

Increasingly, building owners and designers are requiring that building materials and furnishings meet indoor air quality criteria.

Air Quality and Composite Wood Products

Melissa G.D. Baumann

CAAA	Clean Air Act Amendments
FPL	Forest Products Laboratory
HAP	Hazardous air pollutant
MACT	Maximum achievable control technology
MDF	Medium density fiberboard
OSB	Oriented strandboard
PF	Phenol-formaldehyde
pMDI	Polymeric methylene diisocyanate
VOC	Volatile organic compound

As high quality timber for lumber becomes increasingly scarce, composite wood products will become even more important in replacing solid wood for many applications. In the United States, the 1997 shipments of particleboard and medium-density fiberboard (MDF) totaled more than 540 million square meters (19-mm basis), and 1998 production of oriented strandboard (OSB) and softwood plywood totaled 2.69 billion square meters (9.5-mm basis) (Composite Panel Association 1998; Adair, 1999). Production will most likely increase for all of these products, except plywood, during the next five years.

Current environmental awareness has led consumers, manufacturers, and regulatory agencies to raise questions about environmental impacts that may be associated with the manufacture and use of wood composite products. While wood is viewed as a natural building and furnishing material, the processing and the addition of adhesive necessary in the preparation of wood composite products, have caused concern. Consumer and regulatory interest in assuring that citizens are able to work and live in "healthy buildings" has increased the need for information about the types, quantities, and persistence of volatile organic compounds (VOCs) that are emitted from building materials and furnishings, including wood products. The 1990 amendments to the Clean Air Act have increased the pressures on wood products manufacturers to document and control the VOC emissions from their manufacturing facilities.

Research at the USDA Forest Service, Forest Products Laboratory (FPL) is being conducted to identify the compounds emitted from wood products during their manufacture and subsequent use. The FPL researchers are measuring the types and quantities of VOCs that are emitted from particleboard and MDF products to provide quantitative emissions information. This information can be used by other researchers studying indoor air quality of homes and offices where these products are used. The FPL researchers are also evaluating emissions during the manufacture of various composite wood products. Measuring emissions during manufacture of wood composites provides information about the relationship between manufacturing conditions and the types and quantities of emissions. This information will help determine whether changes in manufacturing conditions can be used to reduce emission levels and what the best control strategies are for the types of compounds that are emitted.

Emissions from products

As consumers have become more conscious of energy conservation, they have decreased air exchange rates in home and office buildings. This tightening of the buildings has resulted in increased levels of compounds in the indoor air, and reports of illness related to poor indoor air quality have increased. Many products used indoors (such as furniture, upholstery, drapery, and carpeting) and activities of the building occupants (such as use of cleaning supplies, cooking, and smoking) contribute VOCs to the indoor air. In past years, formaldehyde emissions from wood products, primarily particle-

board and hardwood plywood, have been studied because the adhesive used to bond these products emits formaldehyde. Improvements in adhesive technology and manufacturing techniques have largely allayed concerns about formaldehyde emissions, but questions have been raised about whether there are emissions of other compounds that may adversely impact indoor air quality. Increasingly, building owners and designers are requiring that building materials and furnishings meet indoor air quality criteria. With very little information available for wood composite products, there is no scientific basis upon which to form decisions about product use.

To address this lack of information, researchers at FPL, with assistance from the Composite Panel Association. Gaithersburg, Maryland, obtained samples of particleboard and MDF from mills throughout the United States. Products representing more than 85% of the industry were included in this survey (Baumann, Battermans, and Zhang, 1999). Wood specimens were housed in stainless steel chambers with clean air passing over them providing conditions similar to what would be found in a home or office. Emissions from the specimens were measured throughout a 4-day period. These measurements showed that the primary compounds emitted from the wood were secondary components of wood, such as a-pinene and b-pinene, and wood degradation products, such as alcohols and aldehydes (Table 1). The types of compounds emitted depended upon both the wood species and whether the panel was particleboard or MDF.

Particleboard panels made with pine had the highest emissions levels, primarily due to the terpenoid compounds, which are natural volatile components of the wood. Generally, panels of MDF had lower emissions than panels of particleboard. This difference is probably due to VOCs being driven off during the manufacturing of MDF. In this research, the significant

number and amounts of degradation products (such as pentanal, hexanal, and nonanal) in the emissions was surprising because these compounds are not components of the adhesives and they have not previously been identified in the extractable compounds from wood. Further work is being conducted to determine how these compounds are formed, and research on

emissions from composite wood products will be extended to include other products such as plywood and OSB.

Emissions during manufacture

The passage of the Clean Air Act Amendments (CAAA) in 1990 brought large sectors of the wood composites

Compound	Number of samples						
	Southern Pine		Other pines		Hardwood		Douglas Fir
	Particle-board(22)	MDF (6)	Particle-board (8)	MDF (5)	Particle-board (3)	MDF (5)	Particle-board (4)
Terpenes							
a-pinene	2 2	0	8	0	3	0	3
Camphene	1 6	0	4	0	0	0	0
b-pinene	2 2	0	7	0	2	0	1
3-carene	0	0	8	1	2	0	1
p-cymene	2 2	2	8	2	0	1	2
Limonene	1 5	1	8	2	0	1	1
Borneol	2 2	5	8	5	0	2	3
Aldehydes							
Formaldehyde	2 2	6	8	5	3	5	4
Acetaldehyde	2 2	6	8	3	2	5	3
Propanal	1 2	1	4	0	2	0	0
Butanal	1 3	3	2	2	1	1	1
Pentanal	2 2	5	8	1	3	0	0
Hexanal	2 2	5	8	4	3	5	4
Heptanal	2 1	5	8	1	1	0	0
Benzaldehyde	2 2	5	8	5	2	2	1
Octanal	2 2	5	8	3	3	1	1
t-2-octenal	2 2	5	8	2	3	1	2
Nonanal	2 2	5	8	4	3	1	1
Ketones							
Acetone	2 2	6	8	4	3	2	3
2-heptanone	2 2	4	8	1	1	0	0
Alcohols							
1-pentanol	3	2	2	0	0	0	0
1-heptanal	1 8	4	6	1	0	0	0
Other							
Acetic acid	3	0	1	2	2	3	0
2-pentylfuran	2 2	6	8	3	3	1	1

industry under new regulations. Emissions of VOCs that are precursors for the formation of tropospheric ozone are limited depending upon the air quality of the area where the manufacturing site is located. For a special class of 188 compounds designated as hazardous air pollutants (HAPs), the CAAA requires control by use of maximum achievable control technology (MACT) if emissions of HAPs exceed threshold levels. The MACT regulations are set by EPA for each industry.

The next two years will be crucial for the wood products industry because their MACT regulations are scheduled to be promulgated in November 2000. To develop adequate MACT regulations, information about the types and quantities of emissions from wood products manufacturing is needed to determine: (1) what VOCs are emitted and at what emission rates, (2) whether manufacturing process changes can help to control or eliminate VOC emissions, and (3) which types of wood products manufacturing facilities emit high enough levels of VOCs that they will be required to install the MACT controls.

Most of the compounds, such as terpenes, emitted during the manufacture of wood products are likely to fall under general VOC regulation, and will not be subject to MACT regulation. However, the adhesives used to manufacture composite wood products all contain at least one of the special group of compounds classified as HAPs. The HAPs that are known to be present in wood adhesives are formaldehyde, methanol, phenol, and the methylene diisocyanate monomer. Other HAPs that have been identified in emissions from wood product manufacturing include acetaldehyde, acrolein, benzene, naphthalene, toluene, and xylenes.

Collecting emissions information at actual manufacturing facilities is prohibitively expensive and often very difficult. To avoid these costs, FPL researchers, in collaboration with industry and university researchers, are working on laboratory tests that can provide the needed information. Research is being conducted to determine whether a laboratory test method can be used to estimate the

expected emissions from a product being pressed in a manufacturing facility and to determine how conditions during pressing affect the types and quantities of VOC emissions.

In one study, a laboratory test method was developed and compared with stack test data from manufacturing facilities. During this research, the National Council of the Paper Industry for Air and Stream Improvement was responsible for collecting emissions from manufacturing facilities while members of the Amino and Phenolic Wood Adhesives Association and researchers at FPL tested emissions from panels as they were pressed under laboratory conditions. In this work, the stack testing data correlated well with the laboratory data for methanol and formaldehyde. Correlations for other compounds, such as terpenes, and for the total amount of VOCs were not as successful, perhaps due to aging and outgassing of the wood between the time of emission collection and panel pressing. Products that were included in this study were particleboard, hardboard, plywood, and OSB with a variety of wood species. Compounds detected during the laboratory phase of the research included many of the same compounds as in the product tests reported above. Terpenes were the predominant emissions from the softwood products, but in all products, oxidized compounds such as alcohols and aldehydes were also present in significant quantities.

To determine the effects of press conditions on VOC emissions, FPL and University of Maine researchers completed an in-depth study of press emissions while pressing panels with all three of the major adhesives used in wood composites, phenol-formaldehyde (PF), urea-formaldehyde (UF), and polymeric methylene diisocyanate (pMDI). Similar to what was found in the product emission measurements, the compounds emitted during pressing of panels were primarily materials present in wood and degradation products from the wood, including terpenes and aldehydes. The addition of the adhesive resin was not shown to significantly increase the emissions of most VOCs, and for pMDI, the application of the resin actually decreased the VOC emissions. The wood alone was found to

have some formaldehyde emissions, and these emissions decreased upon pressing with either PF or pMDI resin.

The increased use of composite wood products as substitutes for lumber in many applications requires that we must know more about the VOCs that these products emit during manufacture and use. The research outlined in this article should contribute to the basic information necessary to evaluate these composite products and determine whether or not they are contributing to air quality problems.

References

Adair, Craig. 1999. Personal Communication. APA—The Engineered Wood Association, Tacoma WA.

Baumann, M.G.D., Battermans, S.A., and Zhang, G.Z. 1999. Terpene Emissions from Particleboard and Medium Density Fiberboard. *Forest Products Journal* 49(1): 49-56.

Composite Panel Association. 1998. 1997 Annual Shipments Report and Downstream Market Survey. Composite Panel Association, Gaithersburg, MD.

Melissa Baumann is a Research Chemist at the USDA Forest Service, Forest Products Laboratory in Madison, Wisconsin. She is a member of the Wood Adhesives Science and Technology Research Work Unit studying the environmental effects of wood adhesives during manufacture and use. Research in this area has primarily focused on emissions of VOCs from wood composite products such as particleboard, fiberboard, plywood, and oriented strandboard. Baumann received her bachelor's degrees in chemistry and environmental studies from Tufts University in Medford, Massachusetts, and a doctoral degree in inorganic chemistry from the University of Wisconsin-Madison.





4

**Air Quality and Composite
Wood Products**

Melissa G. D. Baumann

Increasingly, building owners and designers are requiring that building materials and furnishings meet indoor air quality criteria.