i-LAB S560 Users Guide For Membrane Patch Colorimetry

i-LAB method for measurement of the Membrane Patch Colorimetry is an exclusive application to CleanOil. It uses methods developed to measure this color and calculate the delta-energy difference between a new (clean) patch and the sample patch. This is done by the application of a surface reading adapter for the i-LAB spectrometer.

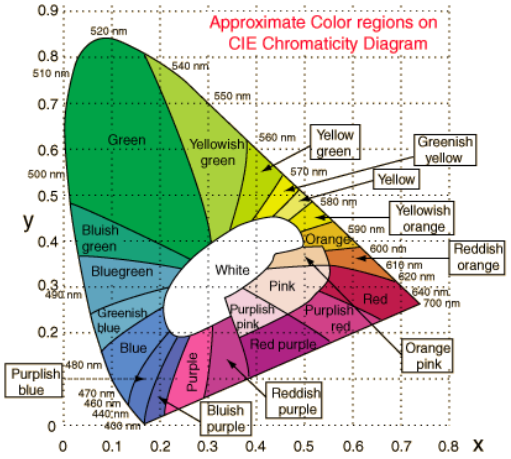
i-LAB Measurement

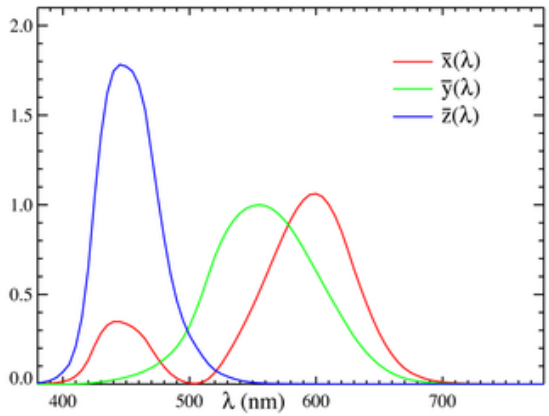
The iLAB has been designed with built-in source, sampler and detection system. It also contains embedded software designed to control the spectral acquisition, storage, processing, reporting and external data output. The procedure of performing and combining these tasks is defined by a series of processing steps. These process steps allow the user to run sophisticated spectral operations from the acquisition of the spectrum to calculation and processing of the results.

The i-LAB measures the visible spectrum of a sample through the use of LED light source and LVF detector. The light source is a series of Light Emitting Diodes (LEDs) designed to cover the full spectral range. The intensity of the LEDs are designed to have default values that were balanced to produce maximum performance. There are two white lights and one blue. The white and blue lights are turned on at different times to develop an optimized light full visible spectrum. The detector is Linear Variable Filter (LVF) that is intimately coupled to the detector system. The LVF in this case was integrated with a 128 pixel CMOS array.

For the surface analyzer method, the light source is reflected down the inside of the surface adapter to illuminate the surface of the sample. This illumination has absorption and reflection color characteristics that are reflected back up the other side of the surface adapter to the detector. Similar to any other light spectral measurement a background or reference spectrum is first obtained. This reference sample should be one that reflects “white” light back to the detector. White light is the color of all wavelengths reflecting back. The sample being measured will have different color absorbing portions of the light that is not reflected back to yield a spectrum. The sample spectrum and background

spectrum are processed together to yield a transmission spectrum. This spectrum is stored and used for further processing. This means a white sample should produce a 1.0 spectrum and a black sample will produce a 0.0 spectrum. As with normal spectral measurements, there are intensities of white and black that can be measured between the 1.0 and 0.0 values.





This reflectance mode operates no different from a cell or transmission mode. Light is sent to the sample and light is returned to the detector. In the transmission mode the light goes through the sample. In the reflectance mode the light is reflected to the detector. In both cases the sample will absorb portions of the light and allow other portions to continue to the detector. What gets to the detector is the spectrum. A red sample is that color because it either allows the red color to come through the solution or absorbs all the color but the red and reflects red to the detector.

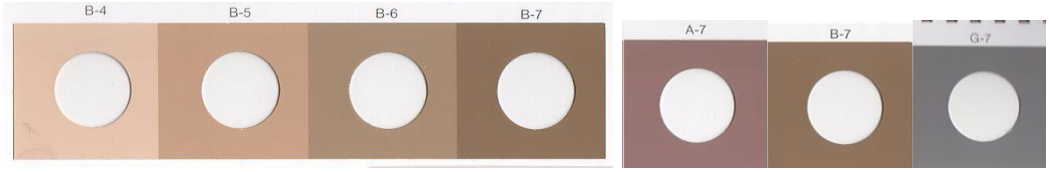
There are numerous methods of processing spectral measurements. The simplest is visual observation of the spectrum. Since intensity and wavelength can be observed, one gains significant qualitation and quantitation of the sample's color over simple visual observation of its color.

One can increase the sophistication of the analyses by studying one or more peaks and relating this to the concentration of a specific component. This, however, doesn't study the overall color of the spectrum. The CIELAB measurement of color is an attempt to boil down this color spectrum into a simpler set of numbers. The default surface method utilizes this calculation.

Definition of Surface calculations:
Surface Colorimetric measurements can be quantified by the use of ASTM E308 parameters. This standard defines the CIELAB parameters. By this means, the complex spectrum can be condensed into a simple set of parameters. The parameters used to define an observed color are the three main values

representing the visual color space. This color space is defined with “a*”, “b*” and “L*”. a* is the change in color in the red spectrum. a* is positive in the red direction and negative in the green direction. b* is the change in color of the yellow spectrum. b* is positive in the yellow direction and negative in the blue direction. L* is the change in shade from white to black. They are calculated against a standard white sample spectrum. This way the spectrum is always compared to what the user defines as “White”. These values are based off the CIE tristimulus values X, Y, Z – similar to the RGB values in printing and computer screens. The RGB values are not being used simply because there is not a defined standard for RGB. From the visual spectrum of the sample and that of the reference “white” sample spectrum, the tristimulus values or the two samples are calculated. These tristimulus values are then used together to calculate the color space values a*, b* and L*.

Examples of CIELAB Data



	L*	a*	b*
B4	82.5	7.0	15.5
B5	66.7	9.6	19.6
B6	67.3	3.9	12.3
B7	50.7	4.2	13.2
A7	72.2	5.3	1.8
B7	50.7	4.2	13.2
G7	65.8	2.7	-1.8

From this example one can observe a steady increase in the darkness of the color in the B-series with the lowering of the L* with a* and b* also darkening. With the A-B-G7 series, the darkening is varying as well as the other colors. Even though B7 looks darker it has a higher b* value – meaning that it is more yellow than blue. This sample is also more green than red.

***i-LAB* Loaded Methods**

The i-LAB has three methods preloaded for measurement of membrane patch colorimetry. The patch should be generated as per ASTM D02 C01- WI 13070

Methods:

MPCbackg *– Membrane Patch Colorimetry Background Measurement*

- This method is used to measure and store the background (or clean patch) spectral data.
- It should be run before one measures the sample patch
- A clean patch should be measured periodically

MPC_dE *– Membrane Patch Colorimetry Measurement*

- This method is used to measure, reports to the i-LAB screen and store the a CIE delta energy (CIE_dE) value calculated against the clean patch data stored from the method MPCbackg
- The CIE_dE value is based on a D65 light source and 10 Degree Observer – using the calculations in ASTM E308.
- The log data can be extracted into Excel using the program i-LAB Datalog

CIE_dE *– Membrane Patch Colorimetry Measurement*

- This program is identical to the MPC_dE method except that all the testing data is saved.
- Instead of just saving the CIE_dE value to the log, this method also stores the spectral and the CIE variables to the Results Log.
- This method is typically used for further research method development.
- The log data can be extracted into Excel using the program i-LAB Datalog

Measuring Membrane Patch Colorimetry Results

Install the surface measurement adapter/head onto the i-LAB. The adapter should be installed such that the two indents fit snuggly against the bracket of the i-LAB. Before each measurement, the user should confirm that the adapter is properly installed. Turn on the i-Lab and press the Menu button to bring up the Menu. Press the Center button to bring up the methods stored on the i-LAB.

Use the up-button or down-button to pick the method to be run. Press the center button to activate method.

Place the sample patch to be measured on a flat piece of aluminum foil with the color (sample) side up. Light from the measurement can be reflected through the patch material itself, therefore it is important for the user to have a consistent backing of the patches. Aluminum fold is that consistent backing.

Place i-LAB onto the sample where the surface adapter is only covering the colored (sample) portion. Press the action (center) button on i-LAB to start the method's measurement. The results of the sample measurement will be displayed on the i-LAB screen when the measurement is complete. By pressing the Center-Action Button the results will be saved and you will be returned to the Method Menu. The data is stored in the log of i-LAB by time and date of the

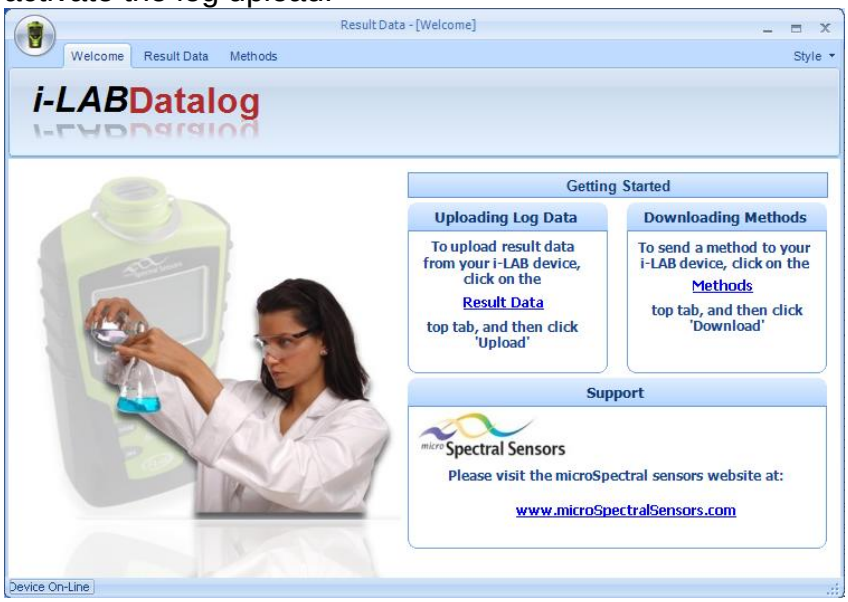
analyses. Keeping track of this information will allow proper results storage and retrieval.

If i-LAB is not properly placed on the patch a Scan error “Saturation has occurred” will appear on i-LAB screen. This is designed to let the user know when a mistake in analyses methods has been done. Re-seat the adapter and i-LAB on the sample and repeat the analyses.

A background or reference sample should be chosen that is as pure white as possible. This is to get the best representation of white reflectance as possible. One should always use this same background sample for consistent sample results. The method ***MPCbackg*** should be used to measure this background sample before running a sample measurement. The samples are then measured using the method ***MPC_dE*** or ***CIE_dE***. Although this instrument is very stable, it is a good practice to periodically rerun the background sample to insure no instrumental changes have occurred since the last referencing.

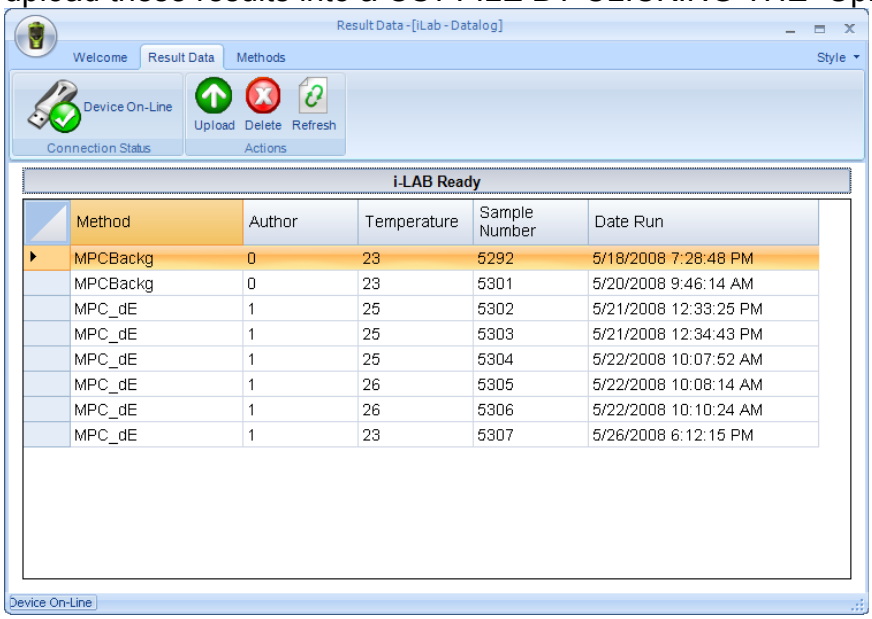
Extracting Data from i-LAB’s Log.
The log data from membrane patch colorimetry (MPC) measurements can be retrieved or downloaded from the i-LAB into a CSV file (read by Excel) using the supplied software “i-LAB Datalog”.

Upon opening of the software, the screen will be displayed showing an option of uploading log data or downloading a method. Clicking on the “Results Data” will activate the log upload.

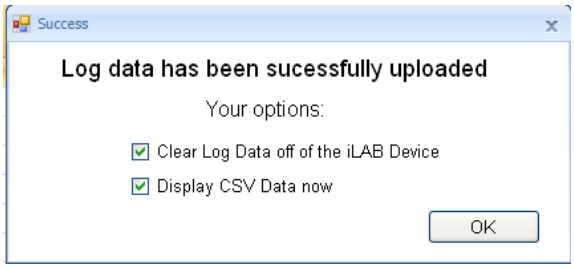


When the data upload form appears the program will load a lost of sample results into the window. This will take a minute or so depending upon the number of

results on the i-LAB. After the results have been loaded, the user may choose to upload these results into a CSv FILE BY CLICKING THE “Upload” button.



This action will open the form below, which gives the user the options of clearing the data off i-LAB after upload or leaving it stored. It also allows the option of displaying the CSV data just uploaded.



The uploaded data will be posted into the file:
“My Documents\iLABResultData.CSV”

If Excel is the default CSV reader program, it will be opened to display the data.

The output results format for the MPC_dE method data is:

STD_DEV	METHOD NAME	TEMPERATURE	SAMPLE NUMBER	DATE RUN	TIME RUN
24.09348	MPC_dE	24	173	5/31/2008	5:07 PM

The column labeled “STD_DEV” is the “CIE delta energy” result. This is from the i-LAB variable used to originally store this calculated variable.

The output results format for the CIE_dE method data is considerably more complex, since all the data is user and the calculation is stored. This method reports the data as:

XSPECTRUM_UDF	YSPECTRUM_UDF	USER_VAR1	USER_VAR2	AREA	Y_PEAK	USER_VAR1
400	1.4504	90.20621	97.73578	99.12942	-4.307985	139.4608
401	1.4409					
402	1.4291					
403	1.4157					
404	1.3991					
405	1.3802					
406	1.3621					
407	1.3388					
408	1.317					
409	1.2885					
410	1.2566					

Continuation of Row 1

Y_VALUE	USER_VAR1	USER_VAR2	Y_MAX
-19.81577	91.49918	96.62742	98.693

Continuation of Row 1

Y_MAX	USER_VAR1	Y_MAX	STD_DEV
-0.0899434	103.4062	0.1294613	20.39104

Continuation of Row 1

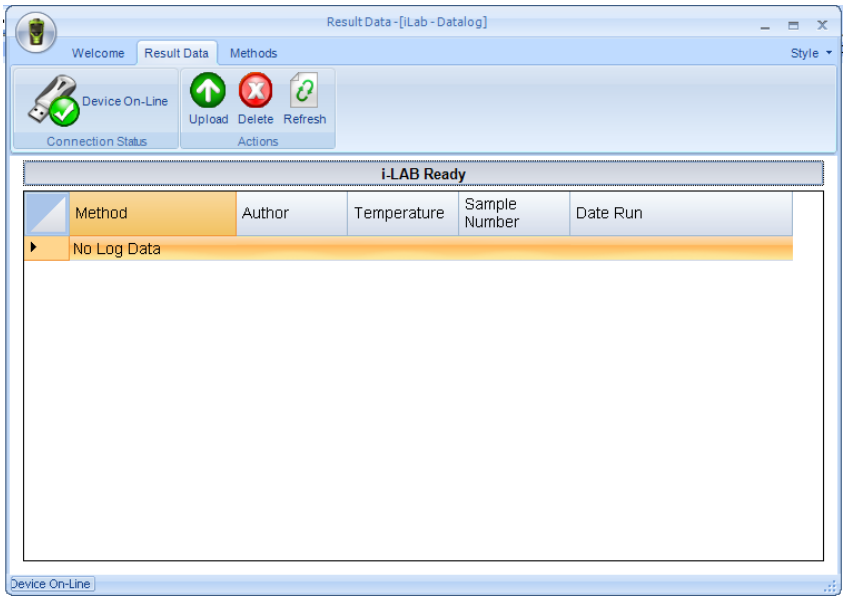
METHOD NAME	TEMPERATURE	SAMPLE NUMBER	DATE RUN	TIME RUN
CIE_dE	25	173	5/31/2008	5:20 PM

The column definitions for these results are:

- XSPECTRUM_UDF = X-spectral values for the sample spectrum (nm)
- YSPECTRUM_UDF = Y-spectral values for the sample spectrum (transmittance)
- USER_VAR1 = CIE X Sample
- USER_VAR2 = CIE Y Sample
- AREA = CIE L* Sample
- Y_PEAK = CIE a* Sample
- USER_VAR1 = CIE Z Sample
- Y_VALUE = CIE b* Sample
- USER_VAR1 = CIE X Blank
- USER_VAR2 = CIE Y Blank
- Y_MAX= CIE L* Blank
- Y_MAX = CIE a* Blank
- USER_VAR1 = CIE Z Blank
- Y_MAX = CIE b* Blank
- STD_DEV = CIE delta Energy
- METHOD NAME = name of the method use to generate this data
- TEMPERATURE = temperature of the i-LAB during the test measurement
- SAMPLE NUMBER = chronological sample number

- DATE RUN = date sample was run
- TIME RUN = time sample was run

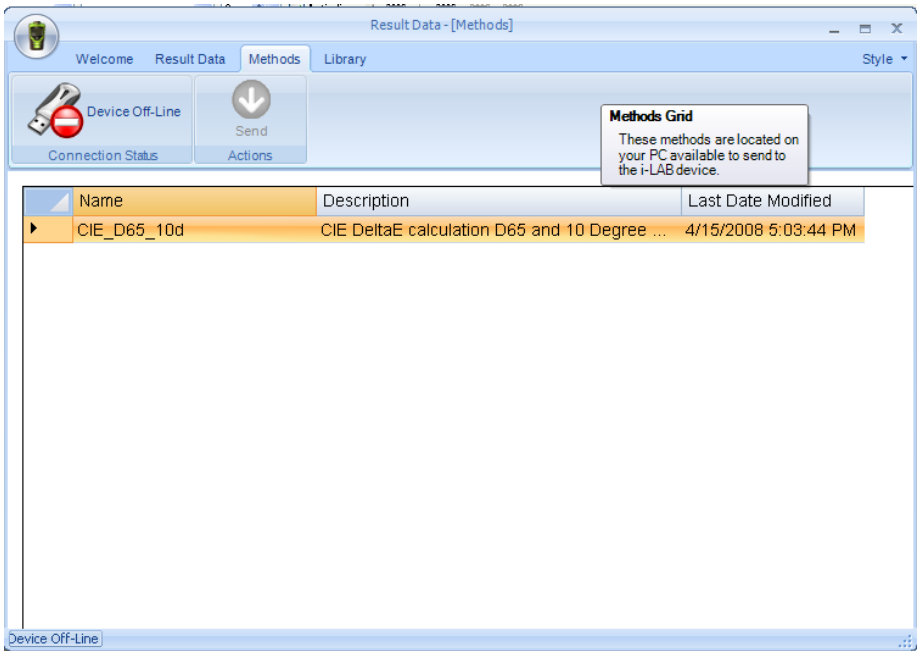
If the data has been cleared from the i-LAB or there is no data currently stored in the i-LAB's log one will observe the program displaying that no data is in the log.



Updates or Upgrades

If an update for the i-LAB Datalog software exists and the user's computer has internet access, there is an auto-update function built-in the software. This auto-update function will check for any updates and notify the user when the program is first opened of any updates and that one is available to be handled.

Method or i-LAB firmware is also capable of being updated if a newer revision becomes available. This includes the addition of new methods for i-LAB.



Interpretation of CIE_dE data for the Membrane Patch Colorimetry

There are four ranges of Varnish Potential Rating Severity:

1. **Normal range:** This indicates that there are low levels of the precursors that lead to soft contaminants (varnish).

2. **Monitor range:** This means the production of varnish within the system could be approaching soon and the oil condition should be watched. Typically samples in this range will not show varnish problems already, however they may start forming it when the lubricant is cooled to an ambient temperature. If the antioxidants have been depleted, the formations of varnish precursors are forming at a reasonably high rate. It would be expected that the condition of this lubricant would deteriorate quickly.

3. **Abnormal range:** This means that there is an increased level of soft contaminants due to oil degradation. These soft contaminants will form varnish in tight clearance zones or cooler spots in the system. The oil may also cause servo valves to stick or seize causing a unit trip, especially after a shut-down and the unit is being brought back online. Inspect filters and reservoir (when possible) for signs of varnish formation and bearings for temperature increases. Pay particular attention to Last Chance Filters and pencil strainers before the hydraulic circuit's valve blocks.

4. **Critical range:** This means that there is an increased level of soft contaminants due to oil degradation. These soft contaminants will form varnish in tight clearance zones or cooler spots in the system. The oil may also cause servo valves to stick or seize causing a unit trip, especially after a shut-down and the unit is being brought back online.

These ranges are defined by the color on the patch. The more color, or higher the CIE delta energy values, the high the varnish potential. A general range has been developed by CleanOil for these ranges:

Normal Range less than 15 CIE_dE
Monitor 15 to 30 CIE_dE
Abnormal 30 to 40 CIE_dE
Critical 40 up CIE_dE