

File Navigation Measurements Utilities Save Color Masks Apply Color Masks Help
Colors Along Selected Line
Color Along Selected Line for Trimmed DSCN4416.JPG
Color Intensity (0% = No Intensity, 100% = Max Intensity)
Relative Position Along Line (Blue End to Red End)
Average Intensities
Red 64%
Green 56%
Blue 40%
Pixels 1017
Display: Red On Green On Blue On Average Off
Export To JPEG
Export to Text
Print Graph
Close

#3



File Navigation Measurements Utilities Save Color Masks Apply Color Masks Help
Color Histogram of Displayed Image
Color Distribution in RGB Image: Trimmed DSCN4416.JPG
Selected Area
Red: 61%
Green: 41%
Blue: 5%
Pixels: 6650
Full Image
Percent
0 1 2 3 4 5 6 7 8
0 20 40 60 80 100
Color Intensity (0% = No Intensity, 100% = Max Intensity)
Color histogram of currently displayed image, and, if an area is selected, the color histogram drawn in a brighter color.
If a masked image is being displayed, the color distribution of the image being masked is drawn.
Selected Area: Red On Green On Blue On Average Off
Full Image: Red Off Green Off Blue Off Average Off
Export To JPEG
Export to Text
Print Graph
Close

#5



File
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Measurements
Utilities
Save Color Masks
Apply Color Masks
Help
Color Histogram of Displayed Image
Color Distribution in RGB Image: Trimmed DSCN4416.JPG
Percent
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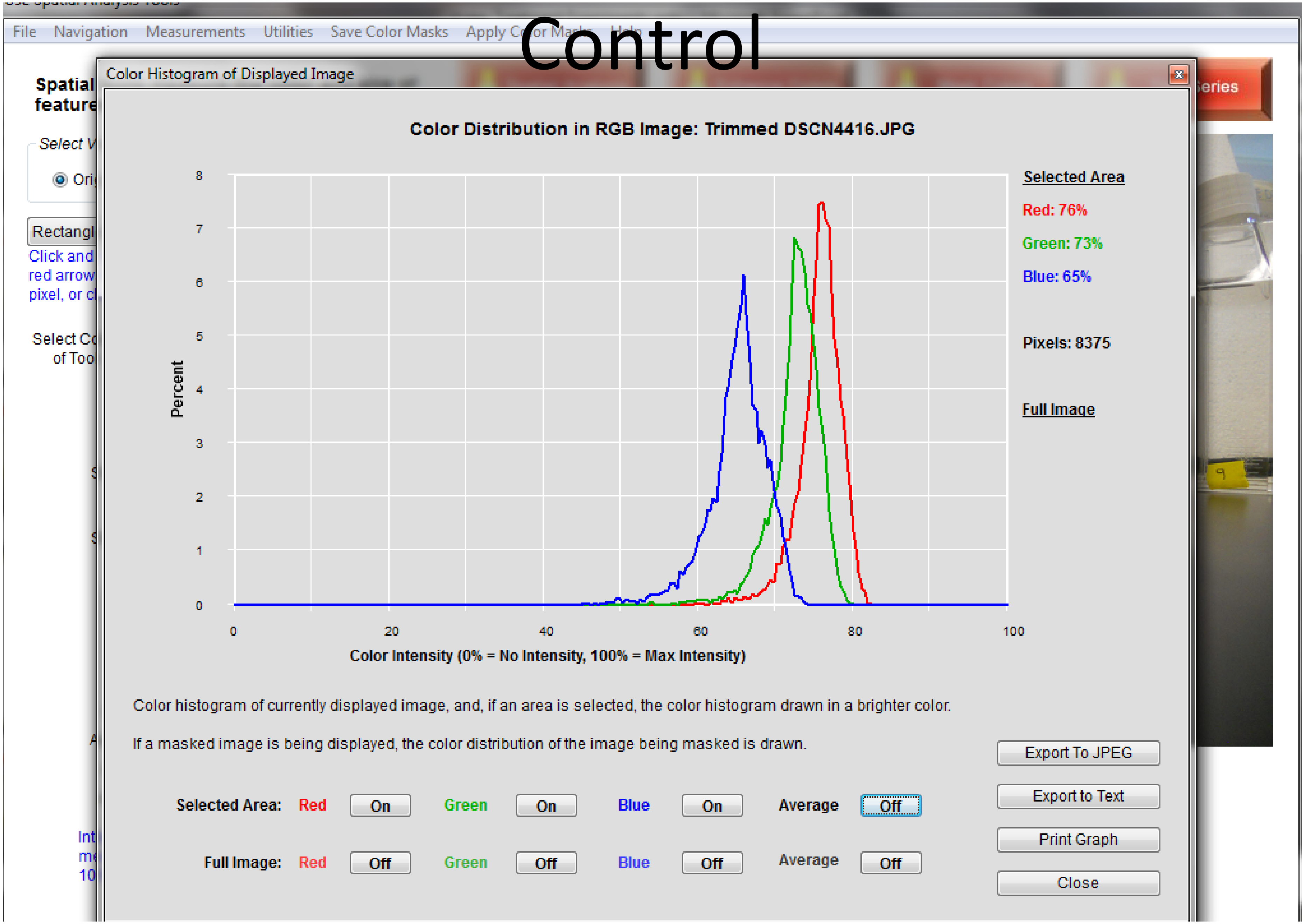
40
60
80
100
Color Intensity (0% = No Intensity, 100% = Max Intensity)
Selected Area
Red: 74%
Green: 67%
Blue: 43%
Pixels: 8625
Full Image
Color histogram of currently displayed image, and, if an area is selected, the color histogram drawn in a brighter color.
If a masked image is being displayed, the color distribution of the image being masked is drawn.
Selected Area: Red On Green On Blue On Average Off
Full Image: Red Off Green Off Blue Off Average Off
Export To JPEG
Export to Text
Print Graph
Close

Control


File
Navigation
Measurements
Utilities
Save Color Masks
Color Histogram of Displayed Image
Color Distribution in RGB Image: Trimmed DSCN4416.JPG
Percent
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4
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6
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8
0
20
40
60
80
100
Color Intensity (0% = No Intensity, 100% = Max Intensity)
Selected Area
Red: 76%
Green: 73%
Blue: 65%
Pixels: 8375
Full Image
Color histogram of currently displayed image, and, if an area is selected, the color histogram drawn in a brighter color.
If a masked image is being displayed, the color distribution of the image being masked is drawn.
Selected Area:
Red
On
Green
On
Blue
On
Average
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Full Image:
Red
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Off
Blue
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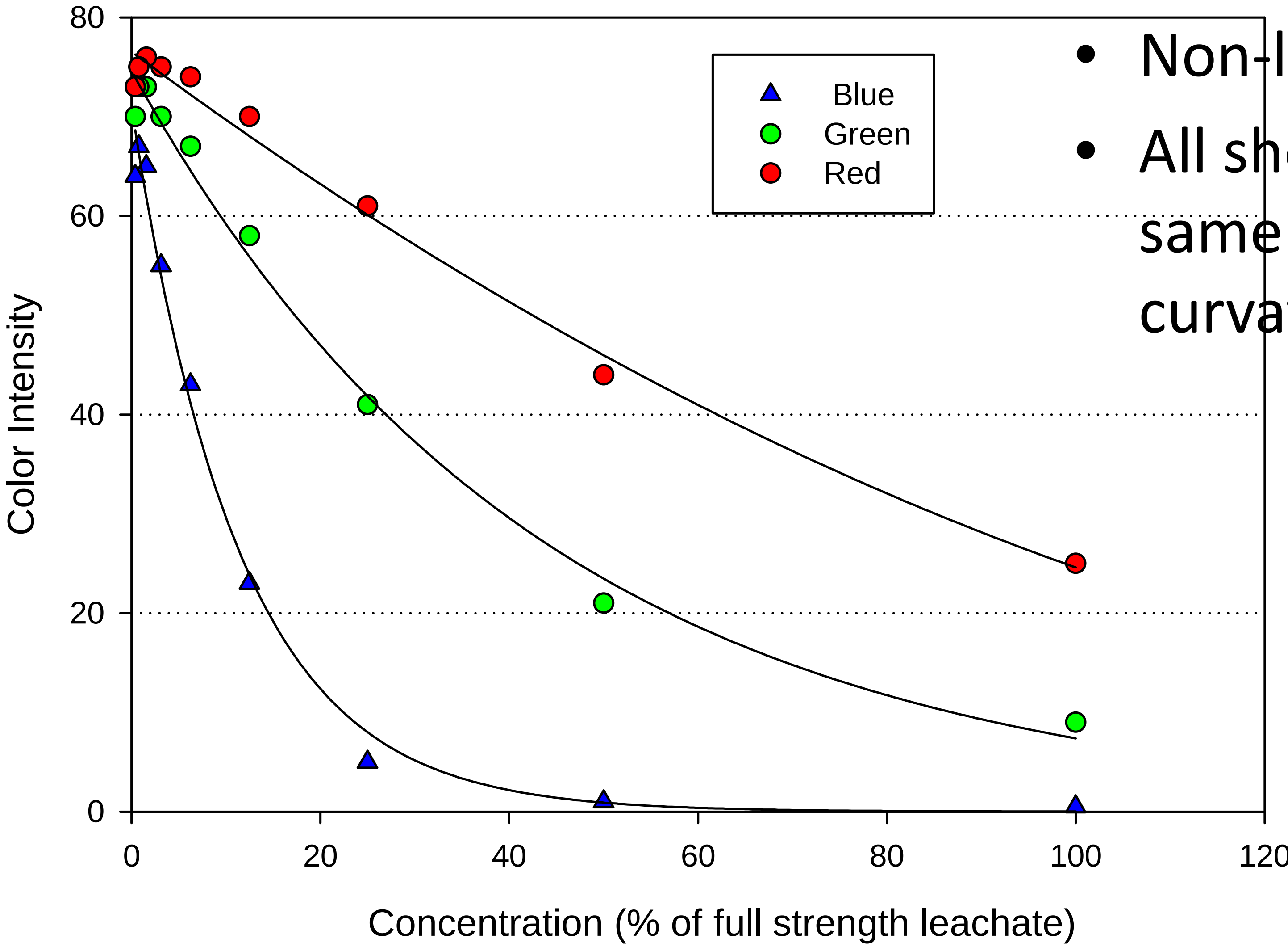
Average
Off
Export To JPEG
Export to Text
Print Graph
Close

Direct Calibration



- Non-linear
- All should have the same exponential curvature

Beer's Law: making it linear

- Concentration of a solution of an absorbing compound or a mixture of compounds with fixed proportions is directly proportional to the logarithm of the light intensity for experimental (I) divided by the light intensity for the blank (I_o)
  - This is the "Absorbance"

$$Absorbance = -Log(\frac{I}{I_o})$$

Fixed value dependent on your bottle

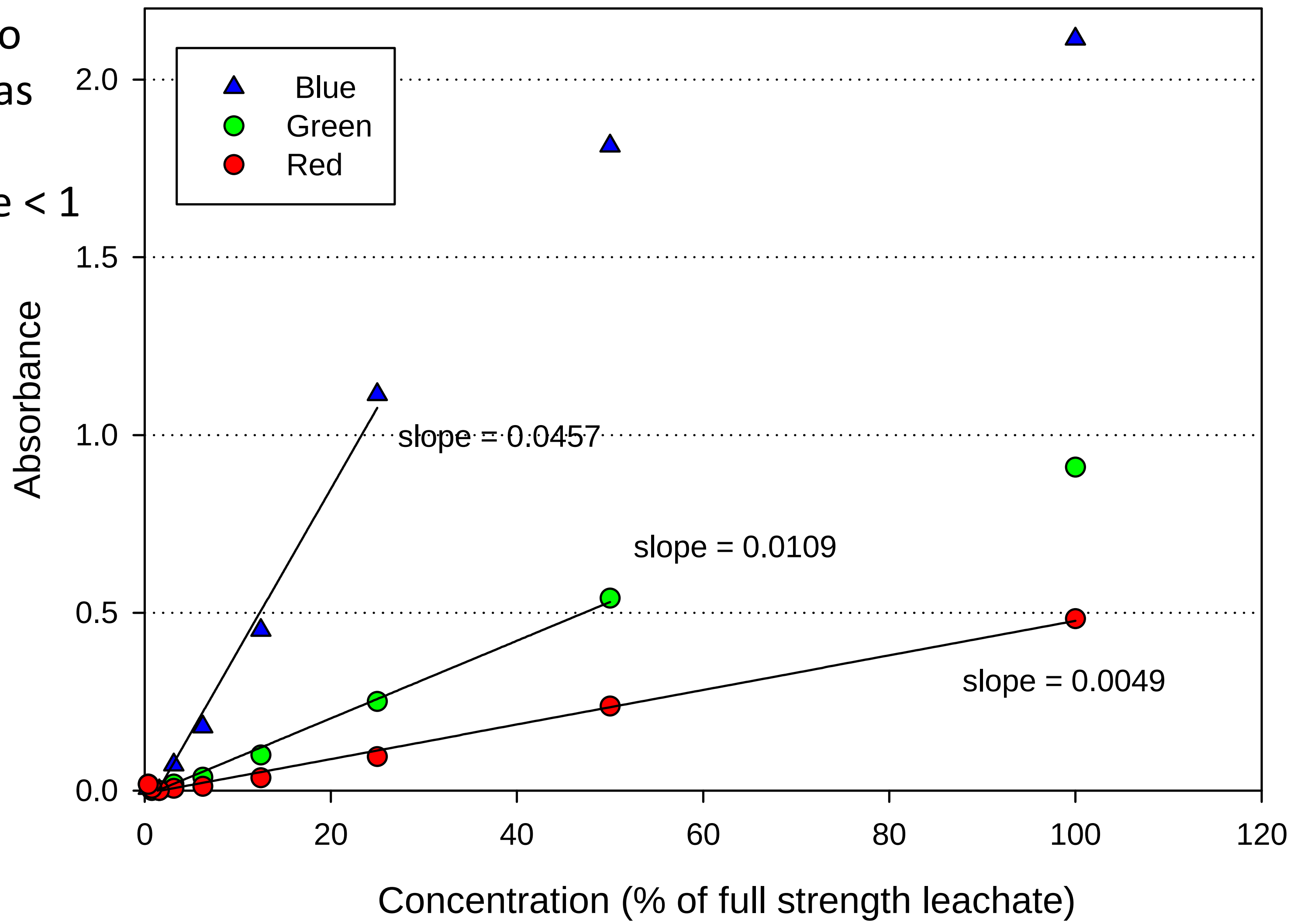
Fixed value determined by analyzing a "standard"

$$Absorbance = concentration \; x \; pathlength \; x \; absorptivity$$

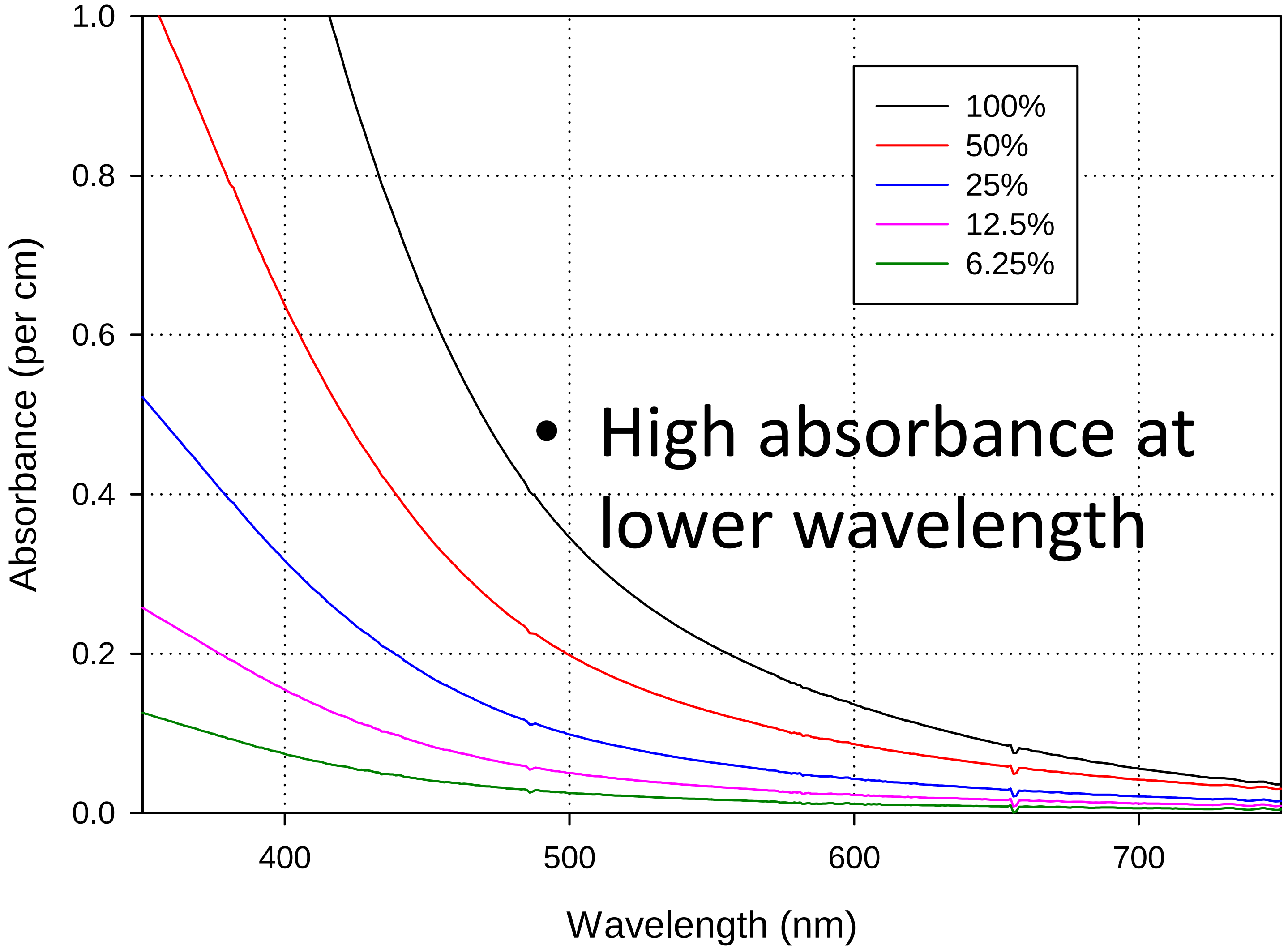
What you're trying to determine

Culture Bottles: “Absorbance”

- Linear
  - Conforms to Beer’s law as long as Absorbance < 1



Spectrophotometer: High Resolution Absorbance Spectra



- High absorbance at lower wavelength

Camera vs Spectrophotometer

- Can give equivalent answers