Dimensional Stability of Particle Board and Radiata Pine Wood (*Pinus radiata* D. Don) Treated with Different Resins

Nellie Oduor
Forest Products Research Centre
Kenya Forestry Research Institute
P.O Box 64636-00620, Nairobi, Kenya

Peter Vinden and Peter Kho
Faculty of Agriculture and Forestry
The University of Melbourne
Creswick, Victoria 3363, Australia

Abstract

Particleboard and solid wood stakes were treated with either an isocyanate or phenol formaldehyde resin and exposed in soil beds comprising three different soil types and two moisture contents. The treatments resulted in a marked improvement in the dimensional stability of particleboard but had no effect on solid wood. Higher moisture uptakes in stakes exposed in sandy soils indicated that the technique used for measuring soil water holding capacity needs to be reviewed.

Keywords: Dimensional stability, Particleboard, *Pinus radiata*, isocyanate resin, phenol formaldehyde resin, soil beds

1.0 Introduction

Wood is a very hygroscopic material and swells to a great extent when placed in contact with water. It is also an extremely anisotropic material. Internal stresses build up following moisture pick-up, causing dimensional changes. This property or attribute of wood compromises its performance in humid environments.

A number of chemical compounds have been investigated for dimensional stabilization of wood. The most studied treatments for wood have been acetylation (Clermont and Bender, 1957; Risi and Arseneau, 1957a; Rowell, 1975; 1982; 1985; 2005). Other chemicals include alkyl chlorides (Risi and Arseneau, 1957b; Rowell, 2005), lactones (Goldstein et al., 1959; Rowell, 2005), aldehydes (Tarkow and Stamm, 1953; Rowell, 2005), nitriles (Baechler, 1959; Goldstein et al., 1959; Rowell, 2005), epoxides (McMillin, 1963; Ellis and Rowell, 1984; Rowell and Ellis, 1984a; 1984b; Rowell, 2005) and phenolic resins (Goldstein et al., 1959; Rowell, 2005).
Chemical modification is defined as "a chemical reaction between some reactive part of a wood cell wall component and a single chemical reagent, with or without a catalyst, to form a covalent bond between the two" (Rowell, 1982). Examples of covalent bonds are esterification, etherification, acetal formation, crosslinking and bulking (Stevens et al., 1979). This excludes all impregnation treatments which do not form covalent bonds, polymer inclusions, coatings, and heat treatments (Rowell., 1975).

Dimensional instability is greater in reconstituted wood products, such as waferboard, flakeboard, and particleboard, than in solid wood products. There is need to conduct extensive research into applying the principals of chemical modification to these products. In theory, the chemical modification of panel products can be carried out at three stages during the manufacturing process:

- Chemical treatment of the wood particles or fibres prior to manufacture. This can be carried out either before or after drying of the varnish; e.g. acetylation of particles.
- During board manufacture.
- Post board manufacturing- for instance when all trimming and sanding has been completed.

The advantages of post manufacture treatment include:

- Treatment is on final product (independent of the manufacturing stage), thus eliminating problems associated with disposal of contaminated residues.
- Treatment levels can easily be adjusted to allow market requirements to be met on demand.
- The use of more toxic chemicals can be facilitated because of the containment possible in a pressure treatment vessel.

The research outlined in this paper investigates post board manufacture, dimensional stabilisation using isocyanate and phenol formaldehyde resins. The objectives were:

(i) To determine both the dimensional stability and decay resistance of boards treated with these resins
(ii) To evaluate soil-bed techniques as a method for evaluating dimensional stability and decay resistance.

This paper summarises the results for dimensional stability.

2.0 Methodology

2.1 Preparation of the soil beds

Three different types of agricultural soil were selected from the Creswick region in Victoria. These included a sandy loam, a red clay-loam and black clay soil. The soils were air dried and then sieved through a two-millimetre mesh. Previous studies - for example, Vinden *et al.* (1982) have shown that drying the soil increases the virility of the soil and aids the process of sieving.

Nine plastic containers each measuring 45 cm x 28 cm x 20 cm deep were filled with each soil type to within 4 cm of the top of the container. Distilled water was then added to achieve the required water holding capacities of 98% and 102% using the procedure outlined in BS 1982: Part 2 (1990). The soil beds were then thoroughly mixed to ensure uniform moisture distribution. Water holding capacity (WHC) (the water availability of the soil.) was measured using the technique described by Savory (1971). He defines WHC as “the moisture content of saturated soil after exposure to the Suction exerted by a vacuum pump for ten minutes”.

2.2 Preparation of the test specimens

Two types of stakes were used in the experiment. Timber stakes measuring 5 mm x 10 mm x 150mm were cut from clear Radiata pine sapwood. Particleboard stakes had dimensions of 10 mm x 20 mm x 150 mm. The stakes were sanded, the width, thickness and length measured and their weights recorded. The moisture content of these stakes ~~were~~was calculated from representative samples using the oven- drying method. The stakes were then vacuum-impregnated with isocyanate and phenol formaldehyde resins. The viscosity of each resin was modified by adding a low boiling point solvent to each of the resins.

Treatment schedules involved using a pressure of -0.70 kPa (guage) for 30 seconds for particleboard stakes and a 2-minutes soak for the timber samples. Loadings of 21% were achieved. These stakes were then cured at 5O°C for 24 hours to prevent resin bleed. The dimensions and weights of the stakes were then recorded. The samples were leached according to the procedure described in BS 5761 Part 2 and then dried in an oven at 60°C to constant weight. The weight, dimensions, deflection values and initial moisture contents of the control stakes were determined prior to the exposure trials.

2.3 Planting the test specimens

Both the treated and the control stakes were planted in rows, leaving approximately 20 mm of the length of the stake protruding above the surface of the substrate. Stakes were placed 20 mm apart and 20 mm from the sides of the containers. They were assigned positions in the containers according to a randomized block experimental design. These containers were then sealed tightly using ducting tape to prevent moisture loss. Prior to putting them into a fungal cellar, the weights of these containers were recorded.

2.4 Incubation

The tightly-sealed containers were then placed in an incubator maintained at 28°C. The weights, dimensions and deflections of the stakes were noted after 3, 6, 9, 16, 45 and 72 days exposure.

3.0 Results and Discussion

Figure 1 shows the percentage swelling against exposure time in days for untreated and treated particle board and timber samples in the three different soil beds. There is a significant difference in swelling between the untreated and treated particleboard samples at the 0.05 level. However, in the first six days there was no significant difference between the treatments (0.05 level). Resin treatments reduced swelling in samples, improving their dimensional stability. The rates of swelling illustrate a large increase in the first days of exposure. This is followed by a slower rate of swelling between the 6th and 16th day. After this period an increase in the rate of swelling of particleboards was observed. This could be due to moisture penetrating to the centre of the board through pathways created by the release of residual compressive stresses imparted to the particle board during the pressing process. Phenol formaldehyde treatments provided greater dimensional stability than samples treated with isocyanate resin.

Swelling values for all solid wood treated samples were not significantly different from the controls (0.05 level). However isocyanate wood samples placed in red soil were significantly different (0.05 level) after 3 and 16 days exposure. Likewise the phenol formaldehyde treated samples were different (0.05 level) in sandy soils after 9 days exposure. There were no significant differences in swelling between isocyanate and phenol formaldehyde resins.
Figures 2 shows the percentage weight gain against exposure time for untreated and treated particleboard in different soil beds. Samples in the sandy soils had significantly higher weight gains than those in red and black soils. The weights of these samples increased rapidly after two weeks.

Figure 3 shows the percentage weight gain against exposure time for untreated and treated wood samples in different soils. There were significant differences (0.05 level) between the controls and treated samples. Samples placed in sandy soils exhibited higher weight gains than samples placed in other soil beds. This tendency is similar to the one shown in figure 2 for particleboard samples.

Figure 1: Percentage swelling vs. time of exposure (days) for untreated and treated particleboard and Radiata pine stakes

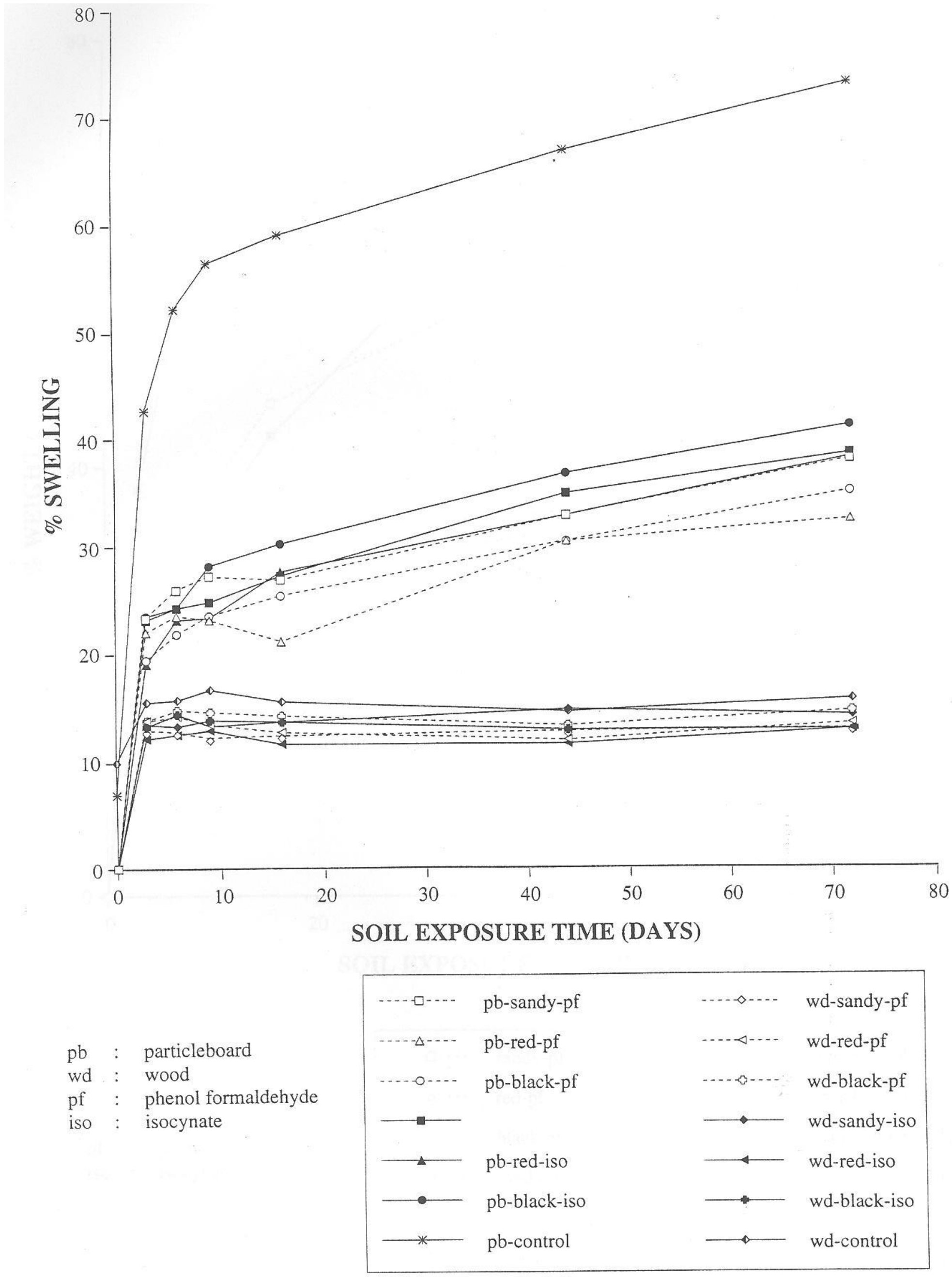


Figure 2: Percentage weight gain vs time of exposure (days) for untreated and treated particleboard stakes

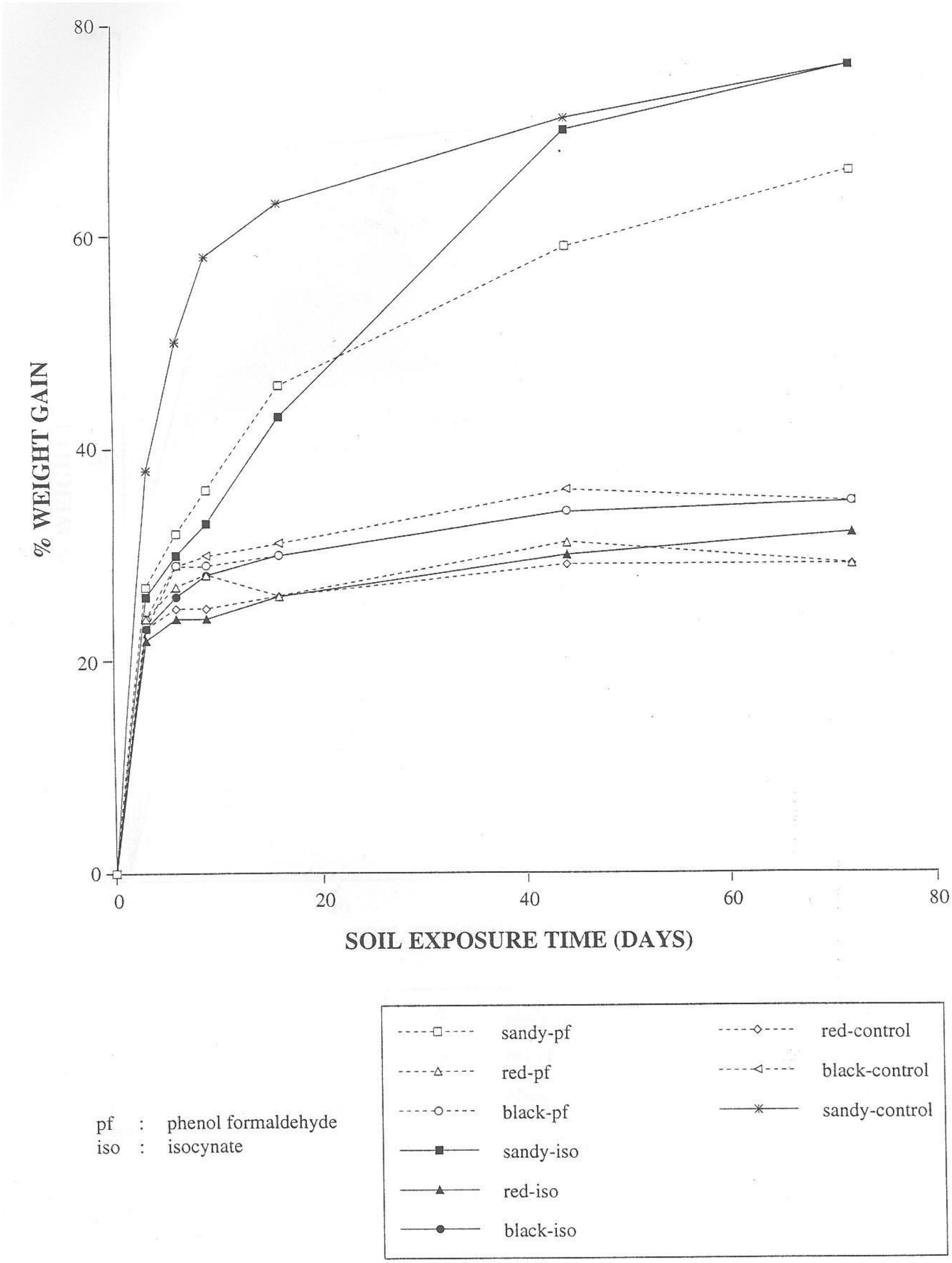
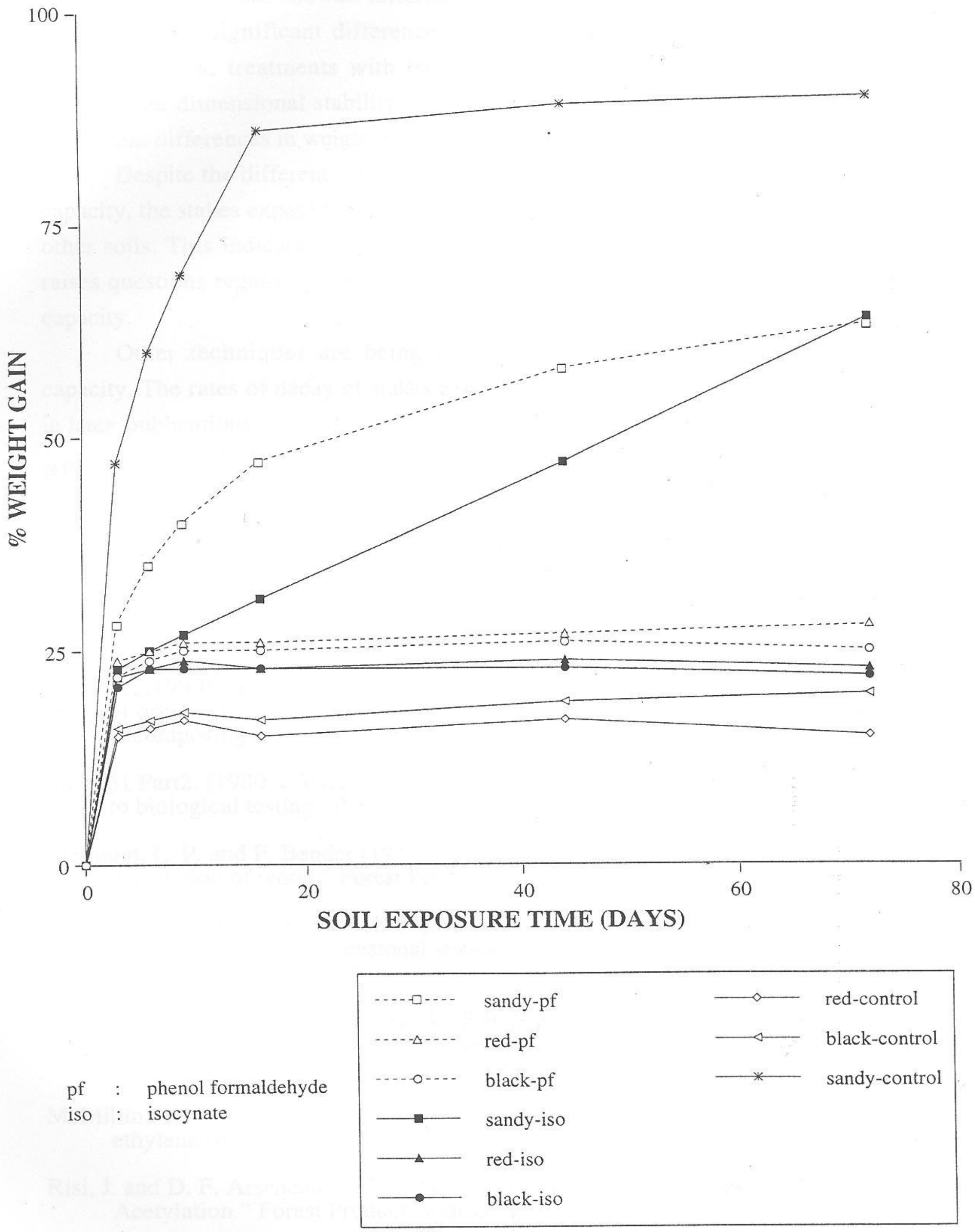


Figure 3: Percentage weight gain vs time of exposure (days) for untreated and treated Radiata pine stakes



Conclusion

Particleboard samples treated with isocyanate and phenol formaldehyde resins had lower volumetric swelling and weight gains than untreated controls. Thus the treatments improved the dimensional stability of particleboard samples. There was also a significant difference in swelling between samples treated with isocyanate and phenol formaldehyde. There were no significantly different weight gains between treated samples and controls.

Wood samples showed different swelling trends to particleboard samples. There were no significant difference in swelling between treated samples and controls. Thus, treatments with isocyanate and phenol formaldehyde did not improve the dimensional stability of solid wood samples. However, there were significant differences in weight gain between treated samples and controls.

Despite the different soil types being conditioned to the same water holding capacity, the stakes exposed in sandy soils tended to take up more moisture than the other soils. This indicates greater availability of free moisture in sandy soils and raises questions regarding the validity of the method for measuring water holding capacity.

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