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Field-Proven Strategies for Reducing VOCs from Hardwood Drying

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## Field-Proven Strategies for Reducing VOCs from Hardwood Drying

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### *Abstract*

A very sharp VOC rise occurs during late drying of hardwood oriented strand board (OSB) flakes. Methanol and aldehydes, the principal VOCs released, arise from wood degradation, which accelerates when the wood is almost dry, and the temperature rises due to the loss of evaporative cooling. A slight increase in final flake moisture reduces the period of exposure of the dry wood to high temperature, and VOC emissions decrease. The inverse relationship between final flake moisture and VOC release was confirmed during full-scale field trials. Increasing final flake moisture by only a few percentage points dramatically reduces VOCs. Removal of fines through green-screening also reduces VOCs, since fines tend to over-dry.

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VOC reduction from wood drying operations typically relies on control devices such as regenerative thermal (or catalytic) oxidation units (1-3), which are expensive, both in terms of capital and maintenance. Since the VOC concentration in the dryer air stream is too small to sustain combustion, natural gas must be added, and CO<sub>2</sub>, a greenhouse gas, is released from the control unit. The industry has taken the position that the NO<sub>x</sub> generated by these control devices may outweigh any benefit from VOC reduction, since atmospheric ozone formation is NO<sub>x</sub>-limited in the typically rural areas that host these mills. The reliance on control devices would be minimized if emissions could be reduced through process changes. In a previous paper, we outlined strategies for reducing VOCs from softwood (4). We now explore some of the parameters that govern emissions from hardwood, and demonstrate through both laboratory and full-scale fieldwork, that major VOC reductions can be taken through relatively minor changes in drying parameters.

### *Experimental*

Aspen OSB flakes were obtained from Georgia-Pacific's Woodland, ME, facility, and from a mill in the Northern United States. Laboratory-scale drying was conducted in a 1.5-inch diameter ceramic tube furnace (4) whose 1.5-inch midsection was electrically heated. Samples (<8 g.) were placed in a ceramic boat in the heated zone. Air was metered to the tube inlet at 2 l/pm, and the entire furnace emissions were drawn into a JUM Model VE7 flame ionization analyzer (FIA), through its built-in pump. This unit is used in EPA Method 25A for monitoring

total gaseous non-methane emissions (5). Field measurements were made by EPA Method 25A from the dryer air stream before the wet ESP.

Degradation products from hardwood flakes were measured by drying flakes at 160°C for 2 hours, while collecting the emissions in two serial chilled traps, each containing 30 mL of water. Over 95% of the weight lost from the wood was recovered as condensate in the first trap. No organics were detected in the second trap confirming that carryover was minimal. The green-basis product distribution from five replicates as determined by GC/FID was methanol: 101±9 µg/g, pentanal: 73±20 µg/g; hexanal: 30±3 µg/g; unknowns (quantified as pentanal): 54±5 µg/g. The compounds identified are similar to those observed earlier (6).

## ***Results and Discussion***

### ***Laboratory measurements***

Flakes cut into 0.5 x 5 mm pieces were mixed and dried for various periods at various temperatures. The VOCs released from aspen and yellow poplar are illustrated in Figures 1 and 2, respectively; the corresponding figure described earlier for pine (4) is provided in Figure 3 for comparison. Note the sharp rise in VOCs from dried hardwood that occurs across all temperatures. Hardwood VOCs are mainly methanol and aldehydes, which are degradation products. Initially, the evaporating water cools the green wood, and VOC release is low since wood degradation is slow. When the cooling effect ceases late in the process when the water is mostly gone, the flake temperature rises, degradation accelerates, and the VOCs rise sharply. In contrast, softwood VOCs are mainly terpenes (7,8), and since they can either be solvent-extracted or dried out of wood, they are, essentially, distillation products. Their VOC release is also low during early drying, but for different reasons; the vapor pressures of the terpenes rise when evaporative cooling decreases (4,9). Thus, both softwood and hardwood VOCs increase during late drying because the flake temperature rises. For softwood, the vapor pressure is affected; for hardwood, wood degradation accelerates. The sharpness of the rise in Figures 1 and 2 is surprising, and indicates a high activation energy for VOC generation. The immediate practical outcome of this result is that over-drying should have a proportionately much greater effect on hardwood than on softwood. Since fines present in the furnish will especially tend to over-dry. VOCs should decrease if fines were screened out prior to drying.

Retaining higher moisture in the flake may also assist in the subsequent pressing operation. Aspen flakes dried at 105°C to various final moistures were pressed (without added resin) to approximately 48 lb/ft<sup>3</sup>. The press used was an electrohydraulic device described earlier (10,11), and the furnish was placed between its heated (180°C) and vented cold platens at 1,900 psi. for 50 seconds. Both control (unpressed) and pressed flakes were then re-dried for 1 hour at 130°C, the VOCs were monitored, and the difference was taken as the amount released during pressing. The results are shown in Table 1. Approximately 1.5-2.8% water was also lost during pressing. The wetter flakes released less VOC during pressing, probably because evaporative cooling moderated the flake temperature and retarded wood breakdown and VOC generation. These results are preliminary since no resin was included, and the VOCs were not directly measured during pressing. Nevertheless, a wetter flake does seem to also reduce VOC release during pressing.

### *Field trials*

A field trial was conducted at an OSB facility located in the Northern US on August 18-20, 1997, in order to determine the effect of inlet temperature, final flake moisture, and the presence of fines on VOC release. Aspen was the principal furnish processed, but other species, including softwood, represented up to 10% of the charge. The facility had been green-screening through a 3/8" screen, and this was continued for the first two days of the trial. Green-screening was discontinued on the final day, i.e. fines were included in the furnish.

Figure 4 illustrates VOC, final flake moisture, and dryer temperature profiles for August 18. While VOC and temperature profiles were acquired continuously, flake moistures were only obtained periodically, and Figure 4 includes VOC and temperature data corresponding to the available flake moistures. The VOCs are expressed as a "% of maximum", where the "maximum" was the highest VOC observed on a ppmv basis over the three-day trial period. The feed rate of the furnish was stable, and did not materially contribute to the variability.

Figure 4 demonstrates an inverse relationship between VOC and flake moisture. Ideally, the dryer temperatures should have been constant since they also influence VOC release (9). However these temperatures are controlled by flake moisture (if the feed rate is constant), and changing only one variable at a time in the field is very difficult. The weak correlation between VOC and outlet temperature is probably just an indirect illustration of the VOC-moisture correlation, since the outlet temperature changes with flake moisture. Unexpectedly, there was no clear dependence of VOC on inlet temperature, probably because it was masked by the much stronger VOC-moisture relationship. Similar behavior is observed in the August 19 results illustrated in Figure 5 where the VOC link to flake moisture is compelling.

VOC levels measured on August 20, where fines were included in the furnish, were much higher than those for the preceding days, indicating that fines contribute disproportionately to the emissions. The sensitivity of the relationship between VOC and final flake moisture is amplified in the presence of fines, as shown in Figure 6. Fines tend to over-dry, which occurs more readily at <3.5% moisture. The potential for over-drying is reduced at or above 3.5% flake moisture, and fines do not contribute additional VOC in this region. Clearly, green-screening is an inexpensive and effective means of reducing VOCs.

Some of the above observations were confirmed at the Georgia-Pacific mill at Woodland, ME. The mill was required by the State of Maine to reduce VOC emissions owing to its location in the Northeastern ozone corridor. A trial was conducted during the week of October 13, 1997 to demonstrate options for VOC reduction. The flake moisture-VOC relationship observed earlier at Bemidji was reproduced at Woodland as illustrated in Figure 7. Woodland uses mainly aspen, but includes up to 25% of pine in its furnish. Since pine releases much more VOCs than softwood, pine was progressively added to the furnish, and the VOCs measured. The sharp decrease in emissions with decreasing softwood content is unmistakable in Figure 8. Hence, a combination of decreasing softwood content and increasing final flake moisture greatly reduced VOCs. The higher moisture (6-8%) flakes require a moisture-tolerant resin for the subsequent pressing operation, but these are commercially available, and have been used in field trials for other purposes.

We showed earlier (4) that VOCs from softwood drying decreased if the wet line was maintained at the surface for as long as possible. These considerations are even more critical for hardwood. Both green-screening and increasing final flake moisture extends the dry line at the surface. Other benefits derive from both practices. Since fines reduce strength and consume a disproportionate amount of resin, their removal is desirable from a product viewpoint. Moisture retention also improves board quality as will be described later. However, the approach does have a single drawback. Board delamination tends to occur when the pressure is released after pressing if the final flake moisture exceeds 9%. Drying to very low moisture minimizes the need for tight moisture control, since the flake moisture is then well below the 9% threshold. Increasing final flake moisture decreases the margin of safety. Nevertheless, this restriction is not overly burdensome, since the Woodland mill has successfully run under these conditions for extended periods.

#### *Acknowledgments*

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#### *Literature Cited*

1. Yeo, B. Proc., AIChE Annual Meeting, St. Louis, Missouri, 1993.
2. Grzanka, R. *PaperAge*, April, 1996, 14-15.
3. Matros, Y.S.; Bunimovich, G.A.; Patterson, S.E.; Meyer, S.F. *Catalysis Today*, 1996, 27, 307-313.
4. Banerjee, S.; Su, W.; Otwell, L.P.; Hittmeier, M.E.; Nichols, K.M. *Environ. Sci. Technol.*, May, 1998.
5. Method 25A - *Determination of Total Gaseous Organic Concentration using a Flame Ionization Analyzer*, 40CFR Part 60, 870-872, August 1, 1995.
6. Carlson, F.E.; Phillips, E.K.; Tenhaeff, S.C.; Detlefson, W.D. *Forest Products J.*, 45(3), 71, 1995.
7. Cronn, D.R.; Truitt, S.G.; Campbell, M.J. *Atmos. Environ.*, 1983, 17, 201.
8. Flodin, K.; Andersson J. *Eur. J. Forest Pathol.*, 1977, 7, 282.
9. Banerjee, S.; Hutten, M.; Su, W.; Otwell, L.P. *Environ. Sci. Technol.*, 29, 1135 (1995).
10. Mahmood, T.; Zawadzki, M.; Banerjee, S. *Environ. Sci. Technol.*, in press.
11. Banerjee, S.; Mahmood, T.; Phelan, P.M.; Foulke, R.W. *Water Res.*, 32, 258 (1998).

<b>Table 1: VOCs (<math>\mu\text{g/g}</math>) released during pressing<sup>1</sup></b>			
<b>moisture content (%, dry basis)</b>	<b>VOC</b>		<b>VOC lost during pressing</b>
	<b>control</b>	<b>pressed</b>	
4.44	398	223	175
4.62	404	190	214
5.55	350	320	30
5.56	358	297	61
7.75	300	268	32
8.62	306	248	58
12.66	239	213	26
12.88	240	221	19
<sup>1</sup> average of 2 determinations			

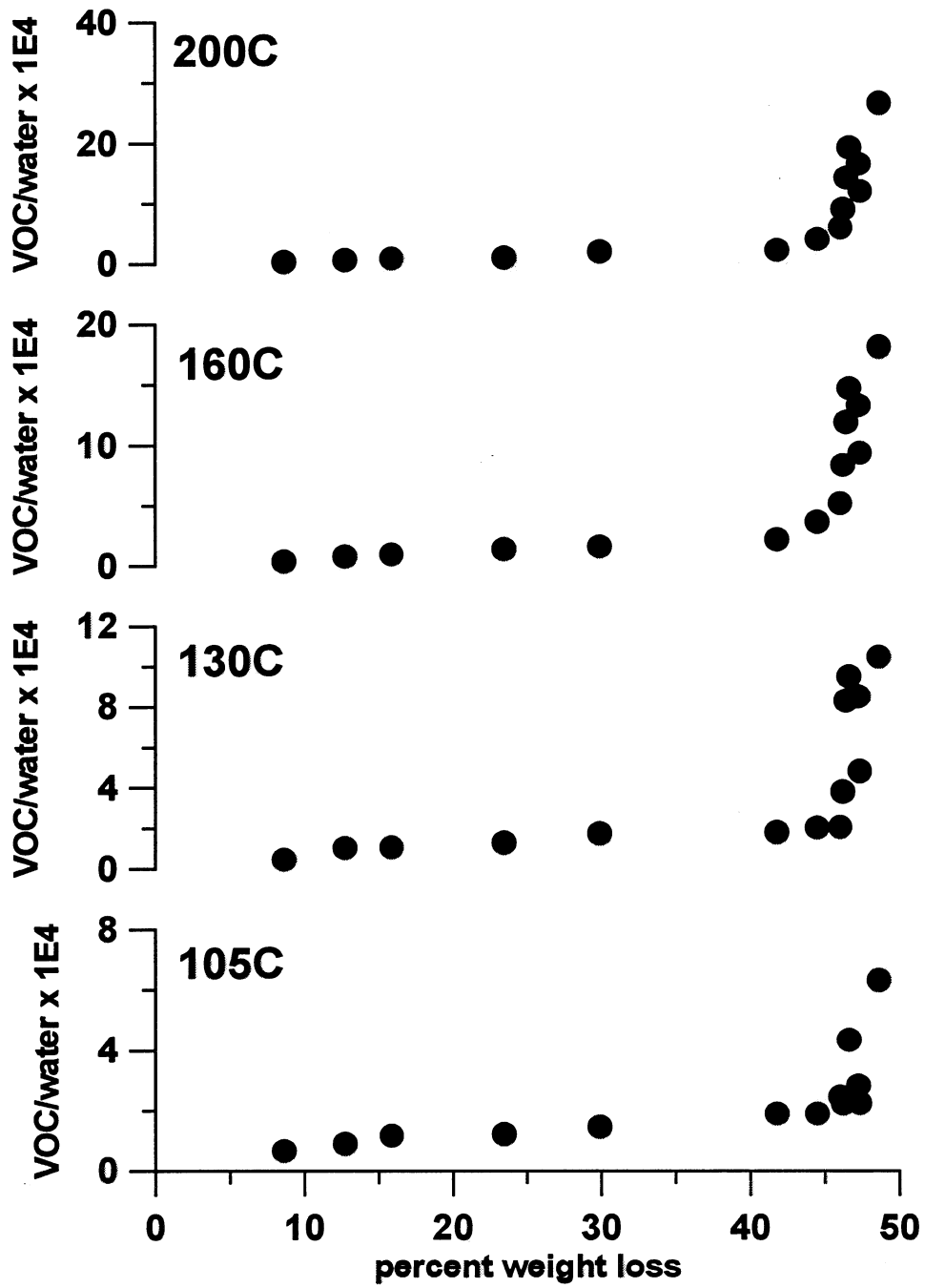


Figure 1: Effect of temperature on VOC emissions from aspen.



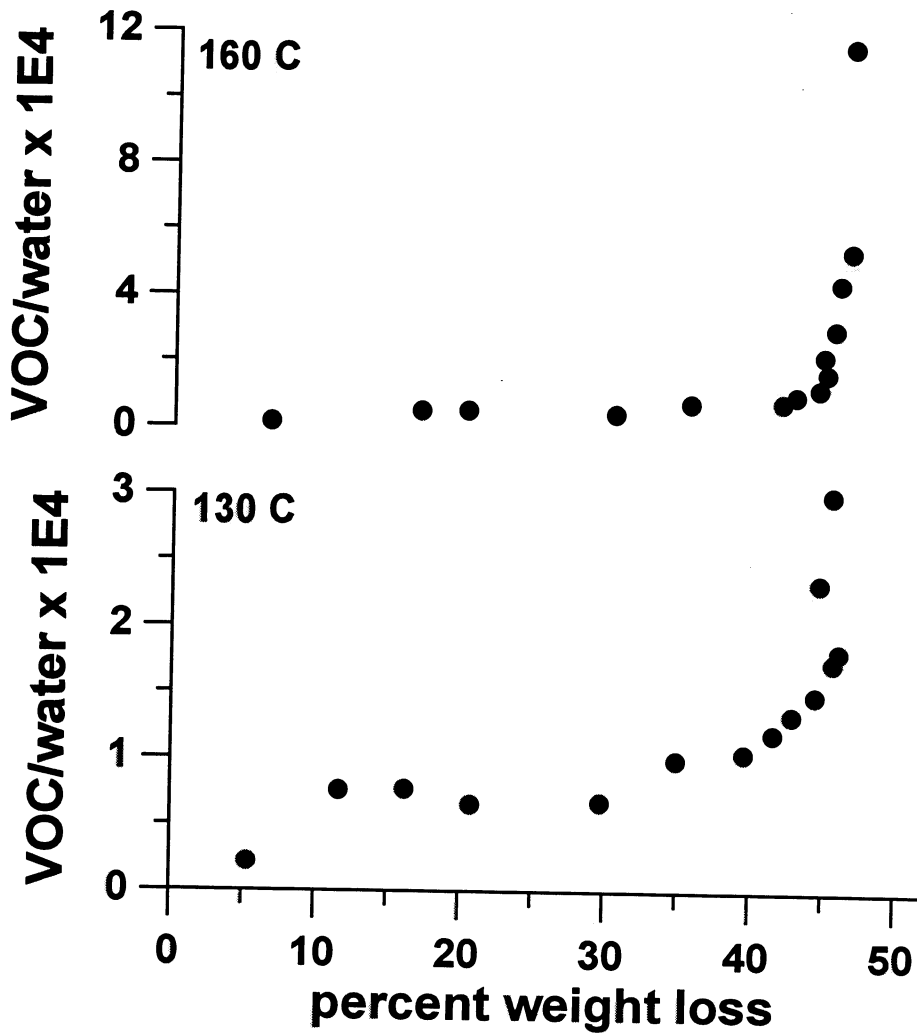


Figure 2: Effect of temperature on VOC emissions from yellow poplar.

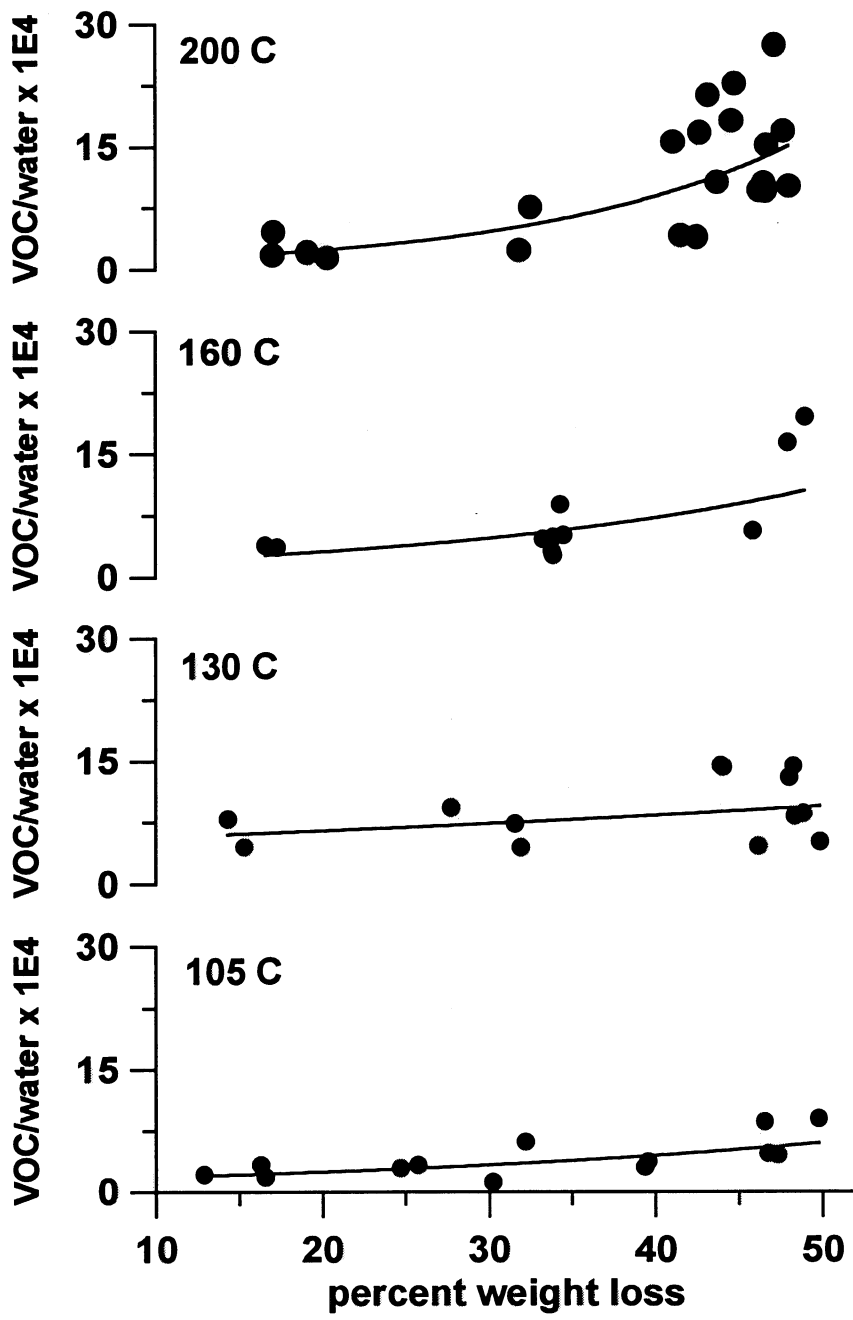


Figure 3: Effect of temperature on VOC emissions from pine.

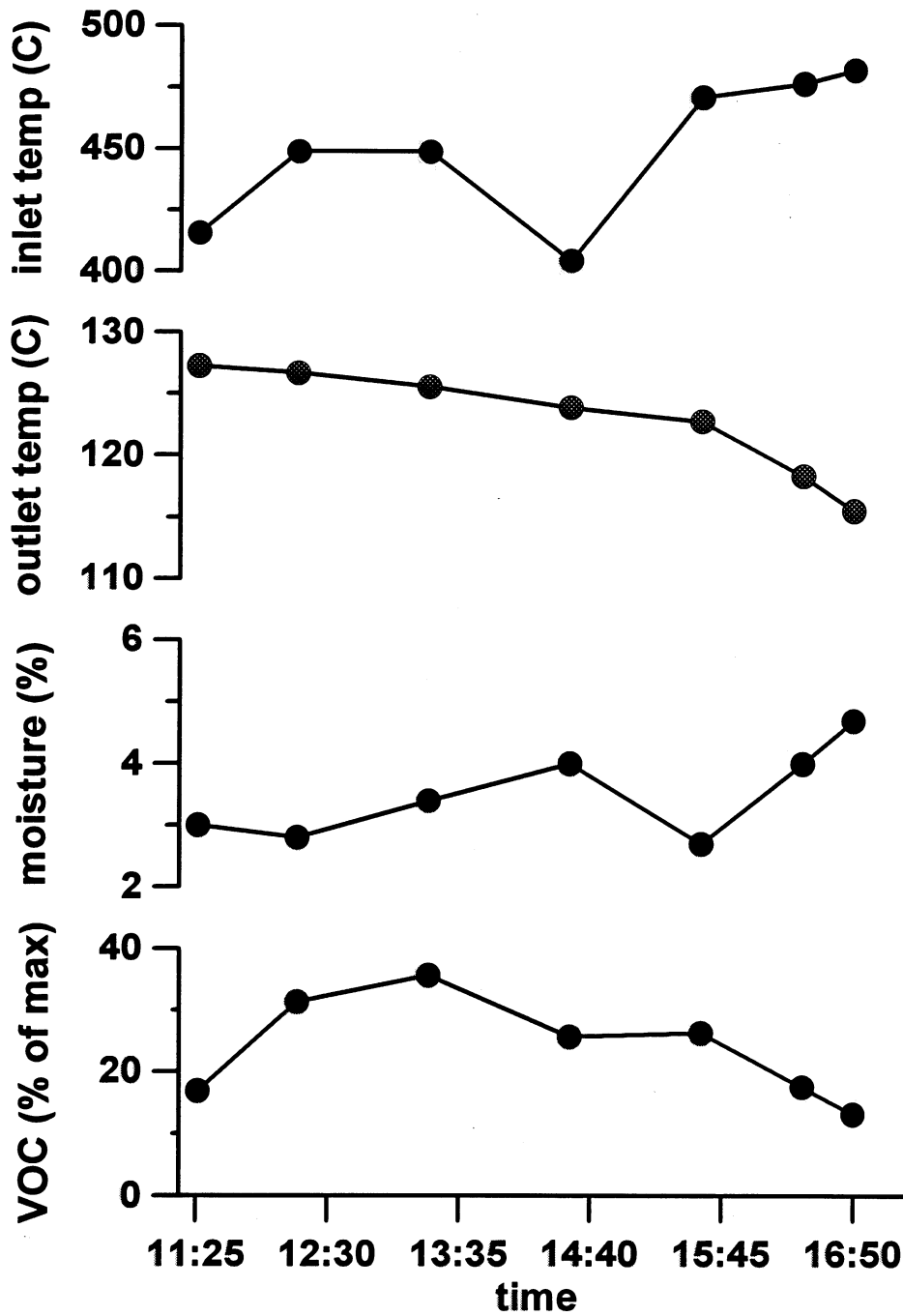


Figure 4: VOC, flake moisture, and dryer temperature profiles for the 8.18.97 (fines excluded) trial at a Northern US mill.

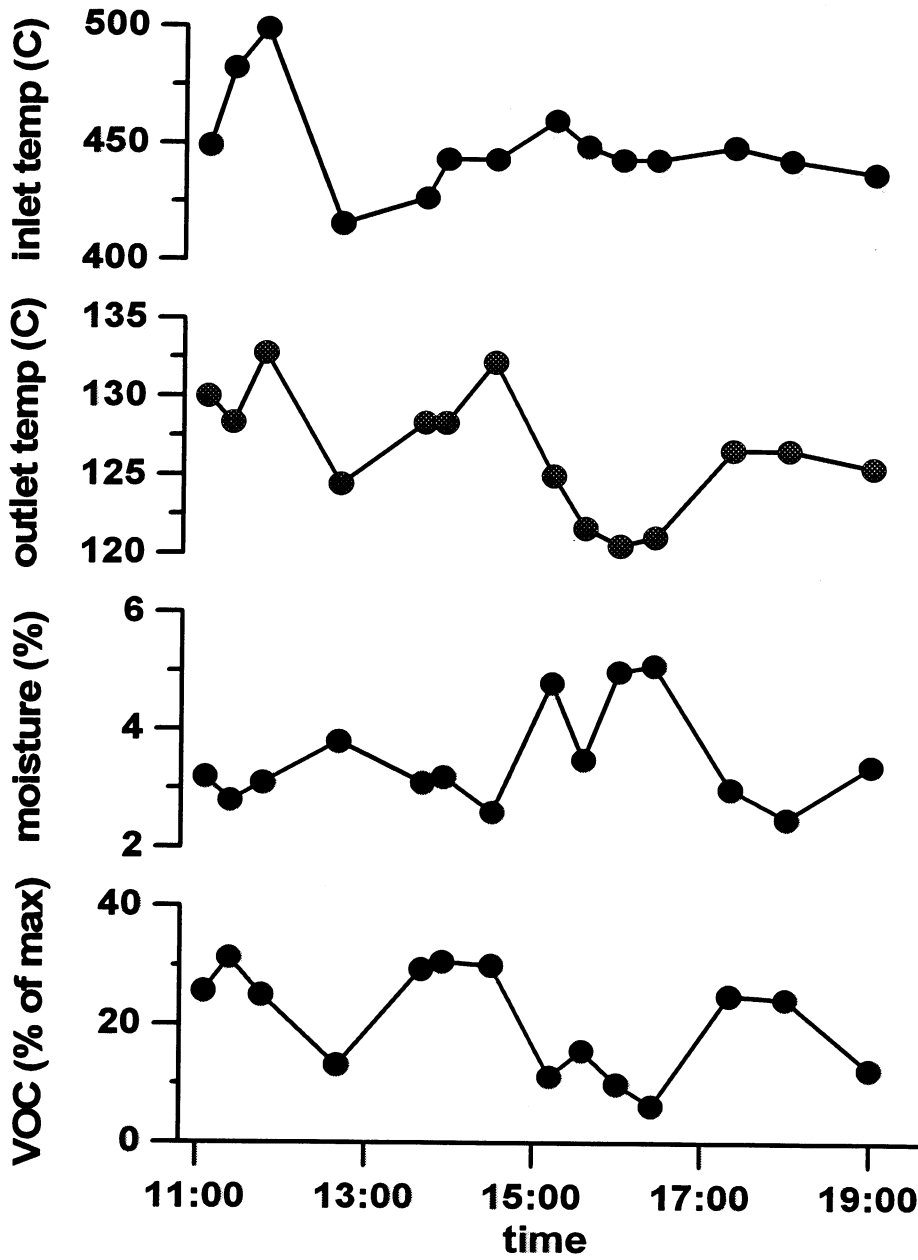


Figure 5: VOC, flake moisture, and dryer temperature profiles for the 8.19.97 (fines excluded) trial at a Northern US mill.

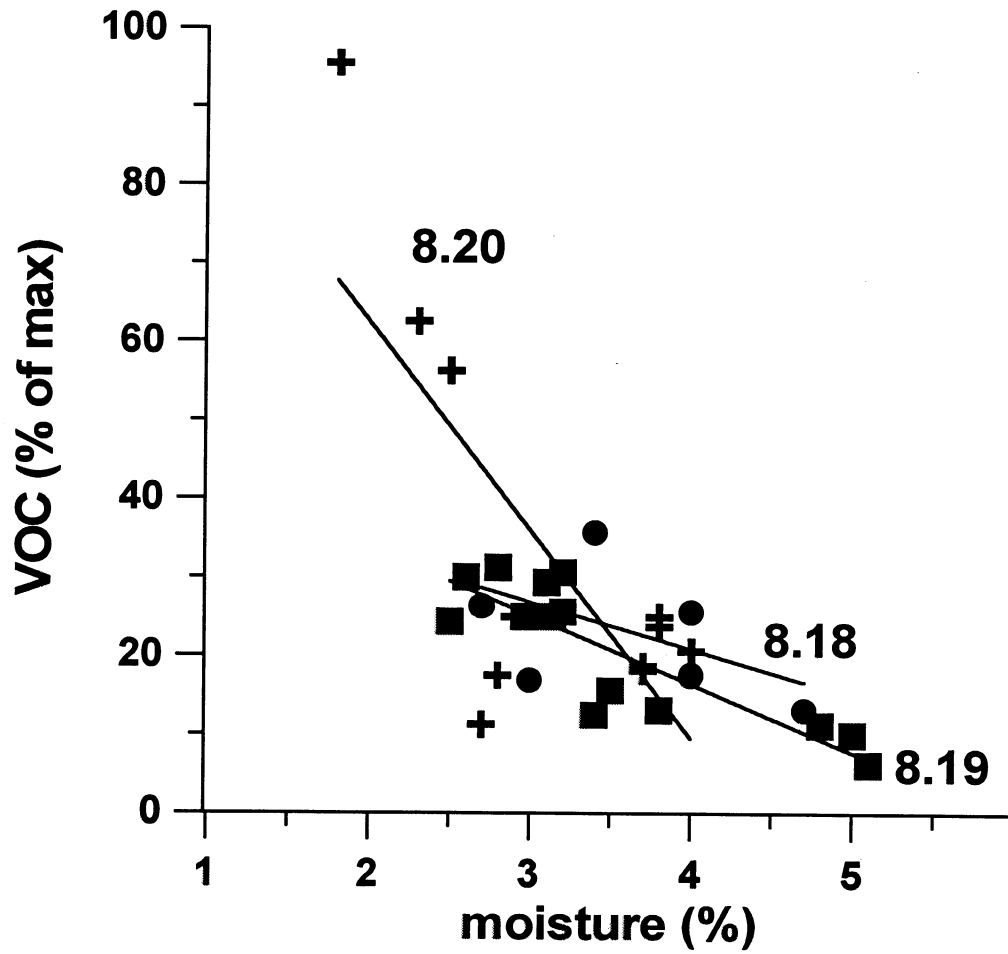


Figure 6: Effect of fines on VOC emissions from hardwood.

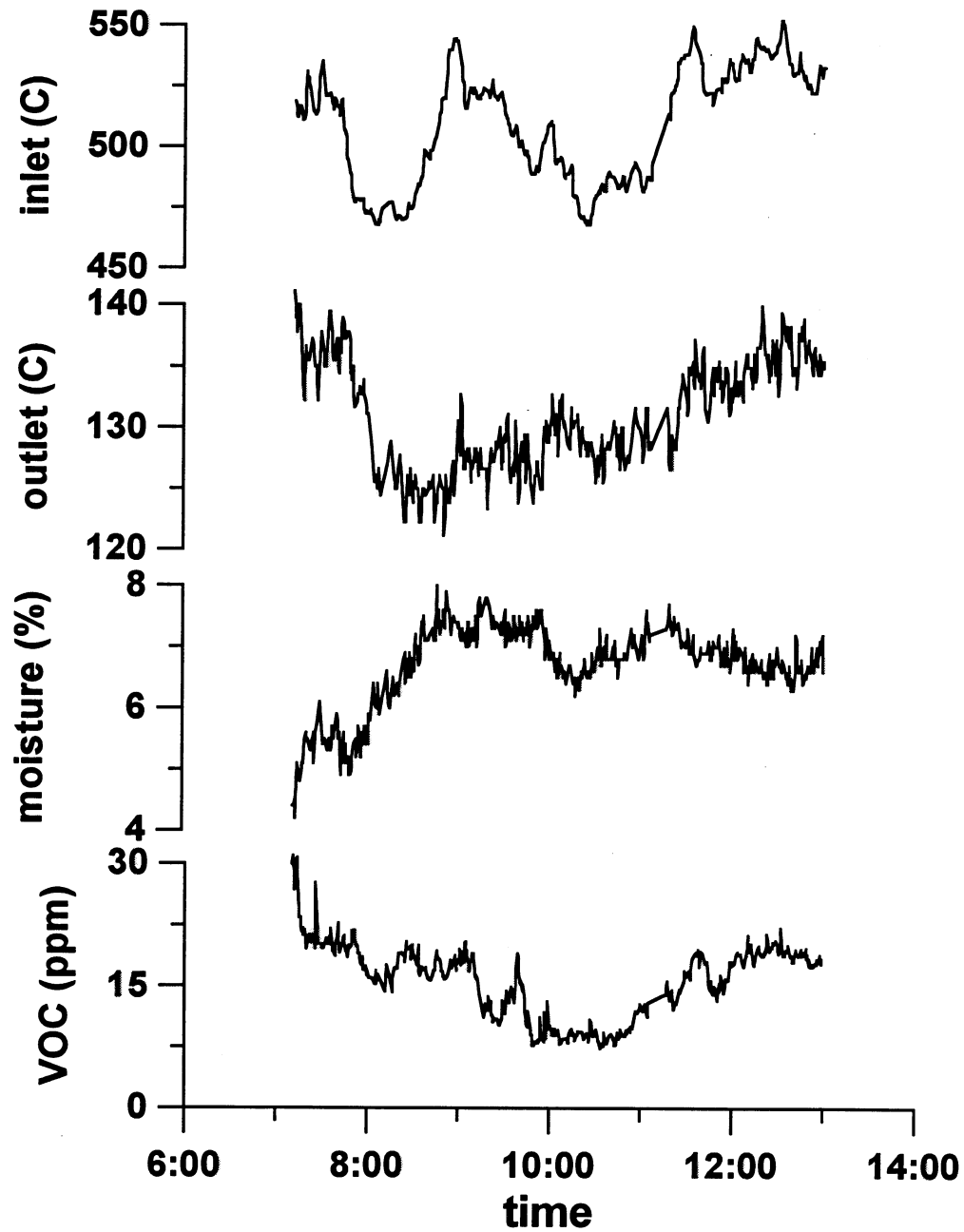


Figure 7: Profiles for the core dryer (100% aspen) for the 10.14.97 Woodland trial.

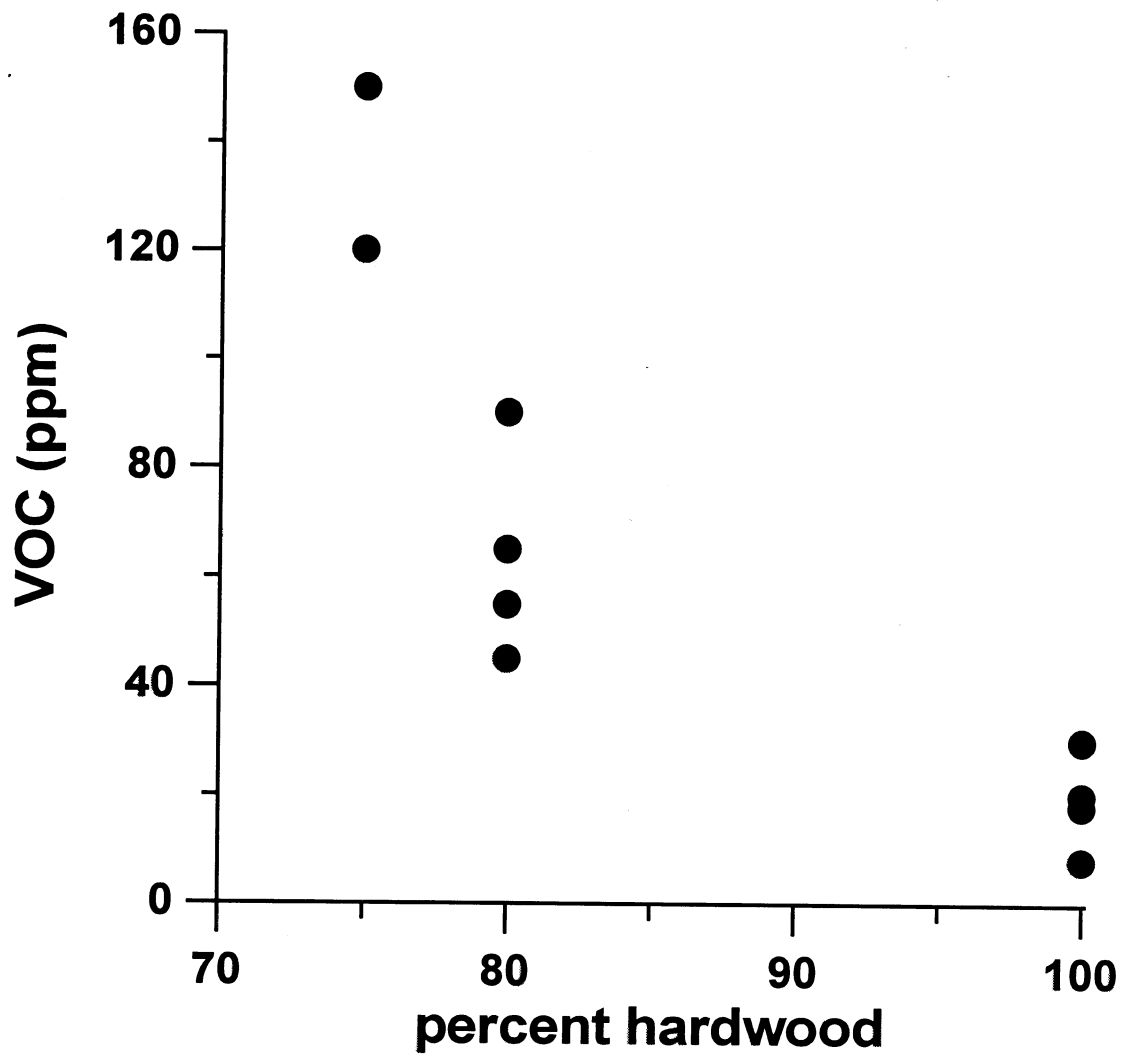


Figure 8: Relationship between VOCs and wood species.







