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4,4′-Methylenebis (2-Chloroaniline): An Unregulated Carcinogen

Elizabeth Ward, PhD, Alexander Blair Smith, MD, MS, and William Halperin, MD, MPH

4,4′-Methylenebis (2-chloroaniline) (MBOCA) is a confirmed animal carcinogen. It is used commercially as a curing agent for polymers containing isocyanate. There are no adequate studies documenting a carcinogenic risk for MBOCA in humans; however, studies in rats and dogs have shown that MBOCA is a carcinogen. Also, MBOCA is structurally similar to aromatic amines, which cause bladder cancer in workers with occupational exposure. Manufacture of MBOCA in the United States ceased in 1979. However, estimates of the number of workers potentially exposed range from 1,400 to 33,000 in the manufacture of MBOCA-cured products. Presently, there are no federal regulations limiting occupational exposure to MBOCA. An occupational standard for MBOCA proposed by the Occupational Safety and Health Administration was remanded by the Third Circuit Court of Appeals on procedural grounds in 1974. NIOSH recommended in 1978 that MBOCA be treated as a potential human carcinogen and that worker exposure be controlled so that it does not exceed 3 $\mu g/m^3$ of air determined as a time-weighted average concentration for up to a 10-hour workshift (the lowest level that can be reliably measured). In this paper, we will review the literature in regard to MBOCA's carcinogenicity, describe industrial use and extent of worker exposure, and review MBOCA's status in relation to occupational regulations in the United States and abroad.

Key words: occupational bladder carcinogen, carcinogen policy, OSHA regulations, MBOCA

INTRODUCTION

4,4′-Methylenebis (2-chloroaniline) (MBOCA) (Fig. 1) is a proven animal carcinogen [NIOSH, 1978]. Presently, there are no federal regulations limiting occupational exposure to MBOCA; a standard for MBOCA proposed by the Occupational Safety and Health Administration was remanded by the Third Circuit Court of Appeals in 1974 [Synthetic Organic Chemical Manufacturers Association, 1974]. MBOCA is used commercially as a curing agent for isocyanate-containing polymers.

LITERATURE REVIEW OF DATA

MBOCA has been found to be weakly carcinogenic in mice [Russfield et al, 1975] and strongly carcinogenic in rats [Stula et al, 1975] and dogs [Kommineni et

The National Institute for Occupational Safety and Health, Division of Surveillance, Hazard Evaluation and Field Studies, Cincinnati, OH.
Address reprint requests to Elizabeth Ward, PhD, NIOSH, Mailstop R-16, 4676 Columbia Parkway, Cincinnati, OH 45226.
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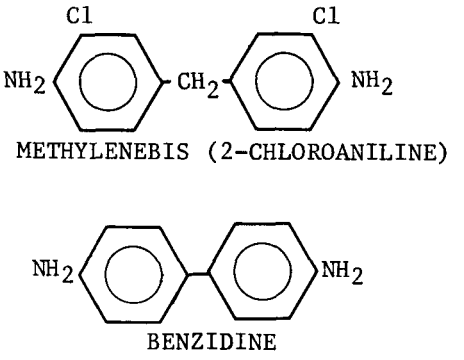

Fig. 1. Chemical structure of MBOCA and benzidine.

al, 1979]. The results of the animal studies are summarized in Table I. Target organs for tumor induction by dietary administration of MBOCA differ by species. In mice, MBOCA produced a significant excess of hepatomas [Russfield et al, 1975]. In rats, the lung was a consistent target organ in five studies [Stula et al, 1975; Kommineni et al, 1979; Steinhoff and Grundman, 1969; Steinhoff and Grundman, 1971; Stula et al, 1971]; an excess of hepatomas and mammary carcinomas was also observed in this species. In dogs, the target organ is the bladder [Stula et al, 1977].

Among the rodent carcinogenesis studies, the largest and most completely reported was conducted by Kommineni et al in 1979. Kommineni administered MBOCA in the diet of male rats to determine a dose-response effect, correlate urinary MBOCA excretion with tumor induction, and assess the effect of a protein adequate (PA) versus a protein-deficient (PD) diet. Rats fed a protein-deficient diet were dosed at 0, 125, 250, 500 ppm, and rats fed a protein-adequate diet were dosed at 0, 250, 500, and 1,000 ppm (mg of MBOCA/kg of diet). MBOCA administration continued for 18 months. Body weights and size and location of gross masses were recorded every 4 weeks; urinary MBOCA excretion was measured in ten rats from each group (groups ranged from 50 to 100 rats) at 0, 4, 26, 52, and 76 weeks.

In the rats fed a PA diet at 1,000 ppm, 62% of rats developed adenocarcinomas of the lung (0 among controls, $p < .001$), 28% developed mammary carcinomas (1 among controls, p .001), 22% developed zymbal gland tumors (1 among controls, $p < .001$), and 36% developed hepatocellular carcinomas (0 among controls, $p < .001$). In both PA an PD groups, the lungs were the most sensitive organ, and a linear dose response was observed. Mammary carcinomas were elevated in the PA but not in the PD groups. An excess of hepatocellular carcinomas was observed only at the highest dose level in both groups. At the 500-ppm level, overall tumorigenic activity was roughly comparable in the PA and PD groups.

Among animal test systems, the dog is one of the best predictors of bladder cancer in humans. Beta-napthylamine, benzidine, and 4-aminobiphenyl are all known human carcinogens that have been shown to produce bladder cancer in dogs [Stula et al, 1977]. Thus, MBOCA's demonstrated carcinogenicity in this species, reported by Stula et al in 1977, is important in evaluating the potential carcinogenicity and target site for MBOCA in humans. Six female beagle dogs were given 100 mg MBOCA, by capsule, 5 or 7 days per week for up to 9 years. Six dogs were maintained as untreated controls. Blood samples and 24-hour urine samples were collected from each dog

before treatment began and at 3- to 10 month-intervals throughout the study. Urine sediment cytology, but not urinary MBOCA levels, were reported. Survival times and body weights of treated and control animals were similar. One MBOCA-fed dog died after 3.4 years because of "pyometria and pyelonephritis," which the authors deemed unrelated to MBOCA ingestion, and one MBOCA-fed dog was euthanized at 8.3 years because of diabetes insipidus. All dogs except the one that died at 3.4 years were able to maintain their body weights during the 9-year test.

After 7 years on test, dogs fed MBOCA developed an increase in red blood cells, leukocytes, and epithelial cells in their urine. Epithelial cells showed cell abnormalities corresponding to grade IV or V in Papanicolaou classification of cells in the human urine (the grades in this classification range from I to V based on increasingly atypical or malignant characteristics).

Four of five treated dogs surviving over 8 years had papillary, transitional cell carcinomas of the urinary bladder; the fifth had a tumor of the urethra. Three of the four transitional cell tumors of the bladder were multiple. None of the control dogs had tumors of the urinary tract. Three of the five treated animals had nodular hyperplasia of the liver; no controls had such lesions. Stula et al in 1977 also compared their results to other studies of the carcinogenicity of aromatic amines in dogs. They estimated the following order of increasing potency: benzidine, MBOCA, 3,3'-dichlorobenzidine, 2-acetylaminofluorene, 2-napthylamine, and 4-aminobiphenyl. In perspective, workers exposed to benzidine have been shown to die of bladder cancer at a rate of 20 times greater than the normal population [Case and Hosker, 1954].

In summary, the animal evidence for MBOCA's carcinogenicity is strong and consistent. Several other chemicals in the aromatic amine group have been shown to produce highly elevated (20-fold or greater) risks of bladder cancer [Case and Hosker, 1954; Zavon et al, 1973]. A comprehensive review of aromatic amine carcinogenesis noted that the most potent carcinogens among the aromatic amines possess certain structural identifying characteristics, such as 1) one, two, or three conjugated aromatic ring systems, 2) an aromatic amine group substituted on the position para to the conjugated amine system, and 3) groups such as methyl, methoxy, or fluorine substituted in relative positions to the amino group [Committee on Amines, 1981]. MBOCA possesses all three of these characteristics, while benzidine possesses only the first two.

As yet, there is no direct evidence that MBOCA is a carcinogen in humans. However, no adequate epidemiologic studies of workers exposed to this chemical have been conducted. In 1971 Linch et al [1971] reported that no bladder tumors had been observed in 178 MBOCA production workers with "random exposure" to MBOCA from 1954 to 1969 or in 31 workers active in MBOCA production from 1969 to 1970. As of November 1981, no cases of bladder cancer had been observed in members of this cohort who were still employed by the company and who are followed by annual urine analysis and urine cytology. Cancer incidence among employees who have left the company has not been monitored. The failure to identify an excess cancer risk in this group of workers does not represent a definitive negative study because, on average, the workers had less than 20 years since first exposure and there was limited statistical power to detect an excess of cancer of the bladder. For most human bladder carcinogens, the average latency (time from onset of exposure until diagnosis or death) is 20 years or more [Matanoski and Elliott, 1981].

TABLE I. Tumors Observed in Highest Dosage Group*

Authors	Species, strain	No. of animals per dosage group	Dose range[a]	Lung adenoca	Mammary adenoca	Zymbal gland adenoca	Hepato-cellular cancer	Hepatoma	Heman-giosar-coma	Bladder cancer
Steinhoff and Grundmann [1969]	Wistar II rats, protein-deficient diet	25 Males, 25 females	27 g/kg total dose	+	–	–	+	–	–	–
				+	–	–	+	–	–	–
Steinhoff and Grundmann [1971]	Wistar rats	17 Males, 17 females (34 total)	500–1,000 mg/kg body weight injected subcutaneously once a week for 88 weeks	+	–	–	+	–	–	–
Stula et al [1971]	CLR-CD rats	Unknown	1,000 ppm	+	+	–	+	–	–	–
Russfield et al [1975]	Mice—random-bred albinos derived from HaM/ICR strain	25 Males, 25 females	1,000–2,000	–	–	–	–	–	–	–
			1,000–2,000	–	–	–	–	++	–	–

Russfield et al [1975]	Charles River CD-1 rats	25 Male	500–1,000	–	–	–	–	–	–	–
Stula et al [1975]	ChR-CD rats									
	Protein-adequate diet	50 Males,	1,000	++	–	–	–	–	–	–
		50 females	1,000	++	–	–	–	–	–	–
	Protein-deficient diet	25 males,	1,000	++	++	–	–	–	–	–
		25 females	1,000	++	–	–	++	–	–	–
Kommineni et al [1979]	Charles River Sprague-Dawley Rats									
	Protein-adequate diet	50–100 Males	250–1,000	++	++	++	++	–	–	–
	Protein-deficient diet	50–100 females	125–500	++	++	++	++	–	++	–
Stula et al [1977]	Beagle dogs	6 Females	8–15 mg/kg body weight/day	–	–	–	–	–	++	

*++ $p < .05$; + p not calculated/reported.
[a]ppm in diet unless noted.

In addition, the number of workers employed in production at this plant was only 209, and the intensity and duration of MBOCA exposure was not well defined.

The only other published information regarding MBOCA's carcinogenicity in humans is as-yet unpublished data from a study of workers at a British chemical plant that produced MBOCA and a variety of other chemicals. Although the study found excess morbidity and mortality from bladder cancer, work records were insufficient to identify workers employed directly on the MBOCA production process (R.A. Cartwright, personal communication, 1987).

In the United States, researchers from the National Institute for Occupational Safety and Health (NIOSH) are conducting a prospective study of bladder cancer incidence and mortality among workers exposed to MBOCA during its production at a Michigan chemical plant from 1968 to 1979. This cohort consists of 530 individuals whose mean latency is 11 years. Because the mean or median latency of occupational bladder carcinogens ranges from 18 to 44 years, [Matanoski and Elliott, 1981] definitive results cannot be expected now. With prospective follow-up, if there is an excess risk it will be possible to detect it as soon as it is apparent. As of 1985, the power of the study is 80% to detect a ninefold increase in bladder cancer incidence; by 1995, the power will be 80% to detect a fourfold increase.

HISTORY AND DESCRIPTION OF MBOCA'S USE IN THE UNITED STATES

Virtually all of the MBOCA consumed in the United States is believed to be as a curing agent for isocyanate-containing polymers [Linch et al, 1971]. Polyurethane or polyisocyanate resins were introduced in Germany in 1937 [Badner and Kelly, 1959]. However, their production in the United States began in the late 1950s [Gianatasio, 1969]. Production of MBOCA was first reported to the US Tariff Commission in 1956 [Linch et al, 1971], and in 1959, an article was published describing the use of MBOCA in a room-temperature curing system for curing polyurethanes [Badner and Kelly, 1959].

MBOCA has been produced by two US companies, both of which ceased production by 1980. Total domestic production is estimated to have reached at least 3.3 million pounds by 1970 [Versar, Inc., 1982]. Since 1980, all the MBOCA used in the United States has been imported from Japan [Versar, Inc., 1982] at an estimated rate of 1.0–3.5 million pounds per year [Versar, Inc., 1982].

The polyurethane manufacturing industry is listed under Standard Industrial Classification (SIC) 3079, miscellaneous plastics products. The extent of MBOCA use is difficult to characterize because not all polyurethane manufacturing plants use MBOCA, and those that do so use it in a variable proportion of their products. It is estimated that 200–400 US firms are engaged in the manufacture of MBOCA-cured products [Versar, Inc., 1982]. Estimates of the current number of US workers potentially exposed to MBOCA range from 2,100 to 33,000 depending on whether exposures to unresolved generic products are excluded [National Occupational Hazards Survey, 1977]. In 1979, JRB Associates estimated that there were 1,400 US workers directly exposed and 7,400 indirectly exposed by working in polyurethane manufacturing processes involving MBOCA. In 1982, the EPA estimated 1,400–2,720 directly exposed and 7,600–15,200 indirectly exposed [Environmental Protection Agency, 1983]. Most MBOCA-exposed workers are employed in small establishments where few workers are direclty exposed to MBOCA [JRB Associates, 1981].

According to the JRB Survey of 33 firms, the average number of total employees at plants using MBOCA was 49.7, and the average number of MBOCA-exposed workers was 7.95 [JRB Associates, 1981].

DATA ON CURRENT EXPOSURE CONCENTRATIONS

The degree of worker exposure at facilities that use MBOCA in the manufacture of polyurethane products is also difficult to estimate. Available data consist of a published report concerning a small polyurethane elastomers plant in Italy [Traina et al, 1969], an unpublished California OSHA survey of 11 polyurethane manufacturing plants [Pedco Environmental, Inc., 1984], an unpublished Michigan OSHA survey of 26 MBOCA-user plants [Pedco Environmental, Inc., 1984], and a NIOSH Health Hazard Evaluation at a ski boot plant in Colorado [Gunter, 1974]. None of these surveys of MBOCA-user plants involved a sufficiently representative sample of US plants or was reported in sufficient detail to generalize the results to worker exposures in the US as a whole.

One problem in characterizing the degree of exposure to MBOCA prevalent in US industries is the paucity of air sampling data. MBOCA air concentrations are seldom measured because of data showing that air levels are an inadequate gauge of potential worker exposure [Linch et al, 1971]. Linch examined the correlation between urinary MBOCA levels and MBOCA air concentrations determined by personal monitoring at an MBOCA production facility. In one area of the plant, only 15% of air samples were above the limit of detection for the air sampling method (which was 0.01 mg/m^3), while urinary MBOCA concentrations ranged from 70 to 1,500 μg MBOCA per liter of urine [Linch et al, 1971]. The urinary MBOCA concentrations were up to 15 times the current California OSHA standard of 100 μg MBOCA/liter urine [California Administrative Code, 1979]. Linch concluded that the MBOCA excreted in the urine had probably been absorbed through the skin.

Wipe sampling can be useful in identifying contaminated work areas for cleanup but only indirectly reflects worker exposure. Biological monitoring for MBOCA, by measuring the concentration of MBOCA in urine, has been adopted as the primary method of monitoring occupational exposure to MBOCA by many polyurethane manufacturing firms [Polyurethane Manufacturers Association, 1983]. Biological monitoring is certainly promising as a method to assess qualitatively if an exposure has occurred and to help ascertain exposure by all routes. However, in a preliminary investigation of the efficacy of urinary monitoring for MBOCA, a number of problems have been identified, including lack of validation of the methods of MBOCA measurement that are in commercial use and lack of a scientific basis for setting standards or guidelines to interpret sample results [Ward et al, 1986].

While monitoring of urine for MBOCA is in use in particular plants, the absence of a national surveillance system for these results limits their utility in estimating industry-wide levels of exposure. In the absence of systematic data that can be used to evaluate exposure to MBOCA among US workers, there are data indicating that MBOCA exposure is inadequately controlled in some situations. In one effort to characterize MBOCA exposures among US workers, we assessed data from a commercial laboratory that analyzes the majority of samples collected for urinary MBOCA determinations in the United States. During 1980 to 1983, this firm had analyzed 3,323 urinary MBOCA measurements submitted by 54 companies. Of these, 16.9%

had MBOCA concentrations exceeding 50 μg MBOCA/liter urine, a limit used in a 1980 temporary standard in Michigan [Michigan Toxic Substance Control Commission, 1982], and 9.2% of samples had MBOCA concentrations exceeding 100 μg MBOCA/liter urine, the enforceable limit for urinary MBOCA in California [California Administrative Code, 1979]. These measurements were made by the commercial laboratory using a semiquantitative thin-layer chromatography technique, which had not been validated against published methods [NIOSH Manual of Analytical Methods, 1982].

Another source of data are plant inspections by Michigan and California OSHA from the mid-to-late 1970s. Their data were recently summarized by Pedco Environmental Inc., under contract to the Environmental Protection Agency [Pedco Environmental, Inc., 1984]. Pedco combined results of 28 plant inspections conducted by Michigan OSHA, 11 inspections conducted by California OSHA, and two investigations conducted by NIOSH researchers. Wipe and air sampling data were tabulated by type of MBOCA purchased (liquid or solid), process, and whether or not engineering controls were present.

In the analysis of wipe samples, the data were first screened to eliminate wipe samples taken from nonwork surfaces and those surfaces with which process workers were unlikely to come into contact. The highest surface MBOCA concentrations in plants using solid MBOCA were observed in areas where MBOCA is stored and manually transferred to the melting operation without engineering controls (37 samples were obtained in 18 such plants; the median value was 847 μg MBOCA/100 cm^2, and seven of the samples were above 10,000 μg MBOCA/100 cm^2) and in the manual transfer of molten MBOCA to the mixing operation and mixing without engineering controls (nine samples were obtained in eight plants; the median value was 1,650 μg MBOCA/100 cm^2). In plants using liquid MBOCA, the highest surface contamination also was found in areas where MBOCA is stored and transferred manually without controls and in the mixing areas in uncontrolled manual operations. In the storage and transfer areas of eight plants, the median of 25 samples was 30 μg MBOCA/100cm^2. In the mixing areas of such plants, the median of four samples obtained at three plants was 15,000 μg/100 cm^2.

The air sampling data available for analysis was considerably more limited [Pedco Environmental, Inc., 1984]. Most of the samples were obtained from melting operations at polyurethane facilities using solid MBOCA. Ten of 17 area samples obtained from 13 such plants exceeded the NIOSH recommended limit of 3 μg/m^3.

EXPOSURE GUIDELINES AND REGULATIONS

Evidence regarding MBOCA's carcinogenicity was reviewed by NIOSH in 1973 and 1978, by the International Association for Research on Cancer (IARC) in 1974, and by the Committee on Amines of the National Research Council in 1981. NIOSH recommended that, based on oncogenic results in three animal test species, MBOCA be treated as a potential human carcinogen and that worker exposure be controlled so that it does not exceed 3 μg/m^3 of air determined as a time-weighted average concentration for up to a 10-hour workshift (the lowest level that can be reliably measured). The IARC concluded that MBOCA is carcinogenic in the mouse and rat after oral administration and produces distant tumors in the rat after subcutaneous administration and noted that there were no conclusive epidemiologic studies

on which an evaluation of MBOCA's carcinogenic risk for humans could be based. The Committee on Amines of the National Research Council concluded that "studies in test animals have demonstrated conclusively that MBOCA is a carcinogen. This activity is to be expected from its structure, which is similar to that of other aromatic amines that cause tumors in humans as well as animals. Although the paucity of epidemiologic evidence does not permit an evaluation of the carcinogenic effects of MBOCA, it is reasonable to assume that, given a sufficiently high exposure, it may also be carcinogenic in humans."

The American Conference of Government Industrial Hygienists (ACGIH) listed MBOCA as an experimental carcinogen in Appendix A of its Threshold Limit Values booklet in 1972, without a recommended environmental limit [ACGIH, 1972]. In 1975, ACGIH revised their designation for experimental carcinogens to be "occupational substances suspected of oncogenic potential for workers" and assigned MBOCA a threshold limit value of 0.22 mg/m^3 with a notation indicating the MBOCA can be absorbed through the skin [ACGIH, 1975]. The designation as an "industrial substance suspect of carcinogenic potential for man" and the threshold limit value have been maintained in the 1986–1987 listing [ACGIH, 1986].

As of 1977, MBOCA was included in lists of carcinogens in national regulations of Australia, the Federal Republic of Germany, and Sweden [WHO, International Labour Office, 1977]. In the United Kingdom (where 2-napthylamine, benzidine, 4-aminobiphenyl, and 4-nitrodiphenyl and their salts have been prohibited since 1967) MBOCA was listed as a controlled substance in the Carcinogenic Substances Regulations 1967 [Committee on Amines, 1981], and its manufacture and use has largely been controlled under the Health and Safety at Work Act, 1974 [Cartwright, 1982]. The environmental control limit in the United Kingdom, which has been in existence since 1976, is 0.05 mg/m^3/8 hours time weighted average (TWA) [Cartwright, 1982].

In the United States, MBOCA is not regulated as a carcinogen, although OSHA's policy is to regulate confirmed animal carcinogens as if they were known to be carcinogenic to man [39 FR 3758, 1974]. The basis for OSHA's policy was stated in the 1974 Occupational Health and Safety Standards for carcinogens: "Once the carcinogenicity of a substance has been demonstrated in animal experiments, the practical regulatory alternatives are to consider them either non-carcinogenic or carcinogenic to humans until evidence to the contrary is produced. The first alternative would logically require, not relaxed controls on exposure, but exclusion from regulation. The other alternative logically leads to the treatment of a substance as if it were known to be carcinogenic to man" [39 FR 3758, 1974].

MBOCA was one of 14 carcinogens included in the Occupational Health and Safety Administration (OSHA) Emergency Standard for Carcinogens [38 FR 10929, 1973] promulgated on May 3, 1973 and in permanent standards promulgated on January 29, 1974 [39 FR 3758, 1974]. In December 1974, the MBOCA standard was remanded by the Third Circuit Court of Appeals on procedural grounds (Synthetic Organic Chemical Manufacturers Association vs. Brennan, Third Circuit Court of Appeals, 1974]. The court determined that the Secretary of Labor had published the proposed rule before an advisory committee had submitted its report and thereby reduced the advisory committee to preparing comments for an existing proposal. The courts did not dispute the basis of the standard or its provisions.

In February 1975, OSHA again proposed a standard for MBOCA that was essentially identical with the standard that had been vacated [FR 4932, 1975]. A

period of written comment on the proposed standard was followed by public hearings conducted on April 1–2, 1975 [Docket on MBOCA hearings, 1975]. There appears to be no official documentation of OSHA's analysis of the hearings or why a standard was not promulgated following the hearings. However, the chief of OSHA's Division of Health Standards Development [Wrenn, 1977] stated that the hearing revealed difficulties in the MBOCA standard during the time it was in force. In particular, it was difficult to enforce work practice and other general requirements for minimizing exposure, without an objective measure of the adequacy of these requirements. As discussed previously, this is a particular problem for MBOCA, because skin absorption is an important route of exposure [Linch et al, 1971] and air concentrations may not provide an adequate gauge of exposure. As of 1977, OSHA was gathering information for a new standard, asking NIOSH to provide information on exposure limits and methods of measurement, and was itself studying the technological feasibility and economic impact of the new standard [Wrenn, 1977].

NIOSH issued a "Special Hazard Review With Control Recommendations" for MBOCA in September 1978. In June 1979, OSHA authorized a phase I report to collect baseline information on the cast polyurethane industry where MBOCA is used. OSHA began work on a phase II regulatory analysis in June 1980, and as of January 1981 work on the new standard was essentially complete [EPA, 1983]. However, no standard was proposed as a result of this research. In August 1985, MBOCA was listed by OSHA as a chemical that will be considered for an occupational health standard if a formal referral is made by the Environmental Protection Agency under Section 9(a) of the Toxic Substances Control Act [Office of Management and Budget, 1985].

In 1985, the EPA proposed a Significant New Use Rule (SNUR), which would have required notification of EPA before manufacturing of MBOCA could be resumed in the United States [50 FR 16519]. This proposal was withdrawn in 1986 [51 FR 13250]. However, at the same time the SNUR was withdrawn, the EPA promulgated a reporting and record-keeping rule under TSCA that will govern potential manufacturers of MBOCA [51 FR 13320]. In June 1986, the Environmental Protection Agency concluded an extensive review process on MBOCA by providing OSHA with all pertinent information it had developed during its regulatory investigation of MBOCA [51 FR 22836, 1986]. Since the EPA had not made an unreasonable risk determination in the case of MBOCA, the agency did not make a formal referral to OSHA under Section 9(a) of the Toxic Substances Control Act.

Several states have had regulations pertaining to MBOCA since the OSHA standard was vacated. The regulations regarding MBOCA in the Federal Carcinogen Standard were never remanded in California. Revised standards for MBOCA adopted in California were put into effect in June 1979 [California Administrative Code, 1979]. Michigan passed emergency rules for MBOCA in March 1980 [Michigan Toxic Substance Control Commission, 1982], after widespread environmental contamination had occurred in the area of a MBOCA production facility [Committee on Amines, 1981]. In October 1981, proposed permanent regulations for MBOCA were turned down by the Michigan legislature [Rubber and Plastics News, 1981].

Since the OSHA MBOCA standard was remanded, OSHA has continued to cite for employee exposure to MBOCA under the general duty clause of the Act, holding that the prior existence of a comprehensive standard has raised MBOCA to the level of a "recognized hazard" [OSHRC Docket No. 70-4005, 1981]. However, three

citations for MBOCA under the general duty clause have been overturned in Occupational Safety and Health Review Commission (OSHRC) judgments [OSHRC, 1981, 1982]. Two of these cases were appealed to the full Commission by the Department of Labor. In August, 1986, the Commission upheld the earlier decision [Commerce Clearing House, Inc., 1986]. (The Occupational Safety and Health Review Commission, a small agency independent of the Department of Labor, reviews OSHA's enforcement decisions that are contested by employers. These decisions, like OSHA standards, are subject to review by the federal courts of appeals [Berger and Riskin, 1978].) In general, OSHREC rulings were based on the argument that use of the general duty clause for MBOCA was an attempt to impose the vacated MBOCA standard without following the procedural requirements of the OSH Act regarding the promulgation of health standards. In one of these decisions the judge stated that "If the use of the general duty clause is condoned to impose an ad hoc comprehensive health standard on employers, the Secretary (of Labor) would have no occasion to promulgate a health standard in conformity with the procedural safeguards contained in Section 6(b) of the Act, 29 U.S.C. 655(b). The Secretary has not proposed a revised MBOCA health standard in almost 6 years, but is content to circumvent the procedural requirements of the Act and the mandate of the court by use of the general duty clause [OSHRC, 1982]."

CONCLUSIONS

Criteria established by various agencies and groups for classifying chemicals as potential human carcinogens have been met for MBOCA since the early 1970s [NIOSH, 1978; Committee on Amines, 1981; IARC, 1974; 39 FR 3758, 1974]. Limited data available on the extent of MBOCA exposure suggest that not all workers in MBOCA-using industries are protected from excessive exposure as mandated by the original OSHA regulation on MBOCA exposure [Pedco Environmental, Inc., 1984; Gunter, 1974]. This regulation required a regulated area to be established and rigorous work practice and industrial hygiene controls to be implemented.

OSHA has cited the difficulty in regulating carcinogens in a timely and efficient manner, noting the long delays between its issuance of a federal register notice of intended rule makings and promulgation of standards for those carcinogens regulated in the 1970s [29 CFR 5002, 1980]. On January 22, 1980, OSHA promulgated a regulation intended to streamline the regulatory process and to provide predictable and uniform criteria for identifying and regulating substances as occupational carcinogens [29 CFR 5002, 1980]. The regulation, which is commonly referred to as the Carcinogen Policy, included criteria and scientific policies for identifying and classifying a substance as a potential occupational carcinogen. The OSHA Carcinogen Policy provides an approach for regulating the numerous chemicals for which there is evidence in animals of carcinogenicity, but for which human data are lacking. One hundred fifteen such chemicals, not all of which are used in the workplace, have been identified [Vainio et al, 1985]. Based on the scientific criteria set forth in the OSHA Carcinogen Policy, MBOCA would qualify as a category I carcinogen for which exposures should be reduced to the lowest feasible level.

Although experimental evidence has existed for more than a decade that MBOCA is a carcinogen, worker exposure is not at this time specifically regulated by OSHA. The 1970 Occupational Safety and Health Act, OSHA regulations issued during the

1970s, and the Carcinogen Policy promulgated by OSHA in 1980 [29 CFR 5002, 1980] provide a legal and scientific basis for control of carcinogens in the workplace. As the MBOCA example illustrates, implementation of these policies has lagged behind their formulation.

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