GDCh-Advisory Committee
on Existing Chemicals (BUA)

BUA Report 238
(Supplementary Reports IX)

Tributyltin oxide
(Bis-[tri-n-butyltin]oxide) (No. 36)

S. Hirzel
Wissenschaftliche Verlagsgesellschaft 2003

GDCh-Advisory Committee on Existing Chemicals (BUA, December 2002)

Chairman:
Prof. Dr. H. Greim, GSF – Institut für Toxikologie, Oberschleißheim

Members:
Frau Dr. M. BETH-HÜBNER, Berufsgenossenschaft der Chemischen Industrie, Heidelberg
Prof. Dr. N. CASPERS, Bayer AG, BIS-SUA-PUA1, Leverkusen
Prof. Dr. H. DREXLER, Institut für Arbeits-, Sozial- und Umweltmedizin, Universität Erlangen
Frau Prof. Dr. H. FOTH, Institut für Umwelttoxikologie, Universität Halle an der Saale
Prof. Dr. Dr. H.-P. GELBKE, BASF AG, Toxikologie, Ludwigshafen am Rhein
Prof. Dr. R. NAGEL, Institut für Hydrobiologie, Technische Universität Dresden
Prof. Dr. Dr. H. PARLAR, Institut für Lebensmitteltechnologie und Analytische Chemie, Technische Universität München
Dr. M. SCHÜMANN, Arbeitsgruppe Epidemiologie der BAGS und des IMDM, Universitätsklinik Hamburg-Eppendorf
Dr. B. STOCK, Bayer AG, BSD-UD-LFS4-PS, Leverkusen
Prof. Dr. R. ZELLNER, Institut für Physikalische und Theoretische Chemie, Universität Essen (Vice Chairman)

Guests:
Dr. M. LULEI, Verband der Chemischen Industrie, Frankfurt am Main
Dr. E. GOEDECKE, Anmeldestelle Chemikaliengesetz, Dortmund
Frau Prof. Dr. U. GUNDERT-REMY, Fachgebiet 8, Bundesinstitut für Risikobewertung, Berlin
MinR Dr. H. A. KLEIN, Bundesministerium für Wirtschaft und Arbeit (BMWA), Bonn
Dr. W. KÖRDEL, Fraunhofer Gesellschaft, IME, Schmallenberg
Dr. N. RUPPRICH, Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, Dortmund
Dr. K. STEINHÄUSER, Umweltbundesamt, Berlin

With the collaboration of:
Frau Dr. H. GREIM, Technische Universität München, Weihenstephan
Dr. G.-R. JÄNIG, Fachgebiet 8, Bundesinstitut für Risikobewertung, Berlin
Dr. R. LAENGE, Berlin
Frau Dr. I. NEUMANN, Technische Universität München, Weihenstephan
Frau Dipl.-Biol. B. PRIESMANN, Institut für Hydrobiologie, Technische Universität Dresden
Dipl.-Ökol. T. SCHMIEGELT, Universität Essen
Frau Dr. B. SCHWARZ-SCHULZ, Umweltbundesamt, Berlin
Dr. R. STANGL, Crompton GmbH, Bergkamen
Frau Dr. K. WIDMANN, Technische Universität München, Weihenstephan

Responsible at BMU:
MinR Prof. Dr. U. SCHLOTTMANN, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Bonn

GDCh Office:
Dr. H. Behret, GDCh, Frankfurt am Main

BUA Report 238

(Supplementary Reports IX)

Tributyltin oxide
(Bis-[tri-n-butyltin]oxide) (No. 36)

edited by the GDCh-Advisory
Committee on Existing Chemicals

GDCh-Beratergremium für
Altstoffe (BUA)

S. Hirzel
Wissenschaftliche Verlagsgesellschaft 2003

Dr. H. Behret
Gesellschaft Deutscher Chemiker
Postfach 90 04 40
D-60444 Frankfurt am Main
E-Mail: bua@gdch.de
Homepage: http://www.gdch.de

Responsible at the BMU:
MinR Prof. Dr. U. Schlottmann
BMU
Postfach 12 06 29
D-53048 Bonn
E-Mail: schlottmann.ulrich@bmu.de

The work for this publication was sponsored by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU) / Federal Environmental Agency (Umweltbundesamt)) and the German Chemical Industry Association (Verband der Chemischen Industrie, VCI)

Bibliographic information published by Die Deutsche Bibliothek
Die Deutsche Bibliothek lists this publication in the
Deutsche Nationalbibliografie; detailed bibliographic
data are available in the internet at http://dnb.ddb.de.

ISBN 3-7776-1260-X

Translated by P. Karbe.

Printed on acid-free and low-chlorine paper.

Printing and binding: Druckpartner Rübelmann GmbH, Hemsbach
Printed in Germany

Preface

The Advisory Committee on Existing Chemicals, BUA for short, was established in May 1982 to help the German federal government cope with the large task of dealing with existing chemicals. In an agreement among federal government, scientific community, and the chemical industry, it was associated with the German Chemical Society (GDCh, Gesellschaft Deutscher Chemiker) to ensure objective work carried out in accordance with scientific principles. Since the beginning of 2001 the BUA has been composed of scientists from the research areas of chemistry, analytics, monitoring, toxicology, primary and secondary exposition, aquatic and terrestrial toxicology, as well as the fate and behaviour of compounds in water, soil and air. The BUA is supported by experts from federal government agencies and the German Chemical Industry Association (VCI, Verband der Chemischen Industrie).

No other national or international body has dealt with the ecological and health-related effects of as many existing chemicals as the BUA. Upon the recommendation of the federal government, the BUA has participated as a Peer-Review Group in the evaluation of ICCA-compounds (ICCA: International Council of Chemical Associations) since 2000 and also acts as the national "Contact Point" in the OECD HPV-Chemicals programme (HPV: High Production Volume). The goal of the initiative is on the one hand to complete the data on the HPV chemicals and on the other to undertake an internationally coordinated evaluation of their hazard potential.

The BUA began an additional national project in 1997, which also selects and assesses existing chemicals with a lower production volume in the range of 100 - 1000 tonnes/year. The chemical industry presents about 50 datasets for such substances each year, for which the BUA sets the priority. Comprehensive reports are published on chemicals suspected of having a hazard potential. If the data available for substance assessment are insufficient, the gaps in knowledge are documented and, if necessary, investigations recommended. The results are published in supplementary reports such as the current volume, the ninth supplementary report, hereby providing a basis for the assessment of such substances. The BUA reports serve the federal government as a basis for measures that help to avoid environmental or health hazards.

On the national level, the BUA has produced comprehensive reports on about 330 substances and carried out preliminary evaluation and classification (priority-setting) for approximately 200 more. The processes leading to priority-setting and the BUA reports are published to lend transparency to the Committee's work. Moreover, BUA addresses scientific questions and problems which apply simultaneously to many compounds and publishes the results. The aim of BUA is to develop assessment concepts, determine data gaps, point out the need for further research and, last but not least, also to reduce information deficits in the general population.

Munich
December, 2002

Helmut Greim
BUA Chairman

Contents

Tributyltin oxide (CAS No.: 56-35-9)
(Bis-[tri-n-butyltin]oxide)

Abbreviations

AAS	Atom absorption spectroscopy
APGW-Amide	Ala-Pro-Gly-Try-NH_2
ARGE Elbe	Working group to prevent water pollution in the River Elbe
BfG	German Federal Hydrology Institute
BgVV	Federal Institute for Consumer Health Protection and Veterinary Medicine
bw	body weight
CPA	Cyproterone acetate (androgen receptor antagonist)
DBT	Dibutyltin
dw	dry weight
EC_{50}	Concentration causing a defined effect in 50 % of the test organisms
FPD	Flame photometric detection
GC	Gas chromatography
IUCLID	International Uniform Chemical Information Database
LAWA	Working group of the German Länder on Water and Wastewater
LC_{50}	Concentration that is lethal to 50 % of the test organisms
LOEC	Lowest observed effect concentration
MSD	Mass selective detection
MBT	Monobutyltin
NOEC	No observed effect concentration
ORTEPA	Organotin Environmental Programme Association (international organisation of manufacturers of organotin compounds)
OSPAR	Oslo-Paris Commission / Agreement
PBT	Persistent, bioaccumulating, toxic
PNEC	Predicted no-effect concentration
PVC	Polyvinyl chloride
RPA	Risk & Policy Analysts Limited, UK
Rpm	Revolutions per minute
Sn	Tin
SPCs	Self-polishing copolymers
TBT	Tributyltin
TBTO	Tributyltin oxide
TGD	Technical Guidance Documents
TOC	Total organic concentration (organic carbon content)
UBA	German Federal Environmental Agency
WHO	World Health Organisation
ww	wet weight

BUA Report on Tributyltin oxide
(Supplementary Report IX)

Summary

Ecological Aspects

Occurrence and Distribution in the Environment

The major producer of TBTO worldwide is Crompton GmbH, which manufactures about 3000 tonnes per year, with a decreasing production volume. TBTO and its derivatives are used in antifouling paints (about 95 %) and wood preservatives (about 5 %). Through its application as stabiliser in the processing of plastics and due to contamination, TBTO traces are also found in consumer articles.

Production-related introduction of tributyltin compounds into the waters of the Federal Republic of Germany are presently estimated at less than 20 kg per year, expressed as tin. An introduction of TBTO into the atmosphere is considered to be negligible, due to its low vapour pressure.

Through its use, the compound can enter waters when antifouling paints are removed or applied. In the area of wood impregnation, an estimated 2.4 t/y TBTO enter wastewaters. The major route of introduction into the hydrosphere is the leaching of antifouling paints. With respect to the introduction into the atmosphere, tin concentrations of 0.005 – 1.1 mg/m^3 were measured in the air when antifouling paints containing TBTO were sprayed. Quantitative data on environmental introductions of TBTO through wastes and their treatment are not available. However, the dust accumulating during the removal or application of antifouling paints can cause considerable water pollution.

In comparison to the values cited in BUA Report 36 (1988), there has been a decline in peak TBT concentrations in the water column in some cases. This would indicate that the legal restrictions on the use of TBT in several countries have had an effect. However, investigations have shown that, contrary to the legal restrictions on its application in small-scale shipping, TBT was obviously still being used.

There are no indications of a substantial decrease in TBT concentrations in sediments. For example, the concentrations in sediments in German and Central European regions are not essentially lower today than those reported in BUA Report 36 (1988). This is probably attributable to the low degree of biodegradation.

For organisms, the contamination situation is more complex. Mainly the high TBT concentrations in animal tissues have decreased in comparison to BUA Report 36 (1988). This applies particularly to molluscs (mussels, oysters) collected in the immediate vicinity of marinas. Investigations of the Environmental Sample Bank have shown that the chronological development of TBT pollution differs for marine and limnetic areas. In the marine area, tissue concentrations of tributyltin remained at a practically constant high level in the sampling period from 1985 to 1996. This consistent TBT pollution is probably due to the continuing and undiminished use of antifouling paints containing TBT in commercial shipping. The ban on the use of paints containing TBT on boats shorter than 25 m has had a positive effect on marinas and similar areas where pleasure boating takes place on a massive scale.

Degradability

The C-Sn bond of TBTO is stable against hydrolysis under environmental conditions. Recent investigations on hydrolytic degradation are not available. In the presence of UV light, the C-Sn bond can be cleaved photochemically; half-lives of a few hours are reported. Photolytic degradation in natural waters is estimated to be considerably slower, as the result of the decreased depths of radiation, due to suspended matter. In the hydrosphere, microbial degradation of TBT compounds to inorganic tin occurs by stepwise debutylation. Biodegradation half-lives cited in the literature from experiments with natural microorganism populations, under aerobic conditions in aquatic systems, are between 2.5 and 225 days and based mainly on microbial substance transformation (primary degradation), but not on complete mineralisation. Other processes are based on adsorption of TBT on suspended matter and particles, which move to the sediment through sedimentation. For sediments, TBT degradation half-lives range from well over one year to 15 years.

Bioaccumulation and Metabolism

Recent investigations on bioaccumulation also confirm that TBT possesses a very high bioaccumulation potential, which can vary greatly among animal species. Published BCF and BAF values are between 80 and 300 000. Investigations on the metabolism show that algae, invertebrates and fish can metabolise TBT to DBT and MBT to differing extents.

Ecotoxicity

Since the publication of BUA Report 36 (1998) additional new data on the toxic effect of TBT on algae and other invertebrates and vertebrates have become available, also from long-term studies and review articles (e.g. Fent 1996a).

Numerous new investigations have been published, particularly on gastropods (prosobranchs), in which the imposex phenomenon and its evaluation were of central importance. NOECs were determined for morphological changes and population-related parameters, such as growth and reproduction. Laboratory investigations showed that, even at very low concentrations (a few ng/l), TBT triggers the development of male sex characteristics in female marine gastropods.

Several field studies have also confirmed that imposex in various gastropods is triggered by TBT pollution in natural waters. Whether all imposex findings in *Prosobranchia* in the environment were caused by TBT has not been clarified (see 7.3). The discussion shows that a meaningful effect monitoring must be accompanied by the monitoring of chemical exposure.

The use of snails in effect monitoring, as proposed by Oehlmann et al. (1996b), should also be understood as a tool for identifying polluted areas. However, the observed effects do not allow a reliable conclusion to be drawn on the TBT concentrations in the organisms, water, or sediment.

In general, the most recent publications by Evans (1999), Evans and Nicholson (2000), Jak et al. (1998), Mattiessen and Gibbs (1998), Miller et al. (1999), Nehring (2000) and Oehlmann et al. (1996a and b) offer very different opinions on the present extent of risk to snail populations due to TBT pollution. In broad coastal areas of the North Sea and the European North Atlantic, there are indications that outside of ports the present TBT pollution is so low that snail populations are no longer endangered. In the immediate vicinity of ports, however, snail populations continue to exhibit a high intensity of imposex or intersex. A high correlation between TBT contents in tissue and in the surrounding water was shown for various snail species by Stroben (1993), Oehlmann (1994) and Nicholson et al. (1998), among others.

An androgenic effect of TBT has been shown and explained mechanistically. Despite some open questions, the findings in gastropods confirm the development of imposex and the subsequent adverse effects on snail populations. A retrospective ecotoxicologic evaluation of TBT can only come to the conclusion that TBT from ship paint is responsible for this damage.

Consequently, this use was - or is to be - prohibited by legal regulations (see 9). A general ban on TBT in other products as well is presently under discussion. A decision by the EU is to be based in part on the final report ”Assessment of the risks to health and the environment posed by the use of organostannic compounds (excluding use as a biocide in antifouling paints) and a description of the economic profile of the industry” (RPA 2002). This report undertook a risk assessment for mono-, di- and tri-substituted organotin compounds used in wood preservatives, heavy industrial textiles and consumer articles.

It is not the purpose of this BUA report to discourse upon the risk assessment of that final report in detail. From a scientific viewpoint, however, especially for a compound with the TBT’s properties, limiting the ecotoxic risk assessment to limnetic ecosystems and, at the same time, deriving a “PNEC for use in the Environmental Risk Assessment“ needs further discussion. It is also not in compliance with the TGD to consider toxicity data from limnetic organisms alone.

In an ecotoxic risk assessment for aquatic ecosystems, the lowest effective value can be based either on the LOEC of 0.002 µg/l (imposex in the dogwhelk *Nucella lapillus*; Davies et al. 1997) or the EC_{10} of 0.0007 µg/l (development in *Acartia tonsa*, copepods; Kusk and Petersen 1997). Results are available from long-term studies with

organisms from at least three trophic levels. Therefore a safety factor of 10 is appropriate. The PNEC for aquatic ecosystems, based on the value for *Acartia tonsa*, is thus 0.00007 µg/l (0.07 ng/l).
The same two effective values can also be used for a marine risk assessment. According to a BUA proposal (BUA Report 220, 2000) a safety factor of 100 is applied, since necessary investigations with marine algae and fish are also available. The PNEC for marine ecosystems, based on the value for *Acartia tonsa*, is thus 0.000007 µg/l (0.007 ng/l).

Due to TBT's properties, a separate risk assessment must be made for the sediment compartment. The PNEC for sediments is derived on the basis of the investigation by Duft et al. (2003), who determined an EC_{10} of 2.39 µg TBT/kg dw (4 weeks, number of embryos without shells, *Potamopyrgus antipodarum*). In accordance with Riedhammer and Schwarz-Schulz (2000, 2001) a safety factor of 10 is used for this value, since results are available from four other long-term toxicity tests with sediment organisms. The PNEC for sediments is thus 0.24 µg TBT/kg dw.

A comparison of these PNEC values with the TBT concentrations found in the various environmental compartments shows that all PNEC values are clearly being exceeded. Since a further reduction of the safety factor is not possible, risk-reducing measures are required, as have already been - or are being - implemented for one area of use. One problem of future risk assessments will be the fact that the proposed PNEC values cannot be chemically analysed with the present detection limits.
Risk assessment should also consider that TBT is definitely a PBT compound (persistent, bioaccumulating and toxic), the regulation of which cannot be handled here.

Especially against the background of the discussion on the use of TBT in wood preservatives, heavy industrial textiles and consumer articles, it would appear necessary, from a scientific viewpoint, to take a closer look at the ecotoxicologic risk assessment of TBT and the other mono- and di-substituted compounds and their substitutes. It has previously been the practice to consider and assess each compound separately, for example TBT, DBT and MBT. To estimate the exposure, however, these three compounds should be assessed jointly, since DBT and MBT are also metabolites of TBT. As no information is available on possible combined effects of TBT, DBT and MBT, this should be examined.

Toxicological Aspects

TBTO is acutely toxic after oral uptake and harmful after dermal application. Inhaled TBTO aerosols, in contrast to TBTO vapours, are highly toxic. TBTO exposure is followed by rapid distribution, mainly to the liver and kidney. The instable hydroxybutyl compounds are metabolised, while splitting off the butyl groups, to di- and monobutyltin compounds and finally to inorganic tin. TBTO is excreted in the bile.

TBTO is immunotoxic. Animal experiments show a decrease in thymus weights, thymus-dependent immunosuppression, haemorrhaging in lymph nodes, and a decreased response to mitogens, viruses, bacteria and parasites. TBTO-sensitivity decreases with advancing age. The LOAEL for the immunotoxic effect was derived to be 0.25 mg/kg bw/day for young Wistar rats and 2.5 mg/kg bw/day for adult animals. The respective NOAELs were 0.025 and 0.25 mg/kg bw/day. Possible mechanisms of action for the thymus atrophy under discussion are the induction of apoptosis, an antiproliferative effect, and disturbance of oxidative phosphorylation.

Target organs in addition to the haematopoietic system are the liver, kidney, adrenal gland, thyroid gland and pituitary gland.

TBTO is severely irritating to the skin and mucous membranes.

In mice, TBTO causes contact allergy.

TBTO is not mutagenic and clastogenic only at cytotoxic concentrations.

In rats, TBTO induced a significantly increased incidence of benign tumours of the pituitary, phaeochromocytomas of the adrenal gland and adenomas of the parathyroid gland.

TBTO does not affect fertility and only at maternally toxic TBTO doses is it embryo- and fetotoxic. A NOAEL for developmental toxicity of 5 mg TBTO/kg bw/day was given.

In man, case studies indicate that TBTO vapours cause nausea, vomiting, headaches, sore throat, irritation of mucous membranes and can also trigger asthma. Dermal contact with liquids containing TBTO can cause irritant skin lesions.