Technical Papers and Documents

ITTO Project 52/99 Rev 2(I)

Development and Extension of Preservation Technology for Tropical Plantation Timber

Guangdong Forest Research Institute
China
October 3, 2003
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A. **Project Identification**
   
a) **Title:** Development and Extension of Preservation Technology for Tropical Plantation Timber.
   
b) **Serial Number:** PD 52/99 Rev. 2(I).
   
c) **Implementation Agency:** Guangdong Forest Research Institute (GDFRI), CHINA.
   
   
e) **Starting Date:** October 26, 2000
   
f) **Actual Duration:** 33 months
   
g) **Actual Project cost (US$):** 378,295 (including the ITTO administration fee US$ 13,690)

**PART I: Executive Summary**

1. **Background Information About the Project**

This project, *PD 52/99 Rev. 2(I)*, was proposed by GDFRI, China in December, 1998 and approved by ITTO in the 28th session May, 2000, Lima. The project agreement was signed in August, 2000 by ITTO and Chinese Government. The total budget of the project is US$ 309,190. The awarded ITTO funding was US$ 166,690 and the Chinese Government fund the matching part of US$ 142,500. The duration of the project was 30 months.

- Natural forest was no longer the timber source we could rely on in the future and fast-growing plantation would become the main resource for timber supply. Some tropical species such as eucalypts and acacia, many bamboo species as well, were developing rapidly in the Southern China. But the wood from the fast growing plantation forest has its obvious disadvantages, being more susceptible to fungi and insects, for example, that limits its utilization scope. If the timber couldn't be well used, the development of plantation would be restricted and the growing demand for timber would create high pressure on nature forest. To promote the development of timber preservation industry and to improve the wood processing techniques was one of the important components to solve the problems faced.

- Lacking of technology and knowledge was the main obstacle prevented the timber preservation industry from developing. To convince people of the
The efficacy of preserve treatment in extending the service life of timber and to develop appropriated technologies for local plantation timber resources were the key pathway to promote this industry.

The development objective of the project was to develop and extend the processing and utilization technology, especially preservation treatment, of timber from tropical plantation in South China. Dissemination of the technologies through demonstration and training for better utilization of this renewable forest resource will relieve the pressure on tropical forest for timber supply and contribute to the sustainable forestry development.

The specific objectives of the project were:

a) To establish preservation standards and procedures related for timber from plantation, mainly focus on some tropical hardwood such as eucalyptus and acacia species.

b) To promote the wood preservation industry in Southern China by demonstration and training.

The outputs of the project, according to the original plan, were as following:

Output 1: Establishment of preservation standards & drying procedures for *Eucalyptus urophylla* and *Acacia mangium*.

Output 2: A pilot preservation plant would be established and demonstration plots in using preserved timber would be set up. The project would disseminate the output through demonstration, training courses and seminar/workshop and publication.

The strategy adopted in carrying out the project was as following:

1. To establish of basic facilities including laboratory and pilot preservation plant for R&D in timber preservation.
2. Generation of appropriate technologies in preserve treating of plantation timber, including eucalypts, acacia and bamboo, for use in agriculture, landscape etc.
3. Setting up of demonstrations to showcase the technologies developed. This involves experiments and tests of preservatives, treated timber and research such as assessment the contamination of treated timber to the environments.
4. International consultancy-this involves introduction of foreign technologies and experience,
5. Dissemination of the knowledge and technologies derived from the project. This includes seminars/workshops, open days, courses, information booklets, TV programs and internet website.

Planned duration and overall cost

1. The planned duration was 30 months
2. The planned overall cost was US$ 309,190

2. Project Achievements

Main outputs achieved

a) Preservation treatment technology of eucalypts timber from plantation, drying schedules, treatment technique and banana post product standard have been developed. These included:
   1. Preservatives selection test for agriculture use. CCA, CCB and ACC were tested and CCA performed best in the field, especially in the high humidity coast line zone.
   2. Field test of CCA treated young *eucalyptus urophylla* used for banana post, it durability, strength and impacts to the crop quality. The results indicated that treated young timber from plantation meets the requirement and better than the tradition material such as untreated Chinese fir and round bamboo with significant benefit.
   3. Economic evaluation of using treated banana post comparing to untreated by the international consultant Mr. Robert Prydon.
   5. Development of the “Preserved treated banana post quality standard”.
   6. Development of the “Safe regulations for treating plant operation”

b) Achievements in R&D. Theses include preservatives and anti-sapstain component development and test, contamination evaluation test, natural duration test of some wood species.

c) A Pilot timber preservation plant was built in 2000 in the campus of GDFRI, which is the first vacuum pressure treatment plant for timber preservation in Guangdong. It is the main equipment for treating timber for demonstration and experiment. Apart from project tasks, it is also used cooperatively with industry in testing and developing preserved timber products.

d) A laboratory with timber sample treatment and biological test has been established. The lab is also inside the GDFRI campus. The planned tests of the project were conducted in this lab. What is doing in the lab. are the soil block test of some bamboo species (*Bambusa sinospinosa*, *Bambusa pervariabilis* and *Sinacalamus latiflorus*) and some new developed preservatives tests. It also
serves the industry. For example the longhorn beetle test for Osmose, anti-mold compound test for a local company etc.

e) A timber exposure test yard with area of 2,500m² was established in GDFRI. Now there are 600 samples in the yard for testing, including different treatment of *Eucalyptus urophylla*, *Pinus mansoniana*, *Populus tomentosa* and *Cunninghamia lanceolata*. There are also some bamboo species sample in testing.

f) Demonstrations plots, including total 13 hectares of preserved timber used in agriculture and landscape construction, have been set up.

<table>
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<tr>
<th>Region</th>
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<th>Area (ha) remained</th>
<th>Planned Area (ha)</th>
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<td>Zhongshan</td>
<td>3.5 (some ruined)</td>
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<td>River Delta</td>
<td>Panyu</td>
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<tr>
<td>Total in Area (ha)</td>
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</table>

The treated posts for demonstration are mostly *Eucalyptus urophylla*. Some treated round bamboo were added in the plots in Panyu.

Landscape demonstration are in the campus of GDFRI, the Guangdong Tree Park and some cooperative demonstrations in some resident blocks in Guangzhou.

g) Seminar/workshop and training. Totally 6 seminars were organized by the project and over 200 participants from every walks were participated. 2 courses/workshop and some open days were arranged for the university students too. The first Chinese Wood Preservation Industry Development Conference was organized and sponsored by the project.

i. It was organized by GDFRI on April 5, 2001. Some 40 participants from the provincial Forestry Bureau, universities, industries and forest research institutes appeared and had an observation to the project laboratory and pilot plant. The Australian experts, Mr. Norton Jack and Mr. Brydon Robert gave presentations on the seminar by the topic of "Timber preservation in Queensland" and "Forest plantation in Australia" respectively.

ii. On September 20, 2001, a seminar was held in Queensland Forestry Research Mr. Li Zhaobang gave a presentation on
Timber Preservation Industry in Guangdong. Attendants, about 25, were from industry as well as the QFRI.

iii. On January of 2002, a seminar about the progress of this project was for the GDFRI scientists and staff. A report about the study tour by the project members to Australia and New Zealand was presented too.

iv. On March 20, 2002, a seminar, organized by the Guangdong Forestry Society and GDFRI, focused on the standard and monitoring system of Preservation Industry in Australia was held in Guangzhou. About 50 participants from the provincial Forestry Bureau, universities, industries and forest research institutes attended. The Australian expert, Mr. Norton Jack gave a presentation and Mr. Li Zhaobang, project leader, introduce the implementation and the output achievements of the project. Attendants felt very educated.

v. On March 22, 2002, a Seminars/workshop with the topic Wood Preservation in the South Guangdong, was organized by Maoming Science and Technology Bureau. Attendants, totally over 50, were from forestry, agriculture, industry and the government departments related. Mr. Li Zhaobang gave a presentation on timber preservation and an introduction of the on-going project. Mr. Jack Norton gave a presentation on timber preservation in Australia and Queensland as well. Some attendants inspected the treated eucalypts banana post demonstration sites in Gaozhou.

vi. On March 25, 2002, another seminar was held in Zhanjiang City in the Eucalypts Research Center(ERC). Participants, about 40 were scientists of ERC and the forestry bureau of the city. Timber preservation development, domestic and abroad, was introduced and the use of Eucalypts plantation timber was discussed.

vii. Since the commence of this project in 2000, open day and courses were organized at lease once a year for the students from South China Agricultural University.

h) Others included dissemination of timber preservation through publications, TV programs, website information and radio broadcast. (any example for the coverage of the project by mass media in China) In June (?) 2002, the project and timber preservation technology was introduced in a CCTV forestry program. In march 2002, the project demonstration and seminar in Maoming City was record and play in the local TV and radio broadcasting. Many banana farmers got aware of the technology from these programs, for example.
i) Technological service and support the development of timber preservation industry. Under the assistance of the project, a treatment plant has been set up and put into operation using the technique derived from the project to produce banana posts. This plant will be managed under the project’s instruction with emphasis on quality control, production safety and environment issues to act as a demonstration plant in the next phase.

j) Apart from the planned species, the technologies developed have extended to use in treating of more local wood species such as pines (Pinus mansoniana, Pinus elliotti), Chinese fir (Cunninghamia lanceolata) and bamboo (Sinocalamus latiflorus and Bambusa pervariabilis) as well. These are all the main tree species for plantation in the south China area.

k) 5 papers were presented in the IRG meeting and national conference.
   i. Jiang Mingliang, et al, Laboratory Evaluation and Field Trial of Chlorothalonil and Copper Based Preservatives and Leaching Performance of Copper in Copper Treated Wood, IRG 33rd Annual Meeting, May, 2001, Cardiff, United Kingdom
   ii. Li Zhaobang, Standardization in the Development of Timber Preservation in China, Chinese Wood Preservation Industry Development Conference, November, 2002, Guangzhou, China;
   iii. Li Zhaobang, Su Haitao, Liang Linqing, Do CCA treated support stakes cause increased arsenic level in crops? IRG 34th 2003 annual meeting, Brisbane, Australia;
   iv. Jiang Mingliang, Li Zhaobang, Laboratory and Pilot Evaluation of Chlorothalonil Formulations for Mold and Stain Control on Some wood Species, IRG 34th 2003 annual meeting, Brisbane, Australia;

l) 2 papers and technical documents have been prepared.
   i. Zhang Yanjun, Determination of the Composition of Wood Preservatives by Routine Chemical analysis, A Comparison Study wit with the Instrument Method.
   ii. Product Standard, Preservative Treated Banana Post

m) 3 papers are in compiling.
   i. He Xuexiang, Liu Lei, Shu Jinzhu, Laboratory test of the Resistance of several Wood Preservatives to Coptotermes formosanus Shiracki
   ii. Su Haitao, Liu Lei, Huang Linfeng, Liang Linqing, Production Schedule of Preservative Treated Banana Post
Specific Objectives achieved

a) One preservation treatment procedures and a standard (to be approved) for timber from plantation have been set up and used in production.

b) Timber preservation industry has its beginning in Guangdong which is indicated by:
   1. The number of treating plants has increased from zero pre-project to currently at least 4, apart from the pilot plant of the project, are in operation in Guangdong. Some more are in preparing;
   2. Treated timber has been adopted and used in more and more fields such as agriculture, landscape constructions, industry packaging and outdoor furniture. Looking back to the situation before this project, no treated timber was used and since lacking of the relevant knowledge, long serve life of treated timber was unbelievable to many.
   3. The first Chinese Wood Preservation Industry Development Conference, sponsored and organized by this project, was held on November, 2002, Guangzhou which indicated that the industry has drawn high attention in the country. The conclusion arose from this conference was: timber preservation industry promises well in China.

Contribution to the Achievement of the Development Objective.

a) Progress has been made towards a sound technical foundation to meet the requirement of the developing timber preservation industry. Currently adequate information is accessible for the potential investors and timber consumers. The technologies derived from this project are adopted by industry.

b) Demonstration plots and structures established by the project have been playing an important role in dissemination the knowledge of high value use of plantation timber. No doubt this will encourage the further development of forest plantation in the tropical area and in someway affect the timber supply pattern in the future.

c) The contribution to the local economic will be very significant in the
future. For example, according to the evaluation made by economist Mr. Robert Prydon, the project’s international consultant, with an economic model, “Comparing the use of treated and untreated banana posts, there is a maximum potential saving of up to RMB 749,000,000 over a six year period.” This is only the direct benefit obtained by the banana farmers in Guangdong.

3. Target Beneficiaries Involvement

1. The wood processing industry is directly benefited by the accessing the new technology. Many potential investors, who have been engaged in wood processing industry, joined the seminars, observed the demonstrations, visited the project facilities or through the media to get aware of the technology.

2. One of the treated timber consumer, the target users of the technology derived from this project are banana plantation owners. They participated the implementation as partners in the demonstration programs. They at first more or less doubted about the efficacy of treatment technology and eventually adopted it after years of observation. They have been actively giving impetus to its extension ever since, which led to a banana post treating plant set up in the main banana production area, Gaozhou, Maoming City. There are totally about 4 thousand hectares of banana plantation in or around this area and RMB 250 per hectare will be saved annually using treated posts instead of the untreated ones.

3. The landscape builder is also one of the main beneficiaries and more and more treated timber is now used in building pavilions, decking, fencing, flower beds etc in parks, gardens or public facilities since some treating plants can provide some products to meet their requirement.

4. The forestry sector, in particular the forest plantation owners will be the beneficiaries too in the future while the treating industry grow up and more and more plantation timber can be treated. Obviously the local economic development will be positive affected by more jobs created, for example.

4. Lesson Learned

a) Development lesson

1. Aspects of project design which most contributed to its success or failure in achieving the Development Objective

1. This project was designed well compatible with the Government's
forestry policies and in line with the local Government's effort in improving the wood processing industry. While the project plan being prepared in 2000, the Guangdong Provincial Government appropriated fund of RMB 1 million (about US$ 120,000) to support this project to set up the pilot treating plant. When the project agreement was signed, the pilot plant was almost ready for experiments so that the project implementation could started-up without any delay.

2. Based on a long term consideration, this project was considered the first step towards setting up a sound foundation in terms of R/D and technical service for the industry. The layout of the project and some activities, such as, basic facilities and experiments were designed and arranged with expanding potential for future extension.

3. The timber preservation R/D initiated by this project can be sustainable only depend upon the growth of industry.

4. At this stage while the industry is still small, further support to strengthen in particular in facilities and technical team is crucial so that;

5. a program to continue actions in this direction is necessary for greater achievements.

· Changes in intersectoral links which affected the project's success
  No critical change occurred during the project execution period.

· Additional arrangements that could improve cooperation between the relevant parties interested in the project

1. More and more cooperative activities such as tests and products development with industry, both domestic and foreign, come up along with the project progress.

2. The laboratory and pilot plant opened for the university and some courses were organized for students. Technical personnel training is important for the future.

3. Cooperating with the TV station, an introduction of timber preservation was involved in a TV popular science program which has given a good education to the public.

· Factors which will most likely affect project sustainability after completion.
1. Supports available to further improve and maintain the on-going long term activities.

2. Well trained technical team.

3. Coherent policies related.

4. A follow-up ITTO project will be a crucial factor.

b) Operational lessons

- Project organization and management

1. Recognizing that to convince people that preservative treatment be effective in extending the usable life of and adding value to plantation timber was one key to success, putting emphasis on demonstrations has proved to be a right decision in the activities arrangement. The scope of demonstrations expanded from agriculture, landscape to outdoor furniture, log-home, decking...etc. The potential users were actively joined the demonstration.

2. As a new research field in China, timber preservation is a mature industry in many countries. With their experience in industry, the Australian consultants had been playing an important role in this project. The observed the whole operation and made many comments and recommendations, most of them proved to be very helpful. The link set up between two countries through their activities will be important in future.

3. That the users directly took part in the experiment as partners in the project increased the technology transferring efficiency. But on the other side, some variation elements might be involved and flexible arrangement should be considered in the plan.

4. Some activities such as contamination test, exposure yard establishment, extra banana post demonstration plots were not planned. Understaffed and financial difficulty limited the effectiveness of these activities. Better planning and project team organization could have led to even better results.

- Project documentation

ITTO has an adequate guidance for project documentation and a seminar
was held on the management of ITTO project, including project documentation, in China last year, which were great assistant for documenting. What put it passive was that some times the preparation of a document was requested before project schedule to meet the ITTO session meeting.

- Monitoring and evaluation, qualify of project planning

1) International expert(s) involved in the project monitoring and evaluation is appropriate because they have experience and expertise in a certain field,
2) The Government officials related inspected the project many times and gave concern to its progress. Further coordination and information exchange between ITTO and local Government in the monitoring would contribute to the project execution.

- Definition of the roles and responsibilities of the institutions involved in the project implementation

Roles and responsibilities defined on subcontract basis is a good way for implementation and management in a project. Agreements were signed between the Executive Agency and the institutes in this project and the implementation of the subcontracts ended well with outcomes expected, the international consultancy in particular.

- Actions to be taken to avoid variation between planned and actual implementation ( schedule, costs, etc)

Variation is sometimes inevitable so that adjustment is necessary. Main changes in this project implementation were:

1. The price of ASOMA X-Ray Fluorescence Spectroscopy Analyzer quoted is much higher than that budgeted. The purchase had to be canceled. a titration method was developed to analyze the treated samples in the experiments. The planned activities were not affected.

2. Some demonstration plots in the Pear River Delta area were abandoned by the farmers because of a banana disease broke-out in 2001. Some of the treated posts and exposure test samples got lost. As a remedial measure, the remained samples were moved to a more secure site and more demonstration plots were set up in Maoming City.

3. Understanding that interest to treated timber was developed in many other aspects apart from agriculture, several demonstration plots inside
and outside the GDFRI campus were set up, including a log-home, pavilions, fence, decking etc. A treating plant, used the technology derived from this project to produce banana posts was established in Gaozhou. All these extra activities led to extra expenditure and 3 months longer in schedule. The provincial Government has allocated fund to cover the inadequate part.

- External factors that influenced the project implementation and that could have been foreseen.

Main change made during the implementation was about the target tree species. *Acacia mangium* was selected as one of the plantation species for tested. It was found that its wood locally produced is not moderately permeable as that from South-East Asian countries, and difficult to treat under normal pressure method. Testing pre-project could have avoided this change.

- External factors that influenced the project implementation and that could not have been foreseen.

What could not be foreseen was the break out of banana disease which ruined the demonstration plots in the Pear River Delta. This affected the extension of the technology in this area.

5. **Recommendations**

1. Well communication with the local Government, organizations and local communities concerned for their supports in preparing the project proposal.

2. A more flexible activities plan will prevent the failure caused by unforeseen factors.

3. Selection of the international experts for the project consultancy is critical. In this project for example, since it's operation was closely linked with industries, it proved to be right that the experts well experienced in industry rather than with research were selected.

4. Study tour to the more advanced countries or and exchanging information and experience with other ITTO project in the same field will be helpful.

5. Normally an executive agency is not necessary experienced with the ITTO project implementation and management. It is recommended that
some kinds of training courses or seminar on project operation and management be organized for the key project persons.

PART II: Main Text

1. Project Results

- Situation existing at project completion as compared to the pre-project situation

  1) A primary R/D base of timber preservation is ready to serve the industry.

  2) Some technologies and Information are accessible for treated timber producers and consumers.

  3) A new industry, timber preservation, was born in Guangdong and now at least 4 treating plants are in operation.

  4) Timber preservation has drawn high attention in China from consumer to government level.

- Although timber preservation industry has over 100 years history in many countries, argument about the impact on the environment from using some chemicals in treating timber is going on. Contamination evaluation test conducted in this project indicated that the technique derived from this project used in agriculture is safe. But further R/D to develop environment sound preservatives and technique is important for the future.

- Since the project, timber preservation is considered as a booming industry by many. Along with the fast growing economic inertia, it will grow fast too in China. With this firm backing, what created by this project will be sustainable.

2. Synthesis of the Analysis

(a) Specific Objective(s) Achievement

The specific objectives planned in this project have been successfully realized.

(b) Outputs

The project main outputs planned are realized with some changes
comparing with the original plan.

(c) Schedule
On the whole, the executives of the project were on schedule. The actual duration was extended for 3 months. But this was because of extra activities approved by ITTO, which extended the output and added to the achievements, as mentioned above.

(d) Actual Expenditures
The total expenditure was US$378,295 which exceeded the original budget for US$69,105. Amount it, the ITTO fund was over expended US$18,394 according to the auditing report.

(e) Potential for replication
To further strengthen and disseminate the results obtained rather than to have another similar project in the same region is appropriate. But a replication in other countries with similar conditions may be potential.

(f) Potential for scaling-up
What has been achieved is the groundwork of R/D erected and a momentum of a new industry created. To strengthen this groundwork to meet the future requirements and maintain the momentum towards a sound and healthy industry, a follow-up project is essential. A project proposal for this purpose is in preparing.

PART III: Conclusions and Recommendations

a) Development lesson
A project which closely link with many aspects of local society in terms of economic, there should be sound consistency between it’s development objective and the government’s policy direction. The support of government and local communities is critical not only financially but in carrying out of project activities.

b) Operational lesson
Seeing is believing. More effort was put on demonstration rather than in R/D in the operation, which result in quick dissemination of knowledge and technology. Of course modern media and communication, such as internet, TV, exhibition etc are important means should be involved in.

c) Recommendations for future projects, regarding
The most important recommendation arising from this report is the need to maintain the momentum created by this project, that is to continue/extend the on-going activities so that the timber treatment industry could be further promoted.

A follow-up project would be focus on developing of specifications and standards for treated plantation timber and establishing of a product quality control system for this growing new industry and organizing more demonstration to provide appropriate and ready accessible information. This project will be significant in high value used of the tropical fast growing tree plantation resources and contribute to its sustainable development.

Comparing the treated timber user was the main participant in the operation of the previous project, the timber preservation industry, both domestic and abroad, and plantation owners could be the important parts to play in the follow-up project. International consultancy was proved to be able to make significant input in the previous project. It is recommend that foreign experts’ activities be a component in the future project.

 Responsible for the report

 Name: Li Zhaobang

 Position held: Project Leader

 Date: August 29, 2003
Laboratory Evaluation and Field Trial of Chlorothalonil and Copper-based Preservatives and Leaching Performance of Copper in Copper Treated Wood

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Paper prepared for the 33rd Annual Meeting
Cardiff, UK
12-17 May 2002
Laboratory Evaluation and Field Trial of Chlorothalonil and Copper-based Preservatives and Leaching Performance of Copper in Copper Treated Wood

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Abstract: Soil block test and field trial of some Chinese plantation wood species pine and poplar treated with chlorothalonil formulations and copper-based preservatives such as ACQ-B and copper citrate (CC) were conducted. The results of soil block test indicated that chlorothalonil formulations and ACQ-B as well as CC are very effective for controlling the 2 fungi species Coniothyrium versicolor and Poria placenta at different retention. There is no significant difference of weight loss among retention level range 2.54-23.1 kg/m³ of ACQ-B and CC in our test.

The durability of wood treated with chlorothalonil oil formulation is better than that of treated with emulsion formulation. ACQ-B and CC treated wood at different retention level are effectively resistant to decay and termite after 36 months field trial at Guangzhou, south China. Leaching rate of copper of CC treated wood is much higher than that of CCA and ACQ-B treated wood by the 2 wood species Pinus massoniana and Eucalyptus urophylla according to AWPA standard M11-87.

Keywords: chlorothalonil, ACQ-B, copper citrate, soil-block test, durability, copper fixation

1. INTRODUCTION

Chlorothalonil is an agricultural fungicide and it also has been used as a wood preservative for preventing decay [1-8], P9 type A oil is the suitable carrier for chlorothalonil as a wood preservative according to American Wood Preserver’s Association (AWPA) standard. The effectiveness of chlorothalonil emulsion as wood preservative for decay control has not been reported in literature. Some copper-based preservatives such as ACQ-B and CC, which are included in AWPA Standard as wood preservatives in recent years, are much environmental friendly than CCA, which is

* This work was supported by China Natural Science Foundation. Mingliang Jiang, corresponding author, email: jiangml@forestry.ac.cn.
widely used around the world and is facing environmental problem. Previous works related to soil-block test and durability were conducted and reported [9-13] as well as the review of fixation of ACQ-B and CC treated wood [13] in recent years. The effectiveness of chlorothalonil emulsion as wood preservative for decay control and the effectiveness of the environmental friendly copper-based preservatives such as ACQ-B and CC to Chinese plantation wood species have not been reported in literature [1-8]. The propose of this paper is:

1) to determine weight loss of some Chinese plantation wood species treated by chlorothalonil emulsion and the copper based preservatives by soil-block test;

2) to determine the effectiveness of natural durability of treated wood under the local circumstance in Guangzhou, South China;

3) to briefly determine the leaching character of copper in ACQ-B and CC treated wood.

2. MATERIAL AND METHOD

2.1 Wood Sample and Fungi

The samples for soil-block test: 10(L) × 20 × 20 mm. Masson pine (Pinus massoniana) and poplar (Populus tomentosa) were the test wood species. Agar rather than soil was used in these test, weight loss was calculated based on the dried weight of treated wood samples prior to incubation and dried weight of samples after 3 month decay. Fungal specie: Corious versicolor (C. v) and Poria placenta (P. p). 4 replica were adopted for each test.

The samples for stake test: Pinus massoniana and Populus tomentosa and slash pine (Pinus elliottii), the common plantation wood species in China. 300(L) × 20 × 20 mm, 10 replicas were adopted for each test.

The samples of leaching test: Pinus massoniana and Eucalyptus urophylla, 20(L) × 20 × 20 mm. 6 replicas were adopted for each test.

2.2 Chemicals

Chlorothalonil (CTL) was purchased from Hunan Haili Group. Emulsion agent was prepared by Lushun Chemical Factory (Dalian). Aero-fuel oil was used as solvent for preparing chlorothalonil oil formulation. Deltamethrin was provided by Tianjing Agrochemicals Coorperation, China. Chlorpyrifos (CPF) was available from Dow Elesco Coorperation, USA. The active ingredient of ACQ-B: Cu²⁺, dimethyldidecyl ammonium chloride (DDAC) and ammonia, CC: Cu²⁺, citric acid and ammonia. DDAC and citric acid and ammonia are commercial available and were purchased in China.
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<td>Populus tomentosa</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>C. v</td>
<td>P. p</td>
<td></td>
</tr>
<tr>
<td>Pinus massoniana</td>
<td>CTL (E)</td>
<td>1.20</td>
<td>9.2</td>
<td>0.2</td>
<td>0.5</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>CTL (E)</td>
<td>2.00</td>
<td>16.0</td>
<td>0.4</td>
<td>1.2</td>
<td>12.9</td>
</tr>
<tr>
<td></td>
<td>CTL oil</td>
<td>1.08</td>
<td>4.3</td>
<td>9.6</td>
<td>7.6</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.43</td>
<td>10.12</td>
<td>1.8</td>
<td>2.3</td>
<td>8.48</td>
</tr>
<tr>
<td></td>
<td>CC</td>
<td>0.25</td>
<td>2.64</td>
<td>2.2</td>
<td>3.9</td>
<td>2.54</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.50</td>
<td>5.10</td>
<td>2.2</td>
<td>4.0</td>
<td>5.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.04</td>
<td>14.8</td>
<td>2.7</td>
<td>3.0</td>
<td>10.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.72</td>
<td>23.1</td>
<td>2.6</td>
<td>3.2</td>
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</tr>
<tr>
<td></td>
<td>ACQ-B</td>
<td>0.25</td>
<td>2.87</td>
<td>1.9</td>
<td>3.2</td>
<td>2.89</td>
</tr>
<tr>
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<td>0.50</td>
<td>5.79</td>
<td>2.3</td>
<td>3.2</td>
<td>5.88</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.98</td>
<td>14.6</td>
<td>3.6</td>
<td>3.5</td>
<td>12.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.70</td>
<td>21.7</td>
<td>3.5</td>
<td>2.3</td>
<td>19.6</td>
</tr>
<tr>
<td></td>
<td>CCA</td>
<td>1.50</td>
<td>10.4</td>
<td>0.3</td>
<td>0.2</td>
<td>8.8</td>
</tr>
<tr>
<td></td>
<td>Untreated</td>
<td>0</td>
<td>0</td>
<td>22.9</td>
<td>34.7</td>
<td>0</td>
</tr>
</tbody>
</table>

CTL (E): CTL emulsion
ACQ-B was prepared according to ASTM D5654-95. CC was prepared according to AWPA P5-99 16. The concentration of ACQ-B and CC was calculated on the basis of CuO and retention of the above was calculated on CuO/0.53 and CuO/0.56 respectively according to ASTM standard.

2.3 Stake test
The stake test site is located in a typical sub-tropical area, Guangzhou, Guangdong Province, South China. The termite occurrence is heavily under the local condition. ASTM D 1758-96 is the reference for ranking standard: 10-complete decayed, 0-complete decayed.

2.4 Leaching test
Leaching test of copper in ACQ-B and CC treated wood were according AWPA M11-87, 1987. The test samples were soaked by distilled water, stirred, replaced the water and collected it. Copper content in collected water was determined by atomic absorption.

3. RESULTS AND DISCUSSION
3.1 Results of soil-block test
The results of soil block test indicated that ACQ-B and CC are very effective for controlling the 2 fungi species at different retention, however there is no significant difference of weight loss between different retention level of ACQ-B and CC in this test. This point is very important to determine the appropriate retention during actual application (table 1). Comparing to the previous paper related to ACQ-B [10], copper tolerance to Poria placenta is not very significant in our test. More typical fungi should be used in the further research since different preservative processes different tolerant to fungal varieties and only 2 fungal species were used in the above test. The treated samples by chlorothalonil emulsion are much resistance to the above fungi, which has not been reported before, whereas Poria placenta seems a little tolerant to chlorothalonil oil during poplar block test.

3.2 Results of field trial
The natural durability of the 3 wood species treated with chlorothalonil oil formulation is much better than that of emulsion formulation from table 2-4, especially for the 2 pine wood species. Probably because emulsion formulation is much likely to leach than oil formulation from the wood to the soil during stake test since emulsion is water-soluble.
Table 2 Results of natural durability of preservatives treated masson pine after 36 months field trial

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Concentrations</th>
<th>Retention (kg/m³)</th>
<th>Exposure months</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTL (E)+CPF</td>
<td>1.2</td>
<td>7.6 + 0.304</td>
<td>12 24 36</td>
</tr>
<tr>
<td>CTL (E)</td>
<td>1.2</td>
<td>4.79</td>
<td>7.8 1 0</td>
</tr>
<tr>
<td>CTL (E) + deltamethrin 1.2+150 ppm</td>
<td>6.67 + 0.063</td>
<td>10 7.4</td>
<td></td>
</tr>
<tr>
<td>CTL oil</td>
<td>1.84</td>
<td>6.91</td>
<td>10 9.9 9.8</td>
</tr>
<tr>
<td>ACQ-B</td>
<td>1.03</td>
<td>8.5</td>
<td>10 10 10</td>
</tr>
<tr>
<td>ACQ-B</td>
<td>1.84</td>
<td>20.9</td>
<td>10 10 10</td>
</tr>
<tr>
<td>CC</td>
<td>1.04</td>
<td>10.7</td>
<td>10 10 10</td>
</tr>
<tr>
<td>CC</td>
<td>1.80</td>
<td>21.5</td>
<td>10 10 10</td>
</tr>
<tr>
<td>CCA</td>
<td>1.50</td>
<td>8.5</td>
<td>10 9.8 9.8</td>
</tr>
<tr>
<td>untreated</td>
<td>/</td>
<td>0</td>
<td>0 0 0</td>
</tr>
</tbody>
</table>

Table 3 Results of natural durability of preservatives treated poplar after 36 months field trial

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Concentrations</th>
<th>Retention (kg/m³)</th>
<th>Exposure months</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTL (E)+CPF</td>
<td>1.2</td>
<td>7.53 + 0.301</td>
<td>12 24 36</td>
</tr>
<tr>
<td>CTL (E)</td>
<td>1.2</td>
<td>5.62</td>
<td>5.8 0.6 0</td>
</tr>
<tr>
<td>CTL (E) + deltamethrin 1.2+150 ppm</td>
<td>7.56 + 0.072</td>
<td>10 8.4 1.0</td>
<td></td>
</tr>
<tr>
<td>CTL oil</td>
<td>1.84</td>
<td>6.39</td>
<td>10 9.1 0.4</td>
</tr>
<tr>
<td>ACQ-B</td>
<td>1.03</td>
<td>8.4</td>
<td>10 10 10</td>
</tr>
<tr>
<td>ACQ-B</td>
<td>1.84</td>
<td>13.6</td>
<td>10 10 10</td>
</tr>
<tr>
<td>CC</td>
<td>1.04</td>
<td>8.1</td>
<td>10 10 10</td>
</tr>
<tr>
<td>CC</td>
<td>1.80</td>
<td>15.5</td>
<td>10 10 10</td>
</tr>
<tr>
<td>CCA</td>
<td>1.50</td>
<td>7.87</td>
<td>10 10 10</td>
</tr>
<tr>
<td>untreated</td>
<td>/</td>
<td>0</td>
<td>0 0 0</td>
</tr>
</tbody>
</table>
Table 4 Results of natural durability of preservatives treated slash pine after 36 months field trial

<table>
<thead>
<tr>
<th>Treatment</th>
<th>concentrations</th>
<th>Retention (kg/m³)</th>
<th>Exposure months</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTL (E) + CPF</td>
<td>1.2</td>
<td>7.53 + 0.301</td>
<td>12 24 36</td>
</tr>
<tr>
<td>CTL (E)</td>
<td>1.2</td>
<td>5.62</td>
<td>10 4.4 2</td>
</tr>
<tr>
<td>CTL (E) + deltamethrin 1.2+150 ppm</td>
<td>1.84</td>
<td>7.56 + 0.072</td>
<td>10 10 3.2</td>
</tr>
<tr>
<td>CTL oil</td>
<td>1.03</td>
<td>8.51</td>
<td>10 9.8 9.4</td>
</tr>
<tr>
<td>ACQ-B</td>
<td>1.84</td>
<td>13.2</td>
<td>10 10 10</td>
</tr>
<tr>
<td>ACQ-B 1.84</td>
<td>1.04</td>
<td>21.0</td>
<td>10 10 10</td>
</tr>
<tr>
<td>CC</td>
<td>1.80</td>
<td>23.0</td>
<td>10 10 10</td>
</tr>
<tr>
<td>CCA</td>
<td>1.50</td>
<td>7.87</td>
<td>10 10 10</td>
</tr>
<tr>
<td>untreated</td>
<td>/</td>
<td>0</td>
<td>5.4 0.8 0</td>
</tr>
</tbody>
</table>

The natural durability of treated pines by chlorothalonil oil formulation is much better than that of treated poplar. For example, the average grade of the 2 pine wood species treated with chlorothalonil oil were 9.8 and 9.4 respectively, whereas the poplar treated with chlorothalonil oil was almost completely decayed after 36 month exposure during natural durability trial. It also indicated that deltamethrin in the chlorothalonil formulation improved the natural durability of the stakes comparing to the stakes treated by deltamethrin free formulation. Further research should be focus on the oil type of chlorothalonil including deltamethrin or other pyrethroids. CPF is still a promising wood preservative especially for controlling termite if we handle it carefully even through it has safety problem to crops released in recent years since requirement of safety impact of wood preservatives is not the same as pesticides used for crops.

The stakes treated by ACQ-B and CC were almost sound after 36-month trial, whereas the untreated stakes were completely decayed and seriously attacked by termites. The retention of ACQ-B and CC in table 2-4 was much higher than that in literature paper released recently [11, 12], especially for the masson pine and slash pine. The stakes treated with ACQ-B and CC at the lower retention of 2-6 kg/m³ were sound after 18 month trial, anyway this survey will be continued for determining the appropriate retention of ACQ-B and CC.

3.3 Results of leaching rate of copper in CC and ACQ-B treated wood

Fixation of preservative in wood is a main factor for long-term protection of
wood, especially for the exterior wood such as in the circumstance of ground contact use.

The copper fixation rate in ACQ-B and CCA-C treated wood is higher than in copper citrate (CC) treated wood when copper retention level (as copper oxide) in the above wood species is almost equal according to AWPA M11-87 standard (table 5). For example, the copper fixation rate in CC treated wood at retention range 1.9-17.8 kg/m³ is from 70.20% to 84.65%. While the copper fixation rate in ACQ-B treated wood is at least 90.04%. The primary result indicated that ACQ-B is promising preservative for ground contact use and CC could be used in less severe condition as ACQ-B and CCA-C even though detailed test including DDAC and citric acid is necessary in the further research.
<table>
<thead>
<tr>
<th>Wood species</th>
<th>preservatives</th>
<th>Retention (as CuO kg/m³)</th>
<th>Total Cu²⁺ in test samples (mg)</th>
<th>Amount of Cu²⁺ in solution after leaching (mg)</th>
<th>Leaching rate %</th>
<th>Copper fixation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masson pine</td>
<td>CCA-C</td>
<td>7.50*</td>
<td>88.12</td>
<td>0.46</td>
<td>0.52</td>
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<tr>
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<td>CC</td>
<td>3.21</td>
<td>122.92</td>
<td>36.64</td>
<td>29.80</td>
<td>70.20</td>
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<tr>
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<td>CC</td>
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<td>680.70</td>
<td>104.70</td>
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<tr>
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<td>ACQ-B</td>
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<td>122.91</td>
<td>6.28</td>
<td>5.11</td>
<td>94.89</td>
</tr>
<tr>
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<td>ACQ-B</td>
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<td>16.76</td>
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<tr>
<td>Eucalyptus</td>
<td>CCA-C</td>
<td>3.32*</td>
<td>39.10</td>
<td>3.64</td>
<td>9.31</td>
<td>91.69</td>
</tr>
<tr>
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<td>73.74</td>
<td>16.76</td>
<td>22.73</td>
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<td>55.48</td>
<td>25.10</td>
<td>74.90</td>
</tr>
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<td>6.28</td>
<td>9.96</td>
<td>90.04</td>
</tr>
<tr>
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<td>ACQ-B</td>
<td>5.88</td>
<td>225.44</td>
<td>0.6</td>
<td>0.27</td>
<td>99.73</td>
</tr>
</tbody>
</table>

*Calculated as CuO, Cr₂O₃ and As₂O₅.
REFERENCE

1. woods, T. L. Chlorothalonil as a New Wood Preservative. Wood Preservation Beyond '90, Forest Products Society, 1995
标准化与木材防腐产业的发展

李兆邦
广东省林业科学研究院（广州 510520）

摘要 中国经济行业发展速度的加快，尤其在东南沿海的产业经济较发达的地区，木材防腐产业的发展和标准执行机制将有利于推动产业的健康成长，也为中国木材防腐工业发展中将不可避免的国内外竞争建立公平的环境。本文对我国木材防腐标准的标准化问题，提出一些建议。

关键词 标准化，木材防腐，建议

尽管我国建成第一家木材防腐处理厂至今已有60年的历史，木材防腐的生产也曾有一定的规模，但生产的技术仍很落后。随着我国经济的发展，木材防腐产品在国际上越来越受到欢迎，这为我国木材防腐产业的发展提供了广阔的空间，但同时对中国防腐产业的政策和环境要求也越来越高。我

国长期以来木材资源匮乏，供需矛盾突出。为了满足生产、生活日益增长的需求，一方面我们已经在发展人工林方面取得较大的成就，另一方面也急需通过木材防腐，提高使用价值来减少木材浪费，重视不够，发展不大。木材防腐工业除了橡胶木的处理期间有所发展外，对木材防腐工业的探索和研究也仍需加强，尤其是加强木材防腐处理技术的研究和推广。木材资源的浪费和损失，是造成木材资源浪费的重要原因之一。美国认为每处理1m³木材，可以少砍伐5m³木材。美国每年防腐木材的产量达到1500多万m³，因此每年少砍伐7000万m³的森林资源。如果我们能够充分、合理、有效地利用木材资源，将会大大节约木材资源。

由于资源缺乏，木材的消费不被鼓励，木材防腐工业也因此没有得到重视。当前我国人工林发展很快，进口木材充足，资源已经不是制约防腐工业发展的因素。相反，可利用的木材资源越来越多是人工林木材，木材的质量不能满足生产上越来越高的要求，对木材防腐和其他加工技术需求更迫切。木材防腐木制品和木材木制品的需求估计在50万m³以上，工业、建筑装修、公共设施等方面的应用所广泛应用。我国的木材防腐产业目前虽然幼稚，但它正处于迅速成长的前夕，是一个在襁褓中的婴儿，发展标准正是为它的健康成长准备一个摇篮。

1、我国木材防腐标准的现状

我国目前只有一个木材防腐术语标准，还有几个试验标准。木材防腐和标准执行和监测机构。事实上，我们目前在科研和生产上只能参照一些外国或国际标准。

木材防腐工业发达国家有相当完善的标准体系。以美国的木材防腐协会标准AWPA Standard 2000 为例，包括：1、防腐剂标准（9个）；2、商品标准（28个）；3、非压力处理标准（2个）；4、使用分类系统（1个）；5、分析方法标准（27个）；6、其他标准（11个）；7、评价标准（16个）；8、转让系数和修正表（1个）。除了8是作为辅助工具，实际标准有94个。

澳大利亚和新西兰标准：1、防腐处理规范，分锯材和原木、重组木材制品和胶合板产品三部分；2、木材防腐剂和防腐处理材的取样和分析方法3、木材防腐处理厂的安全法规。
包括处理厂的设计和处理厂运作两部分，一个木制品防腐剂的试验规范。此外，两国还共同建立了一个监测系统。

两相比较，美国木材防腐工业发达，标准齐全，为各国参照和引用，但体例纷繁复杂，是不断补充、长期需要存在的；澳新标是近年编制的（有的尚未完成），系统清晰，把重点放在防腐木的生产，集中本国树种和产品特点有所创新（后面将提及）。通用性的标准则采用国际先进标准。澳/新的做法值得参考。

2、标准化与产业的发展

“标准化是对实际和潜在问题作出统一规定，供共同使用和重复使用，以在预定的领域内取得最佳秩序和效益的活动”（GB3935.1-ISO/IEC指南2）。如果说我国木材防腐工业尚未很发达，相对于发展国家，我们是落后的。正因为如此，我们有后发的优势，这就是有别人的经验可以借鉴。在标准化方面，我们不必面对很多已经存在的“实际问题”的纠缠，可更专注将来的“潜在问题”上，将事情做得更好。

2.1 建立标准是产业健康发展步。

木材防腐工业处于一个启动期。由于木材防腐产业目前起点低，对资金、技术和设备要求高，产品多样，市场广阔，因而进入成本不高，加上目前还不具备规模化生产的大环境，所以是小资本创业者进入的最好时机。一旦产业活跃起来，必然出现很多小规模处理厂。根据我国的国情，可以预料，如果没有建立标准和监管机制，产品和市场会出现混乱。

防腐木材产品和其他产品不同，它的质量不是很快能在使用过程中反映出来，当发现质量问题的时候，可能是多年以后的事。劣质产品的后果也可能是严重的，比如结构材料；也有可能是影响范围很大的，比如可能带来的环境问题。

很显然，当资本、技术等门槛都很低的时候，建立标准等于是建立一个可以控制的门槛，有了一个以质量等级标准为市场准入的基本条件，对规范市场、打击假冒伪劣产品的生产，保证市场的健康发展将起重要作用。否则，一哄而起，形成市场混乱局面以后再整顿，社会成本必然很大。

2.2 标准化将促进专业技术的进步。

标准化的另一种叙述是“标准化是活动的规则，规范社会人的行为，但对技术科学，尤其是现代工程技术却又基础”。当市场经济中各种贸易和技术的壁垒被消除以后，我们就需要有共同遵守和使用的一种规范来使人类的科技发展和应用有序进行，这就是标准化。”

没有标准，对科研和技术开发不利。竞争是标准的竞争，是标准内的竞争，又是标准间的竞争。没有标准的时候，技术的重要性无法显现。有了标准，就确立了技术的主导权，这是在标准内的竞争。技术的进步又促进新的标准产生。谁掌握了更先进的标准，谁就赢得竞争。这是标准间的竞争。技术正是在这种不断的竞争中得到推动。

目前我国木材防腐领域的科研水平还比较低，在应用技术上比较好，在应用基础上则处于模仿的阶段。当然，这也是必须走的一步。由于科研力量比较薄弱，如果没有标准，将使科研力量更加分散，工作重复，对赶上世界先进水平不利。

2.3 标准化和进入WTO后产业的应对。

进入WTO以后，市场开放和关税壁垒逐步消除，国外资本和技术的进入是必然的。木材防腐工业和其他行业一样面临如何适应经济全球化带来的变化，而且由于我国木材防腐技术水平和规模与先进国家落后很大，就显得更严峻。我们一方面希望引进先进技术设备和资本，又使民族工业在竞争中得到发展，标准的建立更迫切。标准化就是竞争中的一个游戏规则。虽然标准不是保护本国的产品不受外国竞争的影响，而是保证有平等竞争的环境
和条件，但是如果没有自己的标准，既使国外的技术进入无章可循，也使我国的防腐工业在竞争中得不到合理的保护，技术劣势更突出。WTO 制定贸易技术壁垒协定（TBT）来减少和消除不必要的技术壁垒，实际上技术壁垒不仅是存在而且是各国保护自己利益的惯用手法。欧盟、美国及日本积极利用标准化以发展和保护各自的工业，都取得了明显的成效。技术标准是合理和合法的维护我国产业利益的主要手段。TBT 中也规定：在标准的制定、实施方面，如果由于气候、地理因素或基本技术问题等，某种国际标准不适用时，则不要求勉强与该标准一致。木材防腐是以生物（真菌、昆虫）为主要研究对象，与气候条件直接相关，而这些都是有地域性的，在我们制定和执行标准时应当充分考虑和领用这些特殊性，一方面保证国外技术和产品在国内的使用效果，也使自己的工业受到合法的和合理的保护。

现在已经有了国外防腐木材产品进入国内市场，但还不多，我们自己正在努力开发市场。一旦国内市场逐渐成熟和发展，国外资金和技术大力进入参与竞争是必然的，为了我们自己的努力不是仅为别人作嫁衣裳，我们需要增进自己的标准。

3. 关于木材防腐标准化的一些建议

3.1 农管理部门的重视是最重要的，能否尽快建立起我国木材防护工业相关的标准的关键。由于木材资源、生产、加工、科研是林业部门管理，木材防腐产品的应用则是和建设、农业、材料等部门密切相关。所以政府各部门的协调是很重要的，如果能够尽快成立行业协会，将能在这方面发挥一定的作用。

3.2 标准制定的轻重缓急。标准的制定是需要时间的，尤其是国家标准。当前我认为急需确定我国防腐木材标准化的架构和建立与完善某些基础性的标准，比如以下将要提及的载药量单位、防腐木材使用环境等级等。对没有国家标准而又急需时鼓励制定地方和企业标准。广东省已经立项制定农用防腐木材的产品标准，因为农用竹木支撑是有地方特点和近期会有较大发展的产品，亟需建立标准。“国家鼓励积极采用国际标准”（标准化法及其释义），“包括国际标准和国外先进标准”。但是，这里“采用”的含义是指“把国际标准和国外先进标准的技术内容纳入我国标准，并贯彻执行”还有一些建议性的标准如分析测试方法等可以放缓或直接使用国际标准。

竹子是我国的重要资源，竹材的应用越来越受到重视。竹子的防腐、防霉问题已经越来越突出，相关标准还没有国际标准可参照，需要尽快研究和制定。

3.3 木材防腐碳化中有一些是基础性的，它们的确定不但对其他标准制定，而且对技术发展和应用都有很大影响。比如二氧化碳和木材关系是重要的。我们发现澳大利亚和新西兰改用防腐剂重量/木材重量，即 kg/kg 来表示载药量，而不是习惯采用的重量/木材，即 kg/m³。据澳大利亚专家介绍，采用后者更科学、更准确、使用方便和有利于节约防腐剂、降低成本。对于阔叶树木材，由于芯材不能渗透，而且占较大比例，采用 kg/m³是会造成大的误差。如果采用新的单位，牵涉到很多标准。此外还需要一些基础的研究，如各种材的密度和吸药量的测定。防腐木材应用的环境分类，是所有防腐木材产品应用标准的基础。美国分 5 级（UC1-UC5）和阻燃木材 1 级 2 级（UCFA-UCFB），有的级别再分类，共有 12 类；欧新标准分 6 级（H1-H6），比较简明。据 ISO 标准将分 5 级。我们没有这一标准，亟需建立，并应考虑到国际标准接轨。

3.4 一个供讨论的问题。迄今木材防腐虽然在防腐剂的毒性、使用中对环境的影响等问题有过很多争论，其中防腐材使用后的处理是普遍共识的问题之一。防腐木材工业化生产至今有 100 多年，过去用后弃置产生的问题已经越来越突出。有研究利用对 CCA 耐受性好的真菌来处理废弃材，已经筛选出可用的菌种。但是这样处理是否实际可行上有待时间证明。循环经济与知识经济被认为是世纪之交国际社会的两大趋势。循环经济的
所谓“减量化、再利用、资源化”（Reducing, reusing and recycling）原则，一是节约原料；二是材料再用；三是把废弃物作为资源，使环境影响最小。在农用防腐材的推广应用中，我们觉得防腐处理的竹木材使用6-8年是合理的，使用寿命终结后如何处理将是个大问题，由农民自己去掩埋是不可行的，当燃料是不允许的，其他方法处理都将造成环境问题。如果回收，则是一次原料资源，也可以降低农业成本，避免环境的问题。既然不需要长寿命，就可以用抗流失性较差、成本低、低毒性的防腐剂。使用周期短，也增加对木材的需求，对促进人工林发展也有利。随着社会的发展，很多产品的更新周期短了，使用寿命越长越好的观念在改变。防腐木材也一样，除了农用材外，还有很多用途的防腐木材并不是越耐腐越好，如包装用材，甚至某些建筑、园林用材，使用中可能由于机械损伤、风化等造成损坏。

木材是一种量大、使用较集中的材料，容易回收，旧木料的再利用国外已经有较成熟的经验。所以，在标准制定中考虑循环再利用是否必要和可行？值得研究。当然，这还需要科研工作的支持；

3.5 区域问题。木材防护是针对生物的。不同地区有不同的昆虫、真菌和细菌，同一产品在不同地区使用效果自然有不同。美国AWPA标准中就包含使用环境分区分，全国根据环境对木材造成破坏的危险程度分5个使用环境区（deterioration zones）。我国幅员广阔，气候有热带、亚热带和温带，从海洋性到大陆性气候，物种差异更大，制定标准时似应考虑区域，不仅产品使用范围应有地域差异，而且通过不同的地域试验来确定技术标准参数；

3.6 “标准化是一种人类的活动，包括制定和执行。”标准制定是基础，有了标准，实施和执行就是最重要的。标准的实施一方面靠企业的自觉，二是靠行业的自律，三是靠政府管理部门的监管。后者是强制的、必须的。如何执行，澳大利亚的“昆士兰市场的防腐处理木材质量的ABC监理系统”（The QFRI’s “ABC” System for monitoring the quality of preservative treated timber sold into the Queensland market）可以借鉴，它是一种认证制度，产品受检测通过才能生产，以后定期检查，三次检测不合格则禁售。

执行需要一个机构，这个机构应具有：一、权威性。机构需要得到政府有关部门的认证和授权，具备执法功能，并能出具有法律效力的文件、证据；二、科学性。它应有对产品作科学检测和鉴定仪器设备和技术水平，并能保持与行业的发展相适应，不断改善监督检测手段，研究开发能够快速监测的方法，实现监督监测手段的现代化；三、公正性。它不直接参与商业活动或从执行中直接获取利益。

此外，如上（3.5）所述的区域差异原因，我国地理幅员广大、行政管理职能和木材防腐工业的发展地区差异，分地区设置机构是需要的；

3.7 培养行业的标准化人才。标准化需要专门的人才，这里引用一段话：“日本为了更好地参加国际标准化活动，准备大量培养以民间企业为主的国际标准化人才。对国际标准化人才的要求标准很高，要求英语水平高，有渊博的知识，是该领域的技术或标准化的专家；掌握整个国际技术和经济状况的动向；知道自己所属企业、产业在国内及世界上的竞争能力与位置，以及与该技术有关的国外企业和产业的动向；懂得该领域企业和产业的发展战略和有关国家政府的政策策略等。有很好的语言表达能力，能充分向有关各国和各企业的专家说明采用日本标准提案将会给世界上带来的好处。

国务委员吴仪在2002年7月26日召开的全国采用国际标准工作会议说：“国务院各部门和各级政府。对涉及标准制定、基础标准、方法标准以及保证国家安全、保障公共健康和维护民族产业等一些重要标准方面，要在人力、物力和财力上给予支持。”相信木材防腐有关的标准建立和标准化问题必将收到重视，并期望在行业发展发挥应有的作用，促进我
Standardization for the Development of Timber Preservation Industry

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Abstract

The timber preservation industry is small in scale in China. But it is expected to develop rapidly in the near future, in the more developed area such as the south-east coast region in particular. Establishment of standards and monitoring systems are critical for the industry to grow healthfully and to create an impartial environment as well for the competition, which will certainly occur. Some suggestions are put forward and some questions are raised for discussion in this paper.

Keywords standardization, timber preservation, suggestion
Do CCA treated support stakes cause increased arsenic level in crops?

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Prepared for the 34th Annual Meeting
Brisbane, Australia
18 – 23 May 2003

IRG Secretariat
SE-100 44 Stockholm
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Do CCA treated support stakes cause increased arsenic level in crops?

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Abstract

Trial of using CCA-C treated eucalypts stakes for supporting banana plants in Guangdong Province, China, began in 1998 and later it was expanded as a demonstration program of a joint International Tropical Timber Organization-Chinese Government timber preservation project in 2000. The greatest concern was whether the crop would be contaminated by the preservatives, arsenic in particular. Data from four years tracking analysis of bananas collected from the demonstration plots indicated that the arsenic levels were not significantly higher than the levels found in plants supported by untreated stakes. The arsenic content in bananas supported by preservative treated stakes was well below the level specified in food standards of China. Similar results were obtained from a trial of tomatoes and garden peas supported with treated eucalypts and round bamboo posts in pottery pots.

Key words
CCA, crop, arsenic content, contamination

Introduction

CCA was developed and patented in India in 1933 and is widely used throughout the world for treatment of many types of timber commodities which have been made from many kinds of timber species. CCA preservative has been used in China for treatment of sleepers (ties) and mining poles since 1986 but there are no reports to indicate that CCA treated timber has ever been used in agriculture.

Guangdong Province is located in a tropical and subtropical zone of China. Fruit and vegetables are the main crops in this area. Huge amount of wood stakes and round bamboo are used to support the plants. For example, there are about 70 thousand hectares of banana plantation which needs approximately 0.5 million cubic meter of small logs or round bamboo poles to support the plants. The service life of untreated stakes is only 1 to 2 years. Agriculture is a big potential market for preservative treated timber.

Use CCA-C treated eucalypts stakes to support banana plants began in 1998 as a trial of the Guangdong Provincial Government with a project called "Preserved Timber used in Agriculture". In 2000, the International Tropical Timber Organization-Chinese Government joint project "Development and Extension of Preservation Technology of Tropical Plantation Timber" continued this trial and expanded it as a demonstration program.

CCA treated timber has been widely used in many countries for decades for tomato stakes, grape stakes, mushroom trays and planter boxes with no known adverse effects (Gilbert et al 1981). No
evidence was found suggesting uptake and translocation of wood preservative components into the leaf and stem tissue and fruit of plants from adjacent treated posts (Levi et al., 1974). But other reports revealed that elements in CCA treated timber or contaminated soil could be taken up by plant’s root system and the arsenic level in the plant increased (Cooper et al, 1995, Grant et al., 1977). Studies showed a different uptake of elements for different plant species. The concentration of contaminants in different parts of the contaminated plant was also different. (Cooper et al, 1995).

Arsenic is one of the active ingredients in CCA formulations. The trivalent salt of arsenic, “Pishuang” in Chinese, is well known to everyone in China as a most toxic poison as many historic fictions have used it for suicide and murder. The safety of treated timber which contains arsenic is an especially sensitive issue when used in agriculture. A scientific assessment of the risk to health of arsenic treated timber is therefore necessary for the use of this technology in agriculture.

The objective of this study was confined to establishing the arsenic concentration in the edible portion of the plant and to provide data to prove that the use of CCA treated timber in agriculture is safe or not. The species we studied were bananas, tomatoes (*Lycopersicon esculentum* Mill.) and garden peas (*Pisum sativum* L.) because they are the main species that have great potential demand for treated stakes.

**Treated material and test methods**

*Eucalyptus urophylla* logs, with a D.B.H. about 6-8 cm and 4-5m in length, from plantations 3 years old were used for the banana support posts trial. They were air dried to the moisture content lower than 20% and vacuum-pressure treated with CCA-C. The target retentions for trial were 6.4 kg/m³ and 9.6 kg/m³. But the measured retentions determined by weighting samples before and after treatment were in two ranges, 7.2 kg/m³ to 8.1 kg/m³ and 10 kg/m³ to 11.7 kg/m³ respectively. Most of the stakes/posts were fully penetrated except a few with a small portion of heart-wood.

The stakes/posts with the same retention range were used in a plot with the area of about 3 × 20 meters. Each plot was separated by a water channel for irrigation (Figure 1). One or two stakes/posts were installed next to the plant to a depth of 50cm to 60cm into the ground.

Only bananas from the plants supported by stakes/posts of the lower retention, 7.2 kg/m³ to 8.1 kg/m³ were collected for analysis in this study because 8 years service life was considered to be appropriate. The first trial plots were set up in August 1998 at Panyu, Zhongshan and Gaozhou respectively. Panyu and Zhongshan are in the Pearl River Delta area and Gaozhou is located in the south of the province in the tropical weather zone. They are the main banana production areas in

![Figure 1: supporting post was installed (Panyu, 1998)](image)
The first samples collected for test were from Panyu in September 1999, one year after the stakes/poles were installed and then again the second sampling in September 2000. The samples for third and fourth year’s analysis were from Zhongshan and Gaozhou respectively.

Because banana plants are cut down every year after harvest, not every plant bears mature fruit at the collecting time, bananas for analysis were collected randomly from the same plot. Nine samples, each about 1 kg, were picked for testing. Nine samples were taken from an adjacent plot with untreated stakes for control.

Vegetable trial
The vegetable trial was began in September and October 2001 and crops were harvested for test in February 2002. The plants grew in 30mm diameter pottery pots filled with soil obtained from a nearby forest. To prevent the interference from environment, the pots were put on other smaller pots so that the root system was not able to touch the ground (Figure 2 & Figure 3). During the whole growth period, no chemicals, fertilizer or pesticide were used.

The tomato trial used CCA treated eucalypts stakes which were the same as used in the banana plant tests. Treated bamboo was used in both the tomato and garden pea trial. The bamboo poles were pressure treated with 2.3% CCA–C solution. But the retention was not determined.

The tomato plants were tested in six groups and each group had six plants. One group, also had six plants, with untreated supporting stakes, that were used as controls. The garden pea trial was arranged in the same method as tomatoes. Fruit (peas and tomatoes) were collected when they were matured and kept in a refrigerator until there was about 1kg in weigh for each group. Because no fertilizer and pesticide were used, plants didn’t grow well and the fruit was seriously damaged by insects. Only 4 plants of tomato in the control group and 5 plants of garden pea in the control group were bearing enough fruit for test.

Analysis and results
Bananas were peeled and fruit of each group were well mixed before analysis. The analysis was carried out according to the Chinese Standard(GB/T 5009.11-1996) and was conducted by the
Center of Analysis and Test, Guangdong Institute of Eco-Environmental and Soil Sciences. The results are as shown in the following charts. Arsenic concentrations in cropping is expressed as mg/kg based on fresh weight.

![Graphs showing arsenic concentrations in crops](image)

**Figure 1:** Arsenic Concentration in crops - mg/kg in fresh (○-supported with treated stake, □-supported with treated bamboo, △-supported with untreated stake)

**Conclusion**

1. Both sets of results, the 4 years tests on the bananas from the plants supported with CCA-C treated stakes and the trial of tomatoes and garden pea growth with CCA-C treated posts, indicate that the arsenic level is not significantly higher than the level from plants supported by untreated stakes and,

2. The arsenic concentration in bananas or garden peas or tomatoes from plants with CCA-C treated stakes was well below the level, 0.5 mg/kg, specified in food standards of China (GB
3. The 1999’s analysis data shows a higher arsenic level in fruit grown on both treated and untreated posts. This might be because the use of chemical, fertilizer or insecticide. Whatever the cause is, it doesn’t affect the above conclusions.

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Laboratory and Pilot Evaluation of Chlorothalonil Formulations for Mold and Stain Control on some Wood Species

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Paper prepared for the 34th Annual Meeting
Brisbane, Australia
18-23 May 2003

IRG Secretariat
SE-100 44 Stockholm
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Laboratory and Pilot Evaluation of Chlorothalonil Formulations for Mold and Stain Control on Some Wood Species

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ABSTRACT: Laboratory and pilot test of the efficacy of several fungicides such as chlorothalonil and carbendazim for control of mold and sap-stain on bamboo and slash pine and rubberwood were conducted in this paper. The results indicate that:

- Chlorothalonil/carbendazim are more effective for controlling mold and stain than that of carbendazim alone in laboratory test.
- Higher concentration at 0.1-0.2% of chlorothalonil with 0.05-0.1% carbendazim or 0.05-0.1% carbendazim alone are more effective for stain and mold control on slash pine than the formulations of lower concentration in the pilot test.
- The mixture formulations of 0.1-0.5% chlorothalonil/carbendazim are more effective than 0.5% NaPCP or 0.2% carbendazim alone in controlling mold and fungi in rubberwood pilot test.

KEYWORDS: chlorothalonil, carbendazim, wood, stain, mold

1. INTRODUCTION

Chlorothalonil is an agricultural fungicide and it also has been used for controlling certain spectra of wood stain fungi. The most important advantage of chlorothalonil is that it is highly effectively on most fungal species and environmentally friendly if it is properly combined with other fungicides such as copper oxine, MBT and carbendazim etc [1-10]. Some potential commercial formulations containing chlorothalonil for controlling wood stain and mold fungi have been developed in recent years, such as Tuffbrite C (a.i. chlorothalonil and carbendazim), Tuffbrite 404 (a.i. chlorothalonil and copper oxine), NeXgen (a.i. 14.5% chlorothalonil and 14.7% MBT), etc.

Chlorothalonil is a potential alternative preservative to sodium pentachlorophenate (NaPCP), which is strictly restricted or prohibited in some countries but is currently widely used in China for stain and mold control [10,11]. The products of bamboo are floors, handcrafts, poles etc in China. Mold occurrence is a
main factor that restrains its various uses. Pine wood species such as slash pine and masson pine etc are very susceptible to sapstain fungi such as *Ceratocystis imperfecta* and *Botryodiplodia theobromae* Pat [12] and rubberwood susceptible to *Botryodiplodia theobromae* Pat [9] after fresh cut or during air-drying process and moisture content in wood is relatively high. The purpose of this paper is to determine the effectiveness of chlorothalonil formulations for controlling mold and stain on some wood such as bamboo, slash pine and rubberwood.

2. MATERIAls AND METHOD

2.1 Wood Sample and Fungi

The sample size of bamboo [*Phyllostachys heterocyci*a var. *pubescens* or *Ph. edulis*] for laboratory test: 50(L)×4(R)×2(T) mm.

Fungal specie in laboratory test: *Aspergillus niger, Penicillium sp., Trichoderma sp.*

The samples of slash pine (*Pinus elliottii*) for pilot test: disks with diameter of 15-20 cm and thickness of 5 cm. Dipping treatment of formulation 1-8 for 1 min while 9 was dipped in water. Slash pine test site: Guangzhou, Guangdong, China, June 2001.

Rubberwood fresh disks, diameter 5-20 cm, thickness 5 cm; Rubberwood fresh sawntimber, 35×65×500 mm; Rubberwood fresh and just dried veneer, 15×10×2 mm. All rubberwood samples were dipped in formulation 10-16 for 5 min, while 17 was dipped in water. Rubberwood pilot test site: Hainan Island, China, July to August, 1997 and June 2001.

2.2 Exposure to fungi

Bamboo samples were incubated with the above fungal species after dipping the samples in the solutions for 15 seconds according to ASTM D-4445-91. The data were collected after 3-week incubation. Four replications of bamboo for each formulation in laboratory test.

Slash pine disks and rubberwood samples were exposed to natural air for a period to survey natural occurrence of fungal infection after treatment in Guangzhou and Hainan of south China respectively. The data were collected after 19 and 29-day exposure for pine and 9 and 19-day for rubberwood respectively. Three replications of slash pine disks and rubberwood samples for each formulation were used in this pilot evaluation.

2.3 Chemicals

Chlorothalonil (F1) and carbendazim (F2) wetable powder or emulsion, untreated and NaPCP treated for comparison.

2.4 Ranking Standard

According to ranking standard of USDA Forest Service, Forest Products...
Laboratory.
1 - Clean: stain or mold covering less than 5% upper surface.
2 - Light stain: stain or mold covering 5-20% upper surface.
3 - Moderate stain: stain or mold covering 20-40% upper surface.
4 - Heavy stain: stain or mold covering more than 40% upper surface.

3. RESULTS
Table 1 indicates that 0.2% F2 alone is not effective as it was with F1 together for controlling Penicillium sp. and Trichoderma sp. The reason is that each fungicide has its spectral limit for fungal control. So the combination of fungicide might extend their spectra of fungal control. The formulation of lower concentration of F1/F2 such as 0.05% F1 + 0.13% F2 is also not effective as the formulations of higher concentration 0.1% F1 + 0.27% F2 and 0.15% F1 + 0.4% F2.

Table 1. Comparison of the effectiveness of anti-mold treatments on bamboo in laboratory test

<table>
<thead>
<tr>
<th>Anti-mold Treatment</th>
<th>Average ranking ± standard derivation</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aspergillus niger</td>
<td>Penicillium sp.</td>
<td>Trichoderma sp.</td>
</tr>
<tr>
<td>Untreated Control</td>
<td>2.0±0.0</td>
<td>4.0±0.0</td>
<td>4.0±0.0</td>
</tr>
<tr>
<td>0.05% F1 + 0.13% F2</td>
<td>1.5±0.0</td>
<td>2.0±0.0</td>
<td>4.0±0.0</td>
</tr>
<tr>
<td>0.1% F1 + 0.27% F2</td>
<td>1.0±0.0</td>
<td>1.0±0.0</td>
<td>1.0±0.0</td>
</tr>
<tr>
<td>0.15% F1 + 0.4% F2</td>
<td>1.0±0.0</td>
<td>1.0±0.0</td>
<td>1.0±0.0</td>
</tr>
<tr>
<td>0.2% F2</td>
<td>1.0±0.0</td>
<td>2.0±0.0</td>
<td>3.0±0.0</td>
</tr>
</tbody>
</table>

Table 2. Comparison of the effectiveness of anti-stain and mold treatments against disks of slash pine in pilot test

<table>
<thead>
<tr>
<th>Formulation Number</th>
<th>Active ingredients %</th>
<th>Average Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F1</td>
<td>F2</td>
</tr>
<tr>
<td>1</td>
<td>0.05</td>
<td>0.1</td>
</tr>
<tr>
<td>2</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>3</td>
<td>0.1</td>
<td>0.05</td>
</tr>
<tr>
<td>4</td>
<td>0.1</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0.05</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td>7</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9 (untreated)</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Formulations 2 and 4-7 are more effective than other formulations for controlling natural fungal species at Guangzhou from the results in table 2. As the result of laboratory test, the formulations of higher concentration at 0.1-0.2% of F1 with 0.05-0.1% F2 or 0.05-0.1% F2 alone are more effective for stain and mold control than the formulations of lower concentration in this pilot test. The results from other related test suggest that formulation of chlorothalonil/carbendazim might be used for mold and stain control by the local wood processing industries.

Table 3. Comparison of the effectiveness of anti-stain and mold treatments against rubberwood disks, veneer and sawn timber treated with chlorothalonil formulations and NaPCP in pilot test

<table>
<thead>
<tr>
<th>Treatment No</th>
<th>Active ingredients</th>
<th>%</th>
<th>Disks 9-day 18-day</th>
<th>Veneer 9-day 18-day</th>
<th>Timber 9-day 18-day</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.50 F1 0.10 F2 0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>11</td>
<td>0.50 F1 0.15 F2 0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>12</td>
<td>0.25 F1 0.10 F2 0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>13</td>
<td>0.25 F1 0.15 F2 0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>14</td>
<td>0 0.20 F1 0 0 0 0</td>
<td>1.0</td>
<td>1.0</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>15</td>
<td>0 0 0.50 0 0 0 0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>3.0</td>
</tr>
<tr>
<td>16</td>
<td>0 0 1.0 0 0 0 0 0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>17 (untreated)</td>
<td>0 0 0 0 0 0 0 0 0</td>
<td>2.0</td>
<td>3.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

The mixture formulations of 0.1-0.5% chlorothalonil/carbendazim are more effective than 0.5%NaPCP or 0.2% carbendazim alone in controlling mold and fungi during rubberwood veneer test (table 3), the result is much similar to that of laboratory evaluation for rubberwood [10]. Each formulation 10-16 in table 3 is effective in controlling mold and fungi in the timber and disk test. Other formulations containing low concentration of 0.01%F1/0.02%F2 together with 3.25% borax/boric acid are effective for stain and mold control by pressure treatment [12].

4 CONCLUSIONS

1. Chlorothalonil/carbendazim are more effective for controlling mold and stain than that of carbendazim alone in laboratory test.
2. Higher concentration at 0.1-0.2% of chlorothalonil with 0.05-0.1% carbendazim or 0.05-0.1% carbendazim alone are more effective for stain and mold control on
slash pine than the formulations of lower concentration in this pilot test.

3. The mixture formulations of 0.1-0.5% chlorothalonil/carbendazim are more effective than 0.5%NaPCP or 0.2% carbendazim alone in controlling mold and fungi in rubberwood pilot test.

Fig 1, 1-8 means F1/F2 and NaPCP formulation treated disks of slash pine, ratios of 1-8 are described in table 2, 9 means untreated disks.

REFERENCE
1. Woods T L. Chlorothalonil as a New Wood Preservative. Wood Preservation Beyond '90, Forest Products Society
4. Woods T L et al. Evaluation of the Effectiveness of In the Control of Sapstain in the Laboratory and Field Tests. IRG/WP 92-3718
8. Wakeling R, Maynard P. Laboratory & Field Trials of Novel Antisapstain Formulations. IRG/WP 97-30146


Introduction

In November 2000, the Guandong Forest Research Institute (GDFRI) started a project supported by the International Tropical Timber Organisation (ITTO) and the Government of the Peoples' Republic of China. The principle purpose of the project was to extend the processing and utilisation technology, especially preservative treatment, of timber from the tropical plantations of South China.

While the project's principle focus has been technical implementation issues, from the outset it was recognised that a key aim of the project was assessment of the economic competitiveness of treated timber given the undoubted environmental benefits of replacing existing non-renewable materials with long service life, natural, renewable products such as treated timber. This also promises to provide a potentially high value use for the large volumes of plantation thinnings now becoming available.

It is also considered that the lack of general public and timber user awareness of treated timber and its advantages over untreated timber and other alternative products, means that potential consumers will be price sensitive especially until the quality, and therefore value in use, of treated timber can be properly established. This makes it imperative that a reasonably accurate estimate of the whole of life cost associated with the adoption of timber preservation technology in the Guandong market is undertaken. As such, one element of the project has been the development of an economic model estimating the whole of life cost of a timber treatment plant and the associated average treatment cost which will need to be recovered if a timber preservation business is to be financially viable in Guandong Province.

Modelling Approach

In order to estimate this average treatment cost a financial model of a typical greenfields treatment plant located in Guandong has been constructed. This model is based on current proven technology. The model uses a discounted cash flow analysis in which the whole of life costs are discounted to estimate the present value of all future costs and these are divided through by the discounted volume of material produced over the life of the project. This gives an estimate of the levilised cost per unit of production.

The functional form of this relationship is given by:

\[
\text{Levilised Cost per m}^3 = \frac{\sum_{i=0}^{T} (\text{Cost}_i \times (1 + r)^{-i})}{\sum_{i=0}^{T} (\text{Volume}_i \times (1 + r)^{-i})}
\]

Where:
- \(i\) = project year between commencement in year 0 and termination in year \(T\)
- \(r\) = discount rate or cost of capital
- Cost = capital and recurrent cost incurred in year \(i\)
- Volume = Volume of treated material produced in year \(i\)
While pricing decisions at any point in time are likely to vary from this figure, possibly significantly, due to normal competitive market pressures, this levellised cost represents the average price for treating a unit of timber which must be achieved in present value terms if the project is to generate an acceptable financial return.

If producers are to adopt this technology they must be convinced that it is financially viable and that consumers will be willing to pay a premium sufficient to allow a reasonable return on the significant capital investment required to establish a timber preservative treatment plant.

**Model Assumptions**

In constructing this financial model, it has been necessary to make a number of assumptions about the most appropriate technology for a preservation treatment plant in Guangdong. For this project, assumptions have been based on the experience of the project leader Mr Li Zhaobang with the development of the GDFRI's research treatment plant in Guangzhou together with the experience of the Takasho Wood Treating Company in developing a commercial treatment plant in Yunan and information from the variety of commercial treatment plants in Australia. While the exact value for each variable is currently being finalised, it is possible to outline the critical questions that drive each of these assumptions.

**Type of technology**

The treatment technology adopted is the initial driver of the financial model. This technology may be as basic as dipping timber in a chemical bath through to use of vacuum pressure technology. For this project, the use of vacuum pressure technology is considered appropriate for the type of products desired (eg long life treated pinus and eucalyptus material).

**Scale**

The scale of the treatment plant will have a significant impact on total capital costs and is also likely to be a major driver of the level of automation adopted. In practical terms the scale of the plant should reflect the type of products being produced and the level of likely demand for those products. For this project, the optimum initial plant was selected as a pressure vessel with a volume of around 15m³ capable of taking a timber charge in the order of 5 to 6 m³. This plant is easily capable of producing in excess of 2,200m³ per annum of treated timber products working one shift with two charges per shift. This would represent approximately 550 2400mm*75mm*50mm pieces of timber per charge or nearly 250,000 such pieces per annum. A reasonable maximum production on a three shift, 6 day week, 50 week year with three charges per shift could be 13,500 m³ per annum or some 1.5 million pieces (or more).

**Chemicals**

The plant is assumed to use water borne preservatives. There are a range of chemicals that could be used such as CCA or ACQ. The choice of chemical will have a significant impact on recurrent costs as ACQ is likely to be two to three times the cost of CCA.
Treatment Vacuum

The treatment vacuum will have a major impact on capital costs as achieving higher vacuum levels requires significantly better vacuum pumps. The choice of maximum vacuum will be determined by the material to be treated. For this project, timber available for treatment is likely to be either pinus or juvenile eucalyptus. This material can be successfully treated using a maximum vacuum of -80kPa. If older eucalypt material >15 or 20 years is to be treated a vacuum in the order of -95kPa would be required. This would involve significant additional capital expenditure and has not been considered necessary given the characteristics of the plantation material likely to be treated in Guandong.

Treatment or Retention Level

The desired level of preservative retention impacts on cost in a number of ways. Clearly, it is directly linked to the per unit cost of materials and it also impacts on the charge time discussed below. The decision on the treatment level will be related to the final use of the product and the life expectancy required in that use and as such is specific to the target market.

Charge Time

Charge time has the potential to significantly impact on plant capacity. The longer the charge time, the less number of charges that can be treated in a given period. Charge time will not only be a function of the treatment level required but also the specification or capacity of equipment such as vacuum and liquid pumps. As pumps and plumbing will have a strictly limited life (possibly around 5 years), it is possible to start with lower capacity equipment and upgrade as the markets develop. Given the likely treatment levels to be required, a charge time of around 2 hours is considered reasonable although it could potentially be reduced to as little as 1 hour.

Drying

Timber which is to be treated must be dried prior to treatment. This may be done either by air drying or use of timber drying kilns. The use of kilns requires significant additional capital expenditure but reduces timber holding time and associated need for such a large air drying area. It is considered likely that, at least initially, the use of air drying in Guandong would be appropriate.

Loading Technology

The approach used to load and unload the treatment vessel will impact both on capital cost and plant through put and is related to the type of pressure vessel being used. The pressure vessel choice in this context is between a 1 door and 2 door vessel. A two door vessel will significantly speed up loading and unloading but at the cost of a major increase in cost. This is related to the fact that the pressure vessel door represents a major component of the capital cost of the vessel. As such, a single door vessel is considered more likely.

The issue then becomes whether a single or dual rail track loading system is adopted. While a dual track system potentially promised greater flexibility, it also increases complexity and potential for operational problems. As such, the use of a single track with mechanised loading (such as use of a fork lift) is likely to be the preferred option.
Maintenance
In terms of the whole of life cost of a treatment plant, maintenance is not only a variable cost but will also impact on plant life and the capital replacement schedule.

Land Costs
Treatment plants require significant areas of land and this can be a major cost. Land may be purchased or leased and depending on the option selected this can impact on upfront capital cost or ongoing recurrent costs. Land costs will vary with location and the total area required.

Hardened Storage for Treated material
From an environmental perspective it is essential that the treatment plant has appropriate containment facilities to ensure that there are no offsite impacts. For example, freshly treated material should be kept on a hardened area that drains back to the treatment vessel to ensure that no chemical dripping off the charge contaminates the surrounding area.

Energy
Energy costs will impact in a number of ways. Firstly, as a recurrent variable production cost and potentially as a major capital cost in terms of ensuring a reliable supply of electricity.

Waste Management
Appropriate treatment of waste products is essential especially in terms of contaminated waste such as sludge from the treatment storage tanks. Generally, sludge will be either immobilised and placed in storage or recycled.

Staff
The level of staffing will be a function of the technology adopted and the resulting level of automation such as the degree of use of forklifts and other machinery.

Site Rehabilitation
In constructing a whole of life model, it is essential to determine the project life and to provide a sufficient allowance for the rehabilitation the treatment plant site at the end of its useful life.

Miscellaneous Costs
The above cost categories are by no means exhaustive and in developing the financial model it is inevitable that many other additional costs will be identified.

Finalising the Model
Once the fundamental assumptions underpinning the financial model are finalised, it is necessary to collect estimates of the most likely current costs for the plant as specified in order to populate the model. As described above, these costs are both the capital costs of establishing the plant (and future refurbishment) and the annual costs of operating the plant.
There are a number of fundamental country differences between China and Australia that have a major impact on the optimal treatment plant we are modelling. Unlike China, the use of preservative treated timber is well established in the Australian market. In particular, CCA treated plantation grown softwoods are very popular for landscaping and building uses. Also, there are fundamental differences between the relative cost of capital and labour between the two countries. Due to a small population and high per capita GDP, labour costs are relatively high in Australia. This often leads to an increased reliance on capital investment in automation thereby reducing the reliance on labour.

As such, while the technical aspects of preservative treatment of timber may be directly translated between countries, it is critical that the financial modelling is based on the practical implementation in Guandong. The ongoing collection of this information has only been possible through the sustained work that has been undertaken by Mr Li Zhaobang and the staff of the Guandong Forest Research Institute. It is hoped that the financial modelling undertaken as part of this project goes some way towards assisting the introduction of a viable timber preservation industry in Guandong.
Determination of the Composition of Wood Preservatives by Routine Chemical analysis, A Comparison Study with the Instrument Method.

Abstract: Active components of arsenic, copper, chromium and boron in wood preservatives was examined with both routine chemical analysis and instrument analysis. Result shows little difference between the two analytical methods.

Forward
Wood preservatives contains active components, such as arsenic, copper, chromiuni and boron, etc. when treating wood, some water-soluble substance in the wood and a small amount of chemical reaction result accumulated in the preservative solution, correspondently the content of the active components in the preservatives changed. With recycle of preservative solution in wood treatments, amount of the active components reduced. If we can determine and supplement the content of the active components in time, we can improve production efficiency, reduce the cost, so as to control product quality and perfect the process.

There are two kinds of analytical methods: routine chemical analysis and instrument analysis. Generally, instrument analysis is a main used method, because of its stability, accuracy, high sensitivity ease and simplicity of manipulation and fastness. But the cost of the instrument is so expensively that it is unpractical to be used in controlling product quality in wood preservation treatment. Routine chemical analysis adopts the general chemical reaction principle, gets rid of and interfering elements, analyzes the elements one by one. Though its accuracy is not so high as the instrument's, but it is cheap, easy and simple to manipulate. Especially in the remote area with little instrument equipment, routine chemical analysis can replace instrument analysis in quantity monitoring.

Without standard of analytical method and quality index about wood preservatives in China, we adopted AWPA standard and other routine chemical analytical methods to analyze arsenic, copper, chromium and boron in wood preservatives. The result shows that windage between the two kinds of analysis methods is very small.

1. DETERMINATION OF ARSENIC IN ARSENIC CONTAINING PRESERVATIVES (As)

Principle
\[ 2\text{As}_2\text{O}_3 + \text{H}_3\text{PO}_2 = \text{As} \downarrow + \text{PH}_3 + 4\text{O}_2 \]
\[ 4\text{As} + 6\text{H}_2\text{SO}_4 = 2\text{As}_2\text{O}_3 + 6\text{SO}_2 \uparrow + 6\text{H}_2\text{O} \]
\[ 2\text{KBrO}_3 + 2\text{HCl} + 3\text{As}_2\text{O}_3 = 2\text{KCl} + 2\text{HBr} + 3\text{As}_2\text{O}_5 \]

Reagents
- Hydrochloric acid, concentrated.
- Hypophosphorous acid, 50%.
- Sulfuric acid, concentrated.
- Potassium bromate, 0.1000 normal - dissolve 2.784 g. of pure dry potassium bromate in distilled water and make up to 1.000 liter in a volumetric flask.
- Methyl orange - 0.1 percent water solution.

Analytical Procedure
1. Place the sample containing arsenic equivalent to about 0.03 g. of As$_2$O$_3$ in a 250-ml, wide-mouth Erlenmeyer flask and add sufficient water to make a total volume of about 50 ml.
2. Add 50 ml of hydrochloric acid.
3. Add 20 ml of hypophosphorous acid, mix thoroughly and warm the solution on a steam bath until a precipitate forms.
4. Boil the mixture gently for about 15 minutes.
5. With the aid of suction, filter the hot solution through a 10 ml Gooch crucible-containing glass microfiber filter or equivalent, washing the flask and precipitate thoroughly with water.
6. Place the crucible containing the precipitate in the same flask in which precipitation was carried out. Discard the filtrate.
7. Pour 10 ml of sulfuric acid into the flask and heat over an open flame, while agitating, until copious
fumes are evolved. (This should be carried out in a fume hood).
8. Allow the flask and contents to cool and then add 100 ml of water very slowly and carefully, especially at first, as much heat is generated during this addition.
9. Next add 5 ml of hydrochloric acid and 2 drops of methyl orange solution and immediately titrate with standard potassium bromate solution from a 10 ml class A buret.
10. When the solution becomes colorless the end point has been reached.
Calculations
\[(\text{ml KBrO}_3) \times (0.5746) / \text{grams of sample} = \% \text{As}_2\text{O}_5\]
Compare result for routine Chemical analysis and instrument analysis (As$_2$O$_5$ %)

### Table 1

<table>
<thead>
<tr>
<th>Number</th>
<th>routine Chemical analysis</th>
<th>instrument analysis</th>
<th>instrument-chemical</th>
</tr>
</thead>
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<td>0.253</td>
<td>0.227</td>
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<td>0.470</td>
<td>0.456</td>
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<td>3</td>
<td>0.760</td>
<td>0.686</td>
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<tr>
<td>6</td>
<td>1.232</td>
<td>1.296</td>
<td>+0.064</td>
</tr>
</tbody>
</table>

2. DETERMINATION OF COPPER IN COPPER CONTAINING PRESERVATIVES (Cu).

**Principle**

\[
\begin{align*}
K_2\text{Cr}_2\text{O}_7+8\text{HCl}+3\text{C}_2\text{H}_5\text{OH} &= 2\text{KCl}+2\text{CrCl}_3+3\text{CH}_3\text{CHO}+7\text{H}_2\text{O}, \\
\text{H}_2\text{AsO}_3+3\text{HCl} &= \text{AsCl}_3+3\text{H}_2\text{O} \\
\text{Cu}^{2+}+2\text{OH}^- &\rightarrow \text{Cu(OH)}_2 \\
\text{Cu(OH)}_2+\text{H}_2\text{SO}_4 &= \text{CuSO}_4+2\text{H}_2\text{O} \\
\text{Cu}^{2+}+\text{I}^- &= \text{CuI}+\text{I}_2 \\
\text{I}_2+2\text{S}_2\text{O}_3^{2-} &\rightarrow 2\text{I}^-+\text{S}_4\text{O}_6^{2-} \\
\end{align*}
\]

**Reagents**

Ammonium hydroxide; concentrated.
Hydrochloric acid, concentrated.
Sulfuric acid, concentrated.
Alcohol, methyl or ethyl.
Potassium iodide solution, 20 percent. Dissolve 20 g. KI in 80 ml. of water.
Sodium thiocyanate solution, 20 percent. Dissolve 20 g. NaCNS in 80 ml. of water.
Starch indicator solution. Make a paste of 1 gram soluble starch in about 5 ml. of water, add 100 ml water and boil for 1 minute with stirring. Cool and add 1 drop of chloroform. This solution is subject to decomposition and fresh solution should be prepared if a dark-blue color is not produced with a drop of tincture of iodine in 100 ml water on addition of a drop of indicator.
Acetic acid, glacial.
Copper foil or shot.
Nitric acid, concentrated.
Urea solution, 5 percent. Dissolve 5 g urea in 95 ml water.
Sodium thiosulfate solution, 0.1N. Dissolve 24.85 g Na$_2$S$_2$O$_3$.5H$_2$O in water, add 1.0 g. of Na$_2$CO$_3$ as a preservative and dilute to 1 liter. Keep in a brown bottle to standardize in 7-14 days.
Sodium thiosulfate solution, 0.05N. Dilute exactly 25 ml of the standardized 0.1N sodium sulfate solution to exactly 50 ml with freshly boiled distilled water, which has been cooled to room temperature. The normality of this solution, which should be made up immediately before use, is exactly 0.5 times that of the 0.1N solution.

**Analytical Procedure**

1. Place the sample should contain copper equivalent to about 0.02 g. of CuO in a 300-ml Erlenmeyer flask and add 10 ml water. Add 10 ml concentrated hydrochloric acid and a few glass beads. Add 15 ml alcohol carefully, warm to boiling and heat until all chromium is reduced, as evidenced by the absence of any yellowish-green color. The solution should be clear bluish-green. (With ammoniacal copper arsenate a hood
should be used for the boiling.)
2. Wash down side of flask with water. Boil for 1 minute, cool and neutralize cautiously with concentrated ammonium hydroxide until a permanent precipitate just forms. With samples containing small amounts of copper, a precipitate may not form. In this case, adjust the pH to slightly basic with concentrated ammonium hydroxide as measured with pH indicating paper. Add concentrated sulfuric acid drop by drop until the precipitate just dissolves or until the solution becomes acidic. Boil down to a volume of 30 ml. Cool to below 20°C. Dilute to 125 ml.
3. Add 10 ml 20 percent potassium iodide solution and 5 ml 20 percent sodium thiocyanate solution and mix thoroughly by rotating the flask. Titrate from a 10 ml Class A buret with 0.05N sodium thiosulfate solution, adding 2 ml starch indicator just before the brownish color of the iodine disappears. Stop the titration when the color changes from dark blue to light green. With ammoniacal copper arsenate, the end-point change is from dark blue to cream color. (If poor end-points or checks are obtained).
4. For standardization of the 0.1N sodium thiosulfate solution: Dry the potassium bichromate to a constant weight in an oven of 130°C. Accurately weigh approximately 0.15g into a 250ml Erlenmeyer and dissolve in distilled water (20–30ml). Add 10ml 20 percent potassium iodide solution and 5ml 6N sulfuric acid, swirl, and store in a dark room for 5min. Dilute to 100ml with distilled water. Then titrate with sodium thiosulfate solution until the solution color changes from dark brown to light tan. Add 5ml 0.2 percent fresh starch indicator and continue the titration until the solution color just changes from dark blue to green. Then:

\[
\frac{\text{grams potassium bichromate} \times 6000}{294.21 \times \text{ml titration}}
\]

Calculations

\[
\text{(ml Na}_2\text{S}_2\text{O}_3)(\text{Normality Na}_2\text{S}_2\text{O}_3)(\text{Aliquot Factor}(7.96)) / \text{Grams of Sample} = \% \text{CuO}
\]

Compare result for routine Chemical analysis and instrument analysis (CuO%)

<table>
<thead>
<tr>
<th>Number</th>
<th>routine Chemical analysis</th>
<th>instrument Analysis</th>
<th>instrument—chemical</th>
</tr>
</thead>
<tbody>
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<tr>
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<td>6</td>
<td>0.458</td>
<td>0.451</td>
<td>-0.007</td>
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</table>

3. DETERMINATION OF CHROMIUM IN CHROMIUM CONTAINING PRESERVATIVES (Cr)

**Principle**

\[\text{K}_2\text{Cr}_2\text{O}_7 + 7\text{H}_2\text{SO}_4 + 6\text{FeSO}_4 = 3\text{Fe}_2 (\text{SO}_4)_3 + \text{Cr}_2 (\text{SO}_4)_3 + \text{K}_2\text{SO}_4 + 7\text{H}_2\text{O}\]

**Reagents**

- Phosphoric acid, 85% (sp. gr.- 1.71).
- Barium diphenylamine sulfonate solution- 0.20g.
- Barium diphenylamine sulfonate made up to 100 ml. with water.
- Ferrous ammonium sulfate-sulfuric acid solution- 50 g. of ferrous ammonium sulfate (Fe(NH)_4)SO_4*0.61H_2O) and 25ml of concentrated sulfuric acid made up to one liter with water.
- Sulfuric acid, 1:1 solution - add one volume of concentrated sulfuric acid slowly and with constant stirring to one volume of water. Cool before use.
- Potassium dichromate solution, 0.2006N – weigh 9.807 g. of oven-dry potassium dichromate into a 1-liter volumetric flask and adjust to a volume of exactly 1.000 liter with water at laboratory temperature.

**Analytical Procedure**

(The analysis should be performed as soon as possible after sampling.)

1. Place the sample should contain chromium equivalent to about 0.03 g. of CrO_3 in a 500-ml Erlenmeyer flask and add sufficient water to make a total volume of about 200 ml.
2. Add 3 ml. of phosphoric acid and 6 ml. of 1:1 sulfuric acid and stir the solution well.
3. Immediately pipet exactly 10 ml. of ferrous ammonium sulfate solution into the solution and add 10
drops of barium diphenylamine sulfonate solution.
4. Immediately titrate the solution with standard 0.2000 normal potassium dichromate solution from a 10 ml. class A buret.
5. The end-point has been reached when the color of the solution becomes deeply purple or deep greenish.
6. Titration of ferrous ammonium sulfate solution alone - Pipet exactly 10 ml. of the same ferrous ammonium sulfate solution used in the foregoing determination into another 500-ml. Erlenmeyer flask. Dilute to about 200 ml., add 3 ml. of phosphoric acid; 6 ml. of 1:1 sulfuric acid and 10 drops of barium diphenylamine sulfonate and titrate with standard potassium dichromate solution from a 10 ml. class A buret. Ferrous ammonium sulfate solutions change strength quite rapidly. This solution should, therefore, be restandardized at frequent intervals.

Calculations
The difference between the titration of the ferrous ammonium sulfate solution alone and that of the ferrous ammonium sulfate solution plus sample is the measure of the hexavalent chromium content of the sample

\[
\%K_2Cr_2O_7 = \frac{294.19 \times N(V_2 - V_1) \times 100}{m \times 6000}
\]

Compare result for routine Chemical analysis and instrument analysis (CrO\textsubscript{3}%)

<table>
<thead>
<tr>
<th>Number</th>
<th>routine Chemical analysis</th>
<th>instrument analysis</th>
<th>instrument-chemical</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

4. DETERMINATION OF BORON TRIOXIDE IN BORON CONTAINING PRESERVATIVES (B)

Principle

\[
H_3BO_3 + 2[RCH-O]^{+} + 2OH^- \rightarrow [RCH-O]^+ + B_2O_3^{-} + 3H_2O
\]

\[
H^+[RCH-O]^+ + NaOH \rightarrow Na^[RCH-O]^{-} + B_2O_3^{-} + H_2O
\]

R= -CH(OH)CH\textsubscript{2}OH

Reagents
Mannitol powder
Hydrochloric acid, about 0.5N - Standardization not needed
Sodium hydroxide, about 0.5N - Standardize using reagent grade boric acid and precisely determine normality, refer to as Nbase
Phenolphthalein indicator - 1% solution in ethanol (methanol or propanol may be used in place of ethanol)
Methyl red, indicator (sodium salt) - 0.1% solution in ethanol (methanol or propanol may be used in place of ethanol)
Distilled or deionized water

Analytical Procedure
(1) Accurately weigh out (to 0.01 g) 5 to 7 g of treating solution into a 250 ml Erlenmeyer flask. Refer to this as grams of sample. Add distilled water to bring the total volume to approximately 100 ml; swirl to mix.
(2) Add 3 drops of methyl red indicator and stir. Add HCl until solution turns pink then add about 1 ml of excess acid.
(3) Gently boil this solution for 3 minutes to remove CO\textsubscript{2} and cool in an ice bath to room temperature.
(4) Titrate the solution with standardization NaOH to a peach-yellow color (the methyl red neutral point). Up to this point, the volumes of acid and base do not have to be recorded.
(5) To the solution now add 6 drops of methyl red indicator, 8 drops of phenolphthalein, and excess mannitol powder (approximately 30-35 g), and stir to dissolve. The solution will turn a red/pink color.

(6) Titrate the solution with standardized NaOH. The color will change from red/pink to yellow and back to red/pink, which is the end point. Care should be taken to titrate slowly so as not to miss seeing the yellow color entirely.

(7) In order to be sure that the titration is complete, add approximately 10 g of mannitol powder to the solution and stir to dissolve. If the solution changes back to a yellow color, then continue to titrate. If there is no color change upon mannitol addition, then the titration was complete after step 5. Record the volume of NaOH added in step 5 and 6, in ml, as $V_{\text{base}}$.

**Calculations**

$$3.481 \times V_{\text{base}} \times N_{\text{base}}$$

$$\%B_2O_3 = \frac{w}{g}$$

Compare result for routine Chemical analysis and instrument analysis ($\%B_2O_3$)

<table>
<thead>
<tr>
<th>Number</th>
<th>routine Chemical analysis</th>
<th>instrument analysis</th>
<th>instrument–chemical</th>
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<td>6</td>
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<td>0.3187</td>
<td>-0.0109</td>
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</table>

**Conclusions**

According to the results of table 1 to table 4, it is applicable to examine the arsenic, copper, chromium and boron in wood preservatives with routine Chemical analysis. The result of routine Chemical analysis is very close to that of instrument analysis, there are little windage between the two methods, so routine chemical analysis can be used to determine the active components of wood preservative. Routine Chemical analysis need not high quality operational surrounding and equipment condition. It’s easy to manipulate, fast, credible, well repeating and can be used directly on quality monitoring without amend in wood preservation treatment.