Seasonal Dyeing- Color Extraction from the Leaves and Catkins of Cottonwood Trees

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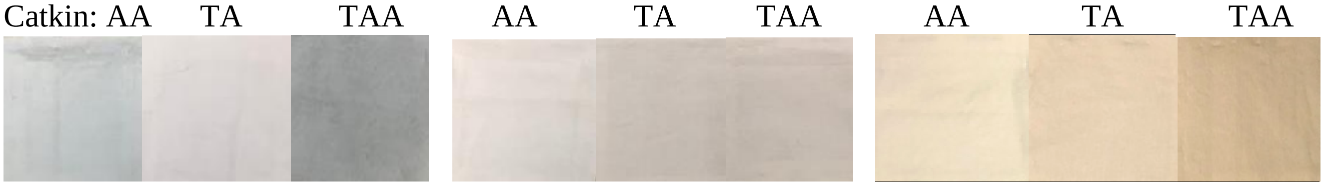
Introduction & Literature Review. Recently, renewed interest in natural dyes for cellulosic fibers has been observed, likely explained by health and environmental concerns related to synthetic dyes (Haar et. al., 2013). Synthetic textile dyeing can be considered the most polluting industrial process (Geelani et. al., 2017). The variability of plant based dyes means exceptional skill is required to achieve the desired hue (Ziarani et. al., 2018; Saikhao et. al., 2018). Color and colorfastness are related to the dyestuff, mordant and concentrations (Arroyo-Figueroa, 2011).

Numerous plant based dyes have been utilized in dyeing fabric throughout history. The Eastern Cottonwood was used by Native Americans to produce dyes of brown and yellow (USDA Forest Service, 2021). Cottonwood trees are members of the genus Populus (Oregon State University, 2021). Native cottonwoods of the Rocky Mountain Region include the Plains (populous deltoides monilifera) and Lanceleaf (Populus acuminate). Recent interest in natural dyes led to exploration of using populous deltoides in dyeing (Geelani et. al., 2017). When using the bark of the populous deltoids as a mordant, dye absorption of Quercus robur was lowest for pre-mordanted cotton fabric (Geelani et. al., 2017). Dyeing cotton with leaves of the Indian Bat Tree displayed good washing, light exposure and perspiration fastness (Kumbhar et. al., 2019). This research dyed with the Plains and Lanceleaf Cottonwood's fall leaves and spring catkins.

Experiment Methodology. 100% cotton, Style #400M (Testfabrics, Inc.) Material was scoured then cooled, rinsed with warm water and air dried. Mordants were tannic acid (TA), alum acetate (AA) or both (TAA). Fabric was wetted out, mordants were 8% weight of fabric, added to distilled water, 40:1. Mordants dissolved, while heat increased to 30 C. Heat increased to 80 C in an hour, lowered to 60 C for 2 hours, stirring every 10 minutes. Fabric cooled for 20 minutes, was rinsed with warm water & air dried. Dye was extracted from fall leaves and spring catkins by gathering raw materials and covering with distilled water. These mixtures boiled and temperatures were lowered to 90 C for 60 minutes, stirring every 10 minutes. Ratio for the leaf dye solution was 15:1 and 20:1 for catkin dye. Samples of each mordant type were dyed without modifiers, with an acid and alkali modifiers. Original pH of the leaf extracted dye was 5, modified to 3 with acid and 10 with alkali. pH of the catkin extracted dye was 7, modified to 1 and 10. Samples were dyed going from 30 C to 80 C over 90 minutes, with stirring every 10.

Results. Leaf: No Modification Acidic Dye bath Alkali Dye bath

Catkin: AA TA TAA AA TA TAA AA TA TAA



Color Calculations: AATCC 173- Calculation of Small Color Differences for Acceptability was used to evaluate changes in color. The value of the mordant was subtracted from each sample for L, a and b values. These differences were squared and added before determining the square root. The average color differences from leaf dye with AA mordant fabric displayed the largest differences in color, 21.33 in the no modifier condition, 18.13 in the acidic and 45.09 in the alkali. Average color differences from the TA mordant fabric were the smallest, 7.37, 4.19 and 25.38. Finally, the TAA fabric average color differences were in the middle, 10.49, 5.86 and 27.77. The color differences resulting from the catkin dyeing on AA fabric again displayed the largest differences in color 23.95 in the no modifier condition, 16.15 in the acidic and 13.01 in the alkali. Average color differences from the TA mordant fabric were overall the smallest, 9.11, 4.09 and 4.12. Finally, the TAA fabric average color differences were in the middle 17.36, 3.81 and 8.31. *Colorfastness to Crocking:* Dry and wet crocking evaluation was done in accordance to AATCC 8. Fabric specimens were cut to 38mm by 127mm. 50mm by 50mm cotton crocking squares rubbed the surface for 10 turns at 1 turn per second. Testing squares were wetted until moisture regain of 65 +/- 5% was achieved. Change in color was evaluated with AATCC EP-2 Staining Scale for Color Change, using .5 rating gradations. Wet crocked samples were evaluated against non-crocked cotton plain weave cloth. Two evaluators analyzed each sample in a light box using the daylight setting. Ratings used scored within .5 of one another on the change scale. Fabric dyed leaf dye solution without modifiers performed well in both the wet and dry crocking for all mordants, scoring 4.5 or above, indicating very good to excellent resistance to staining from dry crocking. When an acidic modifier was added, performance in wet and dry crocking was maintained, though fewer excellent ratings (5.0) were observed. With an alkali modifier, ratings for dry and wet crocking were all above 4.0, primarily 4.5. Fabric dyed with catkins without modifiers performed well in both the wet and dry crocking for all mordants, scoring 4.5 or above, indicating very good to excellent resistance to staining. When an acidic modifier was added, performance in wet and dry crocking was improved, with more excellent ratings recorded. When an alkali modifier was added, ratings for dry crocking and wet crocking for all mordants were 4.5 or above, with a majority 5.0, indicating very good to excellent. *Colorfastness to Artificial Light*: AATCC 16.2 was used as an evaluation guide with a custom built light exposure device modeled after Australian test method 2001.4.21: Determination of colorfastness to light using an artificial light source. Fabric specimens were 68mm by 68mm with an exposure area of 45mm by 45mm. Samples were mounted in the circular lamp and exposed to continuous light for 48 hours before being conditioned. All samples were compared to unexposed samples in a light box using the daylight setting. Change in color as a result of crocking was evaluated with AATCC EP-1 Grey Scale for Color Change using .5 rating gradations. Fabric dyed with leaves without modifiers performed fair to good for all mordants, scoring 3.75 to 4.00, indicating fairly good to good resistance to color change from light exposure. In acidic condition, primarily very good (4.50) ratings were recorded. In alkali condition, ratings were more variable, ranging from 3.75 to 4.25 (fairly good to good). Fabric dyed with catkins without modifiers was fairly good for all mordants, scoring 3.25 to 4.25, indicating fairly good to good. In acidic condition, performance improved, with primarily good (4.0) ratings. In alkali condition, ratings showed variability, from 3.50 to 4.50, indicating fairly good to good.

Conclusion. These results indicate that seasonal leaves and catkins from cottonwood trees can display fairly good to excellent colorfastness to crocking and light exposure. Future investigations could assess ideal extraction methods and concentrations for cottonwood dyeing.

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