X-RAY MICRO-CT REVEALS THE MICRO-DISTRIBUTION OF COPPER IN PRESERVATIVE-TREATED TIMBER

Philip D. Evans[*1,2], Dengcheng Feng[†1], Michael L. Turner[‡2], and Ajay Limaye[3]

[1]Department of Wood Science, University of British Columbia, Vancouver, Canada
[2]Department of Applied Maths, Australian National University, Canberra, Australia
[3]Vizlab, Australian National University, Canberra, Australia

Keywords: timber, preservative treatment, copper, microstructure

Summary: We used X-ray micro-CT to examine the distribution of copper in pine treated with aqueous solutions of either particulate copper carbonate or copper-amine. We discovered that copper is deposited in thin-walled parenchyma cells adjacent to resin canals. This finding is a good example of how X-ray micro-CT is revealing novel information on the microstructure of timber.

1. INTRODUCTION

The global market for the preservation of wood is worth in excess of one hundred billion USD per annum, and the market for preservative chemicals alone exceeds 1.6 billion USD per annum. The chemicals used for wood preservation need to penetrate into and become 'fixed' within wood's porous microstructure to be effective at preventing biological deterioration of treated timber. Hence, there is ongoing interest in looking at the micro-distribution of preservative chemicals in wood. The micro-distribution of preservatives in wood has been examined using a variety of techniques, but the method of choice has been scanning electron microscopy in combination with EDX. We used this technique to examine the micro-distribution of copper in pine wood treated with a particulate wood preservative that was commercialized in 2007, as a replacement for copper-chrome-arsenate [1,2]. We found that copper particles accumulated in the major flow paths within wood (rays and bordered pits). We also used X-ray micro-CT to examine the variation in distribution of copper with depth of treatment and also in different tissues in wood (rays, resin canals, and earlywood and latewood) [3]. We concluded that copper was concentrated in the rays and resin canals in treated wood forming a grid-like network, which was more complete in growth rings near the surface of treated wood. A similar, although not identical pattern of distribution of copper was found in pine wood treated with an 'ionic' amine-copper preservative. Recently, we have reexamined the data sets used in the aforementioned CT studies of the micro-distribution of copper in treated wood, and briefly describe our novel findings in this extended abstract.

2. EXPERIMENTAL METHOD

A block of wood measuring 12 x 12 x 19 mm was each cut from southern pine wood treated with either particulate (MCA, micronized copper azole) or amine-copper (ACQ, alkaline copper quaternary) preservatives. A separate untreated wood block cut from the same parent material acted as a control. The wood blocks were imaged using the ANU's helical cone-beam micro-CT device at a resolution of 5 ± 1 μm. Three-dimensional volumes were used to generate intensity histograms for void, wood and copper within the treated specimens. Thresholding of the peaks in these intensity histograms allowed the different phases in the tomographic images to be identified. Data sets were visualized in two and three dimensions using the volume rendering software Drishti.

*e-mail: phil.evans@ubc.ca
†e-mail: michaelfeng1995@foxmail.com
‡e-mail: michael.turner@anu.edu.au

3. RESULTS

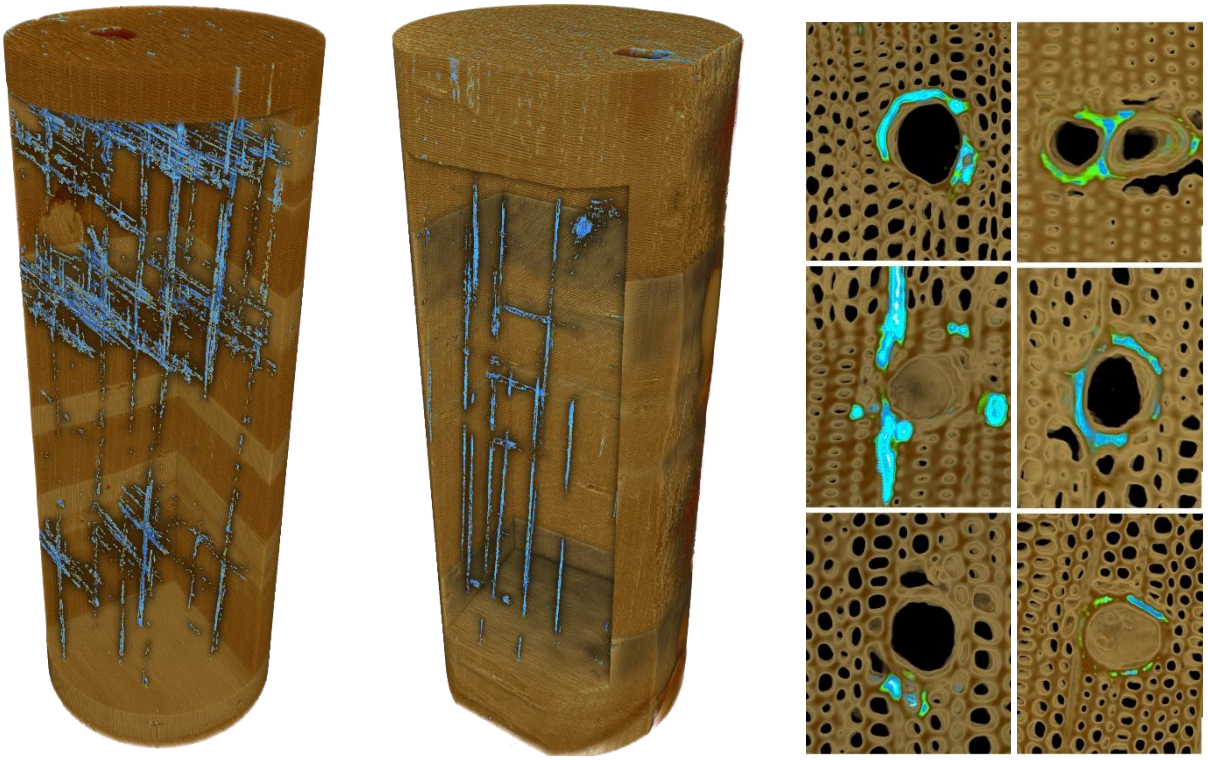
Figure 1a and b are X-ray micro-CT images showing the distribution of copper (blue) in samples cut from southern pine wood treated with MCA (particulate) and ACQ (ionic) wood preservatives, respectively. The tops of the cylinders both contain holes created by staples that were used to fix labels on to the timber at the treatment plant. These holes provide a reference point that can be used to assess the direction of flow of the preservatives into the wood, which is from top to bottom in both cases. Our results confirm our previous findings that copper is located in the rays that run from the outside of the samples to the inside. Sheets of copper run perpendicular to the copper in the rays, particularly in the sample treated with the particulate wood preservative (Fig. 1a). The location of copper in both samples is coincidental with rays containing resin canals (fusiform rays), and axial resin canals that are oriented perpendicular to rays. Hitherto we assumed that copper was located in the radial and axial resin canal voids. Our latest research shows that this is not the case. Instead, copper appears to be located in thin-walled parenchyma cells that are adjacent to resin canal voids (Fig. 1c). It is possible that these parenchyma cells are important flow paths for aqueous preservatives, and further research, possibly using 4-D X-ray micro-CT, is needed to answer this question.

References

[1] H. Matsunaga, M. Kiguchi, & P.D. Evans. Microdistribution of copper-carbonate and iron oxide nanoparticles in treated wood. *J. Nanoparticle Research* 11, 1087–1098, 2009.

[2] P.D. Evans, H. Matsunaga & M. Kiguchi, M. Large-scale application of nanotechnology for wood protection. *Nature Nanotechnology* 3, 577, 2008.

[3] P.D. Evans, H. Matsunaga, H. Averdunk, M. Turner, A. Limaye, Y. Kataoka, M. Kiguchi & T.J. Senden. Microdistribution of copper in Southern pine treated with particulate wood preservatives. *ACS Symp, Ser.* 1158, Chap. 13, pp. 227–238, Wash. D.C., 2014.



(a) **(b)** **(c)**

Figure 1: (a) Copper (blue) in wood treated with the particulate wood preservative, MCA. (b) Copper (blue) in wood treated with the ionic wood preservative, ACQ; (c) Copper (green and blue) in parenchyma cells associated with vertical resin canals (MCA, left; ACQ, right).