Natural Dyes

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Lecture No. # 20

We have been studying a lot about the dyeing process the dyeing machine the various recipes for dyeing and so on and so forth. But one very important factor of the dyed fabric is the assessment of fastness property. So, this lecture is completely dedicated, I have been talking about you know a dye having a good washing fastness or light fastness, and we also saw that in the vat dyes - they have all the types fastnesses very good. Sometimes only the rubbing fastness is not so good for a few of the vat dyes, but by enlarge the vat dye category has very good light fastness, wash fastness, perspiration fastness and rubbing fastness.

So, what how do does one ascertain all these and what goes into the entire process of understanding the fastness properties. So, how do we ascertain, how do we categorize that this dye is good for cotton and this dye is better for silk or wool and so on and so forth. It is on the basis of the assessment of the fastness property. So, let us try to understand the fastness property assessment on dyed fabrics. And in order to understand this let us go one by one looking at the various fastness property machines, how are these machines are designed, how do they work, what do they ascertain, what do they asses and how is the result interpreted and given to their analyzer.

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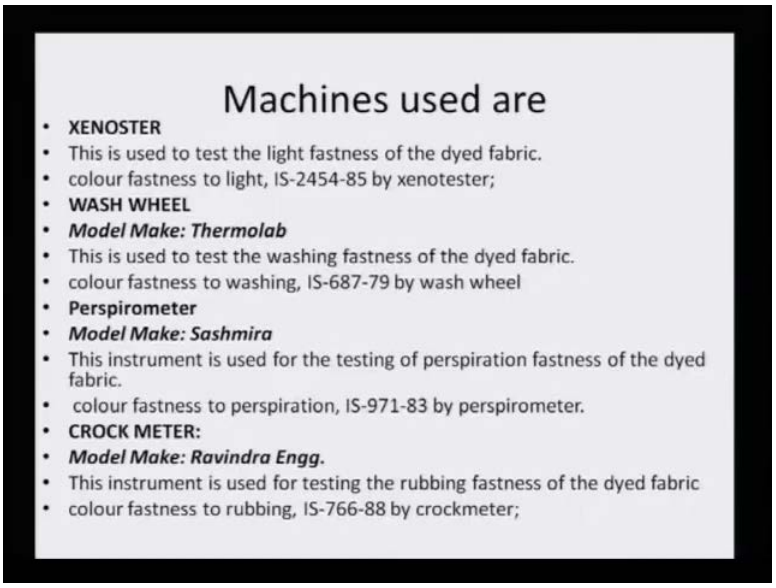

So, let us try to take a look. The machines - that are used are XENOSTER. This is used to test the light fastness of dyed fabric. The color fastness to light by Indian standard IS-2454-85, in the year 85 was first introduced for the dyers. So that XENOSTER machine can be used for an ascertaining the light fastness of dyed fabric.

Similarly, wash wheel is used particularly if the model made by the thermo lab. This is used to test the washing fastness of the dyed fabric. Color fastness to washing was a certain by the Indian standard method 687 which was introduced in the year 79. IS-687-79 means - it was introduced in the year 79, and the IS number is 687; IS stands for Indian standard. Similarly, we have ASTM standards which are the American test methods we have been standards which are form Germany and so on.

The perspirometer is used and the model that is popularly sold is the developed by Sashmira; this instrument is used for testing of perspiration fastness of the dyed fabric. The color fastness to perspiration is evaluated by IS-971-83 by perspirometer, and IS-973 was introduced in the year 1983.

Crock meter - this is a popular model was marketed by Ravindra engineering. This instrument is used for testing the rubbing fastness of the dyed fabric color fastness to rubbing was ascertain by IS-76688 by crockmeter; and which means that it was introduced in the year 88 and the IS (Indian Standard) used for this particular testing method is the IS 766. So, the there are Indians standards available for testing all these

four parameters - that is light fastness, wash fastness, perspiration fastness, and rubbing fastness. So, one has to just look for these IS and follow the procedure and use the right machine for light fastness it is XENOSTER. For finding out washing fastness, it is wash wheel, for finding out perspiration fastness it is pespirometer as the name suggest, and for finding out the rubbing fastness it is the crock meter.

Now, this is how the xenometer machine looks like and there is a source of light for a certain period of time the dyed fabric is actually in a closed machine, it is a exposed to that light and usually it is you know a bright xenon arc light which is shown for 24 hours and the shade is ascertain before and after the exposure and the different shows that whether this was affected by the light of the xenon lamp or not. So, the name xenoster or xenometer because xenon arc light arc is primarily used as a word as a light source for a looking at the fading property of the dye.

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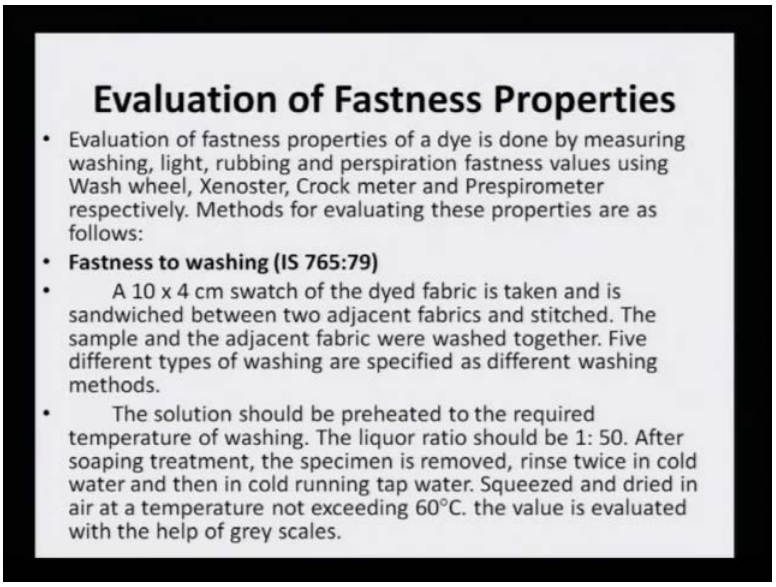

Evaluation of these fastness properties: Evaluation of fastness properties of the dye is done by measuring washing, light, rubbing and perspiration fastness values using wash wheel, xenoster, crock meter and pespirometer respectively. Method for evaluating these properties are as as we know that for washing fastness wash wheel is used, but how is that procedure carried out, what is the methodology. Just the way I told you that for light fastness the methodology is that are fabric piece exposed to light for 24 hours and before exposure to the light the CLAB values are evaluated and then we will come to see CLAB

values soon. But for the time being you just understand that the color of the fabric is ascertained with the help of a colored spectrum or prism and this color is then evaluated after the light exposure, so that is the shows if any if there is any fading it will show differences.

Similarly, for ascertaining washing fastness A 10 is to 4 centimeters swatch of the dyed fabric is taken and is sandwiched between two adjacent fabrics and stitched. The sample and the adjacent fabric were washed together. Five different types of washing are specified as different washing methods. The solution should be preheated to the required temperature of washing. The liquor ration should be 1 is to 50 after soaping treatment, the specimen is removed, rinse twice in cold water and then in cold running tap water. Squeezed and dried in air at a temperature not exceeding 60 degrees. The value is evaluated with the help of grey scales.

So, there is a scaling system and according to that scale, it ranges from 0 to 5. So, that would give whether it is poor very poor, good or very good, or excellent. So, these are the kind of gradation that the grey scale gives to a washed fabric and it is compared with the unwashed fabric; obviously, when we are evaluating any fabric one cannot do a fabric by it is own. It has to be a comparative data of the unwashed and the washed, and so washing is done in a very systematic manner and the outcome that washing as it deteriorated the colors of the fabric or has it remain or allowed to remain the same can be evaluated, and ascertain very accurately.

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This is the wash fastness tester machine, just for your information because these machine models you should be able to appreciate and understand and recognize. You should not say that this is a dyeing machine, no, this actually a wash fastness tester machine.

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Now washing fastness, the color fastness of the textile material is determined by the way of mechanical hesitation of a specimen of textile with the piece of specified adjacent fabric in standard soap solution followed by the rinsing and drying. Thereafter, the changing color of the specimen and stains of the adjacent fabric are assessed with grey,

the standard grey scale. So, there is a standard grey scale the adjacent fabric should not get any color from the dyed fabric that is also a part that whether it is staining the adjacent cloth. It will only stain if the color is bleeding if the color is running out then the adjacent cloth. So, it is not just that simply the cloth, dyed cloth is analyze it is kept with another fresh fabric. So that any color that would run off from the by the process of washing will come to the adjacent fabric. And so, color fastness for or washing fastness is ascertained with the help of this particular methodology.

Features of washing fastness tester: It is fabricated out of quality stainless steel This morning also we were discussing about several, several dyeing machines and their model of all them are made out of stainless steel. So, it goes to prove that dyeing should always be conducted under stainless steel a you know vessels or machines not otherwise. Possess electric heater to heat water in the water bath; the microprocessor based programmer is provided for temperature control; buzzer to indicate the completion of the process cycle or step.

As you know that washing fastness was done in five cycles, and different types different kind of solutions of the soap of different concentrations were added to the to the sample and the outcome was noted. So, there is a microprocessor, you will see that on the top there is a micro processor which can be programmed, and therefore the program that is fed on the microprocessor is actually fed and then it follows the same. And finally, when it is a buzzer indicates that there is the processes complete, so that is how it goes on.

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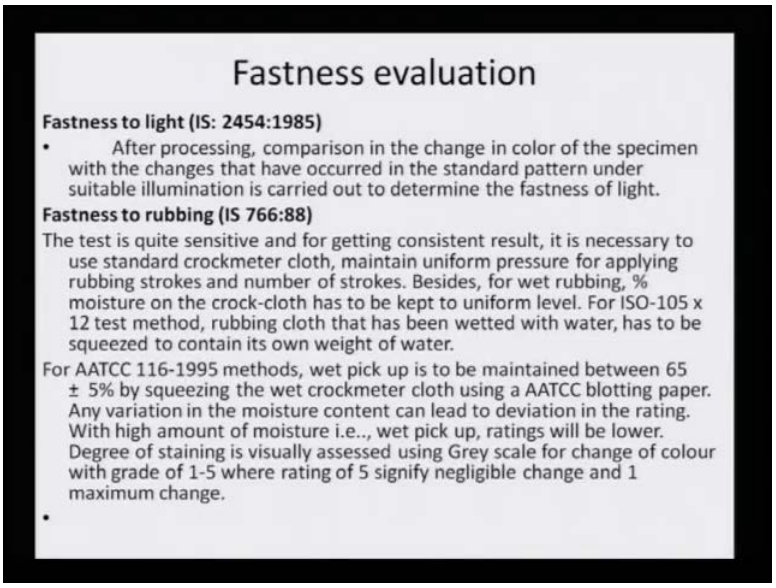

Fastness evaluation of light: After processing, comparison in change in color of the specimen with the change that have occurred in the standard pattern under suitable illumination is carried out to determine the fastness of the light. We have discuss this the (( )), what happens that a sample before and sample after the illumination are evaluated or are kept and then it the CIELAB values actually show whether any kind of fading has occurred or not.

Now, try let us try to look at the fastness to rubbing that is done by IS-766 in and 88 is the number. The test is quite sensitive and for getting consistent result, it is necessary to use standard crock meter cloth, maintain uniform pressure for applying rubbing strokes and number of strokes. Because you see we can just say when we were doing the indigo lesson, the lesson on vat dyes I told you that sometimes some a indigoid dyes or vat dyes have poor or not so good rubbing fastness. So, it is because it was kind of rubbed through the fingers and the color ray ran into the fingers. Now, that shows that it has poor rubbing fastness. Similarly when one is evaluating the rubbing fastness, this crock meter must have everything very well defined.

How many strokes of rubbing will occur number of strokes and what is the kind of pressure that the strokes will be applying and so on and so forth. Besides, rubbing fastness is a certain cloth or a wet cloth as well as for dry cloth. So, that may vary, the values may vary and for rubbing fastness percentage of moisture on the crock clock has

to be kept uniform in at a uniform level. So, several test methods like AATCC methods are also known, but we follow the IS method. And in that wet pickup to be maintained between 65 plus minus 5 percent by squeezing the wet crock meter cloth using the AAT CC blotting paper. Any variation in the moisture contain can lead to deviation in the rating. With the high amount of moisture wet pick up, ratings will be lower degree of staining is usually S using grey scales. So, this there is a grey scale or a scale which is named as grey scale and I told you it ranges from 0 to 5. We will see what it all signifies and thus the rating is done between that. If it is completely like grey scale for change of color with grade 0 to 5 where ratings five signifies negligible change and the rating 1 or 0 shows maximum change is, what is the full range of the grey scale.

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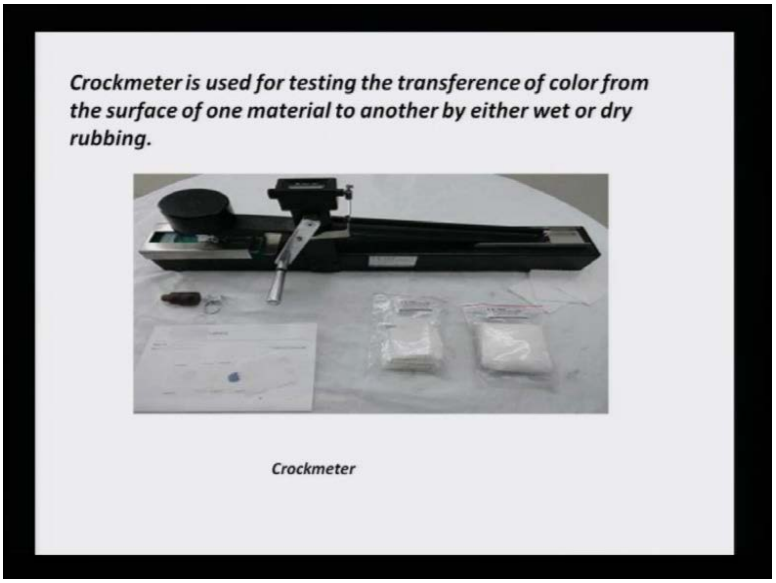

Now this how the crock meter looks like is used for testing the transparence of color from the surface of one material to another by either wet or dry rubbing method.

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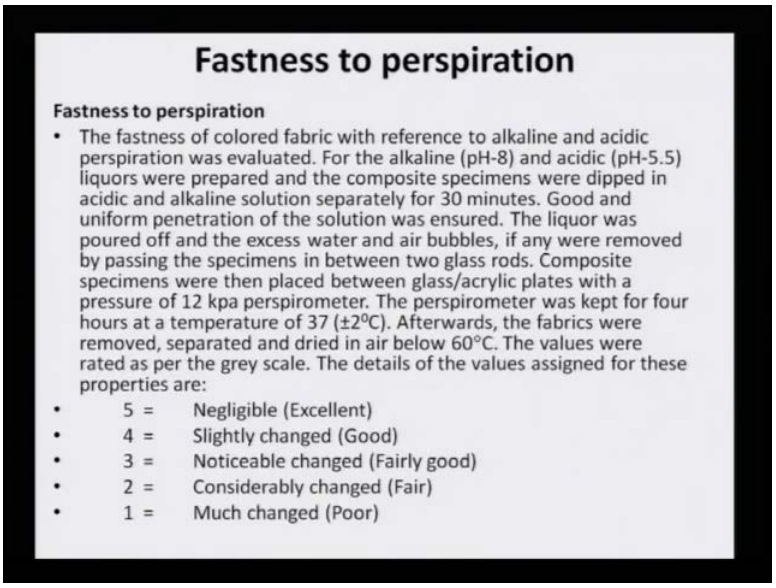

Fastness to perspiration: Fastness to perspiration, the fastness to perspiration is ascertain by the fact that the with reference to alkaline and acidic perspiration it is evaluated. So, it could be if the perspiration is acidic or alkaline, how would the dye fair. So, for alkaline pH is maintained at 8 and for acidic it is in the pH is kept at 5.5, liquors were prepared and the composite specimens were dipped in acidic and alkaline solutions separately for 30 minutes. Good and uniform penetration of the solution was ensured. The liquor was poured of and the excess water and air bubbles, if any were removed by passing this specimen in between two glass rods. Composite specimens were then placed between glass or acrylic plates with the pressure of 12 kpa perspirometer.

The perspirometer was kept for 4 hours at a temperature 37 degrees plus minus 2 degrees. Afterwards the fabrics were removed, separated and dried in air below 60 degrees. The values were rated as per the grey scale. So, you see that the procedural detailed of assessment of these fastness properties are told to you and you also now know that they are analyzed on different machines and there is something called a grey scale which ranges from 0 to 5 or 1 to 5, where five shows negligible change which means it is very excellent dye. Four shows slightly change which means it is a good dye; three shows a noticeable change which is fairly good, but it cannot be said that it is very good, and therefore, there are some changes where we can see that the dyed fabric as shown considerable changes and the next one is considerably change; that means, a lot of dye as run of through perspiration which will mean that it will be having a rating of two, and

when it changes to a large extent then it is much change and it is considered very poor, and that will be rated as one. So, this is the kind of grey scale which exists and this curtains it gives does not give an absolute value that it gives a relative value as to how it has changed from its original specimen. This is how the perspirometer looks like and because it is compressed and this is the model that shows the entire set up.

Now, coming to I was saying that there is a color change. How do we find out that the color has changed, of course, we have a visual way of ascertaining that this is light blue; this is dark blue; this is pink; this is red, but that is not all you can think that this is light blue; I can think it is medium blue. So, it is not what we think a, and we can think differently. It is the way in world over there is a way of describing a color and that is done by the help of CIELAB value as we go a long we will get into the understanding of the CIELAB.

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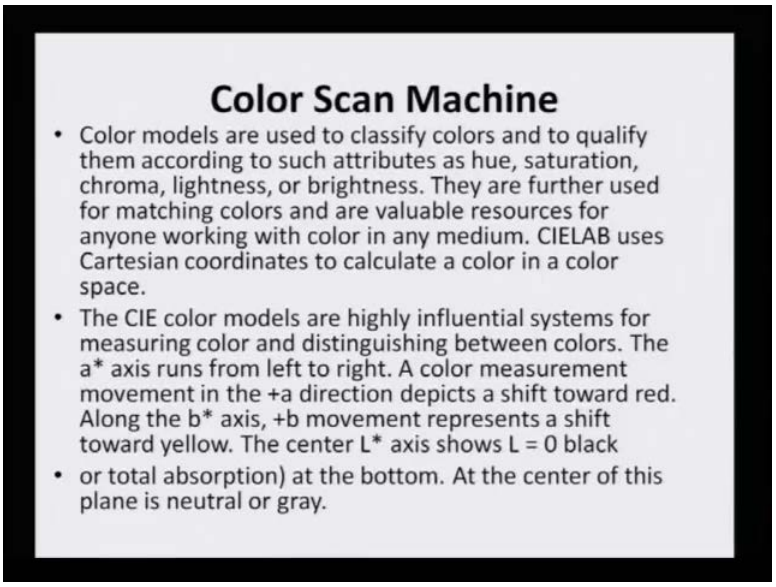

Color modules are used to classify colors and to qualify them according to such attributes as hue, saturation, chroma, lightness, or brightness. They are further used for matching colors and are valuable resources for any one working with color in any medium. CIELAB - S I E L A B uses Cartesian coordinates to calculate a color in a color space. So, there is a way of putting the nomenclature of a color. So, that light dark you know our own assessment of a color doesn’t come into the picture.

A color is described by L A B values, and the process or the fundamental is based on CIELAB – S I E L A B. The C I E color models are highly influential system for measuring color and distinguishing between colors. So, that is the reason why there was a necessity to have a universal or a global way of describing a color. So, anybody in the in America or Europe or India or any place in the world will describe a color by its L A B value only. The a access runs from left to right a color measurement movement in the plus a direction depicts a shift toward red; along the b axis b movement represents a shift towards yellow; the center L axis shows the L 0 as black or total absorption at the bottom. At the center of this plane is neutral or gray.

So, you see that that is how the color was described, and it was very, very easy to then put any color, any shape, any hue into this coordinates. So, you have three coordinates L A and B and all of them are taking or participating in one color or the other. So, it is the combination of this L, A, B which actually describes any shade.

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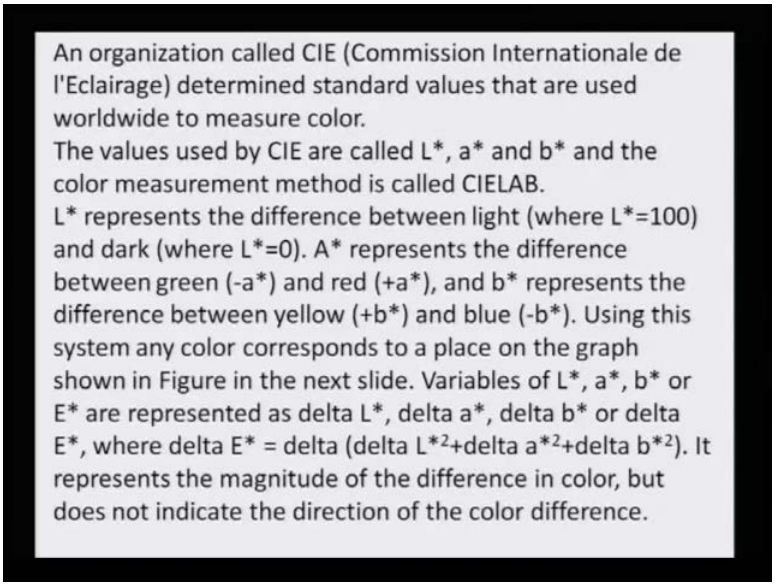

An organization called C I E that is Commission Internationale de L'Eclairage, determined which is a French company determines standard values that are used worldwide to measure colors. So, that is why there was a necessity to have a color system. So, that you know the description does not become difficult and does not become different. The the values used by C I E are called L start, a star, b star use always fine that L is capital, it has an asterisks; a is small - alphabet a, it has an asterisk; and b is

an small, alphabet with an asterisk; that is how it is written and the color measurement method is called CIELAB value. So, that is why it is possible to ascertain the CIELAB value before the light is shown and in a xenon tester and after the light is shown. L represents the difference between light where L star is equal to 100 and dark when L star is 0; a represents the difference between green and red and b represents the difference between yellow and blue. Using this system any color corresponds to a place on the graph shown in the figure in the next slide.

Variables of a star, b star, L star or E are represented by delta L, delta a, and delta b. And therefore, one can find out what is the change? Delta means any change from the initial situation. If the L has change, how much of the L as change and that change will be represented by the delta L. So, it represents the magnitude of difference in color, but does not indicate the direction of color difference. So, it only says from what L value what has reduced. We will come to the slides and you will have a better understanding.

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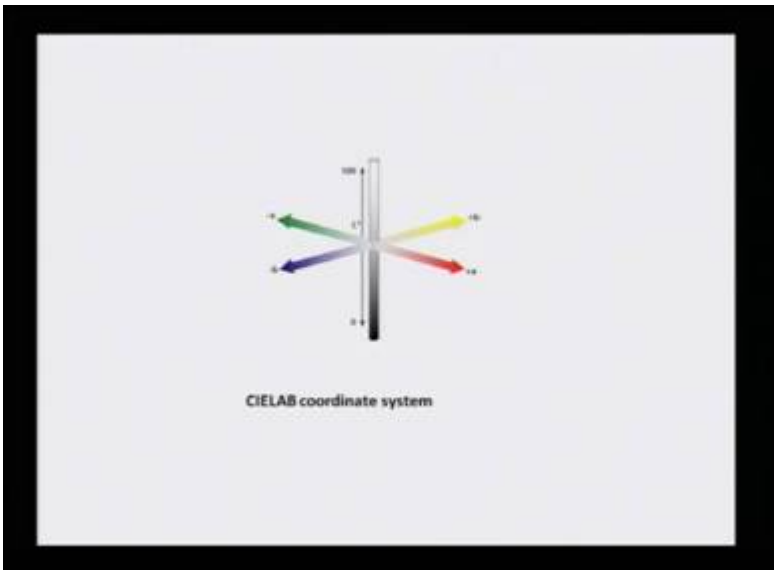

See, this is what the CIELAB coordinates system is all about. L is on the one axis 0 to 100, and then you have plus a to minus a and you have plus b to minus b. And you will see that plus a is red and it is going towards minus a when it becomes green. So, that is how the values are written it is not only the numerical value for a and b; it is also whether it is move towards green then it will have minus value; if it a has a plus value then it is move towards red.

Similarly, look if you at b, the plus b values are the yellows; and the minus b value proceeds towards the blues at the purple. So, this is how the color is described and you will see that one when it is 100 - it is white; and then proceeds towards middle has grey and when L is zero, it is completely dark or black. So, this describes any color, any dye, any dyed fabric in a very efficient manner.

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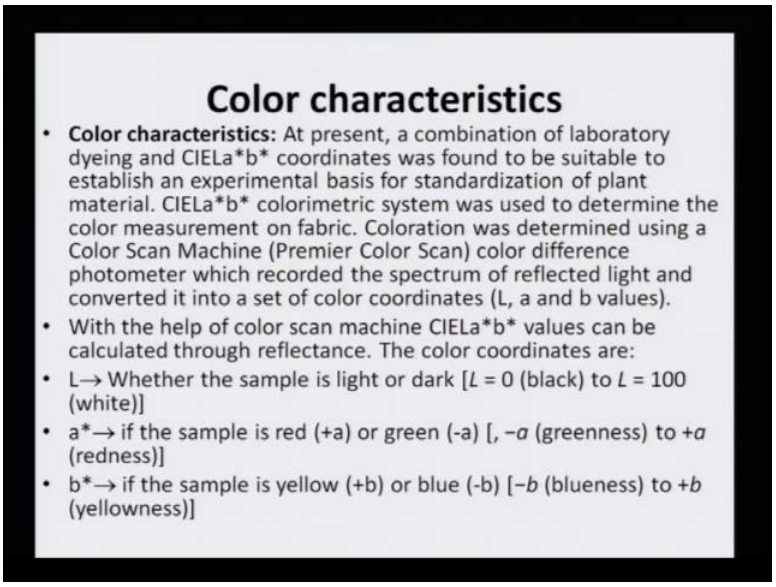

Color characteristics: At present, the combination of laboratory dyeing and CIELAB coordinates was found to be suitable to establish an experimental basis for standardization of plant material. Now similarly, when we understood that CIELAB's describe a color; it was also extend into natural dyes. CIELAB colorimetric system was used to determine the color measurements on fabric - that is the dyed fabric. Coloration was determined using a color scan machine, and in our case we use premier color scan.

I will show how the machine looks like. Color difference photometer which recorded the spectrum of reflected light and converted it to a set of color coordinates that is L, a , b values. With the help of color scan machine CIELAB values can be evaluated through reflectance. So, it totally is a phenomenon of reflectance; when a light is shown what is reflective? The color coordinates are L, whether the sample is light or dark that is L; if it is zero, I told you it is black. If L is hundred, it is white. So, the lower the value of L, the darker will be the shade; the higher the value of L the lighter will be the shade.

Similarly, if the sample is red or green - that is, it will be plus a to minus a, minus a shows greenness and plus a shows redness. Similarly, b star; if the sample is yellow, plus yellow will be you know more yellow and blue will be minus b, and therefore the yellowness is a kind of described by plus b values. These are numerical values I have told you. This is how the colors scan machine looks like and then which go on to understand more about CIELAB.

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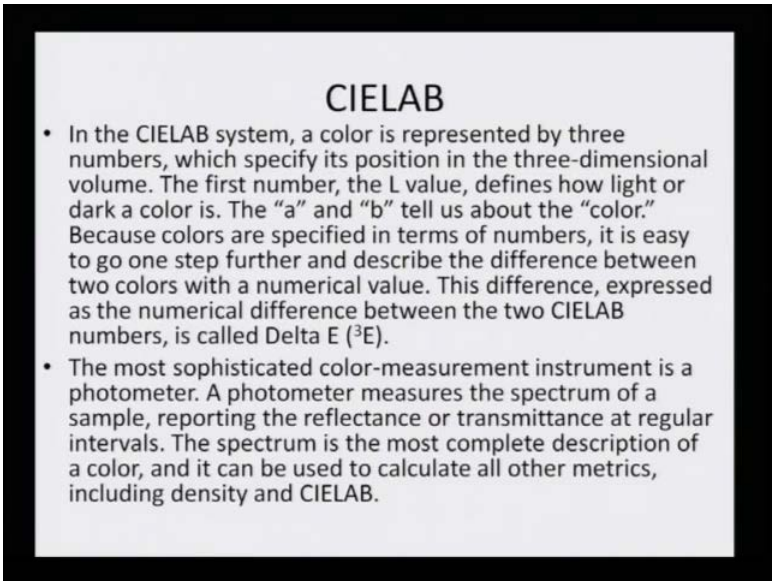

Because you see now, you can appreciate that any color, any dye, any dyed fabric, any extract from the plant material, any synthetic dye, will all go through this CIELAB values system, in order to be described as a colorant. In the CIELAB system, a color is represented by three numbers, which specify its position in the three-dimensional volume. The first number of the L value, defines how light or dark the color is. We just saw that and the a and the b tell us about the color. Because color as specified in terms of numbers, it is easy to go one step further, and describe the difference between two colors the numerical value - that is why it is possible to do the xenon testing. That is the light testing, why? Because you know if a fabric has a number of 53.239 as the starting sample, and after showing the light if the it has faded then it will become lower value of sorry the higher value and it will become 50, it will leave fifties, and it will become 60 or 64. And this difference from 59 to 64 promotes it to become a lighter in shade. So, that is how it is possible to numerically ascertain two colors. The difference express as a

number of difference between the two CIELAB numbers and that is referred as E delta delta E or delta or E delta.

The most sophisticated color measurement instrument is a photometer. A photometer measures the spectrum of the sample, reporting the reflectance or transmittance at regular intervals. The spectrum is the most complete description of a color, and it can be used to calculate all other metrics, including density and CIELAB. So, you see that CIELAB value gives us a complete picture of comparative data of the dye of the dyed fabric and whether the dye has run off or it has got washed off, or it has got a perspiration fastness or not, or whether alkaline and a acidic solutions have made any difference to the dyed fabric or not; all that can be ascertain with the help of CIELAB values.

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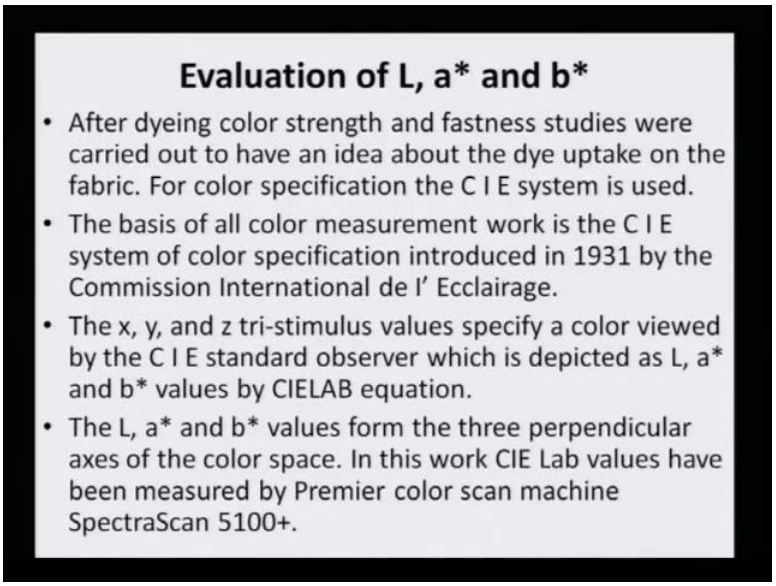

Now, when we try to evaluate the main three values are L, a, and b. After dyeing colors strength and fastness studies were carried out to have an idea about the dye update on the fabric. For color specification the C I E lab's C I E system is used. The basis of all color measurements work is the C I E system of color specification introduced in the year 1931. So, it was only in after 1931 by the commission of International de L' Ecclairage that this color was able to be described. The x, y, and z tri-stimulus values specify a color viewed by the C I E standard observer which is depicted as L prime or L star, a star and b values by CIELAB equation.

The L, a, b values from the three perpendicular axis's of the color space. In this work, the CIELAB values have been measured by the premier color scan machine, and we will try to see that this is like a entire you know globular colored spectrum of which there are three axis's, and all the three of them are occupying different axis's - that is the L, the a, and the b.

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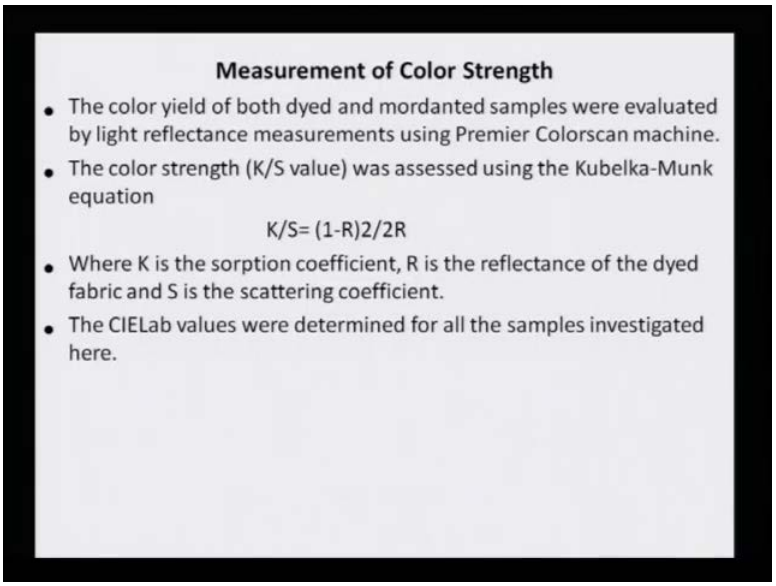

Measurements of colors strength: Even with this color scanning machine, one can make the colors strength measurement by utilizing a formula that was given by Kubelka and Munk. The equation is that K by S is equal to 1 minus R square upon 2 R. Now, you see the color yield of both the dyed and mordanted samples can be evaluated by light reflectance measurements using premier color scan. The same machine which finds out the L, a, b value can also give us the K by S value. The color strength was assessed using Kubelka-Munk equation, and I told you the equation K by S is equal to l minus R square upon 2 R; where R K is the sorption coefficient, R is the reflectance of the dyed fabric and s is the scattering coefficient. So, through this equation mathematically also the color strength of the fabric can be ascertained, and it is the color depth or the color strength which determines how much color has been taken up by the fabric.

The CIELAB values were determined for all the samples investigated and we came to a conclusion that you know this is like giving a full spectrum of information about a dyed fabric. So, not only does it tell us the color shade, but also the color strength; the delta E

value if required, because when we are mordanting. Then from the control sample, how much is the difference - if alum is mordanted and dyed, or if ferrous sulfate is mordanted and dyed. Does it make any changes in the L a, b values? Certainly, it makes, but at the same time is the color strength larger or smaller or equal can also be ascertained.

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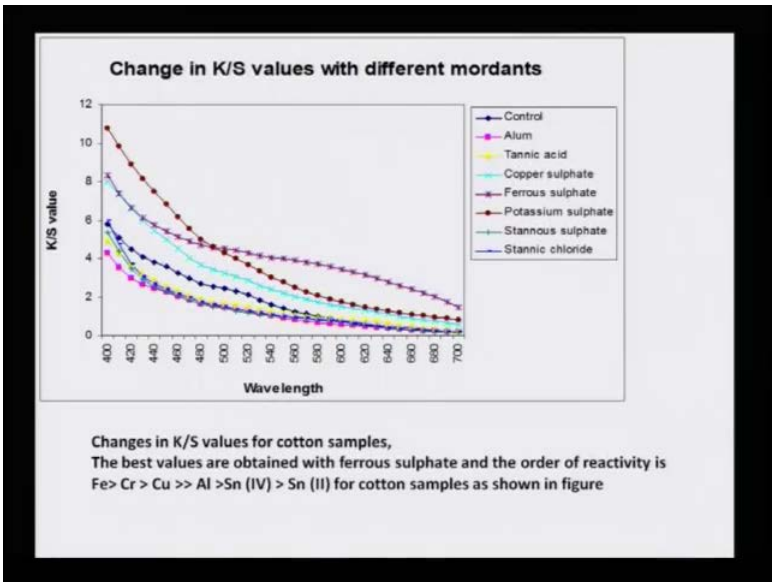

Now, when we try to look at this kind of change in K by S values for different mordants, say for a cotton sample of a given sample, you will see that there are different graphs of different mordant - one is control which is unmordanted, then the pink line is alum, the yellow line is when the fabric is only having tannic acid; the third line is when it has tannic acid and copper sulfate; the fourth line is ferrous sulfate, and tannic acid and so on and so forth. Then you will see stannous stannic have all the mordants have been tried out with this particular dye. And you will see that the longest line is the control, why? Because it is showing that it has take up taken up color. But it is not the strongest colors strength why because it will run off; it is only the superficial color. So, if we have to evaluate among the alum, tannic acid, copper sulfate, ferrous sulfate, potassium sulfate, potassium dichromate and stannous sulfate and stannic chloride.

We will find that the best values are obtained with ferrous sulfate. Why? because it shows the lowest line in the graph. And after that the order of reactivity is that ferrous is larger than the chromium, which is larger than copper which is much, much, much larger than aluminum which is larger than stannic and which is larger than stannous.

So, for cotton samples, this is how the change in color strength is can be ascertained with the help of a mordants. Similarly mordanting, how whether it makes any difference to a dye or not, can be also ascertained with the help of the K by S value - the color strength value. And in the case of silk, the same exercise was carried out by taking because here no tannic acid is used; control alum, copper sulfate, ferrous sulfate, potassium dichromate, stannous chloride, stannic chloride - all these mordants were applied and it was found that the best value was obtained for the changes in the silk samples show that the best value was for chromium. And then further on it goes onto show that the other mordants had it shown color strength effectively.

So, you see that K by S can also be analyzed on the CIELAB machine - that is the premier color machine, or color scanning machine, and similarly the color strength can be also found out by that CIELAB values give the dye description and color strength gives the dye depth.