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COLORIMETRIC DIFFERENCES ON WOOD SUBSTRATE DUE TO VARNISHING INFLUENCE

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ABSTRACT: Digital printing machines with ink jet technology allow printing on wood substrate and varnish can be used as final process in wood finishing. Although varnish is protecting printed ink and increasing mechanical properties of wood surface it is also changing hue and saturation of printed color. The aim of this study is to quantify that difference in color value printed on a wood substrate with and without varnish layer. For that purpose, standardized colorimetric methods were taken based on CIE L*a*b* values using the equation for color differences CIEDE2000.
KEYWORDS: wood substract, varnish, ink jet, CIALAB space, color gamut, color differences CIEDE2000

INTRODUCTION

Digital ink jet printers can print directly on: glass, metal, stone, wood, plastics, etc. They are using solvent ink based on alcohol gel. Wood products as print substrates are characterized by great thickness and specific structure that achieves different surface properties (great absorption, surface roughness and possibility of different surface textures).

For easier maintaining the wood surface the varnish is used. Varnish is a transparent and protective film with glossy or semi-glossy reflection. It is used for increasing mechanical properties of wood surface and for protecting printed ink.

However, in the contact with wood surface, varnish is changing the hue and saturation of the printed color. Colorimetric differences, with and without varnish on the printed wood surface, can be measured with standardized colorimetric method based on CIEL*a*b* values.

L*a*b* (CIELAB) and L*u*v* (CIELUV) color space were designed to be device independent and perceptually uniform. They were introduced in the 1976 by the Commission Internationale de l´Eclairage (CIE - the primary organization responsible for standardization of color metrics and terminology). The CIELAB color space is widely used in color imaging and printing industry while CIELUV is commonly used in the display industry. These spaces are defined in terms of transformations from CIE XYZ tristimulus values to these spaces [1].

Based on CIE L*a*b* values the gamut of reproduction can be also constructed. Color gamut is the range of a set of colors and can be represented as location in a three-dimensional color space. For the gamut of reproduction the ICC profiles are necessary.

The ICC (International Color Consortium) is a consortium of those vendors founded in the year 1993 with the aim of developing a universal color management solution. The ICC profile format, defined by the ICC Profile Specification, consists of various data structures, which provide a mechanism for color transforms [2].

METHODOLOGY

The research was carried out on an ink jet printer DTS (direct to substrate).The printer driver takes RGB values as inputs. A standard X - Rite profile 343 Patches test chart was printed on three different wood surfaces -chipboard, MDF board and spruce board. After the chart was printed and dried on each board, L*a*b* values were measured using a spectrophotometer i1 Pro with 45°/0° measuring geometry, under conditions 50D illumination and 2° observer.The obtained data consisted of values of RGB inputs and their corresponding spectral reflectance.

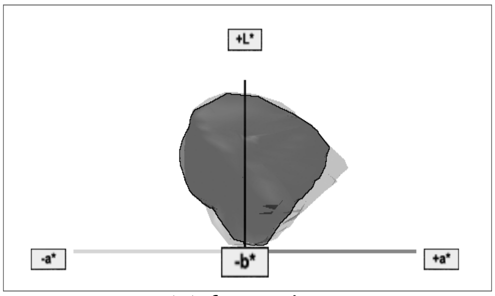
As a wood finishing the varnish was applied, two layer of basic varnish and one waterborne. When varnish was dried the L*a*b* values were measured again under equal conditions.The evaluation was carried out by the values with and without varnish for each of the 343 test chart patches using the equation for color difference CIEDE2000 [3].

$$\Delta E_{00}=\sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2+\left(\frac{\Delta C'}{k_C S_C}\right)^2+\left(\frac{\Delta H'}{k_H S_H}\right)^2+R_T\left(\frac{\Delta C'}{k_C S_C}\right)^2\left(\frac{\Delta H'}{k_H S_H}\right)^2} \quad (1)$$

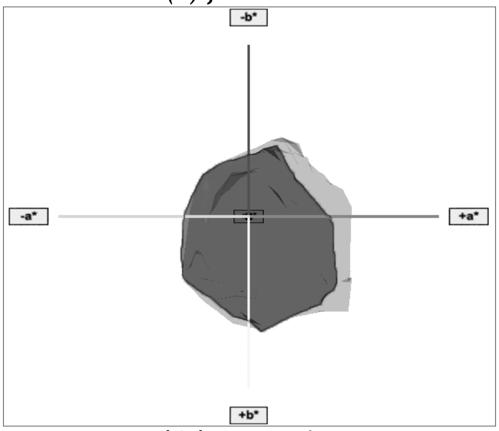
The obtained ΔE errors are Euclidean distances in the L*a*b* space. The minimum, mean, median and maximum of errors were calculated and the results are displayed in Table 1.

Table 1. Evaluation results

	Min ΔE	Mean ΔE	Median ΔE	Max ΔE
CHIPBOARD	0,6686	5,3392	4,8394	15,2802
MDF	0,8630	4,1760	3,1186	32,0223
SPRUCE	1,9271	6,2595	6,2434	9,9459

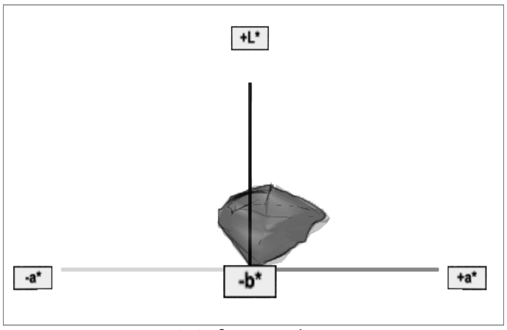


(a) front view

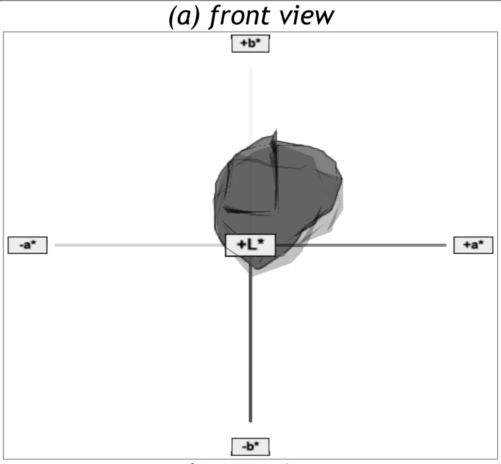


(b) bottom view

Figure 1.(a) front view and (b) bottom viewofcolor gamut without varnish (shown as light gray color) and with vanish(shown as dark gray color) on chipboard

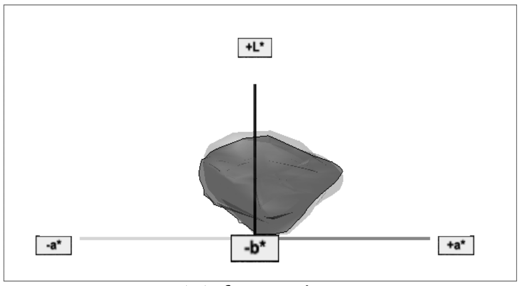


(a) front view

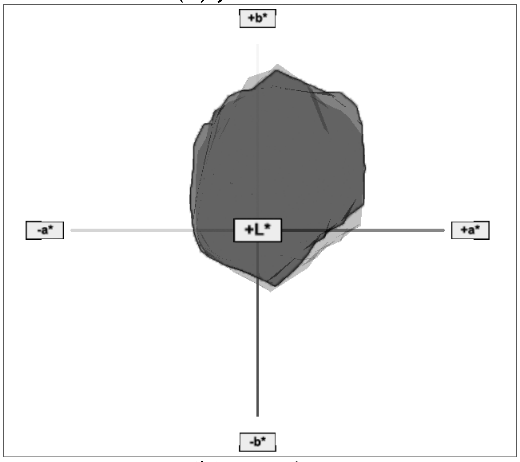


(b) top view

Figure 2.(a) front view and (b) top viewof color gamut without varnish (shown as light gray color) and with varnishing (shown as dark gray color)on MDF board



(a) front view



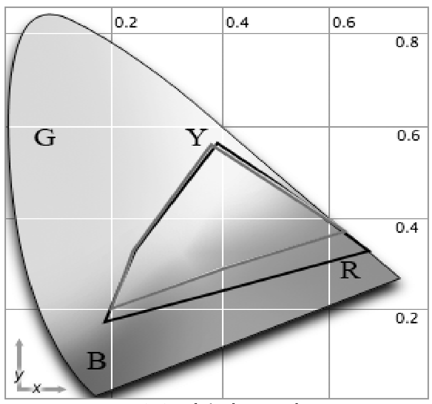
(b) top view

Figure 3.(a) front view and (b) top view of color gamut without varnish (shown as light gray color) and with varnish (shown as dark gray color)on spruce board

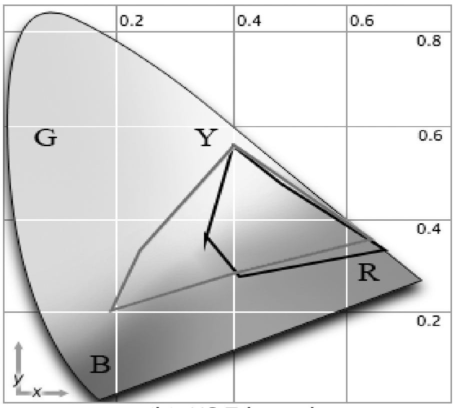
Once the L*a*b* values were measured the ICC profiles were made using Profile Maker 5.0. ICC profiles are required for construction of color gamut. In Color Shop X application the reproduction of gamut were made. Color gamut can be represented as a volume in three-dimensional color space. Therefore, the comparison in 3D color space of color gamut with and without vanish can be seen for chipboard on Figure 1; for MDF board on Figure 2; and for spruce board on Figure 3. in various views.

In the L*a*b* color space: L* represents the lightness, a* encodes the red - green sensation and b* encodes the yellow - blue sensation. Positive +a* indicates a red color and negative -a* a green color; and positive +b* indicates a yellow color and negative -b* a blue color [4].

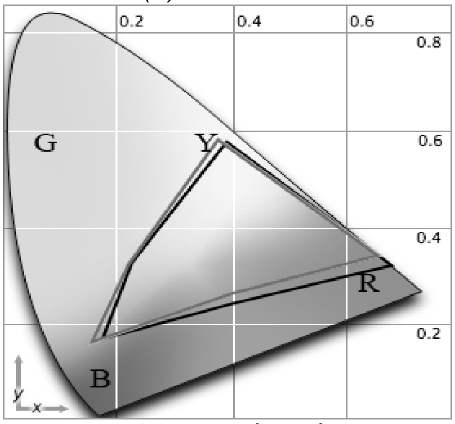
Furthermore, color gamut can also be represented as a vector in two-dimensional space as a unit plane known as spectrum locus in chromaticity diagram (Diagram 1.) [5].



(a) chipboard



(b) MDF board



(c) spruceboard

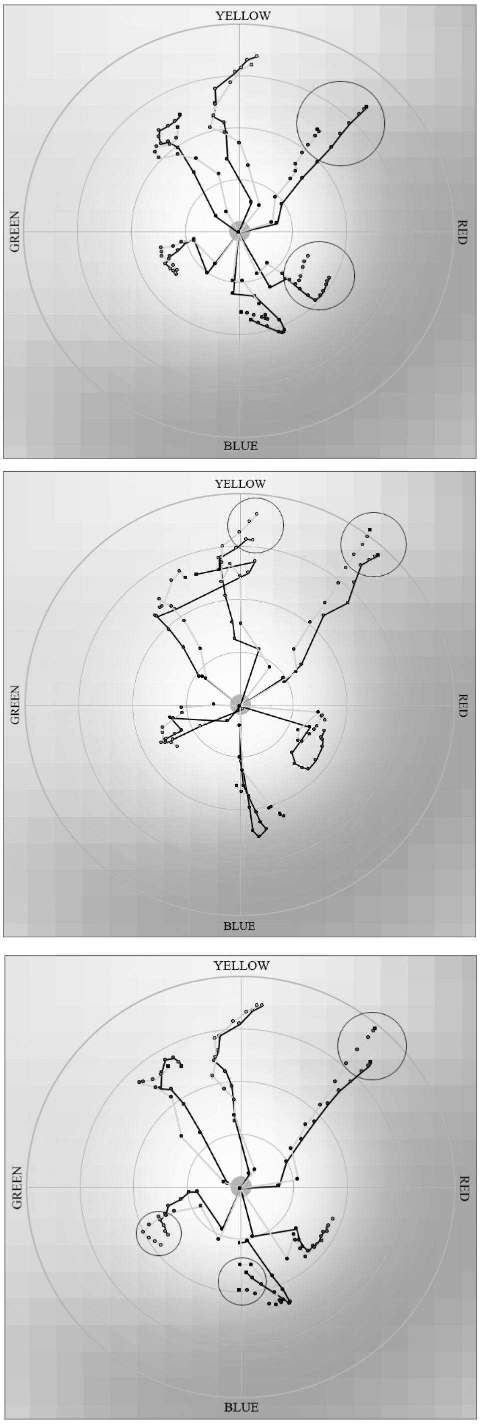
Diagram 1.CIE xy chromaticity diagrams for (a) chipboard, (b) MDF board and (c) spruce board (black stroke shows gamut without vanish, gray with) G = green, B = blue; Y = yellow, R = red

RESULTS

For these research three different wood surfaces were tested -chipboard, MDF board and spruce board. As can be seen from Table 1.the mean error of around ΔE 6is the highest for spruce board, but it is also interesting to note that thespruce board has the highest minimum error of ΔE 1,9 and smallest maximum error of ΔE 9,9. This indicates that the entire color amount after varnishing changed linearly which is nicely shown on the Diagram 1c. However blue tones went to green after varnishing which can be seen on Figure 4c. and the saturation of red color increased which can be seen on Figure 3a.

The smallest mean error of around ΔE 4 is for MDF board although Diagram 1b. shows desaturation of green and blue tones on unvarnished surface. That indicates that MDF board has great absorption properties and that the green and blue tones merged with the surface. Use of varnish not just increased the saturation of these twocolors but also the saturation of yellow color. Desaturation of red can be seen on Figure 2b; and Figure 4b. indicates that red went to yellow.

It is noticeable on the Figure 4a. that the saturation of red color on chipboard with varnish fall drastically which also indicates the maximum error of high ΔE 15,2. This is indicated also by Figure 1a. and Figure 1b. where we can see from bottom view the missing area in a+ zone which represent the red color.



(a)

(b)

(c)

Figure 4.Color gamut in 2D without varnish (shown as dark gray line) and with varnish (shown as light gray line) for (a) chipboard, (b) MDF board and (c) spruce board

CONCLUSIONS

As it was expected, hue and saturation of color printed on wood surface were affected by the addition of varnish. There were no significantly changes in lightness. Wood surface has a yellowish tone and varnish stimulated it more. As the results showed increasing the yellow, green color was increased too. The reason is in fact that green color contains yellow. On the other hand, blue and yellow are complementary color which means that they are opposite and one does not contain the other. That is why blue color failed the most.

The results of this research showed the way of colors changing, therefore, possible solution could be in modified prepress which should be investigated.

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