Preventing termite attack

Environmentally friendly chemical combinations of cashew nut shell liquid, sulfited wattle tannin and copper(II) chloride

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Summary

In this study, a combination of three chemicals (cashew nut shell liquid, sulfited wattle tannin and copper(II) chloride) has been used to develop an environmentally friendly termite preservative. Cashew nut shell liquid (CNSL) is a by-product of cashew nut kernel processing factories and its use in the preservative formulations minimises the wastes from the factory as well as the amount of conventional hazardous preservatives from entering the environment. The formulated preservatives were tested for their ability to preserve wood blocks from a soft wood, ponderosa pine (*Pinus ponderosa*) and a hard wood, trembling aspen (*Populus tremuloide*). Sulfonated wattle tannins alone or combined with copper chloride at different concentrations, and cashew nut shell liquid (CNSL) without or with copper chloride were used in treating the 14 × 14 × 14 mm wooden blocks from the two wood species. The samples were exposed to termite attack in the surveyed fields in Arusha and Moshi, Tanzania. After 108 days exposure, evaluation of termite attack by measuring the weight losses and damage showed that the test wood treated with the combinations 40% CNSL + 1% $CuCl_2$ and 40% CNSL + 2% $CuCl_2$ were among the least damaged.

Introduction

Termites are destructive insects which attack both field and harvested produce. Wood products are also subject to termite and other bio-hazard attack if preventative measures are not taken. These bio-hazard attacks reduce the service life of wood products. In Tanzania for instance, the average service life of a non-durable wood species is about three years although it can be extended by the use of wood preservatives.[1] The extended durability period depends on, among other things, the species of wood, the type of preservative used and the place at which the wood is stored or used. In Tanzania, a survey reports[1] that wood preservation is carried out using creosote (60%), pentachlorophenol (20%), and copper chromium arsenate (20%). The common wood preservatives documented elsewhere to be effective against termites include chlorinated products, boric acid and arsenic compounds.[2–5] Apart from creosote, which is moderately toxic when heated to decomposition, pentachlorophenol, arsenic and chromium compounds are rated as highly toxic industrial materials.[6,7] Chromate salts are associated with cancer of the lungs while arsenic compounds can cause a variety of skin abnormalities including itching, pigmentation and even cancerous changes.[6] Work on preventing termite attack by adding insecticides to wood adhesives used on fabricated building materials has been done and showed good anti-termite properties.[4]

The resistance of wood treated with copper(II) compounds derived from tri- and di-alkylamine–boric acid complexes to termite attack is also found to be good, and is environmentally more acceptable than the use of conventional wood preservatives.[8] Copper complexed with condensed tannin is observed to be an efficacious wood preservative although the combination of the sulfited bark extract (tannin) and copper chloride is reported to be a more effective wood preservative.[9] A notable advantage of using a combination of copper compounds instead of conventional wood preservatives is that termites readily acquire toxic doses by consuming small amounts of the treated wood and thus the nearby untreated wood is protected from termite attack. Moreover, copper compounds are active against fungal attack and hence can also protect the wood in this way.

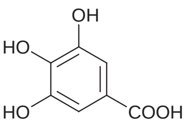
Despite their environmental acceptability over conventional wood preservatives, large doses of copper complexes are environmentally less friendly than chemicals mainly derived from natural sources. The wood preservatives commonly used in Tanzania exert a negative environmental impact as their effluent streams contain particularly persistent toxic compounds such as pentachlorophenol, arsenic and chromium compounds, this calls for the development of alternative wood preservatives from local natural materials. The latter entails finding more environmentally acceptable substances from natural sources like wattle tannins and cashew nut shell liquid (CNSL) that are less toxic than the

Green Context

The discovery and application of environmentally benign new products and product mixtures which can effectively replace hazardous chemicals are important areas of green chemistry. Traditional wood preservatives used in developing countries are often based on a potent mixture of toxic species such as chlorinated phenols, arsenic and chromium compounds. Copper-based preservatives are promising alternatives but can involve unacceptably large quantities of combinations of compounds. In this article the novel combination of cashew nut shell liquid, sulfited wattle tanin and small amounts of copper are shown to be effective mixtures for the prevention of termite attack. *DJM*

conventional wood preservatives used in Tanzania.[6] The possible effluents from either pilot or full scale processes using this new technology will comprise the less toxic cashew nut shell liquid, tannin and small concentrations of copper chloride.

As might be expected from its biological origin, wattle bark extract contains, as well as tannins, a number of chemically distinct constituents. The common hydrolysis product of tannin is gallic acid shown in structure I. In the tree bark, tannin is said to be involved in the protection of the tree from insect and fungal attack.[10] The wattle tannin based adhesive from Tanzania has been extensively characterised and was useful in the formulation of anti-termite compounds.[11] On the other hand, CNSL is an extensively studied,[12–14] naturally occurring phenol obtained as a by-product during the processing of cashew kernels, and contains several phenolic compounds. A major monophenol component of the technical CNSL distillate is cardanol which has a C_{15} side chain in the *meta* position, as shown in structure **II**. The other two chief constituents of the CNSL are anarcadic acid and cardol, shown in structures **III** and **IV** respectively. Minor components include 2-methylcardol (**V**) and a small percentage of polymeric materials. The degree of saturation of the C_{15} alkyl side chain varies from complete saturation to partial unsaturation as shown in structure **VI**.



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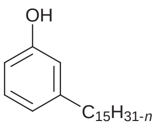

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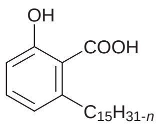

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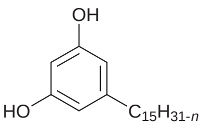

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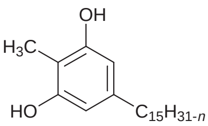
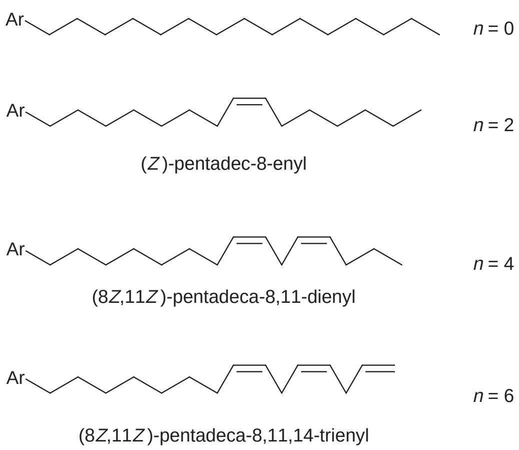


V



VI (structures of C_{15} chains in **II**–**V**)

The phenolic character and the unsaturation in the alkyl side chain make CNSL constituents important reactive materials in the preparation of binders for coatings and anti-corrosive paints and resins.[13] Cashew nut shell liquid is also reported to be used in protecting wood against termites and is especially used in making insecticidal formulations.[15] Since some of these plant natural products have good insecticidal activity and low toxicity to humans, interest in using them as wood preservatives is inevitable.

The above reported use of these natural products against termites has stimulated our interest in developing an anti-termite wood preservative from combinations of cashew nut shell liquid (CNSL), copper(II) chloride, and sulfited wattle tannins. The study objective was to develop a wood preservative using Tanzanian natural products with insecticidal and biocidal activities. Screening of the ability of CNSL and sulfited wattle tannins from Tanzania in combination with commercial wood preservatives to protect against termite attack was done. The wood preservative formulations included the combination of CNSL and $CuCl_2$ at different concentrations, wattle tannins and copper chloride, CNSL alone, wattle tannin alone, copper chloride alone and the control was copper chromium arsenate (CCA).

The uptake and commercialisation of this technology on a large scale is technically feasible by on site recycling of these by-products. This can be achieved by proper engineering design and innovation so as to incorporate the technology into the existing processing factories. On a pilot scale however, off-site recycling is a necessity in order to establish technical and economic viability towards large scale technology. Success in the recycling of cashew nut shell liquid and wattle tannins will be a step towards a cleaner technology which is about minimising the environmental impact of the by-products from the processes. The cost of designing and re-designing the process seems to be one of the probable barriers against commercialisation of the technology. Other likely barriers are the standard of the end-use material and the availability of markets for these preservatives and their products.

This paper reports and discusses the termite preservatives formulated from various combinations of compounds. The amount of CNSL in the combinations was large as cashew nut shell liquid is a by-product of the process and its use in preservative formulations will reduce process releases to the environment. The call for the latter aims at replacing the conventional environmentally hazardous compounds. The results of field tests against termite attack of wood blocks on the formulated preservatives are also reported and discussed.

Materials and methods

Test wood sample preparation and treatment

The test wood blocks were prepared from sapwood of two species; a soft wood ponderosa pine (*Pinus ponderosa*) and a hard wood, trembling aspen (*Populus tremuloide*). Seven hundred and seventy sapwood blocks, each of 14 × 14 × 14 mm size, were cut from air-dried sapwood of the two wood species. The test wood blocks were labelled and conditioned to 50% relative humidity and constant temperature (70 °F) to a constant weight. The blocks were randomly assigned to various treatments as per American Wood Preserver Association (AWPA) standard E10-91.[16] The weight of each block was recorded after treatment with the formulated preservative compounds.

Formulation of preservatives and wooden block treatment

The preservatives were formulated from sulfited wattle tannins, CNSL and copper salts in different concentrations. The control treatments included CCA, copper chloride, dimethyl sulfoxide (DMSO) and distilled water. The treatments were recorded in two categories coded as AS and PP for trembling aspen and ponderosa pine wood species respectively. The original weights of the treated test wood blocks were recorded and thereafter screened against harvesting termites of *Kalotermes spp.* for 108 days field exposure in Arusha and Moshi, Northern Tanzania. The test cubes were spread on top of the pre-cleaned experimental grounds before covering them with the dry plant materials.

Water at an amount of 1000 $cm^3\ m^{-2}$ was sprinkled on the plant materials to provide an appropriate environment for termite activity underneath.

Damage assessment of wood blocks

Damage and weight loss were recorded at an interval of two weeks, with a few exceptions. Damage on the block surfaces was observed visually whereas the block weight losses were determined by collecting the samples from the field and exposing to the laboratory atmosphere for moisture stabilisation before weighing them using a Sartorios analytical balance.

Results and discussion

Field surveys

The fields for exposure of the test wood blocks were surveyed and a large number of termite mounds, measuring up to three metres, on the open plains of Babati, West Kilimanjaro, Sanya plains and along the wheat growing belt of Mbulu Tanzania, were recorded. Damage on big trees, fallen timber, and in seedbeds was also recorded in West Kilimanjaro, Karatu and in Sanya plains. The damage incidence in field crops including beans, maize and wheat was at a peak during the harvesting period (July/August–October) in this part of Northern Tanzania. Considerable damage was also recorded on storage structures in some homesteads visited.

Termite screening responses

The results of different termite screening responses on the remaining percentage weight of the wood blocks after 108 days of field exposure are shown in Fig. 1 and 2. Some of these damage responses showed better results than the commercially used CCA. From the results in the figures, three distinct groups of treatment responses have been identified although they were not all consistent.

The first group is that of the least damaged treated test wood with their mean percentage weight losses after 108 days of field exposure: 3% CCA (2.2%), 1.5% CCA (3.3%), 0.5% CCA (4.8%), 2% $CuCl_2$ (5.5%), 40% CNSL + 2% $CuCl_2$ (10.0%), 2.5% $CuCl_2$ (10.5%), 40% CNSL + 1% $CuCl_2$ (10.8%). The fact that there were no dead termites recorded on the test ground surfaces suggests that the observations can be explained by the possibility that the blocks were not, or only slightly, damaged because either the impregnated chemicals acted as termite repellants or the chemicals made the blocks unpalatable to termites. The repellency effect by some of the plant materials to some insects, including aphid species, is well reported elsewhere.[17]

The second group consists of susceptible impregnated wood blocks. This group includes the following treatments with their percentage loss at 108 days of exposure: water (49.2%), DMSO (30.7), 5% tannin (20.5) and 2% tannin (15.6). These observations may be explained as being due to the effect of the impregnated chemicals in that either the test blocks were still palatable to termites or the chemicals acted as termite attractants. The latter possibility is supported by the well documented literature in that the choice of plant materials for consumption by insects is influenced by a complicated processes involving physical and/or chemical responses.[18]

The third group was evaluated as that of moderate damage. It should be noted however, that there was no consistency in weight losses in all the identified groups. This may have been due to uptake of either moisture or soil particles from the test grounds and a study is underway to identify the cause of this inconsistency.

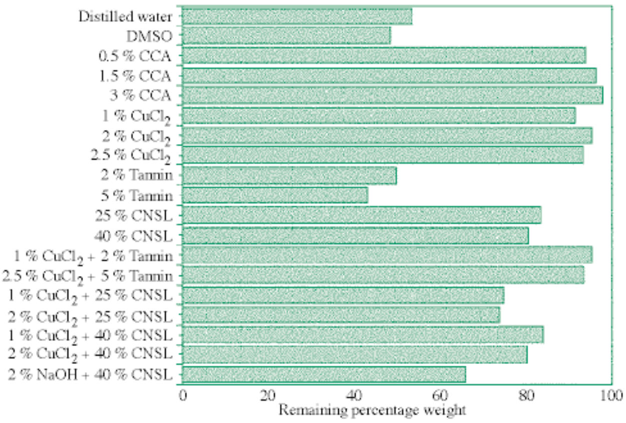


Fig. 1 Remaining percentage weight of wooden blocks after 108 days of field exposure of sample (AS).

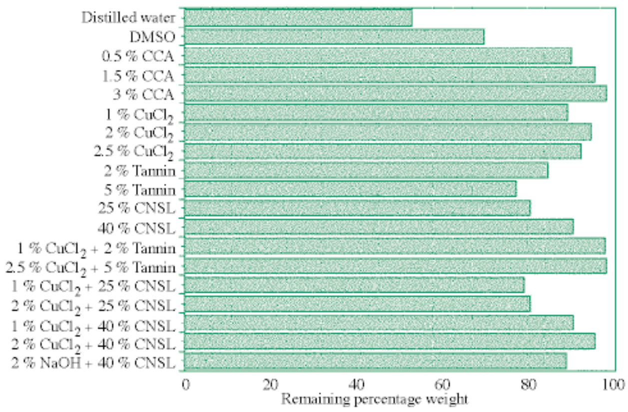


Fig. 2 Remaining percentage weight of wooden blocks after 108 days of field exposure of sample (PP).

Conclusion

Sharp differences between preservative effectiveness on test wood damage have been noticed in terms of the test wood damage response and weight loss. The survival of the termites in the test wood blocks shows that the formulated preservative does not act by killing the termites but is rather linked to the possibility that the compounds made the wood blocks unpalatable to termites or were termite repellents. The least damaged blocks are suggested for a screen against other termite species so as to establish the suitability as anti-termite compounds. If the formulated preservatives are active against other termite species, there is a necessity to try the preservative on a large scale, for it may turn out to replace the environmentally unfriendly wood preservatives currently used in the country.

Cleaner technology is about minimising the adverse environmental impact of releases from industrial processes, and the success in recycling cashew nut shell liquid and wattle tannin will reduce wastes from these processing factories.

Acknowledgements

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