

ABSORPTION AND MOVEMENT OF COPPER AND ARSENIC IN WOOD OF *EUCALYPTUS GLOBULUS* LABILL.

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Abstract

Effect of different ratios of copper and arsenic in aqueous solutions of different concentrations together with immersion time on absorption of these elements by and their movement into the wood of *Eucalyptus globulus* Labill has been described. Arsenic was preferentially absorbed in almost all the treatments while the relative absorption of either of the elements was not affected in any specific way by the concentration level and the immersion time. Arsenic did not affect the movement of copper and it was possible to achieve the desired depth of penetration of the latter.

Introduction

In an unpublished study of the author, it was found that when copper and arsenic are used together in aqueous solutions, not only is the absorption of copper by wood affected but also its movement therein, while arsenic was found to be preferentially absorbed by the wood. Although most workers involved in wood preservation believe in both the screening effects of different elements and their disproportionate absorption by the wood, very little has been published on the subject. Smith and Williams (1973) apparently were the first to record the disproportionate absorption of chromium by wood during pressure treatment with CCA type preservatives. Later Ofori (1980), while working on diffusion treatment of certain Ghanaian timbers, observed preferential absorption of arsenic in relation to copper. In his investigation on the effect of different concentrations of copper and arsenic in aqueous solutions on their relative absorption by wood, he found that wood of different tree species behaved differently to different strengths of these elements.

Vinden (1983) and Ampong and Chin (1983) concluded that the presence of arsenic in aqueous solutions with copper did not prevent the movement of copper in the wood. On the contrary, it has rather been seen to accelerate the movement. The reason for this is believed to be the reduction in the adsorbed copper in mixtures of the two elements in comparison to copper used alone. The reduction in the adsorption of copper in the presence of arsenic has also been studied by Eadie and Wallace (1962), Vinden (1983) and Khan (1986). This suggests that, in the presence of arsenic, more copper should be available for free movement in the wood. The present study was, therefore, planned to find out the effect of factors like different ratios of copper to arsenic in aqueous solutions, solutions strength and immersion time in achieving a balanced absorption of the two with their movement in the wood of *Eucalyptus globulus* Labill.

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Materials and Methods

Green wood of *E. globulus* was cut into rectangular blocks 25mm x 25mm x 75mm with 25mm x 75mm faces in the longitudinal plain and 25mm x 25mm faces in the transverse plain - each block comprising mainly sapwood with a thin layer of heartwood on the inner tangential face. The 25mm x 25mm faces of the blocks were sealed with ABS polymer to prevent end-grain penetration of the preservative. As very little movement of chemicals took place through the heartwood surface, it was easy to determine and measure the depth of penetration down the radial face taking place through the sapwood surface only.

1,500 mls of solutions of copper sulphate and arsenic pentoxide, with copper and arsenic in the elemental ratios of 1:1, 2:1 and 3:1 were prepared in 8, 16 and 32% concentrations (w/w) of total salts.

5 replicates were used for each treatment and each replicate was treated by immersing in the copper-arsenic solution for various lengths of time for 1/4, 6 and 24 hours. After immersion, the blocks were removed from the solution and wrapped in polythene bags to allow copper and arsenic to diffuse into the wood. After one week the samples were unwrapped and allowed to dry under normal atmospheric conditions on a non-absorbent surface. The samples were then cut across the middle and the depth of penetration of copper determined by applying a coating of rubeanic acid on the exposed surfaces. Half of the specimen in each case was analysed for copper and arsenic retentions with the atomic absorption spectrophotometer using the prescribed methods given in British Standards 5666 part 3 of British Standards Institution, 1979.

Results and Discussion

The study shows that, except for one conclusive indication that arsenic was preferentially absorbed in almost all the treatments, confirming the findings of Ofori (1980), the results do not appear to exhibit any definitive trend. All the three factors studied do not seem to exert any definite influence on the relative absorption of the two elements, the degree of disproportionation varying from one treatment to the other. While in certain cases the increase in immersion time gave a better proportionate absorption, in the others it had an opposite trend. In general, for the 8 and 16% solutions (w/w), a higher proportionate absorption of the two elements was recorded with a corresponding increase in immersion time for nearly all the elemental ratios, while for the 32% solution the reverse seemed to be true. On the basis of the results, a treatment with 32% solution having 1:1 copper-arsenic ratio, and 15 minutes dipping was found to give the highest proportionate absorption of the two elements. Moreover among the different elemental formulations, 1:1 ratio gave comparatively better results.

The total retentions of both copper and arsenic, again, do not exhibit any definite trend with the change in relative ratios of the two elements (Table 2). The total retentions were, however, found to increase with increase in solution concentration and immersion

Table 1

Retention of Copper and Arsenic as percentage of the dry weight of wood in various treatments

Sl. No.	Solution Concentration	Immersion time	Cu:As 1:1		Cu:As 2:1		Cu:As 3:1	
			Copper %	Arsenic %	Copper %	Arsenic %	Copper %	Arsenic %
1.	8%	15 min.	0.048	0.056	0.058	0.043	1.35	0.085
2.		6 hrs.	0.096	0.104	0.126	0.095	1.33	0.178
3.		24 hrs.	0.131	0.140	0.243	0.144	1.69	0.252
4.	16%	15 min.	0.110	0.120	0.141	0.094	1.50	0.154
5.		6 hrs.	0.199	0.231	0.256	0.194	1.32	0.292
6.		24 hrs.	0.416	0.432	0.705	0.360	1.96	0.645
7.	32%	15 min.	0.228	0.231	0.273	0.157	1.74	0.296
8.		6 hrs.	0.435	0.526	0.491	0.320	1.58	0.577
9.		24 hrs.	0.659	0.724	0.840	0.569	1.48	0.978

Table 2
Total retentions of copper and arsenic in various treatments

S. No.	Solution concentration (w/w)	Immersion time	Total retentions as percentage of dry weight		
			Cu:As 1:1	Cu:As 2:1	Cu:As 3:1
1.	8 %	15 minutes.	0.104 (0.022)	0.101 (0.018)	0.099 (0.018)
1.		6 hours.	0.200 (0.021)	0.221 (0.027)	0.264 (0.022)
3.		24 hours.	0.271 (0.022)	0.377 (0.042)	0.367 (0.012)
4.	16 %	15 minutes.	0.230 (0.040)	0.235 (0.033)	0.228 (0.014)
5.		6 hours.	0.412 (0.058)	0.450 (0.099)	0.401 (0.020)
6.		24 hours.	0.848 (0.091)	1.065 (0.084)	0.901 (0.184)
7.	32 %	15 minutes.	0.459 (0.060)	0.430 (0.030)	0.428 (0.036)
8.		6 hours.	0.961 (0.023)	0.811 (0.062)	0.818 (0.074)
9.		24 hours.	1.419 (0.183)	1.409 (0.152)	1.421 (0.162)

The value in the parentheses are the standard deviations.

time. Although in the presence of arsenic the adsorption of copper is reduced, Vinden (1983) and Khan (1986) have found small differences in the amount of adsorbed copper in samples treated with high concentration solutions in relation to the total retention. This means that the variation in the results of total retentions of copper and arsenic cannot be attributed to the differences in the amounts of adsorbed copper in different formulations.

It is important to mention here that large variations were exhibited in the results of the individual samples. This was especially true for the solutions with high concentrations where a slight variation in the treatment schedule could cause a major difference in the overall absorption of the two elements. It appears that, due to the differences in the chemical nature and the rate of movement in the wood of the two elements, the process of absorption cannot be treated in simple way. With a view to clearly understand the phenomenon, a more planned study with a larger number of replicates and a wider range of immersion time, needs to be pursued. Furthermore, the results could become more meaningful in the whole subject is treated in terms of gram-moles instead of the simple mathematical ratios. Such an approach could also help in understanding the process of fixation of CCA in the wood.

Table 3 gives the results of the depth (mm) of radial penetration of copper after one week's diffusion time in each treatment. The depth of penetration of copper was found to increase with the increase in the solution concentration and immersion time. The different elemental ratios were not found to have any definite effect on the pattern of movement of copper. Since the amount of adsorbed copper varies only slightly with different elemental ratios (Vinden 1983 and Khan 1986), the depth of penetration of copper, seems to follow, in most cases, the copper content in each formulation. As the amount of arsenic content increases from 3:1 to 1:1 copper to arsenic ratios, there shall be a proportional decrease in the amount of available copper for movement in the wood. This would happen so, unless the amount of copper is kept constant in the preservative and the relative amounts of arsenic varied, depending upon the ratios required. In some of the samples, the depth of penetration of arsenic was also determined by applying a series of solutions described in Standard No. D-3507 of American Society for Testing Materials, 1981. It was observed that, in most cases, arsenic had penetrated into the wood well beyond the depth of copper. This is because, even in the presence of copper, little arsenic is fixed in the cell wall (Eadie and Wallance 1962) and it continues to move into the wood independent of the movement of copper.

Conclusions

The results of the retention of copper and arsenic in different treatments lead us to conclude that neither the three variables studied had any definite effect on the proportionate absorption of these elements nor the total absorption values found to be appreciably affected by different elemental ratios. The most important indication has been the preferential absorption of arsenic by wood during immersion in copper-arsenic aqueous solutions in almost all the treatments. This behaviour of arsenic could be of some

Table 3.
Depth of penetration of copper in various treatments after one week's diffusion time.

No.	Solution concentration (w/w)	Immersion time.	Cu:As 1:1	Cu:As 2:1	Cu:As 3:1
1.	8 %	15 minutes.	4 (0.69)	4 (1.17)	5.5 (1.00)
2.		6 hours.	6 (1.14)	7.5 (0.71)	9 (1.14)
3.		24 hours.	7.5 (1.16)	9 (1.14)	10 (1.29)
4.	16 %	15 minutes.	5 (1.44)	7 (1.14)	7 (0.58)
5.		6 hours.	7 (0.71)	9 (1.28)	10 (1.03)
6.		24 hours.	9 (1.11)	12 (1.41)	12 (1.28)
7.	32 %	15 minutes.	8 (1.03)	8 (1.33)	9 (1.24)
8.		6 hours.	10 (1.42)	12 (0.75)	13 (1.15)
9.		24 hours.	complete	complete	complete

The value in the parentheses are the standard deviations.

advantage in the tropical/subtropical countries where insects and termites pose a major threat to timbers in service. The need, however, arises for strictly monitoring the solution balance in green treatments by diffusion or sap displacement. As to the movement of copper, it was not found to be affected by the presence of arsenic in the various elemental formulations.

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REFERENCES

1. AMERICAN SOCIETY FOR TESTING MATERIALS. 1981. Standard test methods for penetration of preservatives in wood and for differentiating between heartwood and sapwood. A.S.T.M. Standard No. D-3507.
2. AMPONG, K. And CHEN WOO CHIN. 1983. Treatment of messmate (*E.obliqua* Esit) by double diffusion. Preliminary report. International Research Group on wood preservation Document No. IRG/WP/3234, PP.5.
3. BRITISH STANDARD INSTITUTION. 1979. Methods of analysis of wood preservatives and treated timber. Part 3 . Quantitative analysis of preservatives and treated timber containing copper/chrome/arsenic formulations. British Standards B.S. 5666 part 3, London.
4. EADIE, J. and E. M. WALLACE. 1962. Some observations on the fixation of copper and arsenic in *Pinus sylvestris* sapwood: Journal of the Institute of Wood Science, Issue No. 10, 56-65.
5. KHAN, J. A. 1986. Preservative treatment of plantation grown Euclypts by double diffusion. Ph.D. Thesis, University of London, pp.219.
6. OFORI, J. 1980. Preservation of hardwoods in relation to treatment techniques. Ph.D. Thesis, University of London, pp.219.
7. SMITH, D. N. and A. J. WILLIAMS. 1973. The effect of composition on the effectiveness and fixation of copper / chrome / arsenic and copper / chrome preservatives. Part II. Selective absorption and fixation. Wood Science and Technology, 7, 142-150.
8. VINDEN, P. 1983. Preservative treatment of wood by diffusion processes. Ph.D. Thesis, University of London, pp.322.