WHO SPECIFICATIONS AND EVALUATIONS FOR PUBLIC HEALTH PESTICIDES

CYPERMETHRIN

(RS)-α-cyano-3-phenoxybenzyl (1RS,3RS;1RS,3SR)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate

2024

World Health Organization

TABLE OF CONTENTS

DISCLAIMER[1]

WHO specifications are developed with the basic objective of promoting, as far as practicable, the manufacture, distribution and use of pesticides that meet basic quality requirements.

Compliance with the specifications does not constitute an endorsement or warranty of the fitness of a particular pesticide for a particular purpose, including its suitability for the control of any given pest, or its suitability for use in a particular area. Owing to the complexity of the problems involved, the suitability of pesticides for a particular purpose and the content of the labelling instructions must be decided at the national or provincial level.

Furthermore, pesticides which are manufactured to comply with these specifications are not exempted from any safety regulation or other legal or administrative provision applicable to their manufacture, sale, transportation, storage, handling, preparation and/or use.

WHO disclaims any and all liability for any injury, death, loss, damage or other prejudice of any kind that may be arise as a result of, or in connection with, the manufacture, sale, transportation, storage, handling, preparation and/or use of pesticides which are found, or are claimed, to have been manufactured to comply with these specifications.

Additionally, WHO wishes to alert users to the fact that improper storage, handling, preparation and/or use of pesticides can result in either a lowering or complete loss of safety and/or efficacy.

WHO is not responsible, and does not accept any liability, for the testing of pesticides for compliance with the specifications, nor for any methods recommended and/or used for testing compliance. As a result, WHO does not in any way warrant or represent that any pesticide claimed to comply with a WHO specification actually does so.

[1] This disclaimer applies to all specifications published by WHO.

INTRODUCTION

WHO establishes and publishes specifications[2] for technical material and related formulations of public health 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.

From 2002, the development of WHO specifications follows the **New Procedure**, described in the "Manual for development and use of FAO and WHO specifications for pesticides." This **New Procedure** follows a formal and transparent evaluation process. It describes the minimum data package, the procedure and evaluation applied by WHO and the experts of the FAO/WHO Joint Meeting on Pesticide Specifications (JMPS).

WHO specifications now only apply to products for which the technical materials have been evaluated. Consequently, from the year 2002 onwards, the publication of WHO 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 above-mentioned manual.

Part Two: The Evaluation Report(s) of the pesticide, reflecting the evaluation of the data package carried out by WHO and the JMPS. The data are provided by the manufacturer(s) according to the requirements of chapter 3 of the above-mentioned manual and supported by other information sources. evaluation reports include 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 chronological order to this report.

WHO specifications under the **New Procedure** do not necessarily apply to nominally similar products of other manufacturer(s), nor to those where the active ingredient is produced by other routes of manufacture. WHO has the possibility to extend the scope of the specifications to similar products but only when the JMPS has been satisfied that the additional products are equivalent to that which formed the basis of the reference specification.

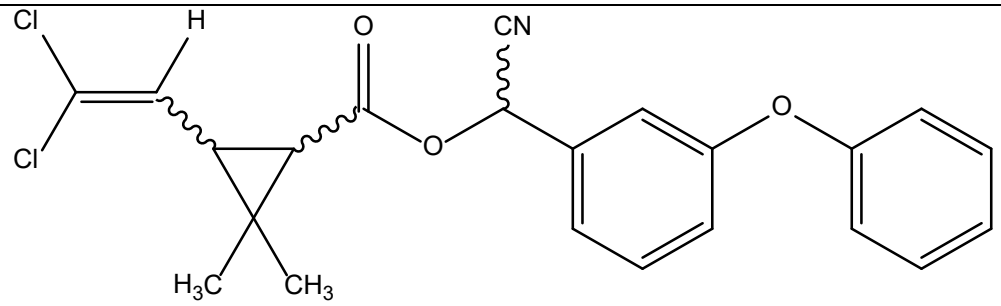
Specifications bear the date (month and year) of publication of the current version. Evaluations bear the date (year) of the meeting at which the recommendations were made by the JMPS.

[2] Publications available on the WHO Prequalification Unit – Vector Control Product Assessment Team (PQT/VCP) website: https://extranet.who.int/prequal/vector-control-products

PART ONE: SPECIFICATIONS

CYPERMETHRIN **Page**

Cypermethrin Information

ISO common names	
Cypermethrin (E-ISO), cyperméthrine (F-ISO)	
Synonyms	
None	
Chemical names	
IUPAC	(*RS*)-α-Cyano-3-phenoxybenzyl (1*RS*,3*RS*;1*RS*,3*SR*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate
CA	Cyano(3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate
Structural formula	
	
Molecular formula	
$C_{22}H_{19}Cl_2NO_3$	
Relative molecular mass	
416.3	
CAS registry number	
523150-07-8	
CIPAC number	
332	
Identity tests	
HPLC retention time, IR, ^{13}C-NMR, ^{1}H-NMR or MS.	

Cypermethrin Technical Material

WHO Specification 332/TC (December 2024*)

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 report (332/2024). This specification 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 specification. The specification may not be appropriate for TC produced by other manufacturers. The evaluation report (332/2024), as PART TWO, forms an integral part of this publication.

1. Description

The material shall consist of cypermethrin together with related manufacturing impurities, and shall be a yellow to brown viscous liquid, free from visible extraneous matter and added modifying agents.

2. Active ingredient

2.1. **Identity tests** (MT 163, CIPAC Handbook F, p. 404, 1995)

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. **Cypermethrin content** (332/TC/M/3.2, CIPAC Handbook 1C, p. 2052, 1985)

The cypermethrin content shall be declared (not less than 930 g/kg) and, when determined, the average measured content shall not be lower than the declared minimum content.

2.3. **Cypermethrin isomer ratio** (332/TC/M/3.2, CIPAC Handbook 1C, p. 2052, 1985)

The cypermethrin cis-isomer content shall be declared and, when determined, shall be between 40% and 60% of the total cypermethrin content as measured under 2.2.

3. Impurities (Note 1)

3.1. **Water** (CIPAC MT 30.6, CIPAC Handbook P, p. 222, 2021)

Maximum: 1 g/kg

3.2. **Hexane** (Note 2)

Maximum: 6 g/kg

3.3. **Permethrin** (Note 3)

Maximum: 6 g/kg

3.4. **m-phenoxyphenylacetonitrile** (Note 4)

Maximum: 13 g/kg

---

* Specifications may be revised and/or additional evaluations may be undertaken. Ensure the use of current versions by checking at the WHO Prequalification Unit – Vector Control Product Assessment Team (PQT/VCP) website: https://extranet.who.int/prequal/vector-control-products/specifications-new-procedure

Note 1 In addition to the relevant impurities to be controlled in cypermethrin TC, permethric acid anhydride may occur as a result of certain manufacturing processes. If this impurity would exceed 0.1 g/kg in the products of other manufacturers, it may be designated as a relevant impurity, and a clause would be required to limit its concentration.

Note 2 A peer-validated method is available for hexane and is provided in appendix 1.

Note 3 A peer-validated method is available for permethrin and is provided in appendix 2.

Note 4 A peer-validated method is available for m-phenoxyphenylacetonitrile and is provided in appendix 2.

PART TWO: EVALUATION REPORTS

CYPERMETHRIN

CYPERMETHRIN

FAO/WHO Evaluation Report 332/2024

Recommendations

The Meeting recommended the following:

i. The FAO specifications for cypermethrin TC, TK, WP, EC and UL developed under the old procedure should be withdrawn; and
ii. The specification for cypermethrin TC, proposed by Hemani Industries Ltd, and as amended, should be adopted by FAO and WHO.

Appraisal

The Meeting considered data on cypermethrin (TC only) submitted by Hemani Industries Ltd (Hemani) from 2020 to 2024 for the conversion of the existing (1995) FAO specifications established under the old procedure for cypermethrin TC, TK, EC, WP and UL into specifications established under the new procedure. Hemani submitted data for the TC only and not for the formulated products. The data submitted met the requirements of the Manual on development and use of FAO and WHO specifications for pesticides (2022, second edition).

Technical grade cypermethrin consists of eight stereoisomers (four enantiomeric pairs) present in roughly equal proportions due to the chirality of two carbon atoms in the cyclopropane ring as well as the aliphatic benzyl carbon atom. These are the four *cis*-isomers ((*RS*)-α-cyano-3-phenoxybenzyl (1*RS*,3*RS*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate) and the four *trans*-isomers ((*RS*)-α-cyano-3-phenoxybenzyl (1*RS*,3*SR*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate).

The manufacturer submitted confidential data on the manufacturing process, together with the manufacturing specification and batch analysis data on cypermethrin TC purity and all detectable impurities at or above 1 g/kg.

A 5-batch analysis GLP study was provided for batches of cypermethrin manufactured during 2020 and 2021, replacing an earlier 5-batch analysis for batches manufactured in 2011 provided with the initial submission to FAO and WHO. The cypermethrin content and cis/trans isomer ratio were determined using the CIPAC method 332/TC/M/3. Contents of the organic impurities were determined using a combination of HPLC-UV, LC-MS-MS and GC-FID methods. Reference standards were used for quantification in all cases. All methods were validated (specificity, linearity, precision, accuracy and LOD/LOQ), and all parameters were within generally acceptable limits. Water was determined using the CIPAC method MT 30.6, while acetone insoluble material and acidity were determined using the CIPAC methods MT 27 and 31.1, respectively.

The mass balances for the 5-batch analysis ranged from 990.6 to 995.9 g/kg. The specified minimum purity of cypermethrin in the TC is 930 g/kg, with a *cis*/*trans* isomer ratio of 40:60 to 60:40. The minimum purity, the isomer ratio, and the maximum limits for the impurities occurring at or above 1 g/kg in the TC were all supported by the 5-

batch data and are statistically justified. The composition of the five batches analysed in 2021 were consistent with the batches from the 2011 5-batch analysis.

The information on the manufacturing process and impurities (identities and limits) were the same as those submitted in support of the registration in Australia, apart from minor differences in the limits due to rounding. The 5-batch analysis provided with the original JMPS submission (relating to batches manufactured in 2011) was the same as that provided for registration in Australia.

The Meeting noted that cypermethrin is commonly used in non-aqueous formulation types, such EC, and considered that water is, therefore, a relevant impurity for the purpose of quality control of products formulated using this source of cypermethrin, with a maximum limit of 1 g/kg.

The Meeting also noted that permethric acid anhydride was considered a relevant impurity at levels ≥ 0.1 g/kg for transfluthrin, another synthetic pyrethroid active ingredient. Permethric acid anhydride could be formed during the manufacture of cypermethrin TC. The 5-batch analysis results completed in May 2021 did not detect permethric acid anhydride (validated limit of quantitation was 0.05 g/kg, limit of detection was 0.0046 g/kg). Therefore, permethric acid anhydride is not considered a relevant impurity in Hemani Industries' cypermethrin TC; however, it may be a relevant impurity in extension applications for cypermethrin.

The Meeting considered that hexane is a relevant impurity for cypermethrin when present at 3 g/kg or above. The 5-batch analysis was conducted using a validated GC-FID method. There is currently no CIPAC method for hexane. The Meeting considered that a maximum limit of 6 g/kg was appropriate for inclusion in the specification for cypermethrin TC. The sponsor GC-FID method has been peer-validated by a second independent laboratory.

The Meeting noted that under the GHS criteria, permethrin is considered a relevant impurity when present at above 1 g/kg, with a maximum acceptable level of 10 g/kg and is a relevant impurity for cypermethrin based on the 5-batch analysis. The 5-batch analysis was conducted using a validated HPLC-UV method. The Meeting considered that a maximum limit of 6 g/kg was appropriate for inclusion in the specification for cypermethrin TC. The sponsor HPLC-UV method has been peer-validated by a second independent laboratory.

The Meeting considered m-phenoxyphenyl acetonitrile is a relevant impurity for cypermethrin TC with a maximum limit of 13 g/kg. The 5-batch analysis was conducted using a validated HPLC-UV method. The sponsor HPLC-UV method has been peer-validated by a second independent laboratory.

Hemani Industries supplied a full suite of physical-chemical test results for technical cypermethrin with all testing performed under GLP, including melting point, density, vapour pressure, solubility in water, methanol, and heptane, $\log_{10}K_{OW}$, hydrolysis, and aqueous photolysis, which were consistent with those reported for pure active ingredient in the 2008 JMPR periodic review evaluation of the residues of cypermethrin.

In studies provided by Hemani Industries, cypermethrin TC showed slight to moderate toxicity to rats by the oral route (LD50 500 mg/kg bw), no more than slight toxicity to rats by the dermal and inhalation routes (LD50 values of >2000 mg/kg bw and LC50 >5.3 mg/L), was not a skin or eye irritant in rabbits, and was not a skin sensitiser in guinea pigs by the Buehler test. It was non-mutagenic in an Ames test and an *in vivo*

mouse micronucleus assay. These results are consistent with the acute toxicity and mutagenicity data evaluated by the 2006 JMPR.

The proposer also provided a summary of publicly available toxicological data for cypermethrin, including sub-chronic, chronic and carcinogenicity, reproductive toxicity and teratogenicity, further information on mutagenicity and neurotoxicity.

The Meeting noted that the existing (1995) FAO specifications for cypermethrin TK, EC, WP and UL, were not supported by the proposer.

Supporting Information
for
EVALUATION REPORT 332/2024

Uses

Cypermethrin is a non-systemic pyrethroid insecticide, with contact and stomach action. It has many uses in agriculture, animal health, and public health pest control. It is registered in a number of countries, including Australia, New Zealand, the USA, Canada, the UK, and the EU.

Cypermethrin acts on the nervous system of insects, disturbing the function of neurons via interaction with the sodium channel.

Cypermethrin is used for control of a variety of insect pests (particularly Lepidoptera) in a range of crops, including cereals, pulse, oilseeds, cotton, and vegetables, and for control of pests of stored grains. It is also used in veterinary ectoparasiticide products, including for control of fleas in dogs, and for control of ticks and lice in sheep, cattle and goats. Finally, cypermethrin is used for pest control in households and commercial premises against a wide variety of pests (including some of public health concern), such as mosquitoes, houseflies, cockroaches, spiders, ants, and clothes moths.

Identity of the active ingredient

ISO common names

Cypermethrin (E-ISO), cyperméthrine (F-ISO)

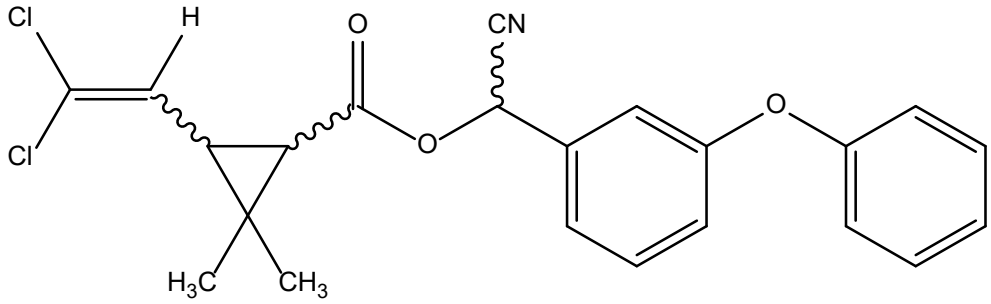
Chemical names

IUPAC:	(*RS*)-α-Cyano-3-phenoxybenzyl (1*RS*,3*RS*;1*RS*,3*SR*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate
CA:	Cyano(3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate

Synonyms:

None.

Structural formula



Molecular formula

$C_{22}H_{19}Cl_2NO_3$

Relative molecular mass

416.3

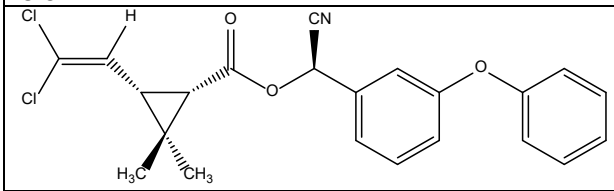
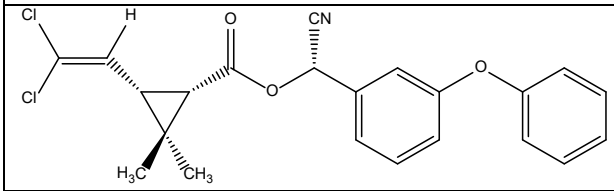
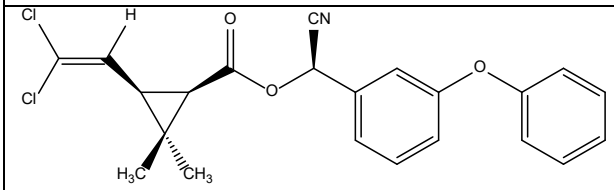
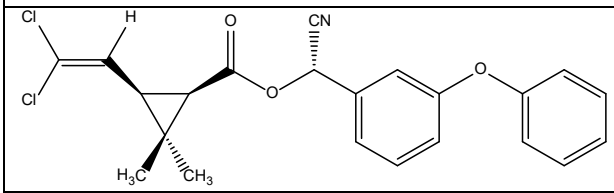
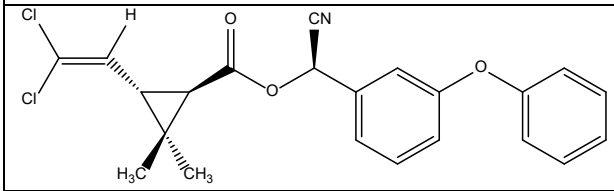
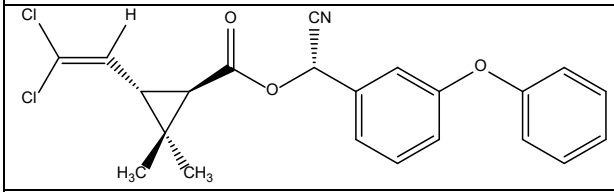
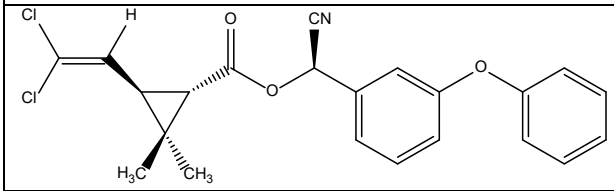
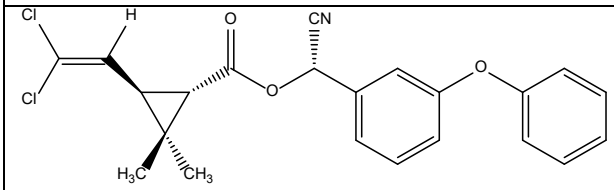
CAS registry number

52315-07-8 (see table below for CAS numbers for individual diastereomers)

CIPAC number

332

Cypermethrin contains three chiral centres, at the benzyl α-carbon, and at positions 1 and 3 of the cyclopropane ring. Hence it consists of eight individual isomers, comprising four pairs of diastereomers (present in approximately equal proportions). There are four *cis*-isomers, and four *trans*-isomers.

Structure	IUPAC name and CAS number
Cis-isomers	
	(*R*)-α-Cyano-3-phenoxybenzyl (1*R*,3*R*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate 65731-83-1
	(*S*)-α-Cyano-3-phenoxybenzyl (1*R*,3*R*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate 65731-84-2
	(*R*)-α-Cyano-3-phenoxybenzyl (1*S*,3*S*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate 72204-44-5
	(*S*)-α-Cyano-3-phenoxybenzyl (1*S*,3*S*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate 72204-43-4
Trans-isomers	
	(*R*)-α-Cyano-3-phenoxybenzyl (1*R*,3*S*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate 66841-24-5
	(*S*)-α-Cyano-3-phenoxybenzyl (1*R*,3*S*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate 65732-07-2
	(*R*)-α-Cyano-3-phenoxybenzyl (1*S*,3*R*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate 83860-32-6
	(*S*)-α-Cyano-3-phenoxybenzyl (1*S*,3*R*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate 83860-31-5

Identity tests

As described in CIPAC method MT 163, the identity of cypermethrin is established by comparison with an authentic reference standard, using at least two of HPLC (332/TC/M/3), infrared, ^{13}C-NMR, ^{1}H-NMR or MS.

Physico-chemical properties of cypermethrin

Table 1 Physico-chemical properties of Hemani Industries cypermethrin TC

Parameter	Value(s) and conditions	Purity (%)	Method	Reference
Appearance	Yellowish semi-liquid material with no characteristic odour at 20 °C	Technical active ingredient (HI), 94.13% purity*	US EPA OPPTS 830.6302, 830.6303, and 830.6304	JRF Study Number 201-2-11-5277
Boiling point	202-203 °C under atmospheric pressure (760 mm Hg)	Technical active ingredient (HI), 94.13% purity*	OECD No. 103/US EPA OPPTS 830.7220	JRF Study Number 203-2-11-5284
Specific gravity	1.2330 (20 °C)	Technical active ingredient (HI), 94.13% purity*	CIPAC MT 3.2.1/US EPA OPPTS 830.7300	JRF study number 236-2-11-5285
Vapour pressure	2.69×10^{-7} Pa (20 °C)	Technical active ingredient (HI), 94.13% purity*	EC method A.4/OECD No. 104/US EPA OPPTS 830.7950	JRF Study Number 207-2-11-5292
Solubility in water	pH 5 buffer: 0.0043 mg/L pH 7 buffer: 0.0042 mg/L pH 9 buffer: 0.0043 mg/L (20 °C)	Technical active ingredient (HI), 94.13% purity*	Column elution method after preliminary tests with shaken flask method - EC method A.6/OECD No. 105/US EPA OPPTS 830.7840	JRF Study number 205-2-11-5288
Solubility in organic solvents	Acetone: 200-250 g/L 1,2-Dichloroethane: 167-200 g/L Ethyl acetate: 200-250 g/L n-Heptane: 57-67 g/L Methanol: 200-250 g/L p-Xylene: 167-200 g/L (20 °C)	Technical active ingredient (HI), 94.13% purity*	CIPAC MT 181	JRF study number 206-2-11-5287
Octanol/water partition coefficient	$Log_{10}P_{OW} = 6.90$	Technical active ingredient	EC method A.8/OECD No. 117/US EPA	JRF Study number 209-2-11-5286

		(HI), 94.13% purity*	OPPTS 830.7570	
Dissociation characteristics	Does not dissociate (25 °C)	Technical active ingredient (HI), 94.13% purity*	OECD No. 112/US EPA OPPTS 830.7370	JRF study number 208-2-11-5291
Hydrolysis characteristics	pH 4 and pH 7: limited hydrolysis at 50 °C (5.9% and 8.7% after 5 days) pH 9: DT50 = 18.6 days (25 °C)	Technical active ingredient (HI), 94.13% purity*	EC Method C.7/OECD 111/US EPA OPPTS 835.2120	IIBAT study number 12487
Photolysis characteristics	DT50 = 9.9 days (25 ± 2 °C, pH 4 sterile buffer, natural sunlight – adjusted to an irradiance equivalent to 50°N winter sunlight)	Technical active ingredient (HI), 94.13% purity*	OECD 316/US EPA OPPTS 835.2210	IIBAT study number 12486

*Batch CM-129-A of the 2011 5-batch analysis.

Table 2: Literature values for physico-chemical properties of alpha-cypermethrin ((R)-α-1S-cis + (S)-α-1R-cis diastereomer), JMPR 2008 evaluation of alpha-cypermethrin

Property	Result
Appearance and odour	White to cream crystalline powder with a mild odour
Melting point (purity 99%)	80.5 °C
Density (purity 97.3%)	1.33 g/cm^3 (20 °C)
Vapour pressure (purity 97.3%)	1.9×10^{-5} Pa (51 °C) 3.4×10^{-7} Pa (25 °C)
Water solubility (98.8% purity, 20 °C)	Deionised water: 23.7 µg/L pH 4 buffer: 4.4 µg/L pH 7 buffer: 2.5 µg/L pH 9 buffer: 20 µg/L
Octanol/water partition coefficient (99% purity)	$\log_{10}K_{OW}$ = 5.2 (25 °C, shake flask method) $\log_{10}K_{OW}$ = 6.9 (22 °C, HPLC method)
Hydrolysis (99% purity, 22 °C – calculated from higher temperature measurements)	pH 5: 162 days pH 7: 46 days pH 9: 2.9 hours
Aqueous photolysis	Limited photolysis occurred after 32 days irradiation in sterile buffer solution
Dissociation constant	Does not dissociate

Table 3: Literature values for physico-chemical properties of cypermethrin trans-2 isomers ((R)-α-1S-trans + (S)-α-1R-trans diastereomer), Pesticide Manual 2016

Property	Result
Appearance	White crystalline powder
Melting point	81-87 °C
Density	1.33 g/cm^3
Vapour pressure (purity 97.3%)	1.8×10^{-7} Pa (20 °C)
Water solubility (25 °C)	pH 7 buffer: 114.6 µg/L
Solvent solubility (20 °C)	Isopropanol: 18 mg/L

	Diisopropyl ether: 55 mg/L Hexane: 8.5 mg/L
Hydrolysis (DT50)	pH 3-6: 50 days (extrapolated) pH 7: 20 days pH 8: 18 days pH 9: 10 days

No literature data was available for physico-chemical properties of the cis-1 ((*R*)-α-1*R-cis* + (*S*)-α-1*S-cis* diastereomer) or trans-1 ((*R*)-α-1*R-trans* + (*S*)-α-1*S-trans* diastereomer) pairs of isomers.

Table 4 Chemical composition and properties of technical Hemani Industries cypermethrin 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 990.6-995.9 g/kg.
Declared minimum content	930 g/kg
cis-isomer content (as a proportion of total cypermethrin)	400-600 g/kg
Relevant impurities ≥ 1 g/kg and maximum limits for them	Water, maximum 1 g/kg Hexane, maximum 6 g/kg Permethrin, maximum 6 g/kg m-phenoxylphenylacetonitrile, maximum 13 g/kg
Relevant impurities < 1 g/kg	None
Stabilisers or other additives	None

Formulations and co-formulated active ingredients

The present submission concerns only cypermethrin technical material (TC). Cypermethrin is commonly formulated as emulsifiable concentrates (EC), aerosols (AE – where cypermethrin is often co-formulated with other synthetic pyrethroids such as imiprothrin or tetramethrin, or with an insect growth regulator such as *S*-hydroprene), ultra-low volume liquids (UL), or suspension concentrates for seed treatment (FS – where cypermethrin is often co-formulated with a fungicide such as tradimenol or tebuconazole). In veterinary ectoparasiticide products, cypermethrin may be co-formulated with an insecticide synergist for use in control of fleas in dogs, used alone in pour-on formulations for control of lice in sheep, or co-formulated with chlorfenvinphos for in dip and spray treatments for cattle.

Methods of analysis and testing

Cypermethrin and its cis/trans isomer ratio were determined using the CIPAC HPLC-UV method (CIPAC 332/TC/M/3). The structurally related manufacturing impurities were determined using HPLC-UV methods. Permethric acid anhydride was determined using an LC-MS method. Hexane was determined using a GC-FID method. Permethrin and m-phenoxyphenylacetonitrile were determined using an HPLC-UV method. The methods for permethrin, hexane and m-phenoxyphenylacetonitrile have been peer validated. Water was determined using Karl Fischer titration (CIPAC MT 30.6), while acetone insoluble material and acidity were determined using CIPAC methods MT 31.1.1 and 27.

Expression of the active ingredient

The content of the active ingredient cypermethrin is expressed as cypermethrin.

Annex 1: Hazard Summary Provided by the Proposer

Notes

i. The proposer has confirmed that the toxicological and ecotoxicological data included in the summary below were derived from cypermethrin having impurity profiles similar to that referred to in the table above.
ii. The conclusions expressed in the summary below are those of the proposer, unless otherwise specified.

Table 5 Toxicological profile of cypermethrin technical material, based on acute toxicity, irritation and sensitisation

Species	Test and cypermethrin used	Purity and isomeric composition	Duration and conditions and guideline adopted	Result	Reference
Rat (Wistar, female)	Acute oral, HI technical cypermethrin	93.56%, cis isomer 50-55%*	Observation: 14 days Doses: 300 or 2000 mg/kg bw, OECD 423	No deaths at 300 mg/kg bw dose or in control group. All rats dosed with 2000 mg/kg bw died within 1 day. LD_{50} = 500 mg/kg bw	JRF study number 401-1-01-6680
Rat (Wistar, male and female)	Acute dermal, HI technical cypermethrin	93.56%, cis isomer 50-55%*	Observation: 14 days Dose: 2000 mg/kg bw, OECD 402	No deaths in treated or control group during study LD_{50} > 2000 mg/kg bw	JRF study number 403-1-01-6681
Rat (Wistar, male and female)	Acute inhalation, HI technical cypermethrin	93.56%, cis isomer 50-55%*	Observation: 14 days Dose: 5.311 mg/L air, OECD 403	No deaths in treated or control group during study LC_{50} > 5.311 mg/L air	JRF study number 405-1-01-6682
Rabbit (albino New Zealand White, male)	Acute dermal irritation, HI technical cypermethrin	93.56%, cis isomer 50-55%*	Observation: 72 hours Dose: 0.5 mL undiluted technical per animal. OECD 404	Not classified as a skin irritant	JRF study number 406-1-01-6683
Rabbit (albino New Zealand White, female)	Acute eye irritation, HI technical cypermethrin	93.56%, cis isomer 50-55%*	Observation: 72 hours Dose: 0.1 mL technical per eye. OECD 405	Not classified as an eye irritant	JRF study number 407-1-01-6684
Guinea pig (Hartley, male and female)	Skin sensitisation, HI technical cypermethrin	93.56%, cis isomer 50-55%*	Buehler method, OECD 406	Not considered as positive for skin sensitisation	JRF study number 408-1-01-6685

*Batch CM-44-A of the 2011 5-batch analysis.

Table 6 Mutagenicity profile of cypermethrin technical material based on in vitro and in vivo tests

Species	Test	Purity and isomeric composition	Conditions and doses	Result	Reference
Salmonella typhimurium strains TA1537, TA1535, TA98, TA100 and TA102	Ames test (*in vitro* mutagenicity test)	Hemani Industries technical, 93.56%, cis isomer 50-55%*	OECD 471, 51.2, 128, 156.25, 312.5, 320, 625, 800, 1250, 2000, 2500, 5000 µg/plate, ±S9	Not mutagenic	JRF study number 481-1-06-6686
Mouse (Swiss albino, male and female)	Micronucleus test (*in vivo* mutagenicity test)	Hemani Industries technical, 93.56%, cis isomer 50-55%*	OECD 474, 25, 50 and 75 mg/kg bw/day, administered orally on each of two consecutive days	Negative for induction of erythrocyte micronuclei in male and female mice at the doses tested	JRF study number 485-1-06-6687
E. coli WP2, *E. coli* WP2 uvrA, *Salmonella typhimurium* TA 1535, TA 1537, TA 1538, TA 98, and TA 100, *Saccharomyces cerevisiae* JD1	*In vitro* reversion mutation test, in presence or absence of a rat liver microsomal activation system	Technical, unstated origin/purity	Up to 2 mg/plate (*E. coli* and *Salmonella*), up to 5 mg/mL (*S. cerevisiae*)	Not mutagenic	Brooks, 1980
Salmonella typhimurium TA 98 or TA 100	*In vitro* reversion mutation test, in presence or absence of a rat liver microsomal activation system	Technical, unstated origin/purity	1 mg/plate	Not mutagenic	Pluymen et al, 1984
V79 Chinese hamster cells		Technical, unstated origin/purity	Up to 20 µg/mL	Not mutagenic	Pluymen et al, 1984
Mice (CD1, male)	Dominant lethal assay	Technical, unstated origin/purity	Single oral doses of 0, 6.25, 12.5 or 25 mg/kg bw. A second and third group received daily doses of 0, 2.5, or 5 mg/kg bw, and 0, 2.5, 5, 7.5, or 10 mg/kg bw respectively for 5 days.	No evidence of dominant lethality found in the single dose experiments. In the first repeat dose study, a significant reduction in fetal implants during the second week of mating, and a marginal increase in early fetal	Dean et al, 1977

				deaths at 5 mg/kg bw/day. This effect was not confirmed by the second repeat dose study, with no effects at any level. In summary, it was concluded that the effects in the first repeat dose group were not treatment related, and there was no evidence of dominant lethality	
Chinese hamsters (male and female)	Bone marrow chromosome assay	Technical, unstated origin/purity	Oral dose with 0, 20, or 40 mg/kg bw. Positive control group received 100 mg/kg bw cyclophosphamide	No difference in chromosomal abnormalities in bone marrow cells 8 and 24 hours after dosing between treated and control groups. Positive control animals showed many chromosomal aberrations.	Seehy et al, 1983
Mouse	Micronucleus test	Technical, unstated origin/purity	Multiple doses by intraperitoneal, oral, or dermal administration	Mutagenic potential was observed after oral administration at 900 mg/kg diet for 7 or 14 days. No effects after single ip injections of 60 or 180 mg/kg bw, or double and triple injections at 60 mg/kg bw. Up to 4	Amer and Aboul-Ela, 1985

				dermal treatments at 360 mg/kg bw gave a significant increase in the frequency of polychromatic erythrocytes with micronuclei.	

*Batch CM-44-A of the 2011 5-batch analysis.

Table 7: Sub-chronic toxicity for cypermethrin technical (literature summary)

Species	Test	Conditions and doses	Results	Reference
Rats (Charles River, male and female)	Oral, repeat dose	0, 25, 100, 250, 750 or 1500 mg/kg in feed (0, 1.25, 5, 12.5, 37.5, or 75 mg/kg bw) for 5 weeks	NOAEL = 750 mg/kg in feed (reduced weight gain and food intake, piloerection, nervousness, reduced coordination, increases in liver weight, blood urea and haemoglobin at 1500 mg/kg in feed)	Coombs, et al, 1976
Rats (Charles River, male and female)	Oral, repeat dose	0, 25, 100, 400 or 1600 mg/kg in feed (0, 1.25, 5, 20, or 80 mg/kg bw) for 3 months	NOAEL = 400 mg/kg. Males in the 400 mg/kg group showed increased kidney weights but no histopathological changes. In the 1600 mg/kg group, signs of intoxication were observed in the first 5 weeks and one animal died. Survivors recovered in the second half of the study but with reduced weight gain, increased organ weights, and histopathological signs. Two rats which were euthanased showed nerve damage.	Hend and Butterworth, 1977

Rats (male and female)	Oral, repeat dose	0, 75, 150 or 1500 mg/kg in feed for 90 days	NOAEL = 75 mg/kg. Reduced weight gain and food intake for both sexes at 1500 mg/kg. Increased liver microsomal oxidase activity for both sexes at 1500 mg/kg and for males at 150 mg/kg, although these changes were substantially reversed during the recovery period. Gross and microscopic examination of tissues did not reveal any significant differences between treated and control animals.	Glaister et al, 1977
Rabbit (New Zealand white, male and female)	Dermal, repeat dose	2, 20 or 200 mg/kg bw in polyethylene glycol for 6 hours per day, 5 days per week, for 3 weeks. Control animal received vehicle only.	Slight to moderate skin irritation observed for the 2 and 20 mg/kg bw groups, with slight to severe irritation observed for the 200 mg/kg bw group. Reductions in food intake, weight gain and gonad weight were observed at the 200 mg/kg bw dose but not at lower doses.	Henderson and Parkinson, 1981

Table 8: Chronic toxicity/carcinogenicity of cypermethrin technical (literature summary)

Species	Test	Conditions and doses	Results	Reference
Rat (Wistar, male and female)	Oral, chronic	0, 1, 10, 100, or 1000 mg/kg in diet for 6, 12, 18 or 24 months	NOAEL 100 mg/kg in diet. Significantly reduced growth rate for both sexes at 1000 mg/kg. No clinical, chemical, histopathlogical or haematological	McAusland et al, 1978

			signs observed, some nerve damage observed in sacrificed animals, but no significant differences between treated and control groups. There was no evidence of carcinogenicity.	
Rat (male and female)	Oral, chronic	0 or 1000 mg/kg in diet for 24 months	Weak induction of the enzyme hepatic microsomal p-nitroanisole O-demethylase observed in treated animals.	Potter and McAusland, 1980
Rat (Wistar, male and female)	Oral, chronic	0, 20, 150, or 1500 mg/kg in diet (equivalent to 0, 1, 7.5, or 75 mg/kg bw for 24 months. 88-93% purity technical, cis/trans ratio of 55:45.	NOAEL = 150 mg/kg in diet (7.5 mg/kg bw). Weight loss, increased liver weight, and some haematological and other clinical changes observed for the 1500 mg/kg dose after 2 years. There was no increase in tumours in the treated animals compared to the control animals.	US EPA 1984
Mouse (Swiss, male and female)	Oral, chronic	0, 100, 400, or 1600 mg/kg in feed (equivalent to 0, 15, 60 or 240 mg/kg bw) for up to 2 years. 91.5-94.2% purity technical, cis/trans ratio of 53:47 or 54:46.	NOAEL = 400 mg/kg in diet (60 mg/kg bw). At 1600 mg/kg in diet, reduced weight gain was observed, along with haematological signs and increased liver weight. No histopathological signs were observed. Incidence of tumours was similar for all groups, apart from a slight increase in benign alveolar lung tumours in females at the	Lindsay et al, 1982

			highest dose. There was no evidence for an increase in malignancy, or an increased response in males. Benign alveolar lung tumours are known to occur at high and variable levels for this strain, and the effect was therefore not considered treatment related. Therefore, the study showed no evidence of carcinogenicity.	
Dog (beagle, male and female)	Oral, chronic	0, 1, 5, or 15 mg/kg bw for 52 weeks. 90.6% purity, cis/trans ratio of 54:46.	NOAEL = 1 mg/kg bw. Liquid stools observed in some of the 5 mg/kg bw animals. In 15 mg/kg animals, loss of appetite, tremors, gait changes, loss of coordination, disorientation, and hypersensitivity were observed, although there were no changes in blood or urine composition or organ weights.	US EPA, 1984
Dog (beagle, male and female)	Oral, chronic	0, 3, 30, 300, or 600* mg/kg in diet for 2 years. 90.6% purity technical, cis/trans ratio 54:46. *Reduced from 1000, to 750, and then to 600 mg/kg by week 8 after severe intoxication was observed at the higher doses.	NOAEL = 300 mg/kg in diet. Reduced weight gain was observed in male dogs at 600 mg/kg, although there were no consistent differences in clinical chemistry or haematology between control and treated animals.	Buckwell, 1981

Table 9: Reproductive toxicity/teratogenicity of cypermethrin technical (literature summary)

Species	Test	Conditions and doses	Results	Reference
Rat (Wistar, male and female)	Multi-generation reproduction study	0, 10, 100 or 500 mg/kg in diet for 5 weeks, followed by mating randomly males and females until two litters had been produced from each of 3 successive generations.	NOAEL = 100 mg/kg in diet. F_0 animals in the 500 mg/kg showed reduced food intake and body weight. There was no adverse effect on reproductive performance or offspring survival, although there was a reduction in total litter weights in 500 mg/kg F_{1a} litters on days 4, 14, and 21, and a statistically significant decrease in litter weights and litter sizes in the F_{1b} litters for the 500 mg/kg group.	Hend et al, 1978
Rat (Sprague Dawley, pregnant females)	Teratogenicity	0, 17.5, 35, or 70 mg/kg bw/day from gestation days 6 to 15.	NOAEL = 17.5 mg/kg bw/day. At 35 and 70 mg/kg bw/day, maternal weight gain was respecitvely slightly and significantly retarded. At 70 mg/kg bw/day, slight to severe neurological disturbances were observed in nearly half of the females. There were no indications of embryotoxicity or teratogenicity at any of the dose levels.	Tesh et al, 1978
Rabbit (Banded Dutch, pregnant females)	Teratogenicity	0, 3, 10, or 30 mg/kg bw/day from gestations days 6-18.	There was no influence on growth, pre-implantation losses, resorptions, fetal deaths, or	Dix, 1978

			numbers and sizes of fetuses. Incidence of fetal visceral and skeletal abnormalities was comparable to the control group, other than a slight increase in abnormalities in the 30 mg/kg bw/day group. No teratogenic effects observed.	

Table 10: Neurotoxicity of cypermethrin technical (literature summary)

Species	Test	Conditions and doses	Results	Reference
Rat	Neurotoxicity, preliminary short-term study	'High' oral doses Lethal or near lethal dermal or oral doses	High oral doses caused unusual gait. Lethal or near lethal oral or dermal doses resulted in positive histopathological evidence of neurotoxicity.	Okuno et al, 1976a and Okuno et al, 1976b

Table 11 Ecotoxicology of cypermethrin technical (aquatic organisms)

Species	Exposure duration	Toxicity reference value (µg ai/L)	Effects
Rainbow trout	96 hours	LC50 = 0.39 µg ai/L	Morbidity
Amphipod	48 hours	LC50 = 0.0036 µg ai/L	Morbidity
Amphipod	10 days	LC50 = 3.6 µg ai/kg (sediment) LC50 = 0.00257 µg ai/L (sediment pore water concentration)	Morbidity and growth
Sheepshead minnow	96 hours	LC50 = 0.95 µg ai/L	Morbidity
Mysid shrimp	96 hours	LC50 = 0.00475 µg ai/L	Morbidity

Annex 2: References

Study number	Author	Year	Title of report and other publication details
JRF Study Number 201-2-11-5277	A.H. Patel, Jai Research Foundation	2012	Appearance (Colour, Physical State and Odour) of Cypermethrin Technical, GLP compliant
JRF Study Number 203-2-11-5284	Taher G. Suratwala, Jai Research Foundation	2012	Boiling Point/Boiling Range of Cypermethrin Technical, GLP compliant
JRF Study Number 207-2-11-5292	Yusuf Vohra, Jai Research Foundation	2013	Vapour Pressure of Cypermethrin Technical, GLP compliant
JRF Study number 205-2-11-5288	Yusuf Vohra, Jai Research Foundation	2013	Water Solubility of Cypermethrin Technical, GLP compliant
JRF study number 206-2-11-5287	Hetal K. Desai, Jai Research Foundation	2013	Solubility of Cypermethrin Technical in Organic Solvents, GLP compliant
JRF Study number 209-2-11-5286	Hetal K. Desai, Jai Research Foundation	2013	Partition Coefficient of Cypermethrin Technical by HPLC Method, GLP compliant
JRF study number 208-2-11-5291	Taher G. Suratwala, Jai Research Foundation	2013	Dissociation Constant of Cypermethrin Technical, GLP compliant
JRF study number 236-2-11-5285	A.H. Patel, Jai Research Foundation	2012	Specific Gravity of Cypermethrin Technical, GLP compliant
IIBAT study number 12487	U.V.S. Pakki, International Institute of Biotechnology and Toxicology	2013	Cypermethrin Technical: Laboratory Study of Hydrolysis in Buffer Solutions of pH 4, 7, and 9, GLP compliant
IIBAT study number 12486	U.V.S. Pakki, International Institute of Biotechnology and Toxicology	2013	Cypermethrin Technical: Laboratory Study of Photolysis, GLP compliant
JRF study number 227-2-12-3771	Manishi Agarwal, Jai Research Foundation	2012 (amended 2014)	Preliminary Analyses of Five Representative Production Batches of Cypermethrin Technical Grade Active Ingredient (TGAI) to Determine % Cypermethrin and to Quantify its Associated Impurities, GLP compliant
JRF study number 401-1-01-6680	Lokendra Singh Kushwah, Jai Research Foundation	2013 (amended 2015)	Acute Oral Toxicity Study of Cypermethrin Technical in Rats, GLP compliant
JRF study number 403-1-01-6681	Lokendra Singh Kushwah, Jai Research Foundation	2013 (amended 2015)	Acute Dermal Toxicity Study of Cypermethrin Technical in Rats, GLP compliant
JRF study number 405-1-01-6682	Neelam Patel, Jai Research Foundation	2013 (amended 2015)	Acute Inhalation Toxicity Study of Cypermethrin

			Technical in Rats, GLP compliant
JRF study number 406-1-01-6683	Trupti Desai, Jai Research Foundation	2013 (amended 2015)	Acute Dermal Irritation Study of Cypermethrin Technical in Rabbits, GLP compliant
JRF study number 407-1-01-6684	Trupti Desai, Jai Research Foundation	2013 (amended 2015)	Acute Eye Irritation Study of Cypermethrin Technical in Rabbits, GLP compliant
JRF study number 408-1-01-6685	Trupti Desai, Jai Research Foundation	2013 (amended 2015)	Skin Sensitisation Study of Cypermethrin Technical in Guinea Pigs, GLP compliant
JRF study number 481-1-06-6686	Kapil R. Nikam, Jai Research Foundation	2013 (amended 2015)	Bacterial Reverse Mutation Test of Cypermethrin Technical Using *Salmonella typhimurium*, GLP compliant.
JRF study number 485-1-06-6687	Kapil R. Nikam, Jai Research Foundation	2013 (amended 2015)	Micronucleus Test of Cypermethrin Technical in Mice, GLP compliant.
JMPR 2006 Toxicological Evaluation of Cypermethrins (including cypermethrin, alpha-cypermethrin and zeta-cypermethrin)	Mueller, U., Lenton, L., and Ray, D.	2006	Cypermethrin (including alpha- and zeta-cypermethrin), Joint Meeting on Pesticide Residues, WHO/FAO, 2006
JMPR 2008 Residues of Evaluation of Cypermethrin	Hamilton, D.J.	2008	Cypermethrin, Joint Meeting on Pesticide Residues, WHO/FAO, 2008
Eurofins Advinus study number G21033	Raju P., A., Eurofins Advinus Ltd	2021	Five Batch Analysis of Cypermethrin Technical, GLP compliant
Eurofins Advinus study number G24223	Shetty, S.B., Eurofins Advinus Ltd	2022	Analysis of Cypermethrin Technical, GLP compliant
KRF study number 22134	Bhandari, N.M., Konark Research Foundation (a division of Saga Research Lab Pvt Ltd)	2022 (amended 2024)	Method Validation for Estimating Permethrin and n-Hexane in Cypermethrin Technical and Analysis of A.I. and Impurities in Cypermethrin Technical, GLP Compliant
KRF study number 23050	Bhandari, N.M., Konark Research Foundation (a division of Saga Research Lab Pvt Ltd)	2024	Method Validation for Estimating 2-(3-phenoxyphenyl)acetonitrile as Impurity in Cypermethrin Technical and Analysis of A.I. and Impurity in Cypermethrin Technical

Appendix 1: Peer-Validated Method for Analysis of the Relevant Impurity N-Hexane in Cypermethrin TC (Proposed By Hemani Industries Ltd)

Principle of the method

The content of n-hexane in cypermethrin TC is determined using by GC-FID with headspace injection.

Preparation of standard solutions

Approximately 0.5 g of n-hexane reference standard is weighed into a 50 mL volumetric flask containing a portion of the N-methyl-2-pyrrolidone diluent and then made up to volume with the diluent, giving a stock solution with an approximate concentration of 10 mg/mL. A 1.75 mL aliquot of the standard stock solution is transferred to a 50 mL volumetric flask and made up to volume with N-methyl-2-pyrrolidone to give the working standard solution (approximate concentration of 0.35 mg/mL).

Preparation of sample solutions

Approximately 0.1 g of cypermethrin TC is weighed in triplicate into separate headspace vials and 1.0 mL of N-methyl-2-pyrrolidone diluent is added. The vials are sealed with rubber septa and aluminium caps using a crimper.

Instrumental method details

Instrument	Gas chromatograph equipped with a headspace sampling system, flame ionisation detector and a PC based data system
Column	DB-624 (30 m × 0.32 mm with 1.8 µm film thickness) or equivalent
Split ratio	14:1
Temperatures	
Detector	250 □C
Column oven	Initial: 50 □C, hold for 5 minutes Ramp 1: 10 □C/min, to 150 □C, hold for 0 minutes Ramp 2: 30 □C/min, to 240 □C, hold for 5 minutes
Gas flow rates	
Nitrogen (carrier)	2.0 mL/minute
Hydrogen	40 mL/minute
Air	300 mL/minute
Nitrogen (make up)	25 mL/minute
Headspace sampler parameters	
Sample temperature	95 □C
Sample line temperature	105 □C
Transfer line temperature	115 □C
Sample equilibration time	10 minutes
GC cycle time	30 minutes
Loop fill/load time	30 seconds
Injection time	30 seconds
Pressurisation time	30 seconds

All parameters are kept constant throughout the analysis. After every 3-9 sample injections, an injection of the impurity working standard solution is made. The peak area is recorded for each injection. The standard solution peak areas (for standard injections bracketing the sample injections) are averaged and used in calculations of

the impurity content. The expected elution time of n-hexane under these conditions is around 3.5-4 minutes.

n-Hexane content in the cypermethrin TC samples is calculated using the following equation:

$$n-hexane\ content\ (g/kg) = \frac{A_{sample}}{A_{standard}(average)} \times C_{standard} \times \frac{V_{sample}}{W_{sample}} \times \frac{P_{standard}}{100}$$

Where A_{sample} = sample peak area; $A_{standard}$ = standard peak area; $C_{standard}$ = standard solution concentration (mg/mL); V_{sample} = sample solution volume (mL); W_{sample} = sample weight (grams); $P_{standard}$ = purity of reference standard (%)

Appendix 2: Peer-Validated Method for Analysis of the Relevant Impurities Permethrin and M-Phenoxyphenylacetonitrile in Cypermethrin TC (Proposed by Hemani Industries Ltd)

Principle of the method

The content of permethrin and m-phenoxyphenylacetonitrile in cypermethrin TC is determined by HPLC-UV.

Preparation of standard solutions

Approximately 10 mg of permethrin or m-phenoxyphenylacetonitrile reference standard are weighed into separate 10 mL volumetric flasks and dissolved in a portion of acetonitrile with shaking. After equilibration to room temperature, the flasks are made up to volume with acetonitrile to give an approximately 1 mg/mL standard stock solution. An approximately 100 µg/mL intermediate standard solution is made up by diluting a 1 mL aliquot of the 1 mg/mL stock solution in a portion of acetonitrile in a 10 mL volumetric flask, equilibrating to room temperature and then making up to volume with acetonitrile. Working standard solutions with appropriate concentration are then prepared for use in TC analyses using acetonitrile as diluent and appropriate size volumetric flasks. In the method details provided, the working standard solution concentrations were approximately 8 or 4 µg/mL for m-phenoxyphenyl acetonitrile and permethrin respectively. Appropriate adjustments can be made to working standard concentrations depending on the concentrations expected in the TC.

Preparation of sample solutions

Approximately 25 mg of cypermethrin TC is weighed in triplicate into separate 25 mL volumetric flasks, dissolved and made up to volume with acetonitrile.

Instrumental method details

<table>
<tr><td>Instrument</td><td>High performance liquid chromatograph equipped with a variable wavelength detector or a diode array detector, an autosampler and PC-based data collection</td></tr>
<tr><td>Column</td><td>Shim-Pak C18 (250 mm × 4.6 mm, 5 µm particle size) or similar</td></tr>
<tr><td>Mobile phase A</td><td>0.1% ortho-phosphoric acid in milli-Q water</td></tr>
<tr><td>Mobile phase B</td><td>Acetonitrile</td></tr>
<tr><td>Solvent gradient</td><td>
<table>
<tr><th>Time (min)</th><th>%A</th><th>%B</th></tr>
<tr><td>0.00</td><td>45</td><td>55</td></tr>
<tr><td>6.00</td><td>30</td><td>70</td></tr>
<tr><td>15.00</td><td>10</td><td>90</td></tr>
<tr><td>20.00</td><td>5</td><td>95</td></tr>
<tr><td>25.00</td><td>5</td><td>95</td></tr>
<tr><td>25.01</td><td>45</td><td>55</td></tr>
<tr><td>32.00</td><td>45</td><td>55</td></tr>
</table>
</td></tr>
<tr><td>Flow rate</td><td>1.0 mL/minute</td></tr>
<tr><td>Detector wavelength</td><td>230 nm</td></tr>
<tr><td>Injection volume</td><td>10.0 µL</td></tr>
<tr><td>Column temperature</td><td>30 □C</td></tr>
</table>

All parameters are kept constant throughout the analysis. After every 3-9 sample injections, an injection of the impurity working standard solution is made. The peak area is recorded for each injection. The standard solution peak areas (for standard

injections bracketing the sample injections) are averaged and used in calculations of the impurity content. The expected elution time of m-phenoxyphenylacetonitrile under these conditions is approximately 10 minutes, while permethrin elutes as two peaks (cis and trans isomers) between 20 and 22 minutes.

Permethrin and m-phenoxyphenylacetonitrile contents in the cypermethrin TC samples are calculated using the following equation:

$$content\ (g/kg) = \frac{A_{sample}}{A_{standard}(average)} \times C_{standard} \times \frac{V_{sample}}{W_{sample}} \times \frac{P_{standard}}{100}$$

Where A_{sample} = sample peak area; $A_{standard}$ = standard peak area; $C_{standard}$ = standard solution concentration (mg/mL); V_{sample} = sample solution volume (mL); W_{sample} = sample weight (grams); $P_{standard}$ = purity of reference standard (%)