FBI - MONTHLY

# RESEARCH NOTES

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RESEARCH NOTES

*A selection of notes on current research conducted by the Canadian Forestry Service, Department of Fisheries and Forestry*

## ENTOMOLOGY

**Aerial Photography (35-mm): Aid to Forest Pest Surveys.**—Aerial observations and ground surveys have been used for the past 20 years to detect and appraise forest insect and disease problems in British Columbia. Color photography, a desirable adjunct to these methods, provides a permanent record suitable for detailed study and specific comparison with subsequent photography. The discouraging physical problems in obtaining timely color photographs with standard aerial photographic techniques include the need for expensive cameras, skilled camera man, specialized aircraft, films and processing, and critical weather.

Klein (J. Forest. 68: 475-478, 1970) and Zsilinszky (Photogrammetria 25: 27-38, 1969/1970) reported that standard 35-mm color aerial photography could be used inexpensively and conveniently in insect-damage surveys. A variation of this method was tried in August and September 1970, during regular pest detection flights in British Columbia by the Forest Insect and Disease Survey. Two 35-mm Asahi Pentax Spotmatic single lens reflex cameras with 1:1.4/50 lenses were mounted on a bar to facilitate the simultaneous operation of both for film comparisons. The cameras were handheld and photographs were taken through or out of the window or through the cargo hatch of a Cessna 185, Cessna 206, Cessna 337 Super Skymaster and deHavilland Beaver, all aircraft commonly used in British Columbia for pest detection and appraisal mapping flights. Films used were Kodachrome-X (color positive film), Ektachrome Infrared Aero type 8443 with "Hoya G" filter (false-color positive film) and Kodacolor-X (color negative film). Photographs were vertical and oblique; those with overlap could be viewed in stereo. Exposures were 1/500 second except when low light levels demanded 1/250 second. Photographs were taken at flying heights that gave scales ranging from about 1:5,000 to 1:50,000.

Insect infestations were photographed near Prince George and Kamloops (spruce beetle, *Dendroctonus rufipennis* (Kirby); Douglas-fir beetle, *D. pseudotsugae* Hopk., and mountain pine beetle, *D. ponderosae* Hopk.), and near Vancouver and Nanaimo (balsam woolly aphid, *Adelges piceae* (Ratz.); spruce budworm, *Choristoneura occidentalis* Free.; black-headed budworm, *Acleris variana* (Fern.), and western hemlock looper, *Lambdina fiscellaria lugubrosa* (Hulst)).

Insect infestations are recognized from the air by three damage symptoms; in the first four insects mentioned, symptoms were dead or dying trees with foliage varying from yellow-green to red and brown, and then thinning as foliage gradually dropped from the trees. Budworm and looper defoliation give infested trees a brownish or reddish tint caused by dead or dying needles that remain for a time in webbing laid down by the feeding caterpillars.

The aircraft used were generally satisfactory for this type of survey, although some had windows that could not be opened conveniently for easy photography. Photographs taken through closed, clear windows were slightly inferior to those taken through open windows, but even tinted windows did not eliminate recordable color tone differences.

Choice of films depended upon the primary use of the photographs and the urgency with which they were needed for viewing. The positive transparency films were useful because they could be projected, and offered sharp reproduction for detailed viewing. When prints were desired, they could be made more quickly from the negative films, and were usually of better quality than when made from slides. Good positive transparencies from negative film takes several weeks longer than for positive film, if normal commercial processing facilities must be used, an important consideration in pest assessment photography where time is usually significant.

Although exposure meters are not designed for Ektachrome Infrared Aero film, good exposures usually resulted, under a variety of lighting conditions, using the meters set at an A.S.A. rating of 100; there was a tendency sometimes to overexpose slightly at settings based on this rating.

The mortality caused by bark beetles and balsam woolly aphid was more pronounced on small-scale, false-color film obliques than on normal-color films. In the former, the affected trees were a distinct blue against the red of healthy ones, while in the latter, the leafless grey stems were often masked by the green-appearing foliage of their healthy neighbors. False-color film was no better than normal-color film for identifying or delineating defoliation caused by the budworms or looper.

Useful mosaics were made from 27 oblique normal-color prints of a 12,000-acre spruce budworm infestation in the Lillooet River Valley near Pemberton, and from 11 prints of an 850-acre black-headed budworm infestation at Green Mountain near Nanaimo. Edge-scale distortion made it possible to assemble only rough mosaics, but the infestations were easily discernible.

The survey at Pemberton can be given as an example of the costs involved in this photographic technique. A normal survey reconnaissance flight was made over the infestation, during which the usual sketch-mapping was accomplished. Immediately afterwards, one observer, who had previously noted the areas of most significant interest, directed the aircraft's return and took photographs. This involved about 30 minutes or $40 of additional aircraft time. This, plus the cost of two rolls of film, including processing and making 3- x 5-inch prints (about $20) added approximately 1½¢ per acre to infestation appraisal costs. Similar costs were involved in taking photographs of the black-headed budworm infestation.

The 35-mm format was a disadvantage when interpreting the film; a slightly larger format (2 inch or 70 mm) would be more convenient and provide better quality and larger photographs. Advancing the film by hand was difficult, especially when two cameras were involved; stereo reproduction and continuous strip photography could be facilitated by an electric film advance system.

These trials indicate that useful photographs can be obtained simply and cheaply during forest pest aerial surveys in British Columbia with standard 35-mm equipment. Such photographs could (a) assist in determining intensity of damage, (b) serve as a permanent record for future study, and (c) supplement observations and sketch maps in describing damage or infested areas accurately. A pictorial record of damage would help the forester select salvage cutting boundaries and delineate areas for aerial chemical control treatments. It would also aid pest surveys by helping sampling crews pick representative locations, both for current and future examinations.—J. W. E. Harris, Forest Research Laboratory, Victoria, B.C.

**Does Fenitrothion Spraying Reduce Parasitism of the Spruce Budworm?**—The pesticide fenitrothion has been used on several million acres in operational spray programs in 1969 and 1970 against the spruce budworm in eastern Canada. Its ability to kill budworm larvae has been well demonstrated, but its immediate and long-term effects on populations of associated arthropods are little known.

In 1970, the influence of parasitism on budworm survival was studied in the context of the spray program in New Brunswick. Pole-stage fir-spruce stands were sampled on sites selected for differences in climatic zone, insecticide history, and budworn density, but as far as possible stand characteristics were standardized (Table 1).

Budworm densities and percent parasitism were measured at intervals in May and June. Collections were made from balsam fir in all plots, but red spruce was sampled only at Nasonworth, Priceville (F), and Fundy Park. The unit sample for determination of parasitism was 200 budworm in the unsorted range of instars present at collection date.

The values of percent parasitism shown in Table 1 are placed with reference to the mean development stage of the budworm population on fir at the time of collection. Sampling from spruce others (mirids, mites) show instability. Parasitism of budworm eggs was less common in repeatedly sprayed plots, but egg mortality from other causes was much greater. On the other hand, there was no indication of any relationship between fenitrothion and disease incidence in budworm populations.

These results suggest that the use of fenitrothion may be weakening a section of the biocontrol complex operating upon budworm larvae and pupae. Although biocontrol mechanisms demonstrably fail to contain full-blown budworm epidemics, they still contribute to budworm mortality, braking runaway increase and hastening the collapse of aging outbreaks; any reduction in their impact would make us more dependent upon chemical control. There is a particular hazard in any proposal to spray incipient outbreaks of scattered high density, since we may be bartering a partially effective biocontrol mechanism for an immediate kill of budworm larvae; in such an exchange, the relief from budworm pressure might be very temporary. If adverse effects of spray program are confirmed, we may need to modify spray formulations or timings; earlier spray dates might lessen toxic effect on pupal parasites.—I. W. Varty, F. A. Titus, T. R. Renault, G. N. Gesner, Forest Research Laboratory, Fredericton, N. B.

TABLE 1. Parasitism at successive samples of spruce budworm larvae and pupae

| Plot locality | Budworm[a] density | Spray history | | Percent parasitism (1970) at mean instar — | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1969 | 1970 | III | IV | V | | VI | | P | |
| Nasonworth, southern N.B. | 120 | Nil | Fen. | | 21 | | 9+[b] | 13 | 0 | | 0 |
| Priceville (D), central N.B. | 105 | DDT | Fen. | | 20 | +21 | | 7 | | 5 | 0 |
| Priceville (F), central N.B. | 90 | Fen. | Fen. | | 13 | + | 11 | 2 | | 0 | 0 |
| Fundy National Park, coastal N.B. | 135 | Nil | Fen. | 34 | | + | | 27 | | 10 | |
| Green River 15, northern N.B. | 120 | Nil | Nil | | 13 | | | 20 | 29 | 33 | 33 |
| Green River 14, northern N.B. | 10 | Nil | Nil | | 10 | 27 | | | | 43 | |
| Green River G5, northern N.B. | 3 | Nil | Nil | | 16 | | | | 26 | | |

[a] Third-instar larvae per 10 sq ft of mid-crown branches on balsam fir (1970); similar densities were present on red spruce.
[b] +denotes fenitrothion spray (1970) in relation to collections.

produced similar values.

Two main groups of parasites affect budworm larvae and pupae. The first comprise the *Apanteles/Glypta/Synetaeria* group which parasitizes the earlier instars. *Apanteles* spp. issue from fourth and fifth instars, and *Glypta fumiferanae* (Vier.) from the sixth-instar hosts, so these parasites are found with decreasing frequency as the population ages. The second group comprises many hymenopterous and dipterous species which begin their larval development in fifth-, sixth-, and pupal-instar hosts. The recruitment of parasites of the second group more than offsets the decrease in parasitism that would otherwise occur on account of emergence of parasites of the first group. Thus, in unsprayed areas, percent parasitism ordinarily shows an increase near pupation time, as is evident in Green River at both high and low budworm densities. Pupal parasitism is thus an important component of the biocontrol complex.

In the sprayed plots, only parasites from the first group were found in any abundance (*Glypta* and *Apanteles*). Pupal parasites were almost entirely lacking; i.e. zero values under P. The 5% recorded at Priceville (D) consisted of *Meteorus trachynotus* Vier. and *G. fumiferanae* in the larval fraction of the host population; the 10% recorded from Fundy consisted of *Glypta* in larvae. Thus in all collections pupal parasites were rare or absent.

The inference from these data is that treatment with fenitrothion may have virtually eliminated late-larval and pupal parasites. This could be due to the effect of the pesticide on adult parasites which are seeking budworm hosts for oviposition in the second half of June.

Other natural enemies of the budworm are being monitored in plots subject to fenitrothion treatment. Populations of some predators (ladybeetles, lacewings, and pentatomids) have suffered sharp reductions since fenitrothion was introduced and

## FOREST PRODUCTS

**Brown Stain in Kiln-Dried Abies amabilis Lumber.**—Unlike the brown stain found in green western hemlock [*Tsuga heterophylla* (Raf.) Sarg.] lumber, which is a superficial chemical stain of no real consequence since it can be planed off (Barton and Gardner, Dep. Forest. Publ. No. 1147, 1966), several cases of a deeper, more serious stain have appeared in kiln-dried amabilis fir [*Abies amabilis* (Dougl.) Forb.] lumber. This brown-stained wood appears somewhat weakened and more friable than unstained wood when probed with a knife. The stain is a more intense black-brown color where the surface of the wood has been exposed to air. Where stickers have lain across boards during kiln-drying, the stain is much less intense (Fig. 1). Also, the stain is less intense internally, but it tends to follow specific growth rings through boards.

A microscopical examination of sections cut from brown-stained wood showed no evidence of decay by wood-destroying fungi and virtually no evidence of the presence of fungal mycelium or spores. The ray parenchyma in stained wood had higher concentrations of dark-brown extractives than similar ray cells in an unstained region.

Close examination of sections of stained wood showed frequent occurrence of large concentrations of bacteria within longitudinal tracheids, resulting in all the three types of pit breakdown (Fig. 2, a, b, c.) described by Greaves (Wood Sci. Technol. 3:150-166, 1969). There was little visual evidence of any significant degradation of walls of longitudinal tracheids or ray cells.

Examination of sections of stained wood under ultraviolet (UV) light (Zeiss photomicroscope, exciter filter BG3, barrier filter 50/44) showed a marked decrease in the natural yellow-green fluorescence of the lignified walls of tracheids, compared with those in unstained wood. Further sections of stained and un-

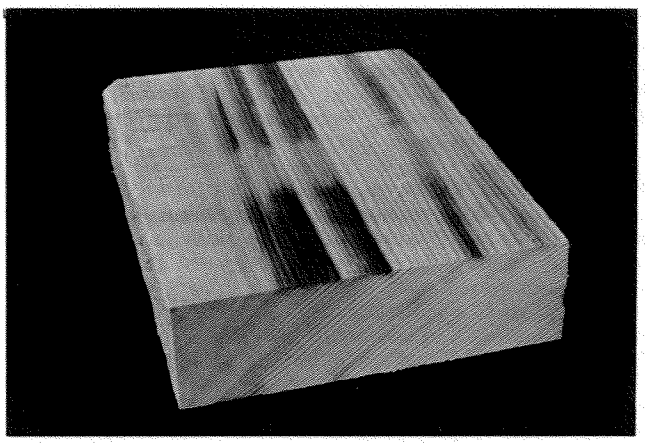


FIGURE 1. Brown stain in a board of kiln-dried amabilis fir, showing paler staining across the grain on the surface where a sticker had lain during kiln drying.

stained wood were treated for five minutes in 0.1% aqueous acridine orange, washed, mounted in glycerine and then examined under UV light as before. Again the brown-stained sections showed a drastic change in fluorescence from the normal, strong yellow-orange fluorescence of unstained wood to a dull brown fluorescence. Even individual adjacent tracheids, one containing large concentrations of bacteria and the other free of bacteria, showed differences in fluorescence.

A chemical investigation of the stained wood revealed the presence of an interesting chromophore not previously found in *Abies*, namely 3,3'-dimethoxy-4,4'-dihydroxystilbene (DDS). A comparison of adjacent stained and unstained sections of wood from the same sample showed that the chromophore DDS was found in much higher concentration in stained wood. Samples of wood taken from unseasoned amabilis fir, showing no unusual stains, contained no DDS. Details of the isolation and identification of DDS are summarized briefly as follows: badly stained areas of kiln-dried wood were cut out and reduced to woodmeal in a Wiley mill; the woodmeal was soxhlet-extracted with methanol for 8 hours and the solution filtered and evaporated under vacuum to a small volume of concentration 100 mg per ml. Methanol extracts of unstained wood were obtained in a similar manner. These methanol extracts were compared on thin-layer silica gel plates using two main solvent systems, chloroform-methanol (7:1) and benzene-ethanol (15:1). In these solvent systems, DDS has an $R_f$ of 0.77 and 0.35, respectively, and can be detected easily by its intense blue fluorescence under UV light and its subsequent rapid conversion (in seconds) to a red-brown visible spot. Ordinary daylight also causes this color change very quickly. By means of preparative thin-layer chromatography, enough material was isolated to provide spectrographic (UV, infrared and nuclear magnetic resonance) proof of the structure of DDS. In addition, DDS was synthesized from vanillin and compared chromatographically and spectrographically with that obtained from stained *Abies*. These comparisons proved it to be the same compound, DDS. In view of its facile conversion to the highly colored benzophenone and its proven presence in stained *Abies* wood, it is speculated that DDS is responsible for the color of kiln stain in amabilis fir.

The observed change in natural and acridine-orange induced fluorescence of brown-stained tracheids might be caused by bacteria degrading lignin in cell walls, similar to the reaction of white-rot fungi as shown by Aufsess *et al.* (Holz als Roh- und Werkstoff 26 (2): 50-61, 1968). The production of DDS also could have resulted from this breakdown of lignin. However, it is also possible that the observed change in fluorescence was caused by the dull-brown fluorescence of oxidized DDS acting to quench the normal fluorescent response of lignified walls independently of any possible degradation of lignin. The elucidation of this problem awaits further study.

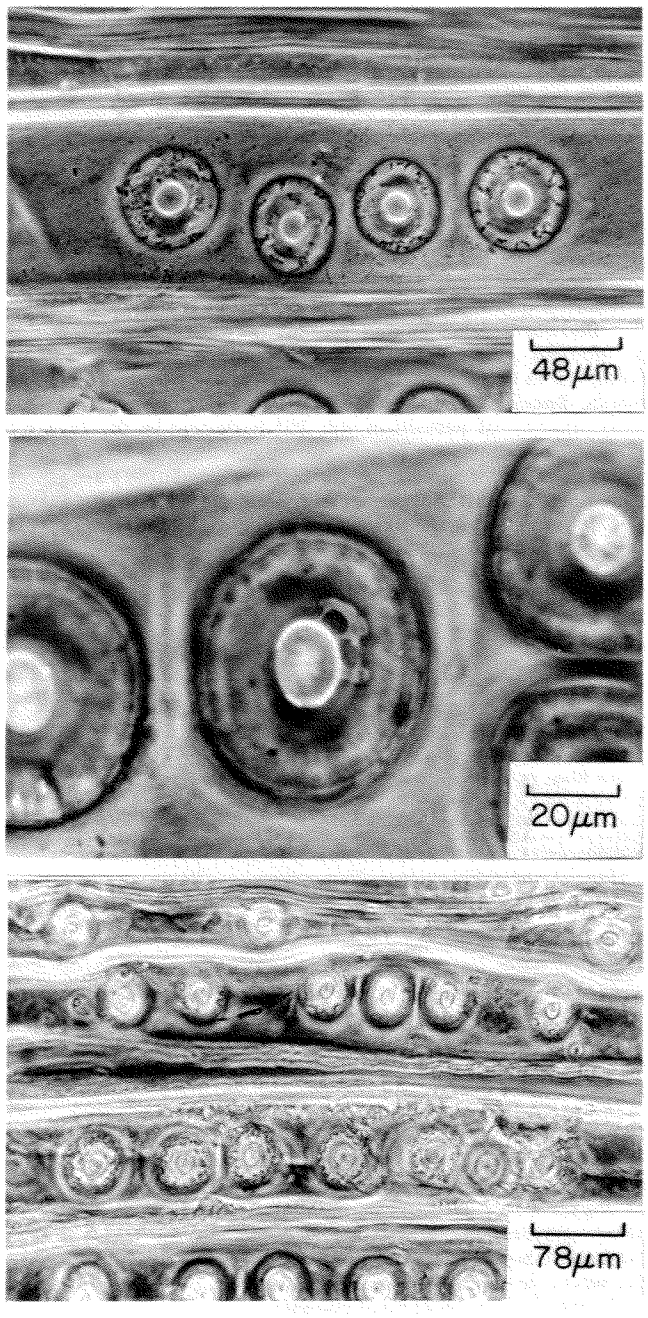


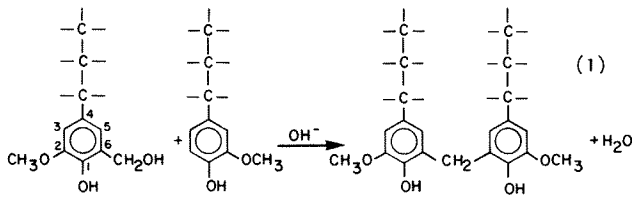

FIGURE 2. Bacterial degradation of bordered pits in kiln-dried amabilis fir: (top) general attack of pit structure; (center) attack of the aperture periphery; (bottom) attack of the extremities of the border ("lacy border").

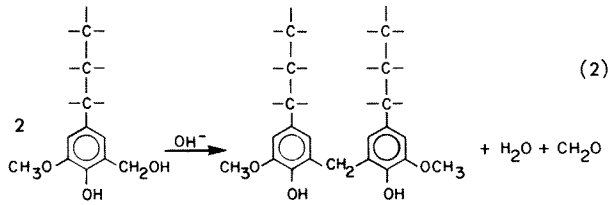
Because of its superficial resemblance to kiln-brown stain common to white pines, samples of eastern white pine (*Pinus strobus L.*) displaying this stain were examined for the presence of DDS, which was found to be absent. Pinosylvin monomethyl ether, a heartwood extractive of pines, was present and did turn brown on silica-gel plates over a much longer period of several days. Since pinosylvin monomethyl ether is a normal constituent of pines, in contrast to DDS which is not a normal constituent of *Abies*, it cannot be concluded that the kiln stain in pine is due to pinosylvin monomethyl ether. In any case, the conjugation pattern of DDS lends itself to ready formation of a highly-colored benzophenone system, which is restricted to a greater degree in the case of pinosylvin monomethyl ether.

These same samples of brown-stained eastern white pine were examined for the presence of bacteria and reduced lignin fluorescence. Sections of the brown-stained wood showed some change in natural lignin fluorescence towards a darker brown, but after treatment with acridine orange a deep red fluorescence resulted. This red fluorescence appeared identical to the red fluorescence of resin-duct tissues and abundant resin within ray parenchyma cells. In the samples studied, there were no bacteria or evidence of bacterial degradation of pit structures. The characteristics of brown stain, therefore, differ between white pine and amabilis fir in several respects.

In conclusion it is suggested that the presence of bacteria in boards of amabilis fir can give rise to a condition called kiln burn, when such material is kiln-dried following normal schedules. The resulting deep-brown discoloration of wood is caused by the presence of DDS, that may or may not have been produced by degradation of lignin.— G. M. Barton and Roger S. Smith, Forest Products Laboratory, Vancouver, B.C.

**A Study of Lignin Model Compounds in Phenol-Formaldehyde Glue Reactions** — The possibility of using lignin and lignin derived compounds as plywood glue extenders depends on a clear understanding of reaction mechanisms. This understanding can best be obtained from studies involving known lignin model compounds. The reactions (1) and (2) occur in base catalyzed lignin-formaldehyde systems. (Marton, J. T. and Falkehag, S.I.; Lignin Structure and Reactions, Advances in Chemistry Series 59. Amer. Chem. Soc., Wash., D.C.). However little has been reported about the rates of these reactions.



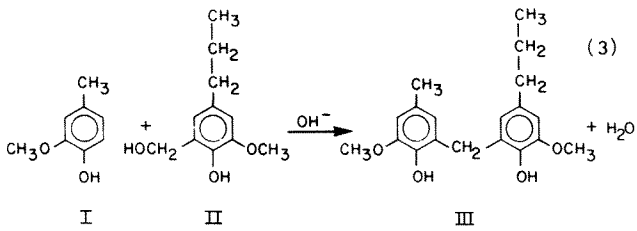



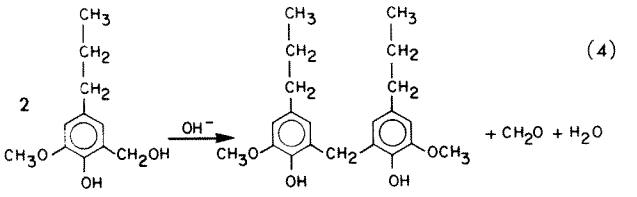

In order to obtain more quantitative information on these competing condensation reactions, both 4-methyl guaiacol (I) and 4-n-propyl-6-methylol guaiacol (II) were used as model compounds. Thus, it was possible to distinguish between reactions (1) and (2) since two different methylene bridged dimers —2,2′-dihydroxy-3,3′-dimethoxy-5-n-propyl-5′-methyl-diphenyl methane (III) and 2,2′-dihydroxy-3,3′-dimethoxy-5,5′-di-n-propyl-diphenyl methane (IV)—would be produced as shown in reactions (3) and (4).

It is important to note that the two model compounds chosen for this study differ only in the length of the alkyl chain and, therefore, should not alter the substitution reactions occuring at position 6.

A 1:1 (w/w) mixture of I and II dissolved in 5% (w/v) aqueous KOH was reacted at 85.5, 90.5 and 100C. The reaction products were analyzed by GLC as their acetylated derivatives on a SE-30 ⅛″ x 6′ S.S. column, which was temperature programmed from 100 to 250C at 6°/min.

The rates of formation for the dimers III and IV at 90.5C *vs.* reaction time are shown in Fig. 1. The ratio rate III/rate IV in this system is 1.8 and is constant with time. Also, this ratio did not change at the other temperatures studied, even though the rates




of formation of III and IV changed by a factor of about six between 85.5 and 100C (Table 1). This constant ratio for the three temperatures indicates that both reactions (3) and (4) have the same activation energies, and the calculated value is 35 kcal/mole.

In contrast to the above results, the activation energies previously measured for condensation reactions analogous to (3) and (4) were found to differ by more than 13 kcal/mole. Sprung and Gladstone (J. Amer. Chem. Soc. 71:2907, 1949) measured an activation energy of 31.5 kcal/mole for the condensation of phenol and saligenin (o-hydroxybenzyl alcohol) [c.f. reaction (3)]; they measured a much lower activation energy of 18.5 kcal/mole for the self-condensation reaction of saligenin [c.f. reaction (4)]. Thus, on the basis of the results of Sprung and Gladstone, Ekman [Tappi 48 (7): 398-402, 1965] concluded incorrectly that reaction (1) does not occur during the alkaline hydrolysis of lignin.

It is significant to note that another dimeric component (minor constituent) was also produced in the reactions described in this note. The compound has been tentatively identified, on the basis of its retention time, as 2,2′-dihydroxy-3,3′-dimethoxy-5,5′-dimethyl-diphenyl methane (V).

This compound could be produced after the released formaldehyde reacted with I to form 4-methyl-6-methylol guaiacol which then could undergo similar condensation reactions as (3) and (4) to produce either III or V.

These results demonstrate that alkyl substituted guaiacol compounds readily undergo both substitution and condensation reactions similar to phenol-formaldehyde reactions. However, since there is but one reactive site for these compounds the

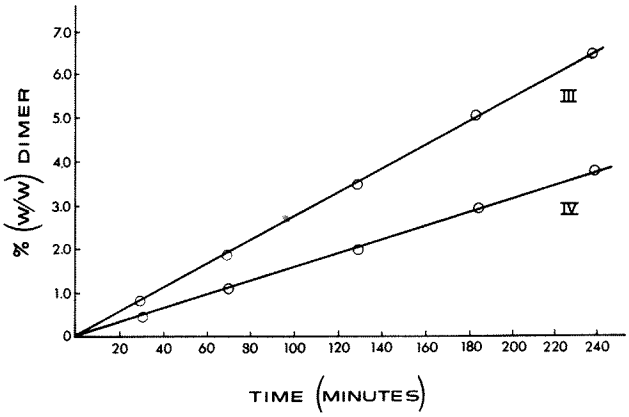
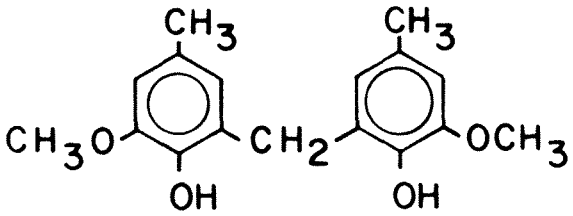



FIGURE 1. Reaction rates for formation of dimers III and IV at 90.5C.

TABLE 1

Rate of formation of III and IV as a function of temperature

| Temperature °C | $10^5$ x rate III g $ml^{-1}$ $min^{-1}$ | $10^5$ x rate IV g $ml^{-1}$ $min^{-1}$ | Rate III / Rate IV |
|---|---|---|---|
| 85.5 | 1.6 | 0.9 | 1.8 |
| 90.5 | 2.7 | 1.6 | 1.7 |
| 100.0 | 9.0 | 5.1 | 1.8 |



V

degree of polymerization is limited to dimeric products; which may be suitable as extenders for plywood glues. It is important to note that the monomeric guaiacol compounds cannot be used directly, as they would chemically react with the resin and block the reactive end groups. The reactivity noted in this note clearly demonstrates the possibility that a lignin-derived compound having more than one reactive position could be developed into a phenolic-type resin.—G. E. Troughton and J. F. Manville, Forest Products Laboratory, Vancouver, B.C.

## PATHOLOGY

**Absence of Decay Development in Two Cases of Top Mortality in Conifers.**—Broken tops and dead leaders frequently predispose trees to infection by decay-causing fungi and consequently are regarded as a sign of extensive stem decay (Wagener and Davidson, Bot. Rev. 20: 61-134, 1954). Separate investigations of the extent of decay development associated with two instances of widespread top mortality in white pine [*Pinus strobus* L.] and jack pine [*P. banksiana* Lamb.], in Ontario have been carried out over the past decade. The unexpected absence of decay and decay-causing fungi in association with these injuries is described.

In the Kirkwood Management Unit in central Ontario, approximately 400 acres were planted with white pine in 1929. Fifteen years later it was reported that upwards of one million of these trees had been damaged by the white pine weevil [*Pissodes strobi* Peck] (Annu. Rep. Forest Insect Surv., Can. Dep. Agr., p. 29, 1944). The 400 acres were largely neglected until 1961 and by that time many of the trees had had leaders repeatedly killed by the insect. In 1961 the Ontario Department of Lands and Forests decided to salvage by cutting the most severely deformed trees, and by spraying the remainder to protect them from future weevil attacks. The Canadian Forestry Service was to determine the extent of heartwood stains and decay in the damaged trees as a guide to whether future stand treatments would be justified economically.

Fourteen living white pine were subjectively selected. Three of these trees had relatively straight stems, and were chosen as being most likely to have escaped weevil-induced leader mortality. The others were selected at widely scattered locations within the plantation to represent the most severely deformed stems. Every noticeable crook in all 14 stems were removed within an 18-inch stem section as a possible weevil-killed leader *locus*. These sections were split longitudinally through the dead, buried leader if one could be found; the appearence of the wood (stained, decayed, etc.) was recorded; from three to seven attempts were made for each section to isolate wood-inhabiting organisms on 2% malt agar media.

Between three and six suspect stem crooks were examined in each tree, for a total of 67 crooks. A total of 324 attempts were made to isolate organisms for the buried, dead leaders and from wood adjacent to and below these leaders. Of these, 296 or 91.4% were sterile, 23 yielded fungi, and five bacteria. Twenty of the 67 crooks were judged to be, almost certainly, the result of weevil injury although the possibility that all 67 crooks were caused by weevils could not be ruled out. At least one of the 20 "probable weevil" crooks occurred in each tree, including the three trees chosen because they appeared most likely to be weevil-free. The majority of these crooks resulted from leaders killed between 1940 and 1944. Of the 119 isolation attempts made from the "probable weevil" crooks, 107 or 89.9% were sterile, 10 yielded fungi, and two bacteria.

No decay was encountered in any of the dissected crook samples. Patches of faint red stain were associated with about 35% of the crooks, and many of the 23 isolations of fungus were obtained from these patches. However, all isolated fungi were Deuteromycetes or Ascomycetes that do not cause decay and are not known to cause stain in white pine. For this reason and because of the length of time that elapsed between the weevil damage and the time of sampling, it is concluded that no significant heartwood stain or decay has formed, or is likely to form, as a result of the weevil damage to white pine in the Kiwkwood Management Unit.

A severe sleet storm occurred in 1960 during the second week of May in the vicinity of Chapleau, Ontario. As a result, practically every jack pine that was not killed in an area of about 1,250 square miles had its top broken off at a diameter between 1 and 3.5 inches. During September 1962, and five consecutive years thereafter, four living, damaged jack pine were felled and the development of stain or decay and the identity of organisms entering the standing stems from the breaks were determined. The sample trees were obtained from three jack pine stands, an 80-year-old stand about 8 miles of Chapleau and two 35-year-old stands, one just outside of the town of Chapleau to the north and the other about 20 miles south. Thus, in 6 years 24 trees were sampled, and from 14 to 22 isolation attempts were made for each tree at points ranging from 0.5 inch to 30 inches below the breaks.

No stem decay was associated with any of the broken tops examined. Some light pink to light red stain was encountered beneath every break. This stain extended downward annually for 5.5 years following the storm (September 1965), to approximately 15 inches, then remained fairly constant. Of the several fungi isolated from the stains, none are known to cause decay in jack pine. The most frequently isolated organism was *Pullularia pullulans* (de Bary) Berkhout, which was isolated from 17 (71%) of the trees a total of 46 times. Thirty-eight (82%) of these were in stained wood within 1.5 inches of the breaks. *Retinocyclus abietis* (Crouan) Groves and Wells was isolated 18 times, but unlike *P. pullulans* it was associated with normal as well as stained wood and was encountered almost as frequently at all sample distances from the breaks. The next three fungi in order of frequency of occurrence were *Tympanis hypopodia* Nyl., *Phoma* sp. and *Rhinocladiella* sp.

The fact that neither decay nor decay-causing fungi were encountered in the stems adjacent to the breaks 7.5 years after the storm is a reliable indication that the jack pine that survived with broken tops will not suffer stem decay as a result. There is some evidence that wound substrates may be relatively resistant to infection during certain periods of the growing season (Davidson and Etheridge, Can. J. Bot. 41: 759-765, 1963). Based on this and other investigations, it is reasonable to postulate that extensive stem decay would have resulted had the jack pine been similarly damaged at seasons other than late spring, i.e. winter or late fall.—J. T. Basham, Forest Research Laboratory, Sault Ste. Marie, Ont.

(*Continued from back cover*)

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