EPA/600/A-96/111

Source Reduction of VOC and Hazardous Organic Emissions from Wood Furniture Coatings

Eddy W. Huang
AeroVironment, Inc.
222 E. Huntington Drive
Monrovia, CA 91016
and
Robert C. McCrillis
U.S. Environmental Protection Agency
National Risk Management Research Laboratory
Air Pollution Prevention and Control Division
Research Triangle Park, NC 27711

ABSTRACT

Under U.S. EPA sponsorship, AeroVironment, Inc. and Adhesives Coating Co. are teaming up to develop and demonstrate a wood furniture coating system containing no volatile organic compounds (VOCs) and no hazardous air pollutants (HAPs), making it less hazardous to use, and emitting no detectable VOCs and HAPs during curing, therefore contributing significantly to emission reduction.

Earlier work on a new topcoat showed excellent performance characteristics in terms of adhesion, gloss value, dry time, hardness, organic solvents content, and chemical/stain resistance. The VOC contents of both the clear topcoat and the white pigmented topcoat were less than 10 g/L, the detection limit of the test method (EPA Method 24). This coating's performance and properties compared favorably with those of other low-VOC waterborne coatings. Currently, low-/no-VOC stain and sealer wood coatings are being developed so that a complete low-/no-VOC wood coating system will be available for public use. The compatibility of coating components (a stain and sealer) to go with the topcoat is currently being evaluated. The complete system will be demonstrated at several furniture plants. A marketing plan of the developed products is part of this demonstration project.

INTRODUCTION

The failure of nearly 100 metropolitan areas in the United States to attain the National Ambient Air Quality Standard for ozone[1] is one of the major environmental issues currently faced by the U.S. Environmental Protection Agency (U.S. EPA) and local regulatory agencies. The formation of ground-level ozone results from complex atmospheric reactions between volatile organic compounds (VOCs) and nitrogen oxides (NO_X) in the presence of sunlight. Thus, the control of VOCs and NO_X, which are precursors of ozone, is essential in order to meet the ozone standard. While most of the large stationary sources of VOC and/or organic, air toxic emissions, are covered by existing regulations, small dispersed sources of these pollutants generally are not and may significantly contribute to the ozone non-attainment problem.

The use of a wide range of consumer products and industrial processes has been identified as a substantial source of VOC and/or organic air toxic emissions. More recent regulatory initiatives are moving the focus away from end-of-pipe controls and toward pollution prevention at the source. Pollution prevention can be achieved by changes in equipment or technologies; process or procedural improvement; raw material substitutions; reformulation or redesign of products; and operational improvement in housekeeping, maintenance, training, or inventory control.

Traditional wood coating technologies emit large quantities of pollutants into the air and consume energy for drying the coatings and powering air pollution abatement equipment. Air emissions can be reduced through a shift from high to low-/no-VOC coatings. By phasing in low-/no-VOC coatings, industries will be able to reduce air emissions without installation of add-on controls and their attendant increase in energy consumption. VOC emissions are released from the coatings during their application and drying/curing. Coatings are applied to protect the wood and create the desired cosmetic look. Substrates commonly used include solid wood, wood composition, simulated wood used in combination with solid wood or wood composition, and paper laminated on wood-fiber based substrates. The typical coating process is to apply the stain, then sealer, and finally the topcoat, with sanding steps between each pair of coats. For a more "custom look," the coating steps could include glaze, toner, and another sealer between the sealer and topcoat steps. The most common method of coating application is by atomized spray inside a spray booth, typically using a high-volume/low-pressure (HVLP) spray gun. Other methods include roller coaters, flow coaters, dip tanks, or hand application (brush, roller, wipe rag). Stains are frequently applied by hand with a wipe rag or hand-wiped after being applied mechanically in order to uniformly color the wood grain.

The percentage of solids in stains is lower than in other coatings; stains contain little or no resin. A stain is primarily a dye dispersed in a solvent. When calculating the VOC content in coatings, including stains, the laboratory measures and then subtracts the water and exempt solvents from the total volatiles to arrive at the VOC reading.

DISCUSSION

The following discussion addresses three areas where emissions can be reduced: low emission wood coatings; a new, zero-VOC/zero-HAP wood furniture coating in development; and application methods which increase coating transfer efficiency resulting in more efficient use of coatings.

Low emission wood coatings

Wood product manufacturers and coating manufacturers have been actively pursuing low-/no-VOC technologies. Waterborne coatings are the most predominant with high solids/catalyzed coatings and ultraviolet (UV) curable coatings becoming more widely investigated. Further development of waterborne UV coatings is a promising avenue for maximum VOC reductions. This technology will reduce VOC from both coatings and cleanup. Implementation of these low VOC coating technologies is expected to provide the wood coating industry with emission reductions.

Waterborne Coatings. Waterborne topcoats generally contain 30-40% solids by weight with a VOC content of anywhere from 100 to 275 g/L. One company listed in the study has a clear topcoat with over 50% solids and 40 g/L VOC content[2]. Most waterborne coatings require some organic solvents (called co-solvents) in the formulation to dissolve the resin. The dissolved resin may then be dispersed in water. Upon application, both the water and the co-solvents evaporate. There are also some resins that release light molecular weight fragments, during cross linking (curing), which become air pollutants.

High gloss finishes may be achieved by applying multiple coats of clear topcoats. The facilities that coat a paper substrate laminated to a wood product need to apply a barrier coat prior to the sealer and topcoat to create the necessary adhesion. Fire and fume hazards are reduced when using waterborne, compared to solvent-borne, coatings.

Waterborne coatings can take longer to cure than conventional solvent-borne coatings. Premature packaging (packaging before the coating is sufficiently cured) may cause pieces of furniture to stick to the packing and cause carton imprinting to occur during shipping. Some companies who have switched to waterborne coatings have set up a temporary storage area to complete the curing prior to shipping. Others have added a heating step by installing gas-fired or infra-red ovens to accelerate the curing of the coated products. The optimum drying temperature for waterborne-coated wood products is 110 - 130 °F (43 -54°C). However, forced drying is not necessarily a requirement to maintain the same production levels of solvent based coatings if there is sufficient space in the facility to accommodate a longer production line.

Another potential difficulty is dusting, which is the settling of sanding dust or dry overspray onto the surface of a partially cured coating. A cleaner environment may be required such as the installation of enclosures around spray booths and at building entrances to minimize dust. Waterborne coatings are more sensitive to changes in temperature and humidity, including during shipment of the finished product. For cleanup, water can be used if the coating is not dry. If cleanup is not performed before the coatings dry, then an organic solvent is required for cleanup. In many cases, waterborne coatings, when cured, exhibit very high chemical resistance and can be removed only by mechanical methods (i.e., sanding).

High Solids/Catalyzed Coatings. Catalyzed conversion varnishes are available with VOC contents typically between that of waterborne and solvent-based materials; but there are some catalyzed coatings at the low end of the waterborne VOC content range. There are both waterborne and solvent-based catalyzed coatings. The solids content is also between that of waterborne and solvent based materials. Currently, a clear topcoat is available with a content of over 95% solids and a VOC content of 40 g/L. One of the more widely used catalyzed coatings is the acid catalyzed, or conversion varnish, system. It is based on a melamine type resin catalyzed by a strong acid catalyst. This coating often contains some free formaldehyde; additional formaldehyde may be formed and emitted during the curing process.

Ultraviolet (UV) Curable Coatings. The three primary factors to consider in selecting a UV coating process are application, lamps, and coating formulation. Different types of lamps emit different wavelengths. Coatings can be formulated for different wavelengths and different applications. Each application dictates the coating formulation and lamp type.

The UV coatings do not cure (they remain wet) unless exposed to UV light. Since the coatings do not cure until exposed to UV light, application equipment does not necessarily have to be cleaned as frequently if the exposure to sunlight and interior lighting is minimal. Cleanup requires a 100% VOC solvent such as methyl isobutyl ketone (MIBK). UV cured coatings may or may not emit VOCs and or HAPs, depending on whether solvents are used for viscosity adjustment and what reaction products are formed during the curing process.

Waterborne UV Curable Coatings. This is an emerging technology. The resins are recently available for manufacturers to formulate into coatings. Waterborne UV curable coatings use water, instead of an organic solvent, for viscosity adjustment. As with 100% solids UV coatings, less VOC is associated with the use of these coatings (generally <24 g/L) compared to solvent-borne coatings. Water can be used for cleanup, which eliminates the high VOC cleanup associated with the 100% solids UV coating process. The coatings are free of multi-functional acrylates, the components which irritate the skin. They have better sprayability with low viscosity. A range of gloss from low to high can be achieved. The cured coatings can be buffed to a high gloss if desired. The coatings are cheaper than 100% solids UV coatings. They have low odor and are nonflammable. Thin films are easily attainable using spray systems, roller coaters, or curtain coaters. If multiple coats are required, each coating can be sanded before the subsequent coating is applied, then finally cured in the UV oven.

The water in the sealer/topcoat (topcoat is recommended to be used as the sealer) must be driven off prior to curing in the UV oven. When the coating is applied, it has a milky finish due to the water in the coating; when the water is gone, the coating film is clear. An infrared (IR) lamp/heater can be used to drive off the water along with parallel air flow. If the water is not completely eliminated before UV curing, the final product will still be milky. The need for additional drying time is probably the biggest disadvantage of the waterborne UV coatings.

Other Technologies. Acetone, siloxanes, and PCBTF (parachlorobenzotrifluoride), recently classified as exempt solvents by the EPA, are not expected to be significant substitutes for VOCs in wood products coatings. Some manufacturers are working on wood coatings with these compounds as VOC substitutes, but no information is available as to what extent these coatings will be found acceptable. Reduced VOC acetone-based products are expected to be difficult to formulate because of acetone's high volatility. Acetone-based coatings would dry quickly, especially upon atomization. Acetone-based cleaning solvents are available, but they too evaporate quickly. Some coating manufacturers have indicated they do not plan to develop acetone containing coatings.

Emission Reductions. Full conversion from nitrocellulose lacquers to currently available waterborne technology will result in a VOC emission reduction of approximately 87%. Further reductions may be possible with conversion to UV technology. Some facilities may elect to convert partially to UV by using UV topcoat and sealer along with waterborne or solvent based stains. This type of hybrid system will have reductions between that of complete waterborne and complete UV systems.

New zero-VOC/zero-HAP wood coating technology

The following paragraphs describe this new coating being demonstrated with EPA assistance and the current status of the work.

Coating development. Adhesive Coatings Co. (ADCO) of San Mateo, California, currently holds patents on some no-VOC coating technologies[3,4,5,6,7]. Under an initial contract from the South Coast Air Quality Management District (SCAQMD) (see ACKNOWLEDGMENTS) to develop a no-VOC wood topcoat, ADCO's coatings were reformulated, and performance characteristics were tested. The resulting topcoat showed excellent performance characteristics in terms of adhesion, gloss value, dry time, hardness, level of solvents, and chemical/stain resistance. The VOC contents of both the clear topcoat and the white pigmented topcoat were less than EPA Method 24 detection limit of 10 g/L. This coating's performance and properties on finished material compared favorably with other low-VOC waterborne wood coatings[8]. However, no-VOC stain and sealer wood coatings need to be developed so that a complete no-VOC wood coating system will be available for public use. It is also desirable to determine the compatibility of coating components (a stain and a sealer) to go with this new no-VOC topcoat.

Under U.S. EPA sponsorship, AeroVironment Inc. and ADCO have teamed up to develop and demonstrate a no-VOC/no-HAP wood furniture coating system. The complete absence of organic solvents in the preparation and formulation means that this new coating system is not only less hazardous to use but also emits no VOCs (as measured by EPA Method 24), and therefore contributes significantly to emission reduction. This new no-VOC coating's high gloss and excellent chemical resistance properties are ideal for the wood manufacturing industry for flat stock; particle, chip, and wafer products; spray primers for door skins; and finishing systems for interior wood products such as furniture and kitchen cabinets. This material can be manufactured using readily available raw materials and standard resin manufacturing equipment without polluting the atmosphere.

The objective of this project is to develop a new no-VOC/no-HAP wood coating system through continuing research, formulation adjustments, and application testing. The high value-added coating products will be developed using existing technical know-how and data related to the new water-based epoxy technologies. In addition to the research and development of a new no-VOC/no-HAP wood coating system, on-site demonstration and workshops will be included as part of this program. A technology transfer plan, which includes working with manufacturers and suppliers, will be developed to get the products into use by the public.

The new two component water-based epoxy coating system developed in this project has the potential to meet the performance of the solvent-based system and may replace current solvent systems. The coatings properties which make them promising can also be applied in the wood products area. These properties include:

- low or no formaldehyde
- extreme water and chemical resistance
- very fast cure
- liquid at high solids
- low temperature cure
- no solvents and thus no VOCs.

In the simple system (consisting of a maximum of four steps including the use of stain, sealer, and topcoat), the stain was either sprayed or wiped on. A seal coat was sprayed, then two topcoats were sprayed on each panel. In order to ensure that evaluations were completely unbiased, the American Society of Testing Materials (ASTM) methods were used as the scientific basis of measurement throughout this project.

Sanding between waterborne coatings is done for three primary reasons. First, sanding smooths the substrate surface before the next coat is applied. Secondly, sanding cuts off any wood fibers which surfaced after the waterborne coatings. This process flattens the substrate surface to make the subsequent layers of coating flow smoothly. Also, sanding scratches or mars the surface of the coating to provide a surface which will allow for a good mechanical bond of the next coat. Many waterborne coatings require this type of sanding between coats because, unlike solvent-borne coatings, waterborne coatings do not remelt between coating layers. For example, with nitrocellulose solvent-borne systems, the solvent in subsequent coats partially dissolves the previously applied coating, resulting in the whole coating's becoming a single layer. Epoxies and urethanes, in contrast, remain in distinct layers.

Grain raising is the swelling and standing up of the wood grain caused by absorbed liquids. Grain raising is more common in softwoods than in hardwoods. During development, it was found that there was slight to heavy grain raising after application of a normal sealer coat. To minimize grain raising, it was found that application of a dust (light) coat of the sealer, to seal the pores of the substrate, followed by a normal sealer coat was effective. The dust coat will seal the wood, and allow for better spraying of a heavier second coat. A technique to minimize grain raising, when using a waterborne coating, is to use a 400 grit wet or dry sandpaper to grind or bite the substrate while applying the stain. The stain should then be wiped off, using conventional methods.

<u>Coating Evaluation</u>. Polymer variations of ADCO's basic EnviroPolymer (A) in combination with each of several proprietary curing agents (B) were tested. All combinations contained no VOCs. Up to eight different ratios were evaluated for each combination, and the best ratio observed was then selected for further evaluation by applying this coating on solid oak. The choice of equipment was a Binks Mach 1 HVLP cup spray gun. Each coat was applied so a wet film thickness between 2 and 3 mils (5 and 7.5 x 10^{-5} m) was obtained. This thickness of coating was chosen because it ensured ease of spraying and good flow characteristics. Also, the film thickness was held as constant as possible, so the evaluation of coatings from different formulations would be consistent.

The most promising formulations were applied to a substrate for further determination of the coatings performance characteristics (dry time, gloss, parallel groove adhesion, scrape/mar, and chemical and stain resistance). Dry time was measured as the amount of time that was taken for the coating to harden before it could be sanded and re-coated. To be objective, a gloss meter was used to put a measured value on the degree of gloss. The method described in ASTM D 523[9] was followed.

Evaluation of adhesion to different surface treatments, or different coatings to the same treatment, is extremely important to the furniture manufacturing industry. The method described by ASTM D 3359[10] was followed. After parallel grooves were cut into the coating, tape was applied over the grooves and removed. The cross-hatch pattern was inspected through a magnifying glass and rated against the standards. Gt 0/5B was the best rating followed by Gt 1/4B, Gt 2/3B, Gt 3/2B, Gt 4/1B, and Gt 5/0B.

A modified ASTM D 2197[11] method was followed to differentiate between degrees of coating hardness. After complete curing, the scrape/mar resistance was determined by pushing the panels beneath a round stylus or loop that was loaded in increasing amounts until marring of the coatings was detected.

Resistance to various household chemicals is an important characteristic of wood furniture finishes. The methods described by ASTM D 1308[12] were followed. This evaluation covers the effects household chemicals have on organic finishes such as discoloration, change in gloss, blistering, softening, swelling, and loss of adhesion.

SCAQMD method 304[13] [Determination of Volatile Organic Compounds (VOC) in Various Materials] was used to conduct VOC analysis. ASTM D 1475[14] was used to determine the density of coatings. Total volatile content was measured by ASTM D 2369[15], and water content was determined by ASTM D 3792[16].

Most wood furniture is finished with nitrocellulose resin-based coatings averaging 750 g/L VOC and 375 g/L hazardous air pollutants (HAPs). In the finishing of an average 4 x 6 ft (1.2 x 1.8 m) dining room table about 9 kg of VOCs and 4.5 kg of HAPs are emitted. While progress has been made to formulate low-VOC coating systems, many of them use ethylene glycol ethers, which are more toxic than most of the solvents used with nitrocellulose systems. The SCAQMD /California Furniture Manufacturers Association/Southern California Edison Cooperative study[17] of low-VOC coatings for wood furniture confirmed that most commercially available water-based coating systems contain VOC and air toxic compounds.

Coating performance characteristics. The resulting wood coating showed excellent performance characteristics in terms of adhesion, gloss value, dry time, hardness, level of solvents, and chemical/stain resistance in laboratory development tests as shown in Table 1. The VOC contents of both the clear topcoat and the white pigmented topcoat were less than 10 g/L, the detection limit of the test method. This coating's performance and properties in finished material compared favorably with those of other low-VOC waterborne wood coatings.

More efficient coating application methods

The application process is a key element in determining how much product is used to complete a given job. The transfer efficiencies of coatings will determine the economic environment in which these products compete. In the application process transfer efficiency, a measure of the quantity of coating actually reaching the part compared to the quantity of coating sprayed, is a major factor impacting air emissions.

In addition to VOC compliance and issues of toxicity, performance characteristics included are ease of use, durability, typical lifetime, and appearance. Ease of use is an appealing attribute of coatings: it can increase the productivity of applicators and minimize the risk of costly application-related failures. Included in this category of features are low temperature cure characteristics, ease of application, fast recoat time, surface tolerance, and high film buildup. Other characteristics which are less often mentioned include recoatability for epoxies, fast cure, fast adhesion, film build on edges, and irregularities.

New application equipment with improved transfer efficiency is available to replace conventional spray guns. These include: airless, air-assisted airless, electrostatic, and high-volume/ low-pressure (HVLP) guns.

HVLP spray coating systems, because they have demonstrated increased transfer efficiency over conventional spray guns, have come into fairly widespread use. Because the HVLP guns use low pressure, the paint particles are carried to the substrate in a low turbulence flow which helps reduce overspray. Depending on their application, HVLP systems have the potential to reduce paint usage, reduce water wash or dry filter maintenance costs, reduce noise, reduce paint booth air turbulence, and improve the worker's environment.

Airless spray equipment is designed to handle heavy-bodied and high solids coatings. Both electric and gas models have been introduced, and some can support up to three guns simultaneously. Other application features include an adjustable width roller frame, roller extension poles, and air-powered paint mixers.

CONCLUSIONS

Compliance with environmental regulations has been and continues to be of concern to wood furniture manufacturers. Solvent-based coatings have been the industry standard since the beginning of the industrial revolution in the United States. With new environmental standards calling for cleaner air and water, many manufacturing processes will have to alter the way they use coating materials. This project was developed to assist wood manufacturers in the conversion to cleaner coatings.

The source reduction opportunities in wood furniture manufacturing include coating reformulation, high solid coatings, solvent substitutes, water-soluble cleaning solvents, higher transfer efficiency, and proper training. The two areas that present the most promising pollution prevention options are coating reformulation and application. The reformulation step would involve a change from a solvent-based to water-based system. The application waste reduction option would involve a switch to high transfer efficiency spray equipment and personnel training.

Water-based products have been introduced to the wood coating industry to replace the high volatile organic compound (VOC) and high hazardous air pollutant (HAP) materials previously used on plywood, hardboard, particleboard, and regenerated wood-finger jointed wood products. Many water-based products, however, exhibit a reduction in performance properties such as hardness, toughness, adhesion, and stain resistance. Their second weakness is in energy consumption; most water-based coatings require long dry times at elevated temperature to achieve proper curing.

Based on the research conducted, conversion to waterborne coatings will take time and adjustment on the part of many manufacturers. There is an educational curve that will take place which will include re-training of workers on spraying techniques, sanding applications, repairability of coatings, and acceptance of the finishes on the open market. In some instances production procedures may have to be altered. Heat may be required to achieve proper curing within some production operations. Manufacturers will have to work closely with raw material as well as coating suppliers. As with any new product, acceptance will take time.

The proper procedure for applying stains and sealer will take time to learn so that grain raising will be minimized. When using waterborne coatings, consideration will have to be given to the appearance of the coatings. Clear finishes with no stains or dyes will tend to be drab in color. In order to achieve a rich, full color, stains and/or glazes may have to be used. Many companies will realize a reduction in materials costs with the use of waterborne coatings. High solids coatings will save many manufacturers money because they will not have to use as much coating to cover a production item. Companies using waterborne coatings will also realize a savings in insurance costs. Because this project was a direct result of industry concerns, three seminars will be held in which the following topics will be addressed:

- Cooperative Partnerships and Compliance
- Live Demonstrations of Spraying Applications
- Sanding Technique
- Testing Results
- Operation and Repair Procedures

A survey will be distributed to furniture manufacturers and wood coating suppliers to collect data and consumer feedback. Besides the emission benefits of this new no-VOC/no-HAP wood coating system, the coating life and wear characteristics will be assessed. This new no-VOC coating system's advantages/disadvantages will also be determined in the consumer follow-up program.

ACKNOWLEDGMENTS

This ongoing program is being conducted under U.S. EPA sponsorship, EPA Contract No. 68-D5-0128, with AeroVironment, Inc. The authors would like to thank Jim Birdsall of Adhesive Coating Co. and John Hornung of JH Associates for their technical contribution. This program is a continuation of prior research, cofunded by the U.S. EPA under Cooperative Agreement CX819072-01-3 with SCAQMD, performed under SCAQMD Contract No. S-C93101 entitled Research and Product Development of Low VOC Wood Coatings.

TABLE 1. CHARACTERISTICS OF ADCO NO-VOC COATING[18]

Drying time @ 70°F (21°C) & 60% RH	20 - 25 minutes
Gloss using 60° gloss meter	50 - 60
Hardness	Pass 2H pencil
Hot/cold check	Passed
Parallel groove adhesion	Gt 0/5
Scrape/mar	1000 g
Stain resistance (after 1 hour of exposure)	Coffee
	Cold/Hot Tap Water
	Detergent
	Ethyl Alcohol
	Grape Juice
	Ketchup
	Laundry Spot Cleaner
	Margarine
	Vinegar
	Vodka
VOC Content	Less than 10.0 g/L (0.1 lb/gal)

REFERENCES

1. Curran, T., R. Faoro, T. Fitz-Simons, N. Frank, and W. Freas, *National Air Quality and Emissions Trends Report, 1990*. EPA-450/4-91-023 (NTIS PB92-141555), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, 1991.

2. Draft Staff Report: *Technology Review for Adhesives, Coatings, Inks, and Solvents*, South Coast Air Quality Management District, Diamond Bar, CA, October 18, 1995.

3. U.S. Patent No. 4,490,520, "Epoxy curing agents, method for making, method for curing epoxy resins, and cured epoxy resins," Adhesives Coating Co., San Mateo, CA, December 5, 1984.

4. U.S. Patent No. 4,574,145, "Epoxy curing agents and method for making," Adhesives Coating Co., San Mateo, CA, March 4, 1986.

5. U.S. Patent No. 4,659, 787, "Method for making epoxy curing agents," Adhesives Coating Co., San Mateo, CA, April 21, 1987.

6. U.S. Patent No. 4,812,493, "Dual cure rate water-based coating composition," Adhesives Coating Co., San Mateo, CA, March 14, 1989.

7. U.S. Patent No. 4,906,726, "Water-based coating compositions containing hydroxides and oxides of calcium and strontium and barium," Adhesives Coating Co., San Mateo, CA, March 6, 1990.

8. Huang, Eddy W., *Research and Product Development of Low-VOC Wood Coatings: Final Report*, U.S. Environmental Protection Agency Report No. EPA-600/R-95-160 (NTIS PB96-121520), November 1995.

9. D 523-89, "Standard Test Method for Specular Gloss," American Society for Testing and Materials, 1916 Race St., Philadelphia, PA.

10. D 3359-93, "Standard Test Method for Measuring Adhesion by Tape Test," American Society for Testing and Materials, 1916 Race St., Philadelphia, PA.

11. D 2197-86, "Standard Test Method for Adhesion of Organic Coatings by Scrape Adhesion," American Society for Testing and Materials, 1916 Race St., Philadelphia, PA.

12. D 1308-87, "Standard Test Method for Effect of Household Chemicals on Clear and Pigmented Organic Finishes," American Society for Testing and Materials, 1916 Race St., Philadelphia, PA.

13. Choa, C.B. and S. Hom, *Laboratory Methods of Analysis for Enforcement Samples*, "Method 304-91, Determination of Volatile Organic Compounds (VOC) in Various Materials," South Coast Air Quality Management District, Diamond Bar, CA, June 1991.

14. D 1475-90, "Standard Test Method for Density of Paint, Varnish, Lacquer, and Related Products," American Society for Testing and Materials, 1916 Race St., Philadelphia, PA.

15. D 2369-93, "Standard Test Method for Volatile Content of Coatings," American Society for Testing and Materials, 1916 Race St., Philadelphia, PA.

16. D 3792-91, "Standard Test Method for Water Content of Water-Reducible Paints by Direct Injection into a Gas Chromatograph," American Society for Testing and Materials, 1916 Race St., Philadelphia, PA.

17. Evaluation of Complete Waterborne Coatings Systems. A Cooperative Partnership Project by South Coast Air Quality Management District, California Furniture Manufacturers Association, and Southern California Edison, August 1995.

18. Huang, E.W., and R.C. McCrillis. "Developing a No-VOC Wood Topcoat," Modern Paint and Coatings, **July 1995**, Vol. 85, No. 7, pp. 38-41.

NRMRL-RTP-P-132

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIE
EPA/600/A-96/111		

4. TITLE AND SUBTITLE	5. REPORT DATE / 6. PERFORMING ORGANIZATION CODE
Source Reduction of VOC and Hazardous Organic Emissions from Wood Furniture Coatings	

7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
E. W. Huang (AeroVironment) and R. W. McCrillis (EPA, NRMRL-RTP)	

9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO. / 11. CONTRACT/GRANT NO.
AeroVironment, Inc. 222 E. Huntington Drive Monrovia, California 91016	11. 68-D5-0128

12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED / 14. SPONSORING AGENCY CODE
EPA, Office of Research and Development **Air Pollution Prevention and Control Division** **Research Triangle Park, NC 27711**	13. Published paper; 9/95-4/96 14. **EPA/600/13**

15. SUPPLEMENTARY NOTES APPCD project officer is Robert C. McCrillis, Mail Drop 61, 919/541-2733. Presented at AWMA Conference, New Orleans, LA, 9/4-6/96.

16. ABSTRACT

The paper discusses the development and demonstration of a wood furniture coating system containing no volatile organic compounds (VOCs) or hazardous air pollutants (HAPs) (making it less hazardous to use) and emitting no detectable VOCs or HAPs during curing (contributing significantly to emission reduction). Earlier work on a new topcoat showed excellent performance characteristics in terms of adhesion, gloss value, dry time, hardness, organic solvents content, and chemical/stain resistance. The VOC contents of both the clear topcoat and the white pigmented topcoat were < 10 g/L, the detection limit of the test method (EPA Method 24). This coating's performance and properties compared favorably with those of other low-VOC waterborne coatings. Currently, low-/no-VOC stain and sealer wood coatings are being developed so that a complete low-/no-VOC wood coating system will be available for public use. The compatibility of coating components (a stain and sealer) to go with the topcoat is currently being evaluated. The complete system will be demonstrated at several furniture plants. A marketing plan of the developed products is part of this demonstration project.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Volatility	Pollution Prevention	13B	20M
Coatings	Toxicity	Stationary Sources	11C	06T
Wood	Stains	Wood Furniture	11L	
Furniture	Sealing		15E	13H
Emission			14G	
Organic Compounds			07C	

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release to Public	Unclassified	
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

EPA Form 2220-1 (9-73)