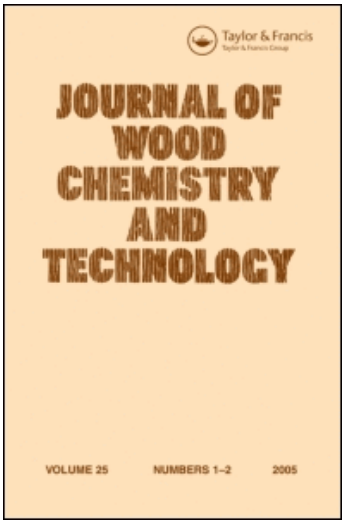

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Differentiation of Jack Pine from Other Conifers by the Analysis of Color Appearance from Chemical Tests

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DIFFERENTIATION OF JACK PINE FROM OTHER CONIFERS BY THE ANALYSIS OF COLOR APPEARANCE FROM CHEMICAL TESTS

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ABSTRACT

Attempts had been made to differentiate jack pine from some common eastern Canadian conifers (balsam fir, tamarack and black spruce) by analyzing the color appearance from three different chemical tests on wood. The tests conducted were based on either the major extractives (ferric chloride test), the pH (bromophenol blue test) or the resin acids (phenol/bromine test). The chemical tests work only on the heartwood; they do not work on sapwood. The results indicated that the measurement of CIE L*,a*,b* color parameters is a useful and rapid means for differentiating jack pine from other conifers studied. The test results can be obtained in 10-15 min when wood flour is used.

INTRODUCTION

Due to some regional shortfalls in wood supply of conventional softwoods such as spruce and balsam fir, the pulp and paper industry is obliged to supplement its raw material supply by introducing some other less desirable species, for example jack pine and larch. The use of jack pine in papermaking is

rather limited because of their inherent physical and chemical characteristics.[1,2] It is of interest for the pulp mills to restrict the amount of this species in their furnish. Hence, developing simple and accurate methods for differentiating the jack pine from other common softwood species is needed.

Identification of wood can be accurately done by microscopic observation based on morphological differences of cell elements,[3] but it is time consuming. Spectroscopy has been used to differentiate wood species, basing on the differences in chemical composition of wood.[4-9] Color reaction test is the most commonly used technique for separating wood species. [10-14] The color reaction method is based on the qualitative and quantitative differences of some natural compounds present in wood. A major problem with the color test lies in the fact that the degree in color difference is difficult to judge with accuracy; each worker responds differently to color description. In this work we developed a technique for differentiating the color produced in chemical reaction by evaluating the color appearance and expressing it in CIEL*a*b* color space system (Tappi test method T524 OM-94). This paper gives an account on the analysis of color differentiation obtained from three different color reaction tests on some eastern Canadian softwoods.

RESULTS AND DISCUSSION

A. Ferric chloride ($FeCl_3$) test

The values of L* shown in all figures are to be multiplied by a factor of 4 to obtained the measured values. All the data represent the average of two measurements with a variation of 3-5%, in general. As Figs. 1 and 2 show, when reacted with ferric chloride jack pine appeared reddish while the other three species greenish, clearly differentiating jack pine from balsam fir, tamarack and black spruce. After a 5-min reaction, the colors remained relatively stable up to 25

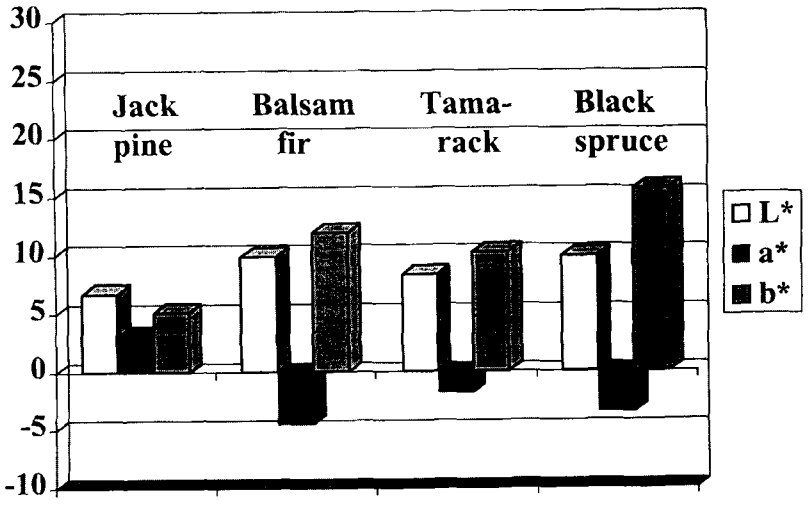

FIGURE 1. Color reaction of ferric chloride test on fresh wood flour. 20 min.

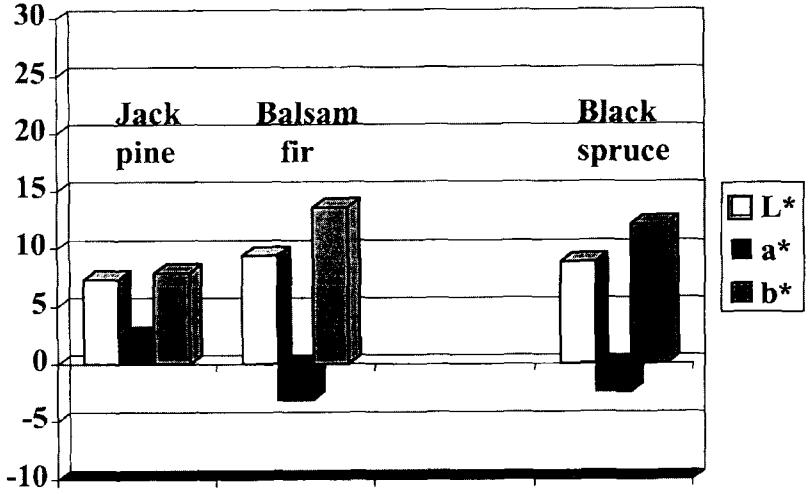

FIGURE 2. Color reaction of ferric chloride test on seasoned wood flour. 20 min.

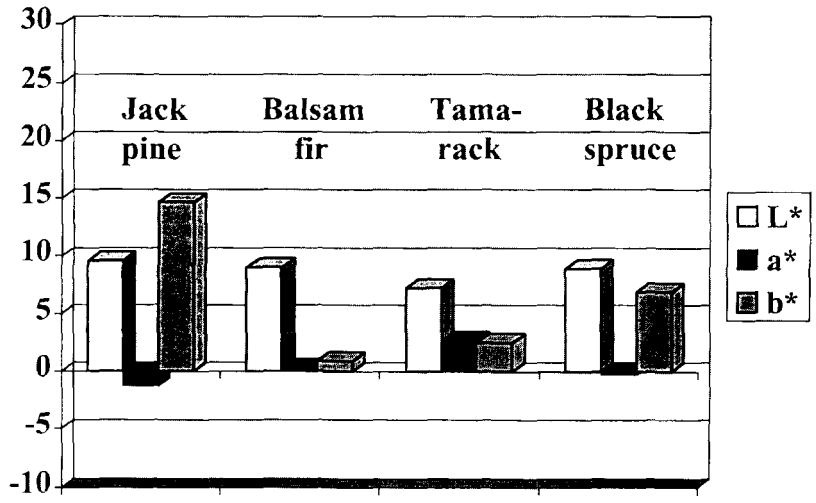

FIGURE 3. Color reaction of bromophenol blue test on fresh wood flour. 20 min.

min. There was a statistically significant difference (at 95% significance level) between the mean values of L*, or a* or b* of the species studied.

B. Bromophenol Blue Test

As Fig. 3 shows, fresh jack pine can be differentiated from the other three species by having a strong yellowish-green when reacted with bromophenol blue. In contrast, the other species gave a yellowish-red. With seasoned wood meal, jack pine turned yellowish-red, while balsam fir reddish-blue (Fig. 4), indicating a change in their pH values during the seasoning. On the other hand, the seasoned black spruce remained unchanged in color appearance when compared with its fresh counterpart. Further, the color obtained by reacting bromophenol blue with fresh wood meal remained particularly stable even up to 30 days. The species were statistically different with respect to the L* or a* or b*, at 95% significance level.

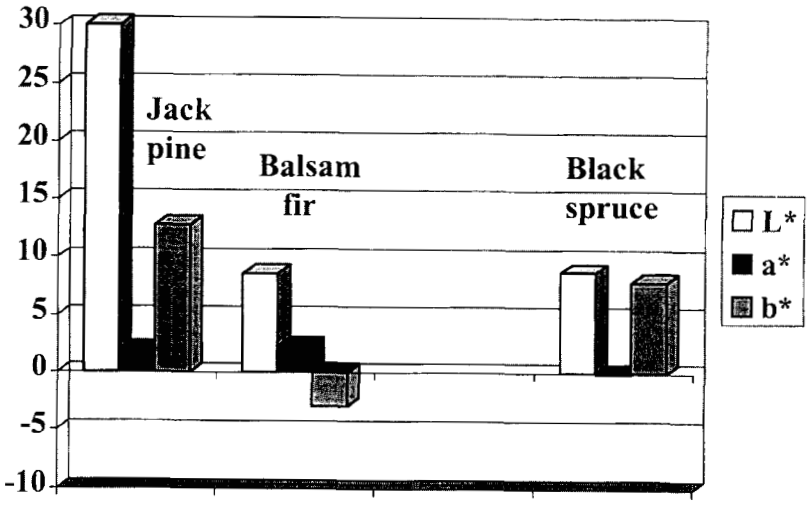

FIGURE 4. Color reaction of bomophenol blue test on seasoned wood flour. 20 min.

C. Phenol/Bromine test

The phenol/bromine test did not give satisfactory differentiation among the species when wood flour was employed, which might be attributed to the low concentration of resin acids. On the other hand, its reaction with wood extract gave good separation between the species tested, as Fig.5 shows. After a 10-min reaction, the jack pine extract turned dark brown, balsam yellowish-green, tamarack yellowish-gray, and black spruce purplish-blue. There was a statistcaly significant difference (95% significance level) between the species in terms of L* or a* or b*. Generally, the color was relatively stable within 80 min.

CONCLUSION

The experimental results show that jack pine can be differentiated from other common eastern Canadian conifers by the analysis of color appearance from

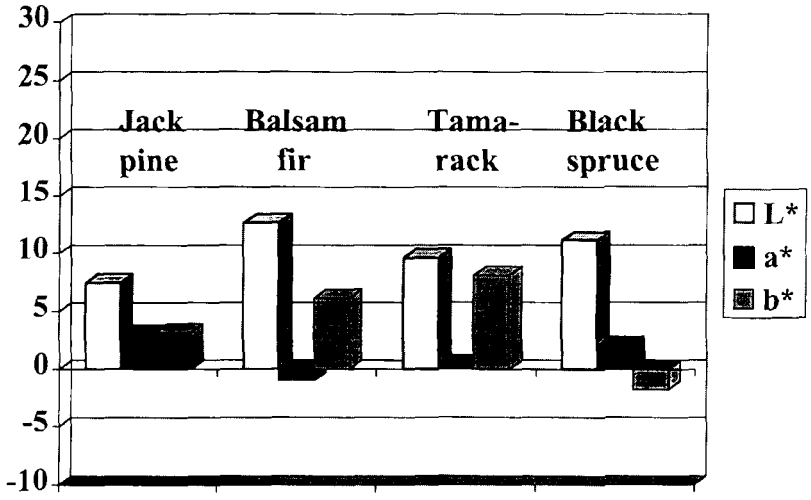

FIGURE 5. Color reaction of phenol/bromine test on wood extract. 10 min.

the chemical tests. The test based on the presence of extractives using ferric chloride as well as that based on the pH value (bromophenol blue) of wood are particularly encouraging. The third test based on the resin acids also produces sharp differences in color appearance permitting a clear separation of jack pine from other species studied. It is concluded that the analysis of color appearance by measuring the L*, a* and b* color parameters greatly facilitates the separation of jack pine from other conifers. The chemical test and the color measurement can be completed in 10-15 min when wood flour is used. It is noteworthy that the technique works only on the heartwood; it does not work on sapwood.

EXPERIMENTAL

Materials

Four common eastern Canadian species were evaluated: black spruce

(*Picea mariana* BSP., 50 years), balsam fir (*Abies balsamea* Mill., 40 years), jack pine (*Pinus banksiana* Lamb., 47 years), and tamarack (*Larix Laricina* Koch, 45 years). The black spruce and balsam fir are conventionally used by the pulp mills while the pine and tamarack are used to a much less extent due to their high extractives content and thick-walled fibres. Sample disks of 5 cm thick were cut, at breast height, from freshly felled trees. All the sample trees contained heartwood. Preliminary trials indicated that chemical tests on sapwood alone did not provide a clear-cut differentiation among the species studied. This is due to the fact most of the color reaction tests are based on the presence of certain types of wood extractives and that the sapwood usually has relatively low concentration of extractives. For this reason a composite material containing both heartwood and sapwood was used in this study. The sample was milled, in green condition, into fine particles (passed 40-mesh) and kept refrigerated until further use. Some samples were seasoned in airdry condition for about 4 months and tested. In some tests, extracts from wood meal were used instead of wood flour. The extracts were prepared by extracting the fresh wood flour (20 g, o.d.) in 400 mL ethanol, at 60°C, for 24 h. The ethanol extract was thickened to 20 mL by evaporation at about 70°C in a rotary evaporator.

Methods

Color evaluation

Color appearance was evaluated using the Tappi test method T524 OM-94 and expressed in CIE L*, a*,b* color space system, where L* represents lightness, increasing from zero for black to 100 for a perfect white; a* represents redness when positive, greenness when negative, and zero for gray; b* represents yellowness when positive, blueness when negative and zero for gray. All measurements were duplicated.

We measured the color appearance by means of an optical tester Technibrite (Micro TB-1C model). The wood flour was first reacted with the desired reagents in a plastic dish of about 5 cm in diameter and formed into a

cake. A sheet of transparent film was used to cover the sample dish to prevent possible chemical contamination of the apparatus.

Color tests

A. Ferric chloride ($FeCl_3$) test

The method is based on a chromatographic detecting reagent for flavonoids, steroids, phenols and tannis.[15] Barton[11] used this technique to differentiate pine and spruce by using chloroform extract. In the method, 1.5g (o.d. basis) of wood flour was mixed with 1.95g of 1%-ferric chloride in a plastic dish. The color was measured as described earlier. The test could be done by dispersing 2-3 mL of ethanol extract on a 6-cm circular filter paper (Whatman #1). After being air-dried for 10-15 min, the extract was sprayed with 1 mL of 1% $FeCl_3$ in ethanol. The treated filter was used for color measurement.

B. Bromophenol Blue Test

The bromophenol blue reaction gives an indication of the acidity of wood in the pH range of 3.0 to 4.6.[16] Kutscha et al[16] used this method to separate eastern spruce and balsam fir. Method: mix 1.5g (o.d. basis) wood flour with 3.3g of 0.1% bromophenol blue solution. The color of the treated wood meal in a plastic dish was then measured.

C. Phenol/Bromine test

This method is based on the differences (types and amounts) in resin acids in different wood species. Kutscha et al[16] suggested that this method might be possible to differentiate spruce and fir, but no concrete technique was given. We developed the following method: 2.5 mL of wood extract was dispersed on a circular (6 cm) filter paper (Whatman #1). After being air-dried for 10-15 min, the extract on the filter paper was sprayed with 1 mL of 50% phenol / CCl_4 (w/v) solution. The treated filter paper was then exposed to bromine vapor for 30

seconds under a hood, and was sealed between two transparencies for measuring its color.

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