FAO SPECIFICATIONS AND EVALUATIONS

FOR AGRICULTURAL PESTICIDES

PIPERONYL BUTOXIDE

5-[2-(2-butoxyethoxy)ethoxymethyl]-6-propyl-1,3-benzodioxole

FOOD AND AGRICULTURE ORGANIZATION *of* THE UNITED NATIONS

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INTRODUCTION

FAO establishes and publishes specifications* for technical material and related formulations of agricultural pesticides, with the objective that these specifications may be used to provide an international point of reference against which products can be judged either for regulatory purposes or in commercial dealings.

Since 1999, the development of FAO specifications follows the **New Procedure**, described in the Manual on Development and Use of FAO and WHO Specifications for Pesticides, which is available only on the internet through the FAO web site. This **New Procedure** follows a formal and transparent evaluation process. It describes the minimum data package, the procedure and evaluation applied by FAO and the Experts of the FAO/WHO Joint Meeting on Pesticide Specifications (JMPS). [Note: prior to 2002, the Experts were of the FAO Panel of Experts on Pesticide Specifications, Registration Requirements, Application Standards and Prior Informed Consent, which now forms part of the JMPS, rather than the JMPS.]

FAO Specifications now only apply to products for which the technical materials have been evaluated. Consequently from the year 2000 onwards the publication of FAO specifications under the **New Procedure** has changed. Every specification consists now of two parts namely the specifications and the evaluation report(s):

Part One: **The Specification** of the technical material and the related formulations of the pesticide in accordance with chapters 4 to 9 of the "Manual on development and use of FAO and WHO specifications for pesticides".

Part Two: **The Evaluation Report(s)** of the plant protection product reflecting the evaluation of the data package carried out by FAO and the JMPS. The data are to be provided by the manufacturer(s) according to the requirements of Appendix A, annex 1 or 2 of the "Manual on the development and use of FAO specifications for plant protection products" and supported by other information sources. The Evaluation Report includes the name(s) of the manufacturer(s) whose technical material has been evaluated. Evaluation reports on specifications developed subsequently to the original set of specifications are added in a chronological order to this report.

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Specifications bear the date (month and year) of publication of the current version. Dates of publication of the earlier versions, if any, are identified in a footnote. Evaluations bear the date (year) of the meeting at which the recommendations were made by the JMPS.

* NOTE: PUBLICATIONS ARE AVAILABLE ON THE INTERNET AT
http://www.fao.org/agriculture/crops/core-themes/theme/pests/pm/jmps/ps/en/

PART ONE

SPECIFICATIONS

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PIPERONYL BUTOXIDE

INFORMATION

ISO common names

Piperonyl butoxide (BAN; accepted in lieu of a common name by BSI, E-ISO, ESA); piperonyl butoxyde (F-ISO)

Synonyms

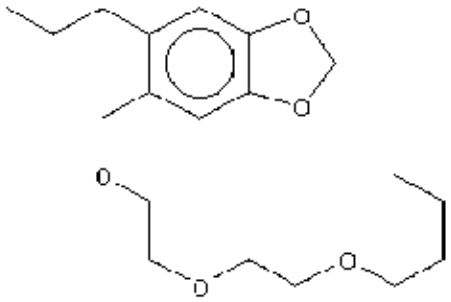
PBO

Chemical names

IUPAC 5-[2-(2-butoxyethoxy)ethoxymethyl]-6-propyl-1,3-benzodioxole

CA 5-[[2-(2-butoxyethoxy)ethoxy]methyl]-6-propyl-1,3-benzodioxole

Structural formula



Empirical formula

$C_{19}H_{30}O_5$

Relative molecular mass

338.4

CAS Registry number

51-03-6

CIPAC number

33

Identity tests

GC retention time, mass spectrum (from GC-MS)

PIPERONYL BUTOXIDE TECHNICAL MATERIAL

FAO specification 33/TC (September 2011*)

This specification, which is PART ONE of this publication, is based on an evaluation of data submitted by the manufacturer whose name is listed in the evaluation reports (33/2010, 33/2011). It should be applicable to TC produced by this manufacturer but it is not an endorsement of those products, nor a guarantee that they comply with the specifications. The specification may not be appropriate for TC produced by other manufacturers. The evaluation reports (33/2010, 33/2011), as PART TWO, form an integral part of this publication.

1 Description

The material shall consist of piperonyl butoxide together with related manufacturing impurities, in the form of an oily colourless to slightly yellow liquid, and shall be free from visible extraneous matter and added modifying agents.

2 Active ingredient

2.1 **Identity tests** (CIPAC/4765, Note 1)

The active ingredient shall comply with an identity test and, where the identity remains in doubt, shall comply with at least one additional test.

2.2 **Piperonyl butoxide content** (CIPAC/4765, Note 1)

The piperonyl butoxide content shall be declared (not less than 920 g/kg) and, when determined, the average measured content shall not be lower than the declared minimum content.

3 Relevant impurities

3.1 **Dihydrosafrole** (CIPAC/4812, Note 2)

Maximum: 0.1 g/kg.

Note 1 Methods for the identification and determination of piperonyl butoxide content in TC were presented at the CIPAC Meeting in 2011 and provisionally adopted as CIPAC methods. Prior to their publication in a next Handbook, copies of the methods may be obtained through the CIPAC website, http://www.cipac.org/cipacpub.htm

Note 2 The method for determination of dihydrosafrole (CAS No. 000094-58-6) in piperonyl butoxide TC is described in Appendix 1 of the Evaluation Report 33/2011, in Part Two of this publication.

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* Specifications may be revised and/or additional evaluations may be undertaken. Ensure the use of current versions by checking at:
http://www.fao.org/agriculture/crops/core-themes/theme/pests/pm/jmps/en/

PART TWO

EVALUATION REPORTS

PIPERONYL BUTOXIDE

PIPERONYL BUTOXIDE

FAO/WHO EVALUATION REPORT 33/2011

Recommendations

The Meeting recommended the following.

(i) The revision of the specification for piperonyl butoxide TC by including dihydrosafrole as relevant impurity with a limit of 0.1 g/kg should be adopted by FAO and WHO.

(ii) The existing FAO draft specification 33/1/S/4 for piperonyl butoxide TC developed under the old procedure should be withdrawn.

Appraisal

The PBO specification for WHO and FAO based on data submitted by Endura was adopted at the 2010 JMPS. The main issues in the specification were, among other points, the reference profile and the evaluation of dihydrosafrole (DHS), an impurity in PBO TC, as relevant impurity (see appraisal of the evaluation report 33/2010).

As the level of DHS was lower than 10 % of the GHS classification limit for carcinogenic mixtures substances (1 g/kg), the Meeting concluded that DHS was not a relevant impurity. In the meantime, Endura has conducted a collaborative trial on determination of PBO in TC and a peer validation for determination of DHS in TC. Based on the carcinogenic properties of DHS, and on the concentrations of this impurity found in the batches used for toxicological studies and in the production batches, the company has proposed (letter dating of 17 March 2011 addressed to WHO) to revise the published WHO specification by including DHS as relevant impurity with a maximum limit of 0.085 g/kg.

The Manual (November 2010 - second revision of the First Edition) states that if a limit below the maximum acceptable for the relevant impurity has been shown to be practical for routine manufacturing (Section 3.1, paragraphs A.5 or A.6), the JMPS will normally adopt it in preference. The current case falls in this category.

Taking into account the recent availability of a peer-validated method to determine DHS in PBO TC (see Appendix 1) and in accordance with the FAO/WHO Manual, the Meeting recommended to adopt the revision by inclusion of DHS as relevant impurity with a limit of 0.1 g/kg. In the same instance, the newly adopted CIPAC method for PBO TC based on capillary GC instead of the packed column method in Handbook H can be referenced to.

SUPPORTING INFORMATION
FOR
EVALUATION REPORT 33/2011

Physico-chemical properties of piperonyl butoxide

Table 1. Chemical composition and properties of piperonyl butoxide technical material (TC)

Manufacturing process, maximum limits for impurities ≥ 1 g/kg, 5 batch analysis data	Confidential information supplied and held on file by FAO and WHO. Mass balances were 98.59 – 99.35% and percentages of unknowns / unaccountables were 0.65 – 1.41% (water accounts for about 0.1% of this fraction but was not analyzed as part of the GLP 5 batch analysis report).
Declared minimum piperonyl butoxide content	920 g/kg
Relevant impurities ≥ 1 g/kg and maximum limits for them	None
Relevant impurities < 1 g/kg and maximum limits for them	Dihydrosafrole Maximum limit: 0.1 g/kg
Stabilisers or other additives and maximum limits for them	None
Melting or boiling temperature range of the TC	Piperonyl butoxide is a liquid both at ambient temperature and also at – 10 °C

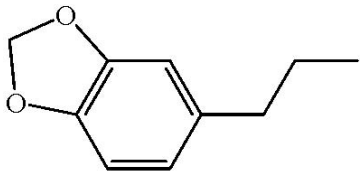
Appendix 1

to FAO/WHO evaluation report 33/2011

Analytical method (GC-FID) for determination of dihydrosafrole in piperonyl butoxide TC

1. SCOPE

This capillary gas chromatography (GC) method provides for the determination of dihydrosafrole (DHS) as relevant impurity in piperonyl butoxide (PBO) technical grade active ingredient.



IUPAC name : 5-propyl-1,3-benzodioxole
CAS n° 94-58-6
MW=164.2

2. SUMMARY OF METHOD

The impurity assay is determined by capillary gas chromatography, using an internal standard procedure.

Significant parameters of the method include:
• thick film capillary column
• split injection
• flame ionisation detection

3. CHEMICALS

[Organic solvents for gas chromatography, Merck or equivalent]

All chemicals should be handled according to normal laboratory safety procedures, in a fume cupboard, wearing a laboratory coat, eye protection and suitable gloves.
If in any doubt about the nature and hazards of the chemicals used in this method, consult the corresponding Material Safety Data Sheet or the supplier safety manual.

n-Hexane or Acetone, organic solvent for gas chromatography.
Dibutyl phtalate (DBF), high purity (99+%) as Internal Standard.
Dihydrosafrole (DHS), Analytical Standard of known purity.

4. APPARATUS AND OPERATING CONDITIONS

The apparatus listed below is that used to establish the method. Consideration must be given to confirmation of the method on other makes of equipment, providing equivalent performance, to ensure that they are suitable.

- **Instrument**: GC system, equipped with split/splitless injector and flame ionisation detector, operating in split mode.
- **Injection mode**: autosampler, syringe size 10 µl.
- **Injection liner**: split inlet liner, single taper, glass wool, deactivated.
- **Injection load**: 1µl.
- **Injection port temperature**: 250°C.
- **Split flow**: 9.9 ml min^{-1}, split ratio 10:1.
- **Gas filtration**: all technical gases should be of high purity. The carrier gas is further purified through a triple filter cartridge containing oxygen and moisture traps.
- **Column dimension**: length 25 m, internal diameter 0.32 mm.
- **Film thickness**: 0.52 µm.
- **Stationary phase**: cross-linked 100% dimethylpolysiloxane.
- **Carrier gas**: High purity helium, mode constant flow, average velocity 22 cm s^{-1}.
- **Oven temperature**:
  Initial isotherm 120°C,
  Initial time 2 min,
  Programme rate 5°C/min,
  Final temperature 285°C,
  Final time 10 min.
- **Run time:** 45 min.
- **Detector temperature**: 300°C.
- **Detector gas flow rates**: according to manufacturers recommendations.

5. CALIBRATION

The calibrations solutions are prepared starting from already diluted solutions.

Preparation of AM Solution, a mother concentrated solution of DHS at about 1000 mg/l:
weigh 250 ± 10 mg of DHS standard in a 250 ml volumetric flask. Dilute to volume with solvent and shake vigorously.

Preparation of A Solution, a diluted solution of DHS at about 40 mg/l:
measure with a precision volumetric pipette 2 ml of the previous prepared AM solution and put into a 50 ml volumetric flask. Dilute to volume with solvent and shake vigorously.

Preparation of the B solution, an internal standard stock solution at about 2500 mg/l:
weigh 250 ± 10 mg of dibutyl phtalate standard in a 100 ml volumetric flask. Dilute to volume with solvent and shake vigorously.

Prepare the calibration solutions at four different concentration levels of the impurity, in presence of the internal standard at 100 mg/l of dibutyl phthalate.

Level 1: measure with a precision volumetric pipette 1 ml of the previous prepared A diluted DHS solution and put into a 50 ml volumetric flask. Add 2 ml of the previous prepared B stock DBF solution. Dilute to volume with solvent and shake vigorously.
The final solution contains about 0.8 mg/l of DHS.

Level 2: use the same procedure of level 1 but put 1 ml into a 25 ml volumetric flask and add 1 ml of the previous prepared B stock DBF solution. The final solution contains about 1.6 mg/l of DHS.

Level 3: use the same procedure of level 1 and 2 with a 50 ml volumetric flask, 5 ml of the A diluted DHS solution and 2 ml of B stock DBF solution. The final solution contains about 4.0 mg/l of DHS.

Level 4: use the same procedure of level 1 and 2 with a 25 ml volumetric flask, 5 ml of the A diluted DHS solution and 1 ml of B stock DBF solution. The final solution contains about 8.0 mg/l of DHS.

Prepare a vial of each of the four level solutions and inject twice each solution in GC at the chromatographic condition described in the paragraph 4.
Plot the Concentration ratio *(DHS/Internal Standard, mg/l)* data versus Peak Area ratio *(DHS/Internal Standard, pA*s.*) data obtained from each chromatogram, and calculate the equation of the calibration curve, expressed as
$Y = A X + B$.

Verify the linearity of the calibration curve: the r parameter must be not less than 0.99.

The concentration at levels 1, 2, 3, 4 of the calibration range corresponds to a concentration of DHS respectively of about 40, 80, 200, 400 mg/kg_{PBO} at the method conditions.

6. CALIBRATION

6.1 Preparation of sample

Weigh (0.500 ± 0.002) g of the PBO to analyse and add 1 ml of DBF stock solution (B solution, paragraph 5) in a 25 ml volumetric flask. Dilute to volume with solvent and shake vigorously. The sample solution contains about 20000 mg/l of PBO, 100 mg/l of DBF.
Prepare a vial of the sample solution and inject twice in the gas chromatographic system at the condition described in paragraph 4.

6.2 Calculation

Calculate the content of the impurity DHS, expressed as mg/kg$_{PBO}$, from the equation of the calibration curve
Y = A X + B, using the formula below.

DHS (mg/kg) = $$\frac{(\frac{Hw}{Iq} - B) * q}{A * w} * 100 * 10000$$

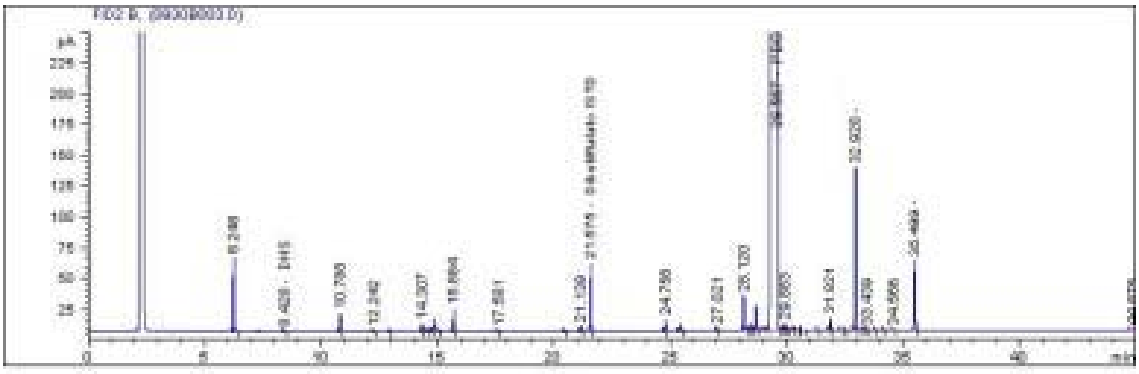
Where:

Hw = mean area of the impurity DHS peak
Iq = mean area of internal standard DBF peak
w = concentration (mg/l) of PBO sample in the sample solution
q = concentration (mg/l) of internal standard DBF in the sample solution, corrected for its purity
A = slope of calibration curve
B = intercept of calibration curve

7. SUITABILITY

Stored or new columns may require conditioning prior to use.
Perform replicate injections of calibration solution until acceptable, repeatable chromatography is obtained.

Compare the chromatogram obtained with that of a typical PBO batch: measure the retention time of the DHS impurity, 8.43 ± 0.3 minutes; measure the retention time of the DBF Internal Standard 21.6 ± 0.3 minutes and its peak area.



If the peaks retention time is not within the quoted window, the oven temperature or the column head pressure may need to be checked or slightly adjusted.

8. REFERENCES

- CIPAC Guideline for analytical methods for the determination of relevant impurities referred to in FAO and/or WHO specifications for pesticide technical grade active ingredients and formulations, CIPAC rev.7 (June 2009).
- Endura: CIPAC Method 4717/m “Determination of Piperonyl butoxide purity assay by capillary gas chromatography” (June 2010).
- For the acceptance criteria: APVMA Guidelines for the validation of analytical methods for active constituent, agricultural and veterinary chemical products (October 2004).

PIPERONYL BUTOXIDE

FAO/WHO EVALUATION REPORT 33/2010

Recommendations

The Meeting recommended the following.

The specification for piperonyl butoxide TC proposed by Endura, as amended, should be adopted by FAO and WHO, subject to clarification of the representativeness of the hazard data elaborated with a composite tox batch for the material produced by Endura and relevance of some impurities detected in the latter material.

Appraisal

The data submitted were broadly in accordance with the requirements of the FAO/WHO Manual March 2006 revision of the first edition and supported the draft specifications for new FAO and WHO specifications.

The toxicology of piperonyl butoxide was evaluated by JMPR in 1995 and an ADI of 0-0.2 mg/kg bw was set. The WHO hazard classification of piperonyl butoxide is: "unlikely to present acute hazard in normal use". The 2001 JMPR concluded that setting an ARfD for piperonyl butoxide was not justified. The GHS acute toxicity category of piperonyl butoxide is 5.

Piperonyl butoxide is classified by US EPA as category III by oral and dermal and as category IV by inhalation exposure routes, as minimally irritating to eyes and skin.

Piperonyl butoxide is an oily liquid at room temperature. It has a low volatility (vapor pressure: 1.33×10^{-5} Pa at 25 °C). The octanol-water partition coefficient indicates that piperonyl butoxide could have a potential to bioaccumulate (log Pow = 4.8 at 20°C, independent of pH), but studies show rapid degradation in the mammalian metabolism and in the environment.

Confidential information regarding the manufacturing process and the identity of the impurities at a level > 1 g/kg was presented. Mass balances were in the range of 985.9 to 993.5 g per kg. The data supported a minimum content of 920 g/kg for piperonyl butoxide in the TC.

The necessity to control residual water or acidity/alkalinity in piperonyl butoxide TC was discussed by the Meeting. Noting the stability of piperonyl butoxide against hydrolytic attack in the pH range of 5 to 9 and taking into consideration that the manufacturing process for piperonyl butoxide includes a purification step for the technical material, the Meeting agreed that limits for water, alkalinity or acidity in the TC were not necessary for the material under consideration and could be removed.

The question of relevant impurities was discussed by the Meeting. During the manufacturing process traces of an intermediate, dihydrosafrole (DHS) could be carried forward to the finished technical material. DHS has been evaluated for carcinogenicity by IARC and classified as possibly carcinogenic to humans (2B) (Ref. 3). DHS has not been detected in 5 batch analysis data submitted by the proposer. The detection limit was lower than 10 % of the GHS limit and DHS was therefore considered non relevant in the TC produced by Endura.

However, this compound could become a relevant impurity if present in other products at higher levels.

The hazard data on piperonyl butoxide was elaborated by a task force using tox batches representing composite products from batches produced by companies participating in the piperonyl butoxide consortium indicated in a footnote in the hazard tables. Information on purity and composition of the tox batches as well as that actually produced by Endura has been provided.

Therefore, a combination of equivalence assessment and bridging was necessary, where the tox batches supported by hazard data was compared with the impurity profile and manufacturing specification of the actual TC produced by Endura.

The Meeting noted that the TC produced by Endura is manufactured using a different route, not starting with sassafras oil but that the toxicity studies were mainly performed using different batches of a sassafras-based product. However, all impurities in the Endura product – including DHS - were present also in the Sassafras-based products actually tested, and their concentrations in these products were similar or higher than in the Endura product; they were thus covered by the toxicity studies. Not surprising, safrole has not been detected in the Endura product, and based on the information on the manufacturing process, it is not expected to be present. In addition, a recent study on the bacterial mutagenicity test with *S. typhimurium* and *E. Coli* strains and carried out with the Endura material was submitted to JMPS and no mutagenicity was observed.

As far as impurities are concerned, the reported limits have been supported by the 5-batch data. The dates of production of the batches tested have been provided. The analytical methods used for quantification and identification of impurities were sufficiently validated for the concentration ranges the impurities occurred in the TC.

The Meeting concluded, that the active ingredient content of the Endura product is higher than that of the sassafras-based product, and all impurities found in the Endura product are present at higher or similar concentrations in the sassafras-based product used in the toxicity studies. The mass-balance is ≥ 980g/kg. Thus the toxicity and ecotoxicity studies performed with the sassafras-based product reflect the hazards of the Endura product too, and represent a worst-case scenario.

A draft specification for TC has been submitted by the proposer, which was broadly in agreement with the requirements of the FAO and WHO Manual (2006). As the proposer produces the TC and sells its piperonyl butoxide to various formulators, a specification for TC only was submitted.

References for the appraisal

1 1995 JMPR Evaluation of piperonyl butoxide, p. 156 Toxicology.

2 Pesticide Synthesis Handbook, Th. A. Unger, Noyes Publication 1996, p. 1004, Piperonyl butoxide.

3 IARC (1987) Supplement No. 7. Overall Evaluations of Carcinogenicity: An Updating of IARC Monographs Volumes 1 to 42, page 62.

SUPPORTING INFORMATION
FOR
EVALUATION REPORT 33/2010

Physico-chemical properties of piperonyl butoxide

Table 1. Physico-chemical properties of pure piperonyl butoxide

Parameter	Value(s) and conditions	Purity %	Method reference and company report number/date
Vapour pressure	2.11×10^{-5} Pa at 60°C (The calculated vapour pressure at 25 °C will be less than 1.33×10^{-5} Pa)	93.0	EPA 796.1950 ABC Laboratories Report No. 38007 (1989)
Melting point, boiling point and/or temperature of decomposition	Melting point: liquid at room temperature Boiling point: 203°C at 0.278 kPa Decomposition temperature: >300°C	94.0 94.47 94.0/97.2	ASTM E537-76 Endura Report No. 735 (2011) Endura Report No. 652 (2009)
Solubility in water	0.034 g/l at 8.4°C at pH 7.02 0.027 g/l at 20.4°C at pH 7.02 0.022 g/l at 33.4°C at pH 7.02	99.35	EEC A6 GAB Report No. 20051476/01/01-PCSB (2006)
Octanol/water partition coefficient	log P_{OW} = 4.8 at 20°C at pH 6.5	99.35	EEC A8 GAB Report No. 20051476/01-PCPC (2006)
Hydrolysis characteristics	Half-life = > 500 days at 25°C at pH 5, 7 and 9, in the dark	92.43	EPA 161-1 HRC Report No. PBT 4/943285 (1995)
Photolysis characteristics	Half-life = 8.4 hours at 25°C at pH 7 when exposed to natural sunlight.	98.3	EPA 161-2 BTC Report No. P0594010A (1995)
Dissociation characteristics	Does not dissociate.	-	-

Table 2. Chemical composition and properties of piperonyl butoxide technical material (TC)

Manufacturing process, maximum limits for impurities ≥ 1 g/kg, 5 batch analysis data	Confidential information supplied and held on file by FAO and WHO. Mass balances were 98.59 – 99.35% and percentages of unknowns / unaccountables were 0.65 – 1.41% (water accounts for about 0.1% of this fraction but was not analyzed as part of the GLP 5 batch analysis report).
Declared minimum piperonyl butoxide content	920 g/kg
Relevant impurities ≥ 1 g/kg and maximum limits for them	None
Relevant impurities < 1 g/kg and maximum limits for them	None
Stabilisers or other additives and maximum limits for them	None
Melting or boiling temperature range of the TC	Piperonyl butoxide is a liquid both at ambient temperature and also at – 10 °C

Hazard summary

The data for piperonyl butoxide were evaluated in support of a new FAO/WHO specification for the TC only.

Piperonyl butoxide, when manufactured by the Endura process, is under patent in several countries worldwide like Australia, Brazil, Germany, India and many others.

The patent has been granted in all the listed countries except BR and JP where the patent application has been published and is being examined.

The draft specification and the supporting data were provided by Endura S.p.A. in 2008.

Piperonyl butoxide has not been evaluated by the WHO IPCS but has been evaluated by the FAO/WHO JMPR last in 1995 for toxicology and last in 2001/2002 for residues. In 1995, the ADI was set at 0 to 0.2 mg/kg bw/day, on the basis of the lowest NOAEL of 16 mg/kg bw/day, determined in the 1 year dog study. In 2002, IEDIs for the five GEMS/Food regional diets were estimated to be between 20% and 40% of the ADI. The Meeting concluded that the intake of residues of piperonyl butoxide resulting from its uses that have been considered by the JMPR was unlikely to present a public health concern. An ARfD for piperonyl butoxide was considered unnecessary. The Meeting therefore concluded that short-term dietary intake of piperonyl butoxide residues is unlikely to present a risk to consumers.

It was evaluated/reviewed by the US EPA last in 2006 (Date of the Reregistration Eligibility Document) and is currently under evaluation/review by the European Commission (dossier submitted under Directive 98/8/EC).

The WHO hazard classification of piperonyl butoxide is: unlikely to present acute hazard in normal use. The GHS acute toxicity category is 5.

Piperonyl butoxide is classified by US EPA as category III by oral and dermal and as category IV by inhalation exposure routes, as minimally irritating to eyes and skin.

Use

Piperonyl butoxide (PBO) is an insecticide synergist. It acts by protecting the co-applied insecticide (e.g. pyrethrins, pyrethroids and other pesticides) from metabolic attack thus allowing them to reach their biochemical targets.

Since piperonyl butoxide inhibits an enzyme system which is catalysing oxidative processes in living systems, it also has an intrinsic toxic potential to arthropods. It is widely used in combination with pyrethrins, pyrethroids and other pesticides, in public health, household and human and veterinary medicinal products, agriculture, stored product protection, home and garden, etc. against a variety of flying and crawling arthropod species, e.g. mosquitoes, houseflies, cockroaches, storage pests, mites, moths, ticks, lice, etc. (*Glynne-Jones, 1998*).

Formulations and co-formulated active ingredients

Piperonyl butoxide is typically co-formulated with pyrethrins or pyrethroids, as well as with other active ingredients. The compound is used in classical formulations like EC, EW as well as in insecticidal treated long-lasting nets (LN).

These formulations are widely registered and sold globally.

Methods of analysis and testing

The analytical method for determination of piperonyl butoxide in the technical material is currently a CIPAC Method published in Handbook 1C. It is a packed column GC method using dicyclohexylphthalate as internal standard and allows the determination of piperonyl butoxide in technical material with a concentration of 800 g/kg. With reference to the CIPAC Guideline “Extension of the scope of methods”, the acceptability range where no additional validation has to be performed is 200 to 50 % from that studied in a collaborative trial. The extension of 800 to 920 g/kg with the new proposed minimum content is therefore well within that range.

As the method in Handbook 1C has been declared as “no longer supported” by CIPAC but still can be used, no method extension to long-lasting insecticidal nets containing piperonyl butoxide is possible. CIPAC has adopted in 2009 a method on determination of piperonyl butoxide in LN by capillary gas chromatography. For consistency reasons, the renewal of the packed column GC method with a capillary column GC method is currently under way and the presentation and possible adoption is scheduled for the 2011 CIPAC Meeting.

Test methods for determination of physico-chemical properties of the technical active ingredient, as presented in *Table 1*, were EPA 796.1950 (Vapour Pressure), EEC A6 (Solubility in water), EEC A8 (Octanol/water partition coefficient), EPA 161-1 (Hydrolysis) and EPA 161-2 (Photolysis).

Physical properties

The specification for piperonyl butoxide TC does not require testing of physical properties, and specifications were not proposed for formulations, so that physical test methods for support of the specifications were not considered in this evaluation.

Container and packaging

It is recommended to use containers made of high-density polyethylene; epoxyphenolic-lined steel, dark glass or aluminium.

It should be avoided to use non-lined steel containers.

Expression of active ingredient

The active ingredient content is expressed as piperonyl butoxide.

ANNEX 1

HAZARD SUMMARY PROVIDED BY THE PROPOSER

Notes:

(i) The proposer confirmed that the toxicological and ecotoxicological data included in the summary below were derived from piperonyl butoxide having impurity profiles similar to those referred in Table 2. The toxicological tests and most of the ecotoxicological tests were generated with a sample of piperonyl butoxide that was manufactured from natural sassafras oil.

(ii) The conclusions expressed in the summary below are those of the proposer, unless otherwise specified.

Table 3. Toxicology profile of the piperonyl butoxide technical material, based on acute toxicity, irritation and sensitization

Species	Test	Duration and conditions or guideline adopted	Batch Number	Result
Rats, male & female	oral	US EPA 81-1	Task Force FEP-100	LD_{50} = 4570 mg/kg bw (males) LD_{50} = 7220 mg/kg bw (females) LD_{50} = 5630 mg/kg bw (combined)
Rabbits, male & female	dermal	US EPA 81-2	Task Force FEP-100	LD_{50} = > 2000 mg/kg bw
Rats, male & female	inhalation	US EPA 81-3	Task Force FEP-100	LC_{50} = > 5900 mg/m^3
Rabbits, male & female	skin irritation	US EPA 81-5	Task Force FEP-100	Not irritant
Rabbits, male & female	eye irritation	US EPA 81-4	Task Force FEP-100	Not irritant
Guinea pig, male & female	skin sensitization	US EPA 81-6	Task Force FEP-100	Not sensitizing

The above toxicological data have been submitted to the FAO/WHO JMPR and were assessed in 1995. The data are property of the Piperonyl Butoxide Task Force II, members of which are Endura S.p.A., McLaughlin Gormley King Co., Prentiss Incorporated, S.C. Johnson & Son, Inc. and Valent BioSciences Corporation.

Table 4. Toxicology profile of technical piperonyl butoxide based on repeated administration (sub-acute to chronic)

Species	Test, duration and conditions	Guideline adopted	Batch Number	Result
Dogs, male & female	8 week oral toxicity 0, 500, 1000, 2000 and 3000 mg/kg diet 0, 14.7, 32, 63, and 90 mg/kg bw/d for males and 0, 14.8, 37, 61, and 85 mg/kg bw/d for females	OECD 409	Task Force FEP-100	NOAEL = 14.8 mg/kg bw/d LOEL = 63 mg/kg bw/d (males) LOEL = 61 mg/kg bw/d (females)
Rabbits, male & female	3 week dermal toxicity 0, 100, 300 and 1000 mg/kg bw/d	US EPA Pesticide Assessment Guidelines, Subdivision F, 82-2	Task Force FEP-100	NOAEL = 1000 mg/kg bw/d LOEL = > 1000 mg/kg bw/d
Rats, male & female	3 months inhalation toxicity Analytical concentration: 0, 15, 74, 155, 512 mg/m³	US EPA Pesticide Assessment Guidelines, Subdivision F, 82-4	Task Force FEP-100	NOAEL = 155 mg/m³ LOEL = 512 mg/m³
Mice, male & female	3 months oral toxicity 0, 10, 30, 100, 300 and 1000 mg/kg bw/d	OECD Guideline 408	Task Force FEP-100	NOAEL = 100 mg/kg bw/d LOEL = 300 mg/kg bw/d
Dogs, male & female	1 year oral toxicity 0, 100, 600 and 2000 mg/kg diet 0, 2.9, 15.5 and 53 mg/kg bw/d for males and 0, 2.7, 16.3 and 71 mg/kg bw/d for females.	OECD Guideline 452	Task Force FEP-100	NOAEL = 16 mg/kg bw/d LOEL = 53 mg/kg bw/d (males) LOEL = 71 mg/kg bw/d (females)
Rats, male & female	2 year oral toxicity and carcinogenicity 0, 30, 100 and 500 mg/kg bw/d	US EPA 83-5	Task Force FEG-32	NOAEL = 30 mg/kg bw/d LOEL = 100 mg/kg bw/d Not carcinogenic (WHO, 1995)

Species	Test, duration and conditions	Guideline adopted	Batch Number	Result
Mice, male & female	18 months dietary oncogenicity 0, 30, 100 and 300 mg/kg bw/d	OECD 451	Task Force FEP-100	NOAEL = 30 mg/kg bw/d LOEL = 100 mg/kg bw/d Not carcinogenic (WHO, 1995)
Rats, male & female	2 generation reproduction 0, 300, 1000 and 5000 mg/kg diet 0, 27, 89 and 469 mg/kg bw/d for males 0, 30, 102, 528 mg/kg bw/d for females	US EPA Pesticide Assessment Guidelines, Subdivision F, 83-4	Task Force FEG-32	NOAEL = 1000 ppm (parents, F1, F2) (89 mg/kg bw/d for males; 102 mg/kg bw/d for females) LOAEL = 5000 ppm (parents, F1, F2) (469 mg/kg bw/d for males; 512 mg/kg bw/d for females)
Rats, male & female	Developmental toxicity 0, 200, 500 and 1000 mg/kg bw/d	US EPA Pesticide Assessment Guidelines, Subdivision EPA F, 83-3	Task Force FEP-100	NOEL (dams) = 200 mg/kg bw/d LOEL (dams) = 500 mg/kg bw/d NOEL (pups) = 1000 mg/kg bw/d LOEL (pups) = no effects No developmental toxicity
Rabbits, female	Developmental toxicity 0, 50, 100 and 200 mg/kg bw/d	US EPA Pesticide Assessment Guidelines, Subdivision EPA F, 83-3	Task Force FEG-32	NOAEL (dams) = 50 mg/kg bw/d LOAEL (dams) = 100 mg/kg bw/d NOAEL (pups) = 200 mg/kg bw/d LOAEL (pups) = no effects No developmental toxicity

The above toxicological data have been submitted to the FAO/WHO JMPR and were assessed in 1995. The data are property of the Piperonyl butoxide Task Force II, members of which are Endura S.p.A., McLaughlin Gormley King Co., Prentiss Incorporated, S.C. Johnson & Son, Inc. and Valent BioSciences Corporation.

Table 5. Mutagenicity profile of technical piperonyl butoxide based on in vitro and in vivo tests

Species	Test	Duration and conditions or guideline adopted	Batch Number	Result
Salmonella typhimurium	Bacterial assay gene mutation (Ames test) In vitro	EPA F, 84-2	Task Force FEP-100	Negative Not mutagenic (WHO, 1995)
Salmonella typhimurium and *Escherichia coli WP2 uvrA*	Bacterial assay gene mutation (Ames test) In vitro	OECD 471	Endura R 1006028	Negative with and without metabolic activation [1]
Chinese hamster ovary cells (CHO)	Mammalian cells clastogenicity chromosomal aberrations In vitro	EPA F, 84-2	Task Force FEP-100	Negative Not mutagenic (WHO, 1995)
Chinese hamster ovary cells (CHO)	Mammalian cells gene mutation in vitro	10-100 µg/mL +S9 25-500 µg/mL –S9	Task Force FEG-32	Negative Equivocal Not mutagenic (WHO, 1995)
Mice, male & female	Micronucleus test In vivo	Doses 0 (vehicle), 300, 1000, 3000 mg/kg b.w.; two applications with 24 h interval, sampling 6 h after last dose	Endura 7/88	Negative Not mutagenic (WHO, 1995)

[1] Study provided to JMPS by Endura in 2010. All other studies: the toxicological data have been submitted to the FAO/WHO JMPR and were assessed in 1995. The data are property of the Piperonyl butoxide Task Force II, members of which are Endura S.p.A., McLaughlin Gormley King Co., Prentiss Incorporated, S.C. Johnson & Son, Inc. and Valent BioSciences Corporation.

Table 6. Ecotoxicology profile of technical piperonyl butoxide

Species	Test	Duration and conditions or guideline adopted	Batch Number	Result
Daphnia magna (water flea)	acute toxicity	EPA, Subdivision E, Series 72-2	Task Force FEP-100	EC_{50} = 0.00051 g/l
Cyprinodon variegatus (sheepshead minnow)	acute toxicity	EPA, Subdivision E, Series 72-3	Task Force FEP-100	LC_{50} = 0.00394 g/l
Selenastrum capricornutum (green alga)	growth inhibition	OECD 201	Endura EN 01-4/38	ErC_{50} = 0.00389 g/l NOErC = 0.000824 g/l
Earthworm	acute toxicity	OECD 207 (1984)	Endura S0477062501	LC_{50} = 423 mg/kg dry soil
Apis mellifera (honey bee)	acute oral toxicity	US EPA 141-1	Task Force FEP-100	LD_{50} = > 25 µg/bee
Pimephales promelas (fathead minnow)	early life-stage toxicity	US EPA 72-4	Task Force PB-200	NOEC = 0.00018 g/l LOEC = 0.00042 g/l
Daphnia magna (water flea)	reproduction and chronic toxicity	US EPA 72-4	Task Force PB-200	NOEC = 30 or 33 µg/l LOEC = 47 µg/l
Colinus virginianus (bobwhite quail)	acute oral toxicity	US EPA 71-1	Task Force FEP-100	LD_{50} = > 2250 mg/kg bw NOEL = 486 mg/kg bw
Colinus virginianus (bobwhite quail)	short-term toxicity	FIFRA 71-2	Task Force FEP-100	LD_{50} = > 5620 mg/kg bw. NOEL = 1000 mg/kg bw

The above ecotoxicological data have not been submitted to the FAO/WHO JMPR before. The data are partly property of Endura S.p.A., and partly property of the Piperonyl butoxide Task Force II, members of which are Endura S.p.A., McLaughlin Gormley King Co., Prentiss Incorporated, S.C. Johnson & Son, Inc. and Valent BioSciences Corporation.

ANNEX 2

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