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Radial Penetration of Safranine in *Populus tomentiglandulosa* T. Lee[*1]

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ABSTRACT

An experiment was conducted to observe the safranine penetration depth in radial directions of *Populus tomentiglandulosa*. Radial penetration was considered from bark to pith. In radial direction, ray parenchyma and intercellular space were considered for the measurement of safranine penetration depth. It was found that sapwood conducted safranine 24.23% higher in radial direction compared with heartwood. Intercellular space conducted safranine 39.27% higher depth compared with ray parenchyma and the penetration depth was 39.41% higher in sapwood compared to heartwood. During safranine penetration, it formed a curvature in the lumen of ray parenchyma. Initially safranine penetration was found high and decreased gradually.

Keywords: Liquid penetration, lateral flow, intercellular space, ray parenchyma, meniscus.

1. INTRODUCTION

The permeability of liquid in wood cell wall material has an importance in studies to investigate the movement of liquid in the living tree. It is reported that aqueous preservative solutions may flow through cell walls by way of cell wall capillaries (Bailey and Preston 1970). So, capillary structures are very important to determine the liquid flow which consists of vessel, wood fiber, ray cell and axial parenchyma. Also the permeability of wood is strongly dependent on its moisture content (Hansmann et al. 2002) as well as the direction of grain (Bolton 1988; Ahmed et al. 2005) and various physical and chemical properties (Wardrop and Davies 1961; Banks 1970). Different techniques and methods so far have been developed to obtain quantitative and qualitative information about liquid penetration (Rudman 1965) and the amount of liquid penetration is not the same for sapwood and heartwood. The solution uptake by cells is affected by wettablility of the surface of the cell lumen (Iida et al. 2002). Factors of prime consideration governing the flow are the amount of pressure, fluid Particularly this species was selected for its simple anatomical features. In this species it has uniseriate rays while Siau (1995) reported that multiseriate rays are low permeable and also bring down the permeability. As safranine is a colored solution, it is easy to observe the flow depth. Although flow depth of liquid is depended upon the surface tension of liquid to be permeated (Chun and Ahmed 2006), this research work was conducted to observe the

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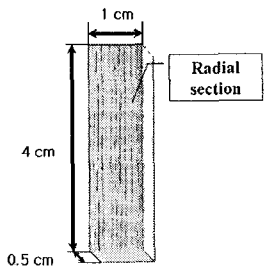
ray parenchyma and intercellular spaces role in lateral flow. viscosity, solvent contact angle, wood pore radius and wood capillary length (Usta and Guray 2001). Based on wood and properties of liquid to be permeated, penetration depth is varied considerably from species to species or same species in different part.

This experiment was conducted to understand safranine penetration depth differences by ray parenchyma and intercellular spaces in between ray parenchyma of *P. tomentiglandulosa.*

2. MATERIALS AND METHODS

2.1 Sample preparation

Wood samples of *Populus tomentiglandulosa* T. Lee were selected from Jiamri, Sabukmeyon, Chunchon, Kangwon do, Republic of Korea (37°51′N, 127°36′E). The sampling criteria were that the selected trees should be clearly dominant and free form visible defects and diseases. The tree's age and diameter at breast height were 16 years and 27cm respectively. Two types of wood samples were collected: sapwood and heartwood. Samples discs were marked to identify top and bottom end. Discs were kept in air tight cellophane bag to protect the moisture loss. Among 16 numbers of annual rings, range of heartwood was 1-10 and range of sapwood was 11-16. To observe safranine penetration in radial direction, 4 x 1 x 0.5cm (longitudinal x radial x tangential) samples were prepared after microtome shaving from 8-9th annual ring from heartwood and 14-15th annual ring from sapwood. As we wanted to know the safranine penetration in radial direction from bark to pith, samples were marked to identify those directions. Total 40 replications were made dividing sapwood and heartwood. Radial surface was considered to observe the radial penetration. In this case, except one radial and tangential surface, all surfaces were coated with silicon resin for preventing the leakage by other surfaces.



<Fig. 1> Sample size for measuring safranine penetration depth.

2.2 Estimation of moisture content

Wood sample were weighed and dried in an oven for 24 hours at 105 °C. Moisture content of wood block in terms of wet weight basis was calculated as the difference between the weights before and after the drying process.

2.3 Preparation of safranine solution

10 g of safranine was added in 500 ml 50% ethyl alcohol. 500 ml of water was added to make the volume 1000 ml. Thus 1% safranine solution was made.

2.4 Camscope observation

Sample moisture content were determined before safranine impregnation. While observing the safranine penetration, the room temperature was 24℃, RH 60% and the wind speed was 0 m/s. Coated samples were fixed on a petridish and safranine was poured on it. With *i*-Solution software, the safranine impregnation video file was captured for 5 minutes for radial penetration of safranine solution. This 5-minute video file consisted of 1500 images. In radial direction, specific frames (300 images/min) were selected at 1, 2, 3 and 4 minute by VitrualDub-MPEG2 software.

2.5 Statistical analysis

Safranine penetration depth differences in ray parenchyma and intercellular spaces of sapwood and heartwood were tested by using a one-way ANOVA. When significant differences occurred ($P \leq 0.05$), the ANOVA procedure was followed by a Duncan significant difference post hoc test to separate the time effects (SPSS, Version 12.0.1, 2003).

3. RESULTS AND DISCUSSION

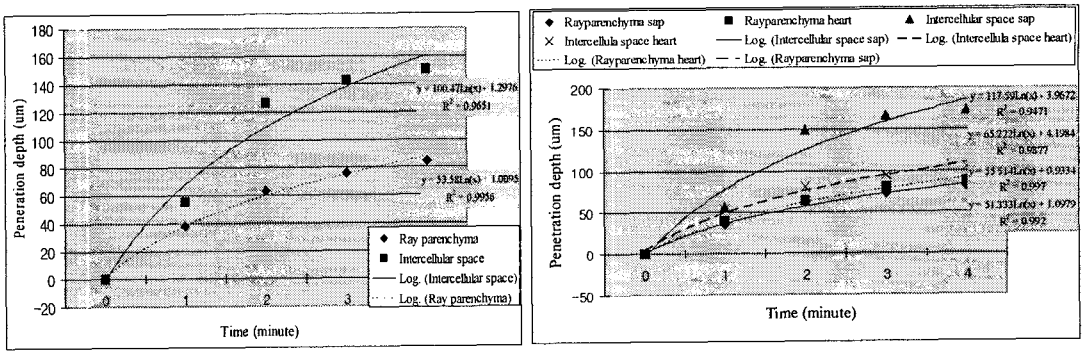
Moisture content of wood plays an important role for the liquid impregnation. Browning (1963)stated that above the fiber saturation point until the cell cavity are filled with liquid water; wood can still up take water by absorption or capillary action. Again excess moisture in wood voids may also act as a physical barrier for the mass flow of liquid (Wirspa and Libby 1950). Moisture content of *P. tomentiglandulosa* was found in sapwood 23.50% and in heartwood 23.04%. In this experiment, we only estimated the penetration depth in above mentioned moisture content level and the safranine penetration depth differences in different moisture level were not considered. Safranine flow depths in radial direction by ray parenchyma and intercellular spaces are presented in Table 1.

<Table 1> Safranine penetration depth in ray parenchyma and intercellular spaces unit: μm

Time (minute)	Ray parenchyma		Intercellular space	
	Sapwood	Heartwood	Sapwood	Heartwood
1	35.91a	39.62a	55.80a	54.41a
2	62.44b	63.75b	148.68b	80.49b
3	72.00bc	79.57c	165.99b	93.79bc
4	80.89c	87.49c	172.65b	104.61c

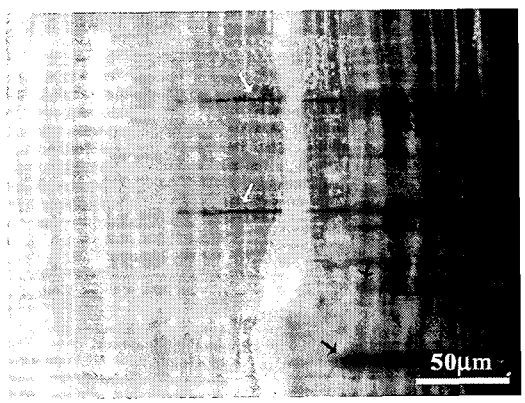
Note: Different lower case letters within in a column indicate significant difference (≤ 0.05).

The primary routes for liquid penetration into wood are provided by capillaries (Smith and Banks 1971; Petty 1970). In radial direction, the capillary structure is made up by ray parenchyma joining together by endwall. Another prime factor is responsible for the variation of penetration depth due to the surface tension of liquid being permeated and cell lumen diameter. Though the safranine penetration depth inray parenchyma was found high in heartwood compared with sapwood (Fig. 2), no statistically significant difference was observed.

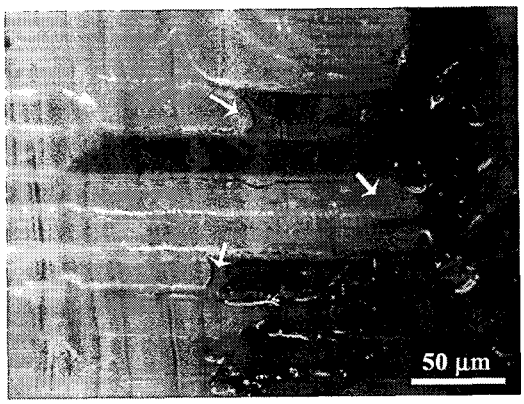


<Fig. 2> Comparison of safranine solution penetration depth in sapwood and heartwood.

Initially, safranine penetration was found high and gradually decreased with the course of time. After one minute penetration of safranine in sapwood, depth was decreased about 42% at two minute, 13% at three minute and 11% at four minute. On the other hand in heartwood, it decreased about 38% at two minute, 20% at three minute and 9% at four minute. Safranine penetration depth in ray parenchyma depends upon the length of the cell, number of and endwall pit size and shape. Endwall interrupted continuous safranine flow. So, intercellular space conducted safranine higher than ray parenchyma (Fig. 3). After one minute of safranine penetration in intercellular space of sapwood, the depth was decreased about 22% at two minute, 10% at three minute and 4% at four minute. On the other hand in heartwood, it decreased about 32% at two minute, 14% at three minute and 10% at four minute.



<Fig. 3> Safranine penetration in radial direction. *White arrow showing intercellular space and black arrow showing ray parenchyma.*



<Fig. 4> Meniscus in ray parenchyma.

If we consider the ray parenchyma as a capillary tube, a curved meniscus will form while penetration. Safranine curved meniscus with ray parenchyma is shown in Fig 4.

4. CONCLUSIONS

In camscope observation, sapwood conducted safranine in higher depth compared to heartwood. Safranine penetration depth in intercellular space was found fast and deep compared to ray parenchyma. No significant difference was observed in lateral conduction of safranine in ray parenchyma present in sapwood and heartwood but the intercellular spaces showed significant differences .Initial safranine penetration rate was found high which gradually decrease with the course of time. Forming a meniscus, safranine was conducted through the cell lumen of ray parenchyma.

5. REFERENCES

Ahmed, S. A., H. D. Park and S. K. Chun. 2005. Effect of pressure on liquid absorbance in main wood species of Pinaceae grown in Korea using Safranine under vacuum. J. Korea Furniture Society. 16(2): 2-11.

Bailey, P. J. and R. D. Preston. 1970. Some aspects of softwood permeability. II Flow of polar andnon- polar liquids through sapwood and heartwood of Douglas fir. Holzforschung 24 (2): 37-45.

Banks, W. B. 1970. Some factors affecting the permeability of Scots pine and Norway spruce. Wood Sci. 22(1): 10-17.

Bolton, A. J. 1988. A re-examination of some deviations from Darcy's Law in coniferous wood. Wood Sci. Technol. 22: 311-322.

Browning, B. L. 1963. The Chemistry of Wood. Interscience Publishers, NY. 48pp.

Chun, S. K. and S. A. Ahmed. 2006. Permeability and meniscus phenomenon in four Korean softwood species. For. Stud. China. 8(3): 56-60.

Hansmann, C., W. Gindl, R. Wimmer and A. Teischinger. 2002. Permeability of wood - a review. Wood Res. Drevarsky Vysk. 47: 1-16.

Iida, I., S. Yusuf, U. Watanabe and Y. Imamura. 2002. Liquid penetration of pre compressed wood VII: combined treatment of precompression and extraction in hot water on the liquid penetration of wood. J. Wood Sci., 48(1): 81-85.

Petty, J. A. 1970. Permeability and structure of the wood of Sitka spruce. Proceeding of the Royal Society of London. B. 175: 149-166.

Rudman, P. 1965. Studies in wood preservation, Part I: The penetration of liquids into Eucalyptus sapwoods. Holzforschung, 19(1): 5-13.

Siau, J. F. 1995. Wood: Influence of Moisture on Physical Properties. Virginia Poly Institute and State Univ., Blacksburg, Virginia.

Smith, D. N. R. and W. B. Banks. 1971. The mechanisms of flow of gasses through coniferous wood. Proceeding of the Royal Society of London, B. 177: 197-223.

Usta, I. and A. Guray. 2001. The effect of wood specimen length on the proportional saturation of preservation fluid in Sikta Spruce (*Picea sitchensis* (Bong.) Carr.) and Corsican pine (*Pinus nigra* var. mantima). Turk. J . Agric. F. 25: 1-4.

Wardrop, A. B. and G. W.Davis. 1961. Morphological factors relating to the penetration of liquids into wood. Holzforschung. 15: 129-141.

Wirspa, V. J. and C. E. Libby. 1950. Penetration of neutral sulphite cooking liquors into yellow birch wood. Tappi. 33(5): 225-231.