Laboratory evaluation of ZiBOC and CCA as an antisapstain on *Populus deltoides*

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**ABSTRACT**

The efficacy of commercial wood preservatives (copper chrome arsenic (CCA), borax-boric acid and ZiBOC, a recently developed environmental friendly preservative at 1 per cent concentration) in inhibiting fungal (Alternaria alternata) discoloration on sapwood of poplar (*Populus deltoides*), assessed by using an accelerated test on samples at 25±2°C and different relative humidity (75±2% and 95±2%), revealed that ZiBOC at both incubation conditions imparted complete protection to the specimens as compared to CCA treated specimens showing slight growth followed by borax boric acid. High humidity promoted the growth of Alternaria alternata in borax boric acid treated specimens. Control specimens showed 100 per cent surface coverage on the wood specimens by the sapstain fungi.

**Key words:** Borax-Boric acid, sapstain, Alternaria alternata, Populus deltoides, CCA, ZiBOC.

Sapstain reduces the aesthetic value of wood, causing great losses in the wood-using industry worldwide (Abraham *et al.*, 1995; Gao *et al.*, 1994; Kreber, 1995; Smith, 1991). During shipment or storage, freshly sawn lumber is susceptible to heavy attack of sapstain fungi. Sap stain fungi rapidly and extensively penetrate the sapwood of trees, logs, sawn timber, lumber, veneer, and other products stored under high humidity and normal temperature. Most of the wood attacking fungi produce pigmented spores or hyphae, which are able to discolor the surfaces or the interior of the wood (Morrell *et al.*, 2002). In addition, discoloration is due to colouring compounds produced by the reaction of the wood components with the secretions of the microorganisms (Hon and Shiraishi, 2001). Sap stain is caused by the melanin-like pigmented fungal hyphae, which are responsible for bluish-black or black discoloration of the wood. Discolorations in the wood of living trees and wood in service are long-known problems and are based on different biotic and abiotic causes (Bauch, 1984; Kreber and Byrne, 1994). High starch content in wood component encourages the growth of sap stain fungi. The wood-discoloring molds and staining fungi live on nutrients in the parenchyma cells of the sapwood. Molds and stain fungi do not diminish wood strength but they reduce the value of wood products (Simpson, 1991). Mold infestations in buildings have received a lot of attention in recent years because of the increasing public awareness. Staining by mould fungi, cannot be removed by brushing or planning. Colonization of wood and wood products by sapstain fungi can be prevented by anti sapstain chemical treatment.

Antisapstain chemicals are used to prevent freshly felled logs and sawn wood from fungi causing a blue-black sap stain. In the past, sodium PCP (sodium pentachlorophenate) was used as antisapstain. Health and environmental concerns resulted in its ban in 1988. More environmentally acceptable antisapstains have been tried throughout the world, including at Forest Research Institute, Dehradun, India. To prevent fungi and insects attack on wood in use, chemicals are used. For internal framing, the wood may be treated with Borax-Boric acid. For external use, the wood may be treated with CCA (copper as CuSO₄), chromium (as K₂Cr₂O₇) and arsenic (as As₂O₅) and ZiBOC (Zinc chloride, ZnCl₂), Borax (Na₂B₄O₇.10H₂O) and Copper sulphate (CuSO₄·5H₂O). Even though CCA has given very promising results but CCA is eco-toxic and carcinogenic which restricts its use.

Poplar wood is suitably utilised for a broad range of wood products worldwide. Many and varied uses of poplar wood include pulp and paper, lumber, veneer, plywood, composite panels, structural composite lumber, containers, pallets, furniture components, match splints, chopsticks, etc. The high cellulose and relatively low lignin content make poplar well suited for pulp and paper products. Poplar pulps, in turn, are utilised in fine papers, tissues, paperboard, newsprint, and packaging papers. While poplar wood continues to be an important raw material in the traditional lumber, veneer, and plywood industries, the most remarkable poplar utilisation is oriented strand board (OSB) and the structural composite lumber. Sapstain of poplar wood has
caused tremendous losses in the wood processing industry, biological control of poplar sapstain fungi is studied to be very real economic significance (Balatinecz et al., 2000).

A variety of fungicides have been developed and tested for control of sapstain (Cassens and Eslyn, 1983; Cserjesi and Johnson, 1982; Drysdale, 1987; Hayward et al., 1984; Kim et al., 1999; Morrell et al., 1998; Presnell and Nicholas, 1990; Wakeling and Maynard, 1997; Wakeling et al., 1999), but efficacy of these compounds vary with wood species and the form in which the wood is treated (Miller and Morrell, 1989; Miller et al., 1989; Tsunoda and Nishimoto, 1985). Clausen and Yang (2003) stated that most studies on preventing discolorations by mould and stain fungi have concentrated on borates. Borates would be a desirable addition to any chemicals because of their low toxicity and wide usage for insect and termite control as well as a fire-retardant. However, the use of borate-containing materials alone cannot be considered as a complete preventative against mould (Fogel and Lloyd, 2002). In this study, the effect of didecyl dimethyl ammonium tetrafluoroborate (DBF) wood preservative on inhibition of mould and stain fungi was evaluated. ZiBOC, a recently developed preservative in Forest Research Institute, Dehradun, India, was tested to evaluate its treatability in meranti wood and compared with conventional preservative CCA (copper chrome arsenic). A significant difference in retention levels of both the preservatives was observed in sapwood, heartwood and pith zones (Tripathi, 2012).

In the present study, the efficacy of conventional preservatives CCA and Borax boric acid was tested to prevent fungal staining of Alternaria alternata, in laboratory and was also compared with ZiBOC, a newly developed eco-safe preservative.

**MATERIALS AND METHODS**

Poplar (Populus deltoides Bartr, ex Marsh) was selected on the basis of its susceptibility to staining fungi. Specimens of size 7x20x70 mm were prepared from sapwood portion of poplar. Sapwood used for the experiment was unseasoned (moisture content higher than 40%), free of knots, visible decay, sapstain and mould. The ability of Borax–Boric acid, CCA and ZiBOC to prevent discolorations by mold and stain fungi was investigated by dipping the specimens in the preservative at 1 per cent concentration for one minute. Ten specimens were used for each preservative and ten untreated specimens served as controls.

**Treatment of specimens**

Treatment of wooden samples was carried out in a 600ml (Borosil make) beaker. Two unused test pieces were placed edgewise on the bottom between the beaker and specimens. Four or five specimens were stacked to make a layer edgewise and then crosswise on the previous layers until they reach the top, but not extending above the rim of the beaker. The specimens were placed in a beaker and solution of preservative was poured on it. These specimens were dipped in it for 30 seconds and then the excess solution was drained off. The beaker was then covered with aluminium foil to prevent drying, and stored overnight. This allows draining of excess solution and give sufficient time for the preservative for surface penetration on wood before inoculation of sapstain on wood. This treatment procedure was followed for all the three preservatives. Specimens dipped in distilled water served as control (Plate-1).

**Preparation of test chambers**

Eight to ten layers of absorbent paper were placed on the bottom of each Petri plate to maintain high humidity during the test period; papers were wet with distilled water until free water appeared. Air bubbles trapped under and between the paper disks were pressed out. Two straight glass rods (2mm in diameter and 70mm long) were placed on the top of the water saturated papers in each petri plate (Plate-2). After treatment, treated and untreated specimens were placed into these petri plates for inoculation (ASTM D4445-09a method).

**Inoculation and incubation**

Actively growing pure culture of Alternaria alternata was brought from Forest Pathology Division, Forest Research Institute, Dehradun, India. The culture was mixed uniformly with 100ml distilled water using a homogenizer. Inoculation was performed using spraying method. After inoculation of wood specimens petri plates were kept in plastic boxes and incubated in dark at 25±2°C in two different humidity levels (1) at 74±2 per cent relative humidity (2) at 95±2 per cent. Both set of specimens were incubated for four weeks initially. The relative humidity was checked at regular intervals with the help of hygrometer. Incubation period was of four weeks. Paper pads were rewetted with sterile water during the incubation period to maintain a “damp condition”. These specimens were sprayed with the fungal suspension at three days intervals until the surfaces of the control specimens were overgrown with sporulating fungi. After four weeks, the growth of fungi was estimated visually using a score scale of 0 to 5 (ASTM D4445-09a). Further the observations were continued till one year to see the permanence of preservative and its efficacy.
RESULTS AND DISCUSSION

Results revealed that in both the incubation conditions, *Alternaria alternata* showed very slight growth (8%) on the specimens treated with CCA whereas no growth was found in ZiBOC treated specimens. It was observed that 80.0 per cent area was covered with the sapstain in control specimens. Sapstain covered 60.0 per cent surface area of specimens treated with Borax-boric acid maintained at 95±2% relative humidity; whereas only 8.0 per cent surface coverage was observed in specimens treated with the same preservative maintained at 74±2 per cent relative humidity (Plate-3 and 4).

Specimens were kept in the same condition for a year and examined later. No growth was observed on the ZiBOC.
Thus it was concluded that ZiBOC showed high efficacy against the sap stain fungi as compared to CCA and borax-boric acid. Higher humidity affected the performance of borax-boric acid, while performance of CCA and ZiBOC were not affected by humidity. This is the first report of successful protection of poplar wood against sapstain treated with ZiBOC.

**CONCLUSION**

The study revealed that ZiBOC acting as preservative through fixation/penetration controlled sapstain for longer duration. The application procedure of preservation is very simple and easy, hence it can be recommended to different stake holders for protection of sapstain susceptible wood species.

**REFERENCES**


Table 2. Mean fungal growth (%) on wood surface treated with different preservatives

<table>
<thead>
<tr>
<th>Preservatives</th>
<th>Observations after three months</th>
<th>Observations after one year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RH (74±2%)</td>
<td>RH (95±2%)</td>
</tr>
<tr>
<td></td>
<td>Mean fungal growth (%)</td>
<td>Visual scores</td>
</tr>
<tr>
<td>Control</td>
<td>80</td>
<td>0</td>
</tr>
<tr>
<td>ZiBOC</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>CCA</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Borax–boric acid</td>
<td>8</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1. Visual scores according to fungal growth on the wood surface

<table>
<thead>
<tr>
<th>Visual score</th>
<th>Sample condition</th>
<th>Fungal growth</th>
<th>Visual scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Clean</td>
<td>No stain or fungal growth.</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>Minor attack</td>
<td>Stain or fungal growth covering less than 20% of the upper surface.</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Light attack</td>
<td>Stain or fungal growth covering 20-40% of the upper surface.</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Moderate attack</td>
<td>Stain or fungal growth covering 40-60% of the upper surface.</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Heavy attack</td>
<td>Stain or fungal growth covering 60-80% of the upper surface.</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Extremely heavy attack</td>
<td>Stain or fungal growth covering more than 80% of the upper surface.</td>
<td>5</td>
</tr>
</tbody>
</table>

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