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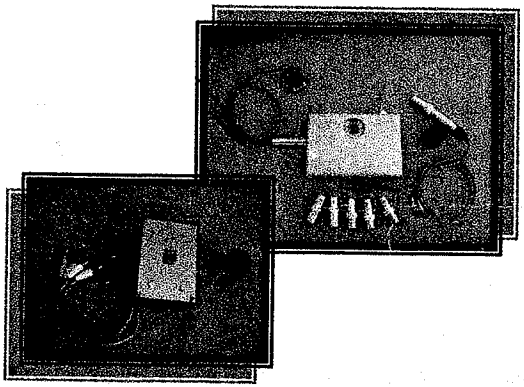
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Colorimetry Measurements with LabWorks



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CORRECTION

The model numbers for the two-color colorimeters were misprinted beginning in SPECIFICATIONS on page 1. The correct model numbers are C0006 or R0006. We apologize for the confusion.

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INTRODUCTION

Colorimetry involves the use of light to determine the concentration of a specific solute in solution. A given molecule absorbs particular frequencies of light and passes others. By determining the degree to which various frequencies are absorbed, the population or concentration of a given molecule in the solution can be determined.

DESCRIPTION

The SCI Technologies Colorimeter comes in two models:

Two-Color Colorimeter (model C0006/R0006)

The Two-Color Colorimeter measures the relative transmission of red or green light through a solution. It is easy to use, durable, and useful in applications that do not require a high degree of accuracy or flexibility.

Interchangeable Colorimeter (model C0022/R0022)

The Interchangeable Colorimeter allows you to connect a variety of light sources, filters, and detectors to measure the relative transmission of light through a solution. It allows customization of experiments for a variety of light sources, filters, and detectors.

SPECIFICATIONS

Two-Color Colorimeter (model C0006/R0006)

The two-color Colorimeter is housed in a 3" x 4" x 1.5" black box with red and green indicator LEDs on the top face (Figure 1). A square hole is cut near the center for insertion of sample cuvettes. The LabWorks™ and LabWorks II® model (**C0002**) has a 3-foot cable with color-coded banana plugs for connecting to the

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interface. The LabWorks II®-100 model (**R0002**) has a 3-foot cable with an 8-pin DIN plug for connecting to the interface, and a slide switch on the face for selecting the LED color to be used.

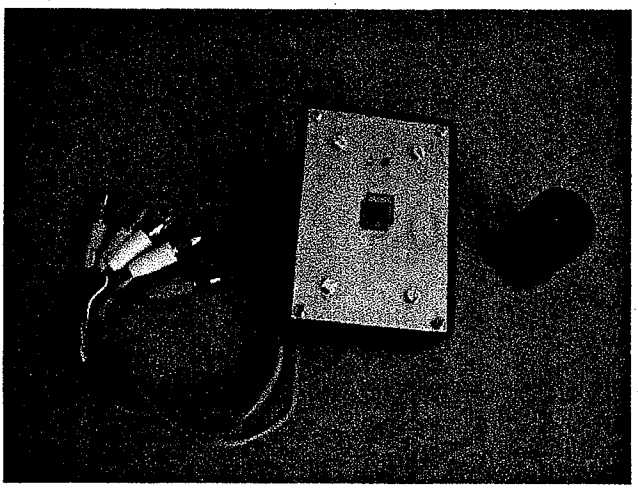


Figure 1
Two-Color Colorimeter

Light Sources:

- Red LED wavelength = 645 nM
- Green LED wavelength = 565 nM

Detector:

- CdS photocell light detector

Cuvette Size:

- 12.5 square cm

Interchangeable Colorimeter (model C0022/R0022)

The interchangeable colorimeter consists of two cables, six light sources, a light detector, and a 4" x 6" x 1.5" wooden block (Figure 2). The wooden block has a square hole cut in the top face for insertion of sample cuvettes, and a hole in each end for insertion of the light source and light detector. In addition, a

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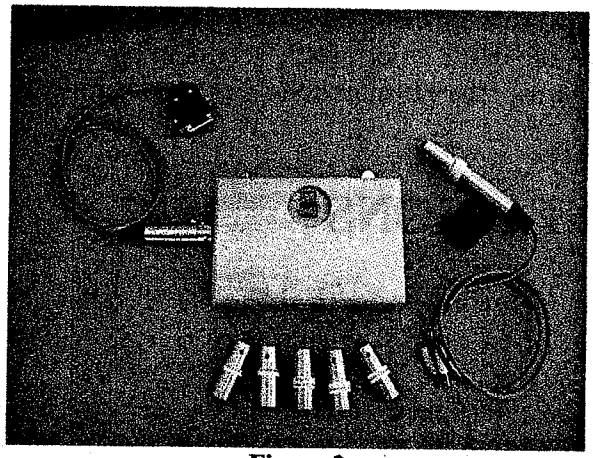


Figure 2
Interchangeable Colorimeter

perpendicular hole on the side of the block can be used for turbidity measurements. A spare light source should be used to plug the perpendicular hole when turbidity measurements are not being made. The LabWorks™ and LabWorks II® model has a 3-foot light detector cable with color-coded banana plugs for connecting to the interface. The light source cable is also 3 feet long and uses a 15-pin connector to plug into the auxiliary port on the rear panel of the interface.

Light Sources:

- White Incandescent
- Red LED wavelength = 635 nM
- Orange LED wavelength = 600 nM
- Yellow LED wavelength = 583 nM
- Green LED wavelength = 565 nM
- Blue LED wavelength = 430 nM

Detector:

- Phototransistor light detector, 18° view

Cuvette Size:

- 12.5 square cm

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Both colorimeter models include an opaque film canister containing two plastic cuvettes. The canister, when inverted over the sample hole in the colorimeter, serves to block out room light. When not in use, the cuvettes may be conveniently stored inside the canister.

CONNECTIONS

Two-Color Colorimeter for LabWorks™ and LabWorks II® (C0002)

1. Insert the green banana plug into either green banana jack labeled "Output 1" or "Output 2" on the front panel of the interface.

2. Insert the white banana plugs into the white banana jacks labeled "Output 1" and "Output 2." Note that the wire color indicates the corresponding LED color and the Output used for each needs to match what is written in your experiment.

3. Insert the blue banana plug into the blue banana jack labeled "DAC 2."

4. Insert the yellow banana plug into the yellow banana jack labeled "I2."

   Note: DAC1 and I1 may be used instead, just make sure that you write your experiment and calibrate accordingly.

Connecting only one white plug with the wire color corresponding to the appropriate LED selects the LED color used in the experiment.

Two-Color Colorimeter for LabWorks II®-100 (R0002)

1. Insert the DIN plug into the jack labeled I/O Port A.

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Note: Port B or C may also be used if you write your experiment and calibrate accordingly.

The slide switch in the top face of the colorimeter selects the LED color used in the experiment.

Interchangeable Colorimeter for LabWorks™ and LabWorks II® (C0022)

1. Plug the 15-pin D-Sub connector of the light source into the corresponding jack labeled "Auxiliary Port," "Auxiliary," or "Accessory" on the rear panel of the interface.

2. Insert the blue banana plug of the light detector assembly into the blue banana jack labeled as "DAC2" on the front panel of the interface.

3. Insert the yellow banana plug of the light detector assembly into the yellow banana jack labeled as "I2" on the front panel of the interface.

4. Insert the black banana plug of the light detector assembly into the black banana jack just below the "DAC 2" and "I2" jacks on the front panel of the interface.

5. Select and attach a light source (LED) to the light source cable. And, if not already attached, plug the phototransistor light sensor into the light sensor cable. To attach, align notches and push together firmly. To separate, push the release button and pull apart.

6. Insert the light source and light detector assemblies into opposite ends of the wooden colorimeter block and clamp in place with the thumbscrews.

7. Block the perpendicular hole in the wooden block with one of the extra LEDs if not measuring turbidity.

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Note: DAC1 and I1 may be used for the light detector if the experiment is written and the calibration is performed accordingly.

Interchangeable Colorimeter for LabWorks II®-100 (R0022)

1. Plug the 8-pin DIN connector on the light source cable into one of the 8-pin DIN jacks on the front panel of the interface.

2. Plug the 8-pin DIN connector on the end of the light detector cable into another one of the 8-pin DIN jacks on the front panel of the interface.

3. Select and attach a light source (LED) to the light source cable. And, if not already attached, plug the phototransistor light sensor into the light sensor cable. To attach, align notches and push together firmly. To separate, push the release button and pull apart.

4. Insert the light source and light detector assemblies into opposite ends of the wooden colorimeter block and clamp in place with the thumbscrews.

5. Use one of the extra LEDs to block the perpendicular hole in the wooden block if not measuring turbidity.

Note: The location of the light detector cable (step 2) determines the calibration routine that should be used (A, B, or C).

CALIBRATION

Windows Software

1. Choose the "Calibrate" button from the Command Bar in the LabWorks Main Window (Figure 3).

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Figure 3
Windows Command Bar

2. Choose the button in the Colorimeter section of the main Calibration window corresponding to the input used for the connections. In the LabWorks™ and LabWorks II® software, the choices would be %Trans 1, or %Trans 2. Choices for the LabWorks II®-100 software include %Trans A, %Trans B, or %Trans C.

3. Insert a sample containing distilled water into the colorimeter and cover with the film canister. Make sure the LED is off. The LabWorks™ and LabWorks II® software uses Switch X to turn the LEDs on or off. The LabWorks II®-100 software uses a software button in the calibration window to turn the LEDs on or off.

4. Wait for the current reading in the first Reading window to stabilize and hit the "enter" key. This will lock the zero percent transmission value.

5. Turn the LED on (see step 3) and wait for the current reading in the second Reading window to stabilize. Hit the "enter" key to lock the 100 percent transmission value. Click on the "OK" button or hit "enter" again to write the calibration information to computer memory (Figure 4).

The LabWorks software will use this calibration information to convert the analog signal from the colorimeter to percent transmission prior to being displayed.

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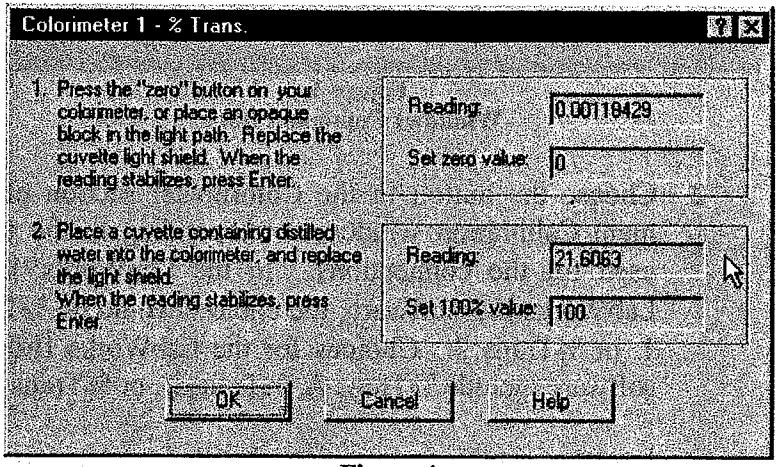


Figure 4
Colorimeter Calibration Window

Calibration information is stored in the computer's memory and will remain until a new calibration is performed. If the computer, interface, or colorimeter is changed a new calibration will have to be performed. Calibrations will also have to be performed periodically due to changes in parameters for the components used in the hardware. For instance, photocell readings will drift when ambient room temperatures change.

See the **Usage** section for programming examples. (Page 10).

DOS and Macintosh software

1. Choose "Calibrate Sensors" from the Main Menu (Figure 5).

2. Select "Probe" from the sub-menu, followed by I2PROBE (I1PROBE if your colorimeter is connected to I1 and DAC1.)

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3. Since the analog output of the light sensor varies linearly with the amount of light it receives, select LINEAR calibration.

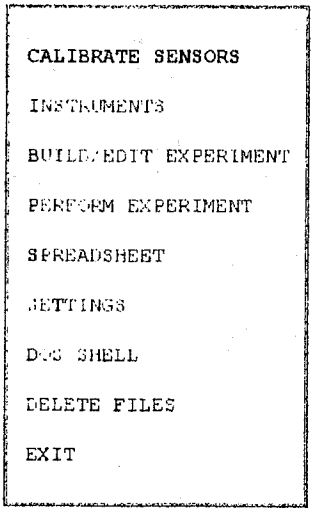


Figure 5
DOS Main Menu

4. The light detector requires a reference voltage. Enter 1000 for the DAC reference voltage. NOTE: The reference voltage is supplied during calibration **ONLY**. Use the SET DAC command to supply a DAC reference equal to the calibration reference voltage during your experiment. See the **Usage** section for programming examples.

5. Insert a sample containing distilled water into the colorimeter and cover with the film canister. Turn switch X off (or unplug both white plugs) to turn off both LEDs. When the input current stabilizes, press "enter." Enter "0" for the zero percent transmission point.

6. Turn switch X on and connect the white plug for the color to be measured (make sure the other plug is disconnected). When the input current stabilizes, press "enter." Enter "100" for the 100% transmission point.

The LabWorks software will then use this calibration information to convert the analog signal from the colorimeter to percent transmission prior to being displayed.

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Calibration information is stored in the interface memory and will remain until a new calibration is performed. If the interface or colorimeter is changed, a new calibration will have to be performed. Calibrations will also have to be performed periodically due to changes in parameters for the components used in the hardware. For instance, photocell readings will drift when ambient room temperatures change.

See the **Usage** section for programming examples.

USAGE

The following programming examples can be used to read colorimeter percent transmission values, store them in a data file, and make a graph of percent transmission vs. time. They assume the software has been properly installed, the user has knowledge of how the experiment builder software works, and a calibration has been performed as described in the Calibration section.

Two-Color or Interchangeable Colorimeter using a LabWorks™ or LabWorks II® interface and Windows software

1 Start Timer1 counting in seconds
2 Send On (averaged reading) to Out1
3 Read Color2 (averaged reading); Store in Variable A; Graph on Y1 Axis
4 Read Timer1; Store in Variable B; Graph on X Axis
5 If SwitchW = Released (fast reading) then GoTo line 3
6 Stop

Two-Color or Interchangeable Colorimeter using a LabWorks II®-100 interface and Windows software

1 Start Timer1 counting in seconds
2 Send On (averaged reading) to OutputA

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3 Read ColorA (averaged reading); Store in Column A; Graph on Y1 Axis
4 Read Timer1; Store in Column B; Graph on X Axis
5 If SwitchW = Released (fast reading) then GoTo line 3
6 Stop

This experiment will store percent transmission readings in Column A of the spreadsheet and send them to the Y-axis of the live graph. It will store time values in Column B of the spreadsheet and send them to the X-axis of the live graph. These values will also be displayed in a text format. Data will be collected until SwitchW is pressed, the Stop button is pressed, or the maximum number of data points has been collected. The command at line 2 is essential to turn the LED light source on if using the Two-Color Colorimeter. Light sources for the Interchangeable Colorimeter are always on, and this command is not needed. The spreadsheet, graph, and text views will all be shown on the screen. This is the most basic colorimeter measurement experiment that can be used and is only intended as a base for more complex experiments.

Two-Color or Interchangeable Colorimeter using a LabWorks™ or LabWorks II® interface and DOS or Macintosh software

1 START Timer1 FOR sec
2 SET DAC2 TO 1000.000000 MILLIVOLTS
3 SEND On TO OUT-1
4 SEND INPUT FROM I2probe TO COL-A
5 SEND INPUT FROM I2probe TO GraphY (0 TO 100)
6 PRINT INPUT FROM I2probe ON LINE 21
7 SEND INPUT FROM Timer1 TO COL-B
8 SEND INPUT FROM Timer1 TO GraphX (0 TO 100)
9 PRINT INPUT FROM Timer1 ON LINE 20
10 IF INPUT FROM SwW = Released GOTO 4
11 STOP

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This experiment will store percent transmission readings in Column A of the spreadsheet and send them to the Y-axis of the live graph. It will store time values in Column B of the spreadsheet and send them to the X-axis of the live graph. These values will also be displayed in a text format. Data will be collected until SwitchW is pressed, or the maximum number of data points has been collected. The command at line 3 is essential to turn the LED light source on if using the Two-Color Colorimeter. Light sources for the Interchangeable Colorimeter are always on, and this command is not needed. The command at line 2 is essential to provide power to the light sensor. Make sure this value matches the value used in the calibration. The display mode (Figure 6) chosen determines which values will be displayed on the screen. This is the most basic colorimeter measurement experiment that can be used and is only intended as a base for more complex experiments.

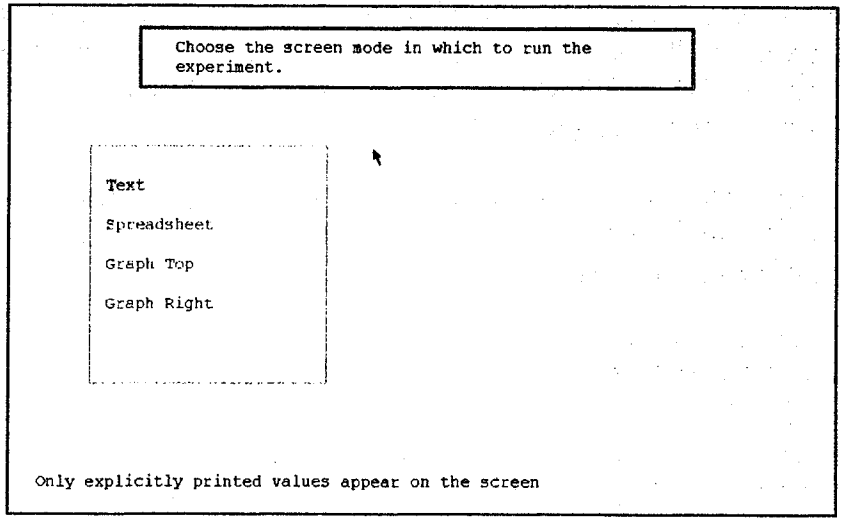


Figure 6
DOS Screen Mode Window

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TECHNICAL SPECIFICATIONS

Two-Color Colorimeter

- Red LED
  - Low Current, Double Heterojunction AlGaAs
  - T-1 Tinted Diffused
  - 60° viewing angle
  - Peak wavelength = 645 nM
  - Supply voltage = 5V
- Green LED
  - Low Current
  - T-1 Tinted Diffused
  - 50° viewing angle
  - Peak wavelength = 565 nM
  - Supply Voltage = 5V
- Light sensor
  - Epoxy-coated Cadmium Sulfide Cell
  - Dark Resistance = 5Mohm
  - Spectral response from 400 to 800 nM
  - Peak spectral response approximately 600 nM
  - Supply voltage user defined (usually 1000mV)

Interchangeable Colorimeter

- Red LED
  - High efficiency GaAsP on GaP
  - T-1¾ Tinted Diffused
  - 60° viewing angle
  - Peak wavelength = 635 nM
  - Constant Current supply = 25mA
- Green LED
  - GaP
  - T-1¾ Tinted Diffused
  - 60° viewing angle

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Peak wavelength = 565 nM
Constant Current supply = 25mA

- Orange LED
  GaAsP on GaP
  T-1¾ Tinted Diffused
  60° viewing angle
  Peak wavelength = 600 nM
  Constant Current supply = 25mA
- Yellow LED
  GaAsP on GaP
  T-1¾ Tinted Diffused
  60° viewing angle
  Peak wavelength = 583 nM
  Constant Current supply = 25mA
- Blue LED
  GaN on SiC
  T-1¾ Water Clear
  24° viewing angle
  Peak wavelength = 430 nM
  Constant Current supply = 25mA
- White Incandescent Lamp
  No specifications available
- Phototransistor light detector
  NPN silicon phototransistor
  TO-46 metal glass lensed can package
  100nA collector dark current
  Spectral response from 400 to 1100 nM
  Peak spectral response approximately 900 nM
  Supply voltage user defined (usually1000mV)

LabWorks II® Interface

- Analog Inputs
  - 2 auto-ranging current inputs
    ±2048µA, 1.0µA resolution
    ±204.8µA, 0.1µA resolution
    ±20.48µA, 0.01µA resolution

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±2.048μA, 0.001μA resolution
- 1 high voltage input
  ±20.48V, 10mV resolution
- 2 pH/mV inputs
  ±2048mV, 1mV (0.02 pH) resolution

- Digital inputs
  - 2 photogate inputs
    5V-power output and input for TTL level signals
  - 1 event counter
    5V-power output and input for TTL level pulses up to a 10 kHz rate
- Analog outputs
  - 2 DAC outputs
    ±2048mV, 1mV resolution
- Digital outputs
  - 2 TTL controlled transistor collector outputs
    5V switched on or off
  - 8 TTL control outputs

LabWorks II®-100 Interface

- Analog Inputs
  - 3 auto-ranging current inputs
    ±2500μA, 1.22μA resolution
    ±250μA, .122μA resolution
    ±25μA, 0.0122μA resolution
    ±2.5μA, 1.22nA resolution
    ±0.25μA, 0.122nA resolution
  - 3 auto-ranging voltage inputs
    ±25V, 12.2mV resolution
    ±2.5V, 1.22mV resolution
    ±250mV, 0.122mV resolution
    ±25mV, 12.2μV resolution
    ±0.25mV, 1.22μV resolution
  - 1 pH/mV input
    ±2500mV, 1.22mV (0.02 pH) resolution

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- Digital inputs
  - 3 TTL compatible digital inputs
  - 2 photogate inputs
    5V-power output and input for TTL level signals
  - 1 event counter
    5V-power output and input for TTL level pulses up to 20 MHz rate
- Analog outputs
  - 3 DAC outputs
    1 ±2500mV, 1mV resolution
    2 ±2500mV, 9.8mV resolution
- Digital outputs
  - 3 TTL controlled open-collector transistor outputs

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