Immunol. **116**, 1284 (1976).
10. B. B. Norman, R. R. Johnson, E. W. Jones, *Fed. Proc.* **34**, 2544 (abstr.) (1976).
11. C. R. Annable, *ibid.* **31**, 2480 (abstr.) (1972); N. Aoki and K. T. VonKaulla, *Proc. Soc. Exp. Biol. Med.* **130**, 101 (1969).
12. J. O. Mista, I. Goodfellow, L. H. Lepow, *Immunochemistry* **10**, 341 (1973).
13. O. Götze and H. J. Müller-Eberhard, *J. Exp. Med.* **134** (Suppl.), 90s (1971); J. Chapitis and I. H. Lepow, in preparation.
14. M. A. Schreger, *et al.*, *Clin. Immunol. Immunopathol.* **5**, 258 (1976).
258 (1976).
15. J. J. Scheidegger, *Int. Arch. Allergy Appl. Immunol.* **7**, 103 (1955).
16. L. Pillemer, L. Blum, I. H. Lepow, L. Wurz, E. W. Todd, *J. Exp. Med.* **103**, 1 (1956).
17. A. P. Dalmasso and H. J. Müller-Eberhard, *J. Immunol.* **97**, 680 (1966).
18. S. Ruddy, L. G. Hunsicker, K. F. Austen, *ibid.* **108**, 617 (1972).
19. T. A. E. Platts-Mills and K. Ishizaka, *ibid.* **113**, 348 (1974).
20. C. A. Alper, K. J. Bloch, F. S. Rosen, *N. Engl. J. Med.* **288**, 691 (1973).
21. L. H. Miller, S. J. Mason, J. A. Dvorak, M. H. McGinniss, I. K. Rothman, *Science* **189**, 562 (1975).
22. S. M. Gravely and J. P. Kreier, *Ann. Trop. Med. Parasitol.* **28**, 198 (1974).
23. N. Nogueira and Z. Cohn, *J. Exp. Med.* **143**, 1402 (1976).
24. R. Jack and P. A. Ward, unpublished observations.
25. K. H. Sibinovic, R. Miler, M. Ristic, H. W. Cox, *Ann. Trop. Med. Parasitol.* **63**, 327 (1969).
26. R. Ladda, M. Aikawa, H. Sprinz, *J. Parasitol.* **55**, 633 (1969).
27. Supported in part by grant AI 09651 from the National Institutes of Health. Serum from the patient with PLD was kindly supplied by R. McLean. The properdin content of RP was determined by J. Chapitis. Purified factor B and the antiserum to that factor were prepared in I. H. Lepow's laboratory.

23 August 1976; revised 15 November 1976

Vol. 196
1977

N-Nitrosodiethanolamine in Synthetic Cutting Fluids: A Part-Per-Hundred Impurity

Abstract. *N-nitrosodiethanolamine has been found to be present at a concentration of 0.02 to 3 percent in several brands of synthetic cutting fluids. Its identity was confirmed by three independent techniques: (i) by measuring the retention times on two different high-performance liquid-chromatography columns, (ii) by dehydration to N-nitrosomorpholine, and (iii) by preparation of the O-methyl ether derivative.*

Cutting fluids are widely used to reduce the temperature of the metal-tool interface during metal cutting and grinding. The majority of cutting fluids used in the United States are synthetic; they contain up to 45 percent triethanolamine and 18 percent sodium nitrite and have *p*H values in the range 9.0 to 11.0. Lijinsky *et al.* (*1*) demonstrated that triethanolamine could readily be nitrosated to form *N*-nitrosodiethanolamine (NDEIA). Using a model system, Zingmark and Rappe (*2*) recently showed that triethanolamine would be expected to undergo in vivo nitrosation under simulated gastric conditions. *N*-Nitrosodiethanolamine is of interest because it has been shown to produce liver tumors in rats (*1*). We report here on its presence in relatively larger amounts as an impurity in commercial cutting fluids.

Cutting fluids were obtained commercially in the Boston area. Authentic NDEIA was prepared as described by Druckrey *et al.* (*3*). The identity of the compound was confirmed by chemical ionization mass spectrometry and electron impact high-resolution mass spectrometry. A high-pressure liquid chromatograph–thermal energy analyzer (HPLC-TEA) was constructed from a high-pressure pump (Waters model 6000A), an injector (Waters model U6K), a column (Waters), and a TEA detector (Thermo Electron model 502) (*4*, *5*).

Cutting fluid was chromatographed as purchased without any treatment on a μ Porasil column (Waters), using as a solvent system 50 percent hexane and 50 percent acetone at a flow rate of 2 ml/min. A peak eluting at the retention time of NDEIA was determined. Since no cleanup was used, the possibility of artifact formation was discounted. Because crude fluid rapidly degraded the column, routine analyses were carried out after first extracting with ethyl acetate in the presence of magnesium sulfate. The extract was filtered through sodium sulfate and then injected onto the HPLC-TEA (*6*). The results are presented in Table 1.

In order to confirm the identity of the peak eluting at the retention time of NDEIA, the compound was isolated (*7*) and studied by three independent techniques.

1) High-pressure liquid chromatography. The isolated sample was injected onto an HPLC-ultraviolet spectrometer or HPLC-TEA by using either a μ Bondapak NH_2 or a μ Porasil column (*8*). With both systems we always observed a material eluting at the same retention time as authentic NDEIA.

Table 1. Concentration of *N*-nitrosodiethanolamine in several brands of synthetic cutting fluids.

Brand	NDEIA (%)
A	2.99
B	1.04
C	0.42
D	0.25
E	0.18
F	0.06
G	0.06
H	0.02

2) Dehydration. The isolated sample, when dehydrated with concentrated sulfuric acid (96 percent) at 155°C for 2.5 hours, yielded *N*-nitrosomorpholine as the dehydration product. *N*-Nitrosomorpholine was detected by combined gas chromatography and high-resolution mass spectroscopy (*9*). The isolated sample did not give an *N*-nitrosomorpholine peak before dehydration.

3) Derivative formation. The *O*-methyl ether derivative of the isolated sample was prepared by methylation with methyl iodide, with sodium hydride as a catalyst (*10*). The methylated sample was distilled and the distillate extracted with methylene chloride. The concentrated extract was then introduced into a gas chromatograph fitted with a Coulson electrolytic conductivity detector in the nitrogen mode (*11*). The presence of the NDEIA derivative in the isolated sample was confirmed when the retention time was compared with that of the *O*-methyl ether derivative of authentic NDEIA.

The cutting fluids that we tested represent only a small fraction of the total number of commercial brands that are available. On the basis of results reported here, we expect that most cutting fluids that contain triethanolamine or diethanolamine and nitrite as additives will be contaminated with NDEIA. To assess the magnitude of the problem, we recommend screening all brands of synthetic cutting fluids.

The *N*-nitrosamine content of cutting fluids is about 40 times higher than the nitrosamine contamination in some herbicides (*12*) and 10^7 times higher than that found in foodstuffs preserved with nitrites (*13*). Persons who use cutting fluids could well be exposed to nitrosamine. Even though the fluids are diluted 10 to 100 times before use, the amount of the nitrosamine present is such that it may pose a carcinogenic hazard to all users.

In the past 30 years, cutting oils have been frequently cited as related to cancer of the scrotum among machine operators (*14*, *15*). Several cutting oils were found to be carcinogenic to laboratory animals (*15*, *16*), and compounds such as polycyclic aromatic hydrocarbons and heterocyclic compounds were believed to be the carcinogens (*17*). Over the past 20 to 30 years, synthetic formulations have replaced the original mineral oils. Almost all of the "cutting oils" used today are of the synthetic variety. The synthetic cutting fluids described here have been in

widespread use for about 20 years and, because of the 20-year latency period expected for human cancer (*18*), we would not expect cancer incidence among machinists to be related to NDEIA. However, machinists may have been exposed to relatively large amounts of NDEIA by skin absorption and inhalation. We suggest that epidemiological studies be initiated to screen workers who have been subjected to NDEIA for prolonged periods. Until now, *N*-nitrosamines have not been directly associated with human cancer because no population groups had been identified that were inadvertently exposed. Cutting fluid users have the dubious honor of being the first such population group to be identified.

Note added in proof: Zingmark and Rappe initially reported NDEIA to be absent from grinding fluid (*2*). Since submission of this manuscript, we were informed by Rappe of a second manuscript (*19*) reporting the presence in grinding fluid stored for 4 to 6 months of a compound which was claimed to be NDEIA.

TSAI Y. FAN, JOHN MORRISON
DAVID P. ROUNBEHLER
RONALD ROSS, DAVID H. FINE
Thermo Electron Cancer Research Center, Waltham, Massachusetts 02154
WALTER MILES, N. P. SEN
Health Protection Branch, Food Research Division, Ottawa, Ontario, Canada

References and Notes

1. W. Lijinsky, L. Keefer, E. Conrad, R. Von de Bogart, *J. Natl. Cancer Inst.* **49**, 1239 (1972).
2. P. A. Zingmark and C. Rappe, *Ambio* **5**, 80 (1976).
3. H. Druckrey, R. Preussmann, S. Ivankovic, D. Schmahl, *Z. Krebsforsch.* **69**, 103 (1967).
4. D. H. Fine, F. Rufeh, D. Lieb, *Nature (London)* **247**, 30 (1974).
5. *D. H. Fine, D. P. Rounbehler, A. Silvergleid, R. Ross, in Second Symposium on Nitrite in Meat Products* (Central Institute for Nutrition and Food Research TNO, Zeist, Netherlands, in press).
6. *The recovery of NDEIA after this procedure was* 100 percent.
7. A 0.1-ml portion of cutting fluid (brand C) was extracted with 30 ml of diethyl ether or ethyl acetate in the presence of 10 g of magnesium sulfate. *The extract was filtered through* 20 g of sodium sulfate. The filtrate was concentrated with a stream of nitrogen to approximately 300 μl and loaded onto a silica gel column (1 by 5 cm), which was washed with 50 ml of diethyl ether and then *eluted with 50 ml of ethyl acetate. The eluate was* concentrated to approximately 300 μl as the final isolated sample. An aqueous solution containing 5 percent each of sodium nitrite and triethanolamine was treated by the same isolation *procedure used for the cutting fluid.* No artifact formation of NDEIA was found during the procedure.
8. The solvent system was 3 percent methanol and 97 percent methylene chloride for the μ Bondapak NH_2 column, and 30 percent acetone and 70 percent hexane for the g Porasil column. The flow rate for both columns was 2 ml/min.
9. The column (6 feet by ¼ inch) was packed with 5 percent Carbowax 20 M on 100- to 200-mesh Chromosorb W High Performance and used isothermally at 180°C. The flow rate of helium carrier gas was 25 ml/min. The mass spectrometer was operated to monitor the molecular ion of *N*-nitrosomorpholine at a resolution of 10,000.
10. N. P. Sen, W. F. Miles, S. Seaman, J. F. Lawrence, *J. Chromatogr.*, in press.
11. The column was packed with 25 percent Carbowax 20 M containing 2 percent NaOH on 80- to 100-mesh Chromosorb P. The temperature of the column was maintained isothermally at 140°C for 3 minutes and then programmed to 180°C at a rate of 10°C per minute. The flow rate of the helium carrier gas was 25 ml/min.
12. D. H. Fine, R. Ross, D. P. Rounbehler, S. Fan, paper presented at the American Chemical Society meeting, San Francisco, September 1976.
13. P. Bogovski and E. A. Walker, *N-Nitroso Compounds in the Environment* (International Agency for Research on Cancer, Lyon, France, 1974).
14. D. N. D. Cruickshank and J. R. Squire, *Br. J. Ind. Med.* **7**, 1 (1950); R. Tourenc, *Presse Med.* **72**, 2009 (1964); J. E. H. Miles, *Med. J. Aust.* **2**, 13 (1970).
15. H. Desoille, M. Philbert, G. Ripault, A. Cavigneaux, H. Rossignoli, *Arch. Mal. Prof. Med. Trav. Secur. Soc.* **T34**, 669 (1973).
16. E. Mastromatteo, *Br. J. Ind. Med.* **12**, 240 (1955).
17. International Agency for Research on Cancer, *Evaluation of Carcinogenic Risk of the Chemical to Man. Certain Polycyclic Aromatic Hydrocarbons and Heterocyclic Compounds* (Lyon, France, 1973), vol. 3, p. 30.
18. R. J. Wauweiler, S. Stringer, J. K. Wagoner, J. Jones, H. Falk, C. Carter, in *Occupational Carcinogenesis*, U. Saffiotti and J. K. Wagoner, Eds. (New York Academy of Sciences, New York, 1976), p. 40; J. D. Gilliam, J. M. Dement, R. A. Lemen, J. K. Wagoner, V. E. Archer, H. P. Blejer, in *ibid.*, p. 336.
19. C. Rappe, *Ambio*, in press.
20. We thank R. Carrigan and G. Gordon of the National Science Foundation for valuable discussions, and F. Benoit of the Health Protection Branch, Ottawa, for carrying out the chemical ionization mass spectrometry. The work at Thermo Electron was supported by NSF grant ENV75-20802.

4 October 1976; revised 12 November 1976

Perception of Impossible Limb Positions Induced by Tendon Vibration

Abstract. *When the wrist flexor muscle is vibrated and the wrist is passively extended to a position close to its anatomical limit, the hand is felt to be bent to a position about 29° beyond its maximum operating range. The mechanism of position sense must in this case be operating on the basis of extrapolation. Ambiguity of sensed position can occur in this situation. Some subjects, when opposing the vibration-induced contraction of biceps, report experiencing multiple forearms.*

Until recently, position sense in limbs was thought to be due solely to the receptors associated with the joint capsule and pericapsular tissue (*1*). However, evidence now strongly suggests a role for muscle receptors, especially the primary endings of muscle spindles (*2*). In this report I present evidence that vibration of muscle tendons can result in errors of position sense as great as 54° when the muscle is passively stretched. Furthermore, the size of this effect is not restricted by the anatomically given limits of flexion and extension.

Cat spindle primary endings are highly sensitive to periodic stretch of small amplitude while secondary endings are not (*3*). In humans, vibration of a tendon causes a predictable increase in the contractile activity of the agonist, caused by autogenous reflex excitation of the alpha motoneurons and reciprocal inhibition of the antagonist. This leads to involuntary movement (*4*). When this movement is stopped by an external agent, the subject reports a persistent illusion of movement in the direction appropriate to extension of the vibrated, and contracting, muscle. This is associated with an error of position sense, also in the direction of extension, the size of which has been reported as being between 5.5° (*5*) and 8° (*2*) when the biceps tendon is vibrated at 100 hertz. McCloskey (*5*) argues that these position signals are not merely the integration of those responsible for the persistent movement illusion, for the size of the position error does not increase with vibration time. Furthermore, procedures that lower or abolish the movement illusion do not similarly affect the size of the position error. This makes the existence of the position illusion of considerable theoretical importance, for it implies that some of the afference from the muscles could be used by the brain as a source of positional information, as distinct from the notion that vibration merely biases position analysis by virtue of the volume of movement information.

Some properties of the muscularly derived position mechanism were studied in right-handed subjects 6 to 40 years of age. The majority were university students and faculty. The apparatus consisted of a vibrator with a piston 15 mm in diameter which was driven sinusoidally at 80 hertz with stroke, under load, of 2 mm. This piston was applied to various sites on the left arm. Objective measurement of the position of the left wrist or hand was achieved by asking the subject, whose vision was occluded, to make a mark with a pen held in the right hand on a vertically mounted Plexiglas sheet adjacent to the left arm. This task used only the position sense of the two arms. Precise localization of wrist or hand of the experimental arm was aided by the experimenter touching one or the other with a slender pointed rod. The effect of

MONITORING PLASTIC PIPE AND PIPING SYSTEM COMPONENTS

Concern for health and environmental safety associated with applications for plastic piping system components is not new. Regulatory agency representatives at all levels of government - federal, state, and local - are aware of the voluntary standards and testing programs available through the National Sanitation Foundation (NSF), a private, not-for-profit organization chartered in 1944 under the Michigan law. NSF is dedicated to service, research, and education, and operates through headquarter offices and laboratories in Ann Arbor, Michigan, with four regional offices in the U.S. and a European office in Geneva, Switzerland. Since 1951, it has adopted more than 50 consensus standards and criteria which are recognized and used throughout the world.

Responsibility for safe drinking water in the U.S. rests officially with the U.S. Environmental Protection Agency (EPA) through the Safe Drinking Water Act (Public Law 93-523) and regulations relating to the Act. A Memorandum of Understanding (MOU), signed by EPA and the Food and Drug Administration (FDA), clarifies and assigns to EPA responsibility for regulating the quality of water in contact with pipe and other items which have the potential for contributing contaminants. Liaison between NSF and EPA is closely maintained.

NSF Standard No. 14, adopted in 1965 and revised most recently in December 1980, relates to "Plastic Piping System Components and Related Materials." Currently 1368 products have been tested and listed by NSF for conformance with Standard 14. From 1956 to 1956, plastics were tested by NSF through contractural agreements with participating companies. Thus, for 25 years, plastics used for potable water and drain, waste, and vent have been tested by NSF. When in complete conformance with the requirements of Standard 14, products are authorized to display the appropriate logo NSF-pw for potable water, and NSF-dwv for drain, waste, and vent. *No piping system components or plumbing products alternative to plastics have been so tested.* Further, complete chemical formulations must be filed for all products included in this program, and rigid additional testing is required for new or modified ingredients. The formulations are confidential and used only for decisions regarding the appropriateness and safety for proposed end use. The rigid test protocols include accelerated extraction testing for chemicals leached from the products, and animal feeding studies for proposed new ingredients which have not received prior sanction from FDA for use in food contact.

Listed products are sampled by regional personnel during unannounced annual visits (currently three or more) to production facilities.

These samples are shipped to Ann Arbor and tested in accordance with Standard 14. Established enforcement procedures require resampling and retesting of failed products. Repeated failures are cause for delisting.

FEDERAL REGULATIONS
Pertinent to Water Exposed to Plastic Pipe

Public Law (PL) 93-523, known commonly as the Safe Drinking Water Act (SDWA), provides the basis for USEPA National Interim Primary Drinking Water Regulations (NIPDWR). (40 FR 59566, December 24, 1975; 41 FR 28402, July 9, 1976; 43 FR 5756, February 9, 1978; 44 FR 42246, July 19, 1979; 44 FR 68624, November 29, 1979; 45 FR 57332, August 27, 1980; and the final rule for control of trihalomethanes is published in 44 FR 68624.)

The NIPDWR's specify maximum contaminant levels (MCL) of specifically regulated inorganic and organic contaminants. The MCL established for total trihalomethanes (TTHMs) is 0.10 mg/l. (TTHMs are defined as the sum of the concentrations of bromodichloromethane, dibromochloromethane, tribromomethane, and trichloromethane (chloroform).) MCLs for carbon tetrachloride and tetrachloroethene are not included in the NIPDWR.

Public Law 92-500, commonly called the Clean Water Act, is the basis for Water Quality Criteria (44 FR, 15926, March 15, 1979; 45 FR, 79318, November 28, 1980).

DOW CHEMICAL U.S.A.

February 16, 1981

MIDLAND, MICHIGAN 48640

FEB 20 1981

Jerilyn Church
Plastic Pipe and Fittings Association
999 N. Main Street
Glen Ellyn, Illinois 60137

Dear Ms. Church:

RE: THE CALIFORNIA HCD AND ABS-DWV

It is an extremely difficult task to reduce to meaningful numbers the potential for extraction or migration of trace contaminants from ABS-DWV into various waste streams. To project further towards estimating how these minuscule amounts of organic leachates might somehow persist through modes of waste treatment, diffusion, degradation, dilution, etc. and accumulate in local, regional, national, or world fresh water drinking supplies in levels detrimental to life becomes extremely speculative.

The plastic pipe adversaries will probably continue to persist in their efforts to establish guilt by implication. It is doubtful that they would be able to establish such guilt on a sound technical basis.

There is a vast difference from developing data for potential migration from DWV systems vs. migration from closed transport systems into the transported media such as water pipes and drinking water. Domestic DWV systems are essentially open systems vented to the atmosphere. They only convey effluent sporadically and seldom if ever at full capacity. There are vapor trap components in the systems which do provide stagnant reservoirs for indeterminate periods of time but these would only constitute a very small fraction of the inside surface area of the entire effluent transport system. Typical residence time for effluent moving through a household drain system would be only minutes or a fraction of a minute.

I would not attempt to establish a practical method of assigning logical estimates of what might be construed as a typical concentration level of a particular trace contaminant leaching from an ABS-DWV system into effluent from a typical domestic residence into a larger outfall of similar effluent.

For demonstrative purposes a theoretical worst case type of example might suffice to establish some perspective for the overall extremely limited potential for residential ABS-DWV systems to be contributory to contamination of fresh and salt water supplies.

Basis for the example will be an established migration rate per 24 hour day of 55 ppb AN from ABS containing 65 ppm AN into water with a 10/1 volume to surface ratio (ml/sq. in.) at 120°F.

Assumptions used for benefit of the exaggerated example:

Typical residence containing 50 ft. 4", 100 ft. 3", and 50 ft. 1 1/2" ABS-DWV. Total volume/surface ratio 13 ml/sq. in.

100 ppm residual AN present in the ABS pipe.

Temp. 120°F

Time 24 hours

The complete system (including vents) is filled with water for 24 hours at 120°F. The system then is drained completely creating effluent containing 65.4 grams AN/liter.

This exaggerated example would generate effluent which is significantly below the EPA Guidelines data for freshwater aquatic life protection of 130.4 g/l for 24 hour average and 300.4 g/l at any time. The same criteria for saltwater aquatic life is 130.4 g/l as a 24 hour average and maximum concentration not to exceed 290.4 g/l at any time (Reference: Federal Register/Vol. 44, No. 191/Monday, Oct. 1, 1979/Notices. Remember, the example is based upon exaggerated average levels of residual AN, residence time, and temperature. Also, the assumption was made that the system was completely filled.

I hope that this brief letter might be of some value in supporting the case of ABS-DWV piping. We certainly can provide more detailed arguments if needed.

Best regards,

J. E. Grybowski

J. E. Grybowski
Plastics TS&D
433 Building
(517)636-0840

sr

2112957

BFG10685