## Wood Protection Research at UBC

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## Background

Currently there are three other faculty members in the Department of Wood Science who conduct research related to wood protection. Dr.'s Stavros Avramidis and Colette Breuil are currently collaborating with F.P. Innovations, in evaluating the usefulness of Radio Frequency heating of wood to control decay fungi, insects and pinewood nematodes (Figure 1).
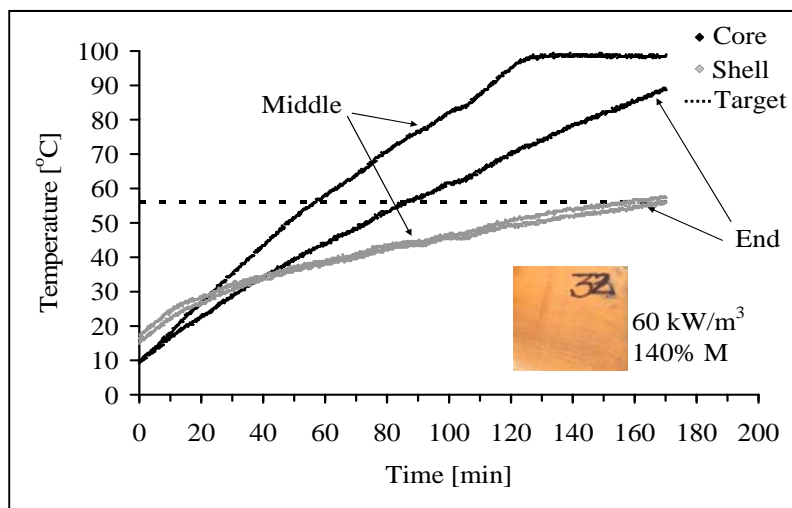


**Figure 1 Typical RF heating curves for 90 mm square western hemlock**

Dr. Breuil has also studied the potential of albino strains of *Ophiostoma* sp in reducing the effects of blue-stain fungi in on unseasoned wood. Dr. Philip Evans has an active research team which examines the factors resulting in the physical degradation of wood during exposure to weathering, as well as methods of reducing the damage by the application of coatings. This paper will highlight selected research on wood preservation undertaken during the past five years, to provide a broad overview of current research interests.

### Overview of Current Wood Preservation Research

**Composite products**

 As the use of composite products continues to increase particularly for structural building components, the need to strategies to protect the wood from decay and termite attack is of high importance. The research at UBC has focused on the potential of glue-line additions of biocide to protect Oriented Strand Board. Selected organic biocides have been evaluated for their compatibility with phenolic and MDI resins and the resultant impact on the strength of the OSB

measured. A number of successful combinations of biocide and resin were identified and durability of the boards measured using standard soil block experiments. (Fang, Ruddick and Smith, 2008 and 2009).

**XPS and EPR**

A major research interest has been the application of advanced instrumental techniques to study the chemical reactions which take place when biocides are impregnated into wood. A considerable body of research has focused on two techniques, Electron Spin Resonance (also known as Electron Paramagnetic Resonance) and X-Ray Photoelectron Spectroscopy. Examples of XPS research are shown in Figure 2. In this research the usefulness of the technique for studying the changes in a triazole (tebuconazole) during reaction with wood and weathering was identified. The two chemical environments of the nitrogen in the triazole with an area ratio in the pure solid of 2:1 were readily observed. Spectra of the chemical in wood also showed that the two nitrogen environments were retained confirming the lack of interaction between the triazole and the wood components.
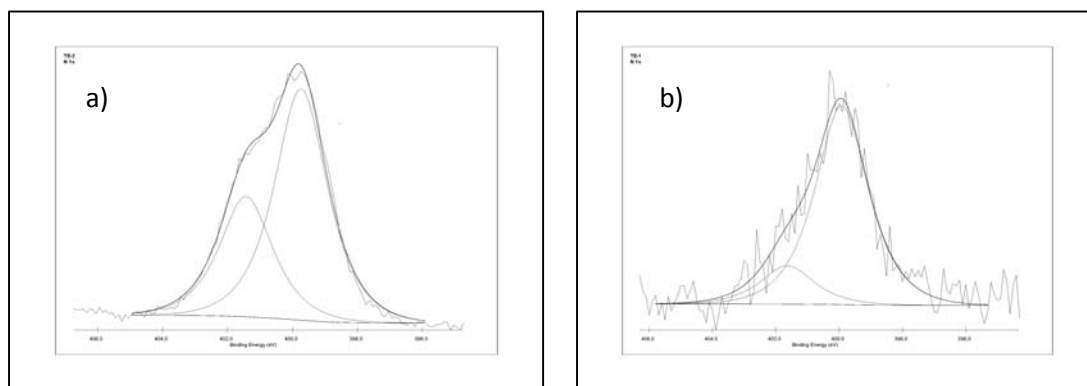


**Figure 2 a) XPS spectrum of tebuconazole clearly showing the presence of two types of nitrogen with a 2:1 ratio and b) the spectrum of tebuconazole treated wood with again the two types of nitrogen visible.**

One technique which is of particular interest is EPR which enables chemical species which are paramagnetic to be studied. EPR is similar to NMR in that both depend on the magnetic moment associated with a spinning particle. EPR spectra depend on determining the g-values for the unpaired electrons in the sample, which differ from those of the free electrons, and are sensitive to the chemical environment of the paramagnetic atom. EPR spectra are usually observed as plots of the first derivative of absorption intensity against the applied magnetic field. Relative intensities can be approximated by comparing peak to peak separations of the first derivative display when more than one species is present and the spectra are relatively simple. In the case of copper EPR spectrum can show hyperfine splitting. This gives rise to a useful parameter A which is strongly influenced by the geometry and types of atoms bound to the copper. Typical copper

EPR spectra are shown in Figure3 with data of some simple copper compounds presented in Table 1.



Cu(Vanillin)$_2$(H$_2$O)$_2$ crystal                    Cu-en treated wood
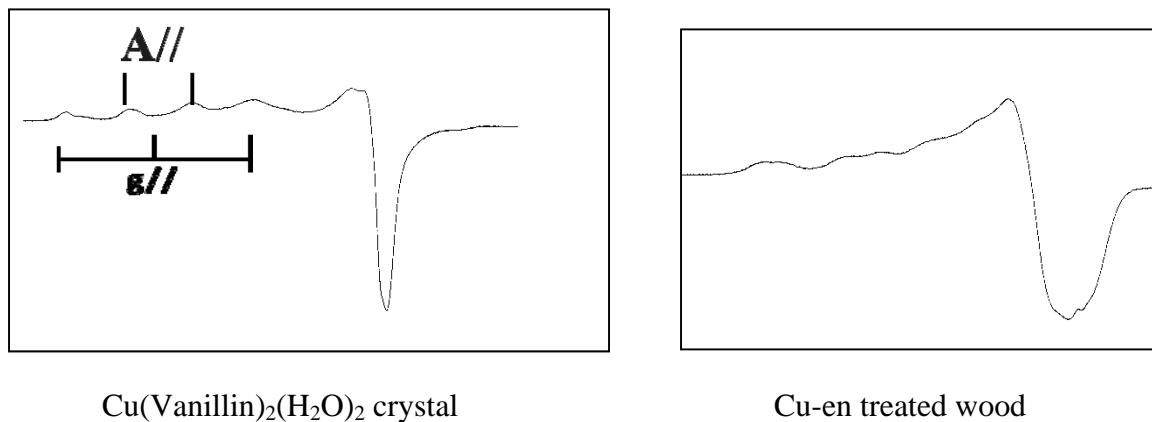
**Figure 3 a) EPR spectrum of crystalline Cu(vanillin)$_2$(H$_2$O) $_2$ and b) (Cu-ethylenediamine treated wood**

It can be seen from the data for the copper sulphate and an ammoniacal copper solution, that the presence of the nitrogen bound to the copper causes the A// value to increase from 150 to 177, while that of the complex of copper sulphate in ethylenediamine increases to 190. Thus it is possible to use this technique to study the complexes formed by copper during fixation reactions in wood. Current research is focused on developing and understanding of the chemistry of different copper based wood treatments.

**Table 1 ESR spectral parameters for Cu(II) in treated wood**

| Treatment | g// | A// | g⊥ |
|---|---|---|---|
| CuSO$_4$ in water* | 2.388 | 150 | 2.080 |
| CuSO$_4$ in wood** | 2.372 | 132 | 2.082 |
| CuCO$_3$/NH$_4$OH* | 2.282 | 177 | 2.069 |
| CuCO$_3$/NH$_4$OH** | 2.272 | 166 | 2.068 |
| [Cu(en)$_2$]SO$_4$ in water* | 2.204 | 190 | 2.064 |

* Measured at temperature 77K

** Measured at room temperature

**Mobility of preservatives in treated wood exposed above ground**

The loss of metal chemicals from treated wood during service has been the focus of a lot of attention in the last decade and was responsible for the withdrawal of chromated copper arsenate (CCA) from the residential treated wood market in 2003. Understanding the mobility of chemicals from treated wood used above ground is therefore extremely important (Cooper, 2006). This research has been ongoing for almost a decade (Chung and Ruddick, 2004) and has involved all of the major waterborne preservatives registered for use in Canada and the USA. A test method was developed and this has been submitted to the American Wood protection Association (AWPA) for consideration as a draft standard. The method involves exposing treated wood samples over a basin to collect the run off during rain events (Figure 4).



Figure 4 test samples exposed for measuring preservative mobility

The research has lead to a better understanding of the role of the climatic conditions which occur in all four seasons in Canada on the preservative movement and depletion from the treated wood. When the treated wood is placed in the field during the summer it first begins to dry. The first rain events in the fall are responsible for the most significant leaching of the preservative. Almost all of the mobile copper in alkaline copper quat (ACQ) was lost during the first few months leaving the surface of the boards depleted of mobile copper. Eventually with the continued rain and cold weather of winter, the boards became saturated and a slow diffusion of mobile copper from deep within the boards towards the surface takes place. This process is further accentuated by the drying of the boards during the spring and summer. With the arrival of the fall rains, a secondary increase in copper depletion was observed. However, it was significantly less than that observed in the first year of exposure. By continuing the experiment over several years it was possible to identify a number of important observations. For example, boards which lost a high amount of copper invariably showed a good correlation with higher losses over the longer exposure period (Figure 5). This observation suggests that problematic treatment-wood combinations could be identified from their higher losses during measurement of stabilization at the treating plant. It was also possible to identify the duration in which mobile copper would be available for wood-ACQ combinations (Figure 6). This is important for two reasons. It allows the modelling of environmental impact of the use of treated decking. And

secondly, mobile copper is required to ensure that checks or splits which form during weathering will have their surfaces coated by the mobile copper, which can ion exchange and thereby fix and protect the checks from fungal decay. It was shown that an average of 0.4 to 0.5 mg Cu/mg of wood was deposited during the first six months (Table 2). This value exceeds that reported for CCA-treated hem-fir (Choi, Ruddick, and Morris, 2004) and also the minimum value determined as being necessary to protect untreated wood from spore germination of common wood decay fungi found in untreated decking (Choi, Ruddick and Morris, 2002).
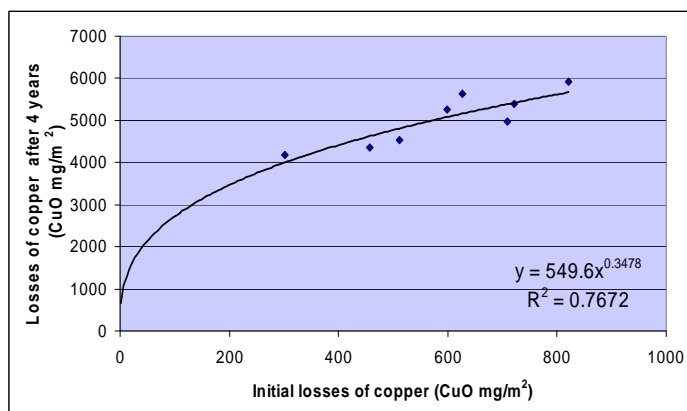


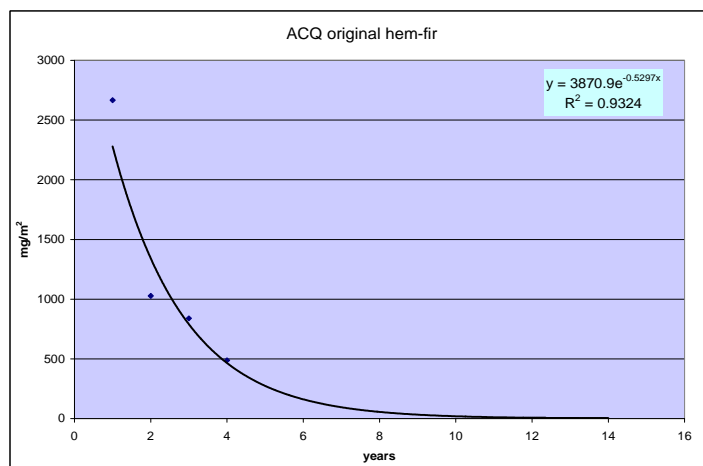Figure 5 Final vs. Initial losses after 4 years exposure



Figure 6 Annual depletion of copper detected in leachate

**Table 2 Copper retentions of check surfaces after 6 months**

| Treatment/species | Average check surface loading | Range of check surface loading |
|---|---|---|
| **CA-B – hem-fir** | **Avge. 0.43 mg Cu/g wood** | **(0.26 – 0.54 mg Cu/g wood )** |
| **ACQ – hem-fir** | **Avge. 0.49 mg Cu/g of wood** | **(0.47 – 0.52 mg Cu/g wood** |
| **CCA – hem-fir** | **Avge. 0.29 mg Cu/g wood** | |

**Corrosion of fasteners in contact with treated wood**

During the past decade there has been considerable interest in developing a standard approach to evaluating fastener corrosion caused by treated wood. The AWPA has been working to identify a testing protocol together with the International Staple, Nail and Tool Association. A draft method has been developed and is being considered as a new ASTM standard. The research described here, is based on the draft method with the following differences (Figure 7). The most significant change is that a sandwich approach is used in which the boards are cut in two and placed with the treated faces together. The fasteners are then placed between the two faces in 80% predrilled holes. This strategy overcomes the limitation of the draft ISANTA method, where large numbers of replications must be used so that sacrificial samples can be removed to check on the progress of the corrosion. The method also uses regular commercial treatments of Canadian wood species, rather than southern pine. This allows the influence of treated refractory species such as spruce to be examined, as well as the corrosion caused by treated heartwood where extractives may reduce the mobility of the biocide.
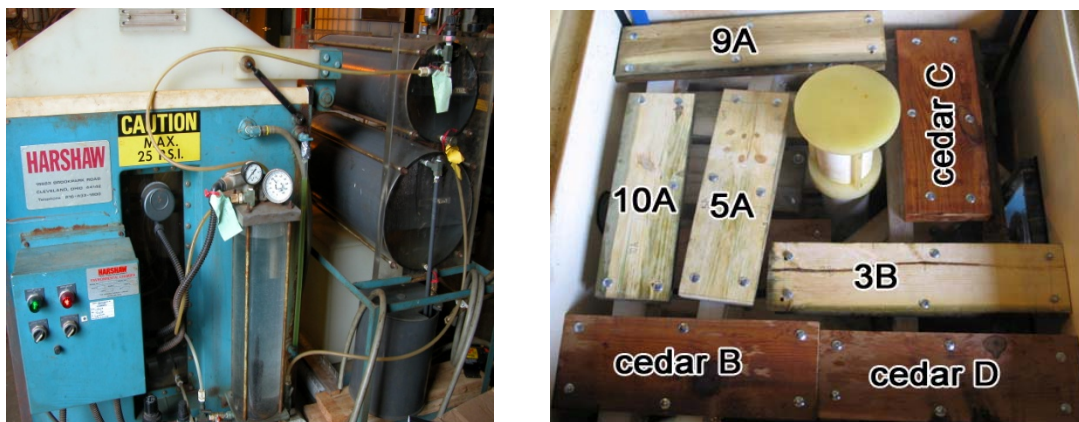


**Figure 7 Exposure of corrosion test samples in the Harshaw environmental chamber**

Previous papers (Ruddick et. al. 2004) have reported the relative corrosion of CCA and ACQ (Figure 8), as well as the influence of water repellents on the corrosion (Figure 9). Other aspects of the corrosion research include the use of other methods to assess the degree of corrosion. Standard approaches include the ASTM visual assessment and the mass losses created. Additional methods include diameter loss, cross sectional area loss and bending yield tensile measurements. Of particular interest is the recent measurement of corrosion in fasteners in contact with micronized copper treated wood. The micronized copper quat (MCQ) and micronized copper azole (MCA) treated wood, both caused lower corrosion of metal fasteners than ACQ treated wood, (Figure 9).The corrosion was similar to that from western red cedar. This research is ongoing.
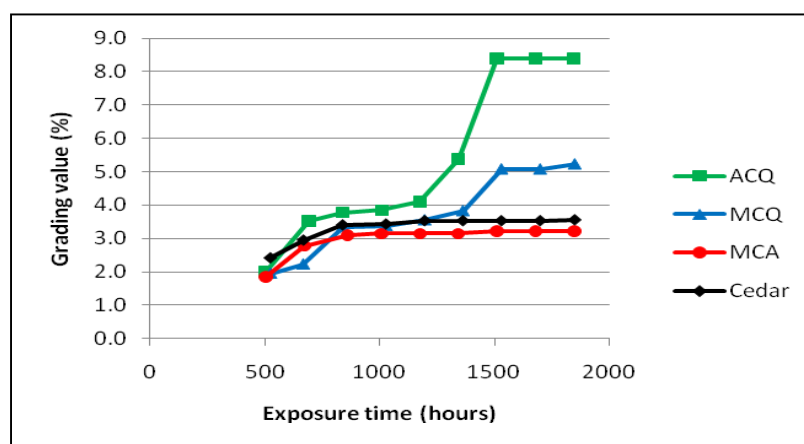
**Figure 8 Relative corrosion of Bright nails by CCA and ACQ treated wood.**
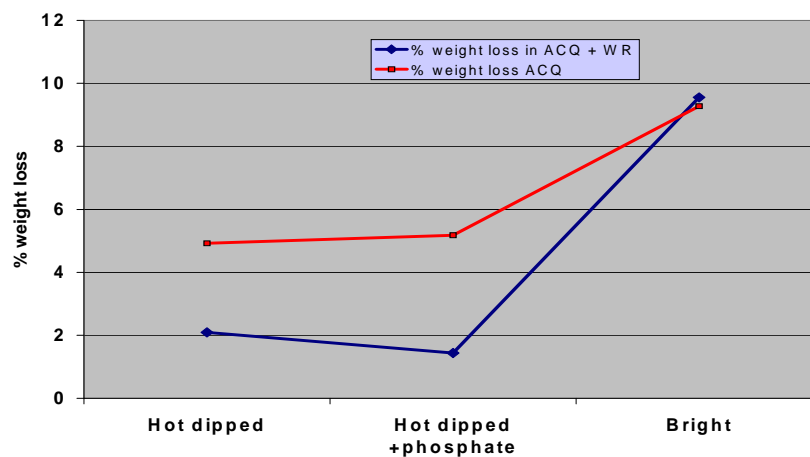


**Figure 9 Water repellents can reduce the corrosion.**



**Figure 9 Micronised copper quat (MCQ) and micronized copper azole (MCA) treated lodgepole pine both caused lower corrosion than ACQ treated lodgepole pine, on hot dipped galvanized fasteners, based on an ASTM visual assessment.**

## References

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