



**German Chemical Society
Gesellschaft Deutscher Chemiker**

GDCh-Advisory Committee
on Existing Chemicals of
Environmental Relevance (BUA)

N,N-Dimethylformamide
BUA Report 84
(December 1991)



S. Hirzel

Wissenschaftliche Verlagsgesellschaft 1994

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Dr. R. Wittlinger, BASF AG, Ludwigshafen a. Rh.

GDCh Office:

Dr. H. Behret, GDCh, Frankfurt am Main

N,N-Dimethylformamide

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edited by the GDCh-Advisory
Committee on Existing Chemicals
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Beratergremium für
Umweltrelevante Altstoffe (BUA)



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Dr. H. Behret
Gesellschaft Deutscher Chemiker
Postfach 90 04 40
D-60444 Frankfurt am Main

Translated by R. Brown

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Die Deutsche Bibliothek — CIP-Einheitsaufnahme

N,N-Dimethylformamide/ ed. by the GDCh Advisory
Committee on Existing Chemicals of Environmental
Relevance - Stuttgart: Hirzel ; Stuttgart : Wiss. Verl.-Ges.,
1994

(BUA report; 84)
ISBN 3-7776-0577-8

NE: Gesellschaft Deutscher Chemiker / Beratergremium für
Umweltrelevante Altstoffe: BUA report

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Printed in acid-free and low-chlorine paper.

Printing and binding: Druckhaus Beltz, Hemsbach
Printed in F.R. Germany

Foreword

The German Chemicals Act (Chemikaliengesetz - ChemG) of 1980 stipulates that certain existing chemicals must be reported to the competent authority, if they exhibit properties which indicate that they may be hazardous, either alone or in combination with other substances.

In the summer of 1982, an Advisory Committee on Existing Chemicals of Environmental Relevance (BUA) was set up by the German Chemical Society (Gesellschaft Deutscher Chemiker - GDCh). It brings together representatives from the scientific community, the chemical industry and the governmental authorities. This Advisory Committee is responsible for elaborating appropriate solutions for substances of relevance for health and the environment on the basis of voluntary measures. It selects and examines existing chemicals from the aforementioned angles. The testing and evaluation are based on scientific criteria alone.

It was, therefore, necessary to develop priority setting procedures. In a first phase reports were only prepared for priority chemicals. Within the framework of a first priority setting procedure, chemicals were compiled from several priority lists and 135 chemicals were selected for detailed substance reports.

In a second priority setting procedure the survey of the German Chemical Industry Association (VCI) on all substances with a production volume of more than 10 tons per year was used as a starting list. Since this survey covered 4,600 chemicals, BUA decided to process the corresponding list in several stages. The first stage included approx. 1,050 substances with a production volume of more than 1,000 tons per year.

Detailed reports are drawn up on chemicals suspected of having a hazard potential and abridged reports on those presenting only a minor hazard potential, according to the current state of knowledge.

The detailed BUA reports take in both the published literature and data from industry. If data for the evaluation of the chemicals are not available, additional studies are recommended and the results are published as updates to the reports. The reports serve as a basis for the instigation of administrative measures, when there are indications of risks to health or the environment.

Tübingen, May 1993

Ernst Bayer
Chairman of the Advisory Committee
on Existing Chemicals
of Environmental Relevance

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BUA Report on N,N-Dimethylformamide

Summary and conclusions

Ecological aspects

Occurrence and distribution in the compartments

Consumption of DMF in pre-unification West Germany was 18,000 t in 1989, falling to 17,000 t in 1990. Production in the former GDR was 15,000 to 25,000 t/a. DMF is mainly employed as a solvent. The amount consumed represents the replacement of the amount of solvent which is not recovered. Of this, about 22 % was employed in polyacrylonitrile fiber production, 39 % in fine chemicals, 10 % in crop protection agent formulations (currently falling) and 17 % in plastic coating. The remaining 12 % of the amount consumed is divided amongst various application areas: surface coatings, polyamide coating, absorbents, cleaners and extractants.

From investigations at four waste water treatment plants operated by DMF users and the producer which cover production and about 60 % of consumption in the pre-unification West German states (corresponding to about 10,700 t/a), it is possible to infer an annual emission of about 122 t of DMF into surface waters, plus the maximum of 230 t/a which pass into the hydrosphere in the most unfavourable case during acrylic fiber finishing. There are no data available on the amounts released by the other users.

In the case of fiber production about 1,000 t of DMF were emitted into atmosphere in 1989 by two users without taking into account the amount outgassed from the raw fiber. This is estimated at about 230 t/a. An emission of about 2 t of DMF/a was determined at a major user (about 4,100 t/a). In the case of another user an emission of 175 kg/a is given. The release of DMF via crop protection agent formulations can be estimated at about 50 t/a taking into account the amount exported. The maximum release in the most unfavourable case may be something over

X

500 t/a. No data are available concerning amounts released by the other users. The remaining emission of DMF can at best be estimated at about 7,300 t/a.

An amount of < 2,325 t/a of DMF waste is disposed of by means of landfill and/or incineration and waste water incineration.

There are almost no data on the occurrence of DMF in surface waters.

DMF has been found in concentrations of up to 66 mg/m³ of air in plants in which it is used (polyacrylic fiber production, artificial leather production).

The residual DMF content in finished articles made of polyacrylic fibers is still about < 0.01 %.

Degradability

On the basis of degradation in the modified OECD screening test with a > 95 % DOC decrease it has been shown that DMF can be classified as readily biodegradable according to the OECD criteria.

The good biodegradability of DMF was confirmed in simulated models of waste water treatment plants after an adequate time of adaptation. Above a threshold loading of 0.8 g of DMF/l day (space loading), the degradation of DMF in the treatment plants described may cease and dimethyl amine may be formed as a toxic metabolite in relatively large amounts.

There are no experimental investigations on the photochemical degradation of DMF in the troposphere. On the basis of estimation methods which give only rough estimated values for DMF, a relatively rapid degradation, with a half-life of no more than a few days, is assumed.

Photochemical degradation in the hydrosphere in layers near to the earth surface is possible, but cannot be quantified. The crucial elimination mechanism in aquatic systems is probably microbial degradation.

Bioaccumulation

The measured Octanol/water partition coefficient $\log P_{OW}$ of DMF is - 1.01. On the basis of the hydrophilicity, bioaccumulation is unlikely. Geoaccumulation is also unlikely.

Ecotoxic effects

The acute toxicity of DMF against the blue algae *Anabaena* was < 48 mg of DMF/l (EC_{50} after 10 days). For *Daphnia magna* an acute toxicity LC_{50} of 16,150 - 26,300 mg of DMF/l (24 h) and 12,350 - 15,700 mg of DMF/l (48 h) has been determined. The no observed effect level (NOEL) for the chronic toxicity against *Daphnia magna* was 1,140 mg of DMF/l (28 days).

The acute toxicity LC_{50} against the following fish has been determined after 24 to 96 h:

Salmo gairdneri 9,800 - 10,600 mg of DMF/l, *Pimeohales promelas* 10,600 - 11,400 mg of DMF/l, *Lepomis macrochirus* 7,100 - 7,500 mg of DMF/l and *Lebistes reticulatus* 1,300 mg of DMF/l (24 h).

The chronic toxicity was between 43 and 98 mg of DMF/l against the brook trout and between 5 and 10 mg of DMF/l against the minnow.

Toxicological aspect

DMF has been known for many years as a solvent with a hepatotoxic potential. This has been found in all the animal species investigated, and even observed in cases of poisoning in crafts and industry. Hepatotoxic effects are observed both after acute and chronic exposure. Central nervous effects, cardiovascular and gastrointestinal complaints and damage to the kidneys and other organs also occur. DMF also leads to synergistic effects with alcohol or to alcohol intolerance reactions.

DMF is readily absorbed orally, dermally and by inhalation. Metabolism

by cytochrome P 450-dependent enzymes in the liver leads to hydroxymonomethylformamide (formerly erroneously assumed to be monomethylformamide and formamide); in addition the cysteine adduct N-acetyl-S-(N-methylcarbamoyl)cysteine is detected in particular.

DMF irritates the skin and mucosal membranes. In animal experiments DMF does not have a sensitizing effect, but there are indications of dermal eczema, possibly as a result of sensitization, in humans.

DMF can also induce embryotoxic and teratogenic effects in animal experiments.

No mutagenic effects were found in the majority of numerous investigations with different end points. There are, however, reports of increased chromosome aberration rates in persons exposed to DMF.

The question of carcinogenicity remains unresolved. To date, there are no valid animal experiments available. In the USA at present, long-term inhalation studies concerning the question of chronic toxicity and carcinogenicity in rats and mice are being performed. In occupationally exposed persons, some case reports point to a possible relationship between testicular tumors and high DMF exposure, but a causal relationship still does not appear to be confirmed.

Recommendations

To date, investigations of chronic toxicity and carcinogenicity are lacking. However, these are at present being carried out by a large US manufacturer, in rats and mice exposed by inhalation. The decision about the type and scope of further investigations of the toxicology of DMF should be modelled on the results of these studies.