

WHO SPECIFICATIONS AND EVALUATIONS FOR PUBLIC HEALTH PESTICIDES

ALPHA-CYPERMETHRIN + CHLORFENAPYR

LONG-LASTING (COATED ONTO FILAMENTS) INSECTICIDAL NET

A racemic mixture of:

(*S*)- α -cyano-3-phenoxybenzyl-(1*R*,3*R*)-3-(2,2-dichlorovinyl)-
2,2-dimethylcyclopropane-carboxylate and
(*R*)- α -cyano-3-phenoxybenzyl-(1*S*,3*S*)-3-(2,2-dichlorovinyl)-
2,2-dimethylcyclopropane-carboxylate

+

4-bromo-2-(4-chlorophenyl)-1-ethoxymethyl-5-
trifluoromethyl-1*H*-pyrrole-3-carbonitrile



**World Health
Organization**

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Disclaimer¹

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* 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. 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.

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.

* Footnote: The publications are available on the Internet under under the WHO Prequalification Team - Vector control products (PQT-VC) website.

PART ONE
SPECIFICATIONS

ALPHA-CYPERMETHRIN + CHLORFENAPYR

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WHO SPECIFICATIONS FOR PUBLIC HEALTH PESTICIDES

ALPHA-CYPERMETHRIN

INFORMATION

Common name

alpha-cypermethrin (E-ISO, BSI), alpha-cyperméthrine (F-ISO)

Synonyms

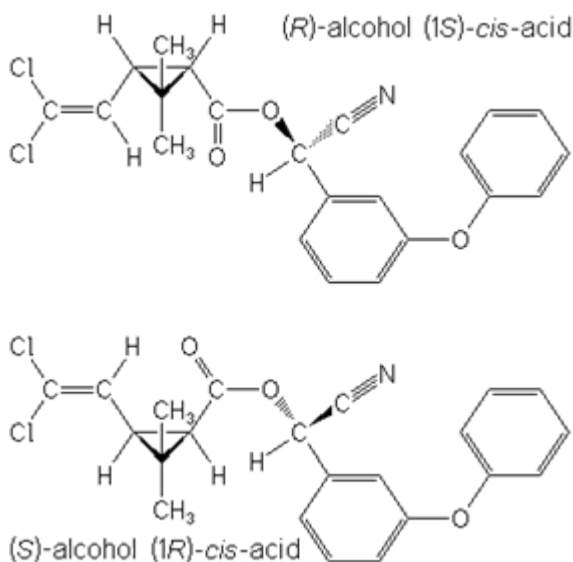
alphamethrin (rejected common name), alfoxylate

Chemical names

IUPAC a racemic mixture of: (*S*)- α -cyano-3-phenoxybenzyl-(1*R*,3*R*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate and (*R*)- α -cyano-3-phenoxybenzyl-(1*S*,3*S*)-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate

CA: [1 α (*S**),3 α]-(\pm)-cyano(3-phenoxyphenyl)methyl 3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate

Structural formula



Empirical formula

$C_{22}H_{19}Cl_2NO_3$

Relative molecular mass

416.3

CAS Registry number

67375-30-8

CIPAC number

454

Identity tests

GC retention time, IR spectrum.

SPECIFICATIONS FOR PUBLIC HEALTH PESTICIDES

CHLORFENAPYR

INFORMATION

ISO common name

chlorfenapyr (BSI, E-ISO, ANSI); chlorfénapyr ((m) F-ISO)

Synonyms

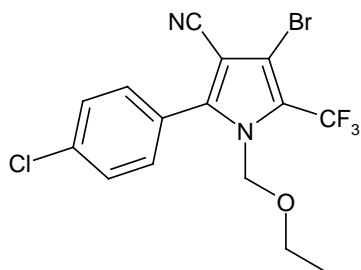
none

Chemical names

IUPAC 4-bromo-2-(4-chlorophenyl)-1-ethoxymethyl-5-trifluoromethyl-1*H*-pyrrole-3-carbonitrile

CA 4-bromo-2-(4-chlorophenyl)-1-(ethoxymethyl)-5-(trifluoromethyl)-1*H*-pyrrole-3-carbonitrile

Structural formula



Empirical formula

$C_{15}H_{11}BrClF_3N_2O$

Relative molecular mass

407.6

CAS Registry number

122453-73-0

CIPAC number

570

Identity tests

HPLC retention time, IR spectrum

WHO SPECIFICATIONS FOR PUBLIC HEALTH PESTICIDES

ALPHA-CYPERMETHRIN + CHLORFENAPYR LONG-LASTING (COATED ONTO FILAMENTS) INSECTICIDAL NET

WHO specification 454+570/LN (July 2019)

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 (454+570/2019). It should be applicable to relevant products of 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 the products of other manufacturers, irrespective of the source of TC. The evaluation report (454+570/2019), given in PART TWO, forms an integral part of this publication.

1 Description

The product shall be in the form of netting (Note 1), consisting of 75 or 100 denier (Note 2) multi-filament (minimum 32 filaments) polyester fibres, treated with formulated alpha-cypermethrin complying with the requirements of WHO specification 454/SC (February 2015) and formulated chlorfenapyr complying with the requirements of WHO specification 570/SC (December 2017), and a polymeric binder, together with any necessary stabilizers, plasticizers and other formulants. The product shall appear clean and shall be free from visible extraneous matter (Note 3), visible damage (such as splitting or tearing) and visible manufacturing defects (such as poorly made seams or a weave that is either not uniform or too loose to remain uniform in use), and shall be suitable for use as an insecticidal net with long-lasting activity (Note 4).

2 Active ingredients

- 2.1 **Identity tests** (CIPAC/5220/m for alpha-cypermethrin and chlorfenapyr and 454/LN/M/2, CIPAC Handbook M, p. 40, 2009 for alpha-cypermethrin) (Note 5)

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

2.2 Alpha-cypermethrin content (CIPAC/5220/m and 454/LN/M/3.1, CIPAC Handbook M, p. 40, 2009) (Notes 5, 6 & 7)

The alpha-cypermethrin content shall be declared (3.2 g/kg for 75 denier yarn, 2.4 g/kg for 100 denier yarn) and, when determined, the average measured content shall not differ from that declared by more than $\pm 25\%$.

2.3 Chlorfenapyr content (CIPAC/5220/m) (Notes 5, 6 & 7).

The chlorfenapyr content shall be declared (6.4 g/kg for 75 denier yarn, 4.8 g/kg for 100 denier yarn) and, when determined, the average measured content shall not differ from that declared by more than $\pm 25\%$.

2.4 Alpha-cypermethrin wash resistance index (MT 195, CIPAC Handbook O, p. 205, 2017) (Note 8)

The wash resistance index of alpha-cypermethrin from the netting, when determined, shall be within the range 90% to 101%.

2.5 Chlorfenapyr wash resistance index (MT 195, CIPAC Handbook O, p. 205, 2017) (Note 8)

The wash resistance index of chlorfenapyr from the netting, when determined, shall be within the range 85% to 99%.

3 Physical properties (Notes 7 & 14)

3.1 Fabric weight (mass per m²) (ISO 3801 / EN 12127)

The mass per unit area shall be declared (30 g/m² for 75 denier yarn, 40 g/m² for 100 denier yarn), and when determined, shall not differ from that declared by more than $\pm 10\%$.

3.2 Netting mesh size

When counted by the method given in Note 9, the average number of complete holes/cm² shall be not less than 24 holes/cm² and the lowest value shall be not less than 24 holes/cm².

3.3 Dimensional stability of netting to washing (Note 10)

Not more than 5% shrinkage/expansion in both directions.

3.4 Bursting strength (ISO 13938:2) (Note 11)

The minimum bursting strength of the fabric shall be declared (not less than 250 kPa for 75 denier yarn, not less than 405 kPa for 100 denier yarn) and, when determined, the average shall be not less than that declared.

If seams are present, their average bursting strength shall be not less than the measured average for the fabric.

3.5 Flammability (EN 1102) (Note 12)

Tested according to EN 1102 the following requirements should be achieved*:

After removing the ignition source the following fire phenomena should not occur:

- ignition
- propagation of the flame or glow.
- flaming debris

- ignition of the filter paper

*Fulfilling the requirements above means that the flame speed rate is 0 mm/s, i.e., no flame or glow achieves first and third marker threads.

Formation of holes is allowed provided that the burnt or melted width and length of the holes does not exceed 50 mm and length is 150 mm, respectively.

4 Storage stability

4.1 Stability at elevated temperature (MT 46.3.4, CIPAC Handbook O, p. 176, 2017)

After storage at $54 \pm 2^\circ\text{C}$ for 14 days, the determined average active ingredients content (measured individually) shall not be lower than 90%, relative to the determined average content found before storage (Note 13) and the product shall continue to comply with the clauses for:

- wash resistance index (2.4 and 2.5),
- dimensional stability to washing (3.3),
- bursting strength (3.4).

Note 1 The specification applies to bulk netting, nets for hammocks and rectangular or conical nets. The netting may be white or colored, for example, green or blue.

Note 2 The linear density (denier) of the fibres cannot be measured in the manufactured net, but should be identified on the packaging.

Note 3 Occasional short lengths of loose thread present in the netting are not considered to be extraneous matter.

Note 4 Long-lasting insecticidal netting is expected to retain its insecticidal activity during its life span and through a specified number of washes (public health products).

Note 5 The capillary GC method using internal standard (CIPAC/5220/m) for the determination of alpha-cypermethrin and chlorfenapyr in coated onto polyester LN was accepted as a provisional CIPAC method in 2019, but the method is not yet published in a Handbook. Prior to publication of the Handbook, copies of the method may be obtained through the CIPAC website, <https://www.cipac.org/index.php/methods-publications/pre-published-methods>

Note 6 The target alpha-cypermethrin content of 3.2 and 2.4 g/kg for the 75 and 100 denier yarn netting or net, respectively, corresponds to 100 mg/m² in both cases. The target chlorfenapyr content of 6.4 and 4.8 g/kg for the 75 and 100 denier yarn netting or net, respectively, corresponds to 200 mg/m² in both cases. These values can be calculated from values for active ingredients content in g/kg and mass of net/m². Mass of net/m² should be determined according to ISO 3801 / EN 12127. In cases of dispute, g/kg values shall be used.

Note 7 Samples should be taken according to Figure 1 or on a convenient diagonal across the width of bulk material. Samples must be sufficiently large to conduct all tests required and representative of the net or netting. Except where seams are to be tested, do not test material within 10 cm of seams or selvages.

Use sharp scissors, or equivalent, to minimize damage to the fibres and fabric and thus avoid any consequential bias in the results of certain tests. Roll up the strips or squares and place them in labelled, new, clean aluminium foil prior to analysis. Samples should be kept cool, avoiding heat sources (including direct sunlight) or freezing, and analyzed/tested with minimum delay. Representative portions (sub-samples) for testing should be taken as described in each test method.

Note 8 The content of alpha-cypermethrin and chlorfenapyr in the net pieces before and after washing should be determined by the method CIPAC/5220/m.

Wash resistance index values higher than 100% up to 101% are acceptable due to the uncertainty of measurement of the CIPAC method MT 195.

Note 9 In the absence of a simple or standard method to determine the size of holes, which may have complex shapes, in highly flexible fabrics, mesh size is determined by counting the number of holes in a square of the fabric. Counting may be done directly on the fabric or indirectly by taking a picture/photocopy of the fabric. Indirect methods may ease counting and provide a permanent record. The number of holes per measured area is converted in holes/cm². Before counting, the fabric should be conditioned according to ISO 139 (4 h, 20°C, 65% relative humidity).

Use a template to define the square of netting, taking care not to stretch or distort the fabric. The template should be a 1-2 mm thick rigid sheet, in/on which an accurately calibrated ($\pm 1\%$ in each dimension) square (e.g. 1 x 1 in or 5 x 5 cm) has been cut/marked. If a template is not available and a ruler must be used, great care is required to ensure that the area counted is square. Where practicable, one edge of the square to be counted should be aligned with a row of complete holes in the fabric. Incomplete holes $\geq \frac{1}{2}$ are counted as complete holes, whereas those $< \frac{1}{2}$ are not counted. Count 5 replicate squares selected according to Note 6, calculate the average and note the lowest value.

Another suitable method is the use of a stereomicroscope with an image analyser software, where the number of holes in a defined area is counted. In case of discrepancy between the netting mesh size using stereomicroscopic method and direct or indirect counting method, the stereomicroscopic method shall be the referee method.

Note 10 Method of preparation, marking and measuring: ISO 3759. Method of washing: ISO 6330. Method of calculation: ISO 5077. Size of test portions: 500 mm x 500 mm; mark off 350 mm x 350 mm within each test portion. Test a total of 4 replicate portions, 2 washed in each of 2 separate loads. Type of washing machine: ISO type A (front loading). Washing programme: 30°C Mild programme. Fill the washer with fabrics and ballast Type III (polyester ballast) up to 2 kg (according to the ISO 6330 standard). Drying: flat drying.

Note 11 Test method: ISO 13938 part 2 with conditioning of the fabric as specified in the ISO standard. The declared bursting strength, and testing for compliance with it, should be based on tests of 7.3 cm² areas of fabric. Proposed specifications based on tests of 50 cm² area must be supported by data showing the suitability of the proposed value and its relationship to minimum of 250 kPa (which is based on 7.3 cm² area). Five replicate tests should be conducted on samples taken at approximately equal distances on a diagonal across the netting, taking no sample within 10 cm of a border or seam. In made up rectangular nets, the "diagonal" may correspond to figure 1. The average of the 5 measurements is calculated.

The method to test seam bursting strength is identical to that used to test the fabric, except that 5 replicate tests should be made, with the seam centred on the test head. Up to 5 seams may be tested but, if there are < 5 seams, replicate measurements should be made on 1 or more seams, to provide a total of 5 measurements.

Note 12 Flammability test according to EN 1102, using the surface ignition method (position the burner perpendicular to the surface of the specimen).

The following observations shall be reported: the afterflame time, the afterglow time, the maximum burnt or damage width and length, whether or not flame reaches vertical edge of the specimen, whether or not a hole is burnt or melted in the sample, whether or not any flaming debris falls below the bottom edge of the sample and ignition of the filter paper.

Definitions according to ISO 4880:1997 (not included in EN 1102:2016 and EN ISO 6941:1995):

- Ignition: initiation of combustion.
- Combustion: exothermic reaction of a combustible substance with an oxidizer, accompanied by flames and/or glowing and/or emission of smoke.

Procedure for measuring burnt or damage width and length dimensions of each sample:

Remove the sample from the sample holder and place it on a flat horizontal surface. Place a rule on top of the test sample along the line of maximum damage and parallel with the length side of the test specimen. Measure the maximum length in millimetres from the lowest point of burnt or damage to the end of the hole. To measure the burnt or damage width, proceed in the same way but with the ruler parallel to the width side of the test sample. Proceed in the same way for the other 5 samples.

Note 13 Samples of the product taken before and after the storage stability test should be analyzed concurrently after the test in order to reduce the analytical error.

Note 14 Normative references for physical tests:

Currently the following standards are the latest versions of the documents to be used for physical tests. The updated version of the standard should always be used when available.

ISO 139:2005/Amd.1:2011 Textiles - Standard atmospheres for conditioning and testing.-
Textiles - Standard atmospheres for conditioning and testing.

ISO 3801:1977 - Textiles - Woven fabrics - Determination of mass per unit length and mass per unit area.

EN 12127:1997 - Textiles - Fabrics - Determination of mass per unit area using small samples.

ISO 3759:2011 - Textiles - Preparation, marking and measuring of fabric specimens and garments in tests for determination of dimensional change.

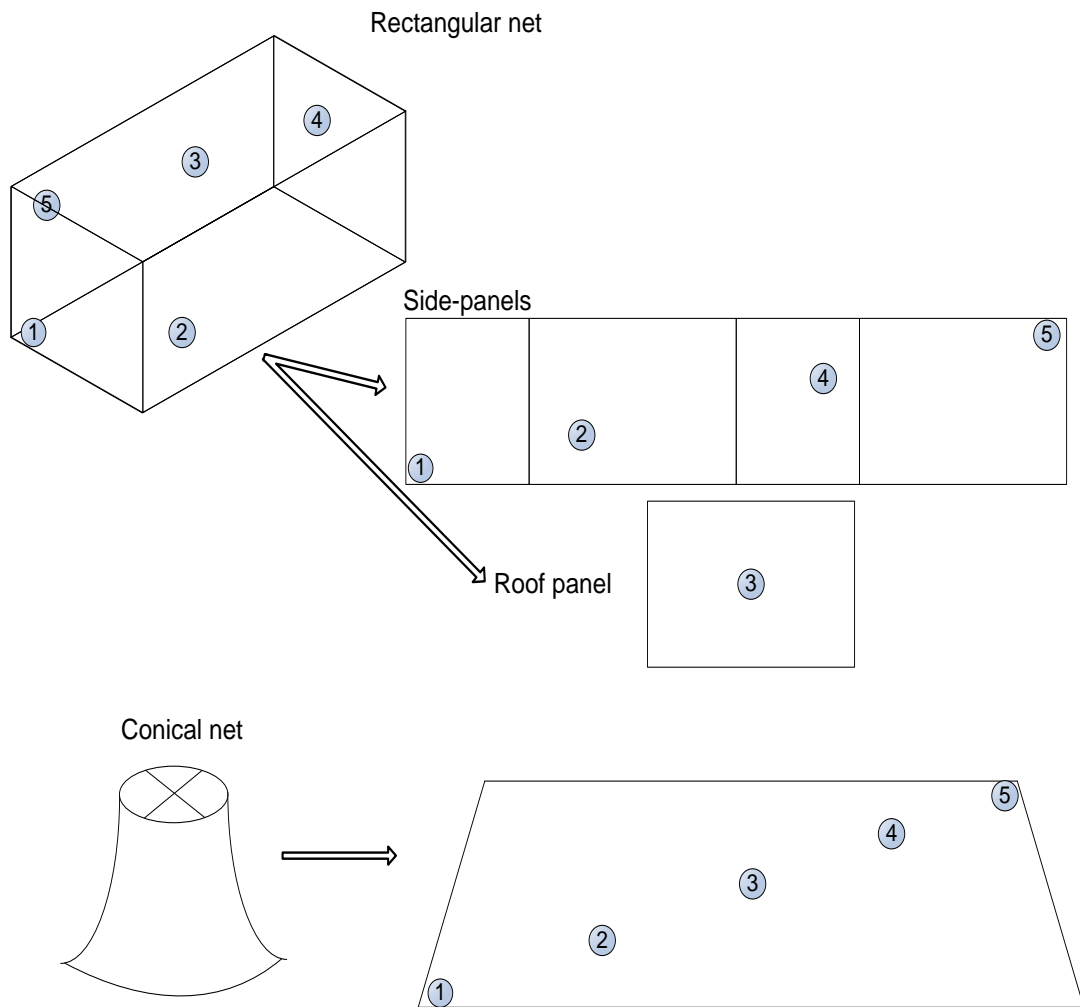
ISO 6330:2012 - Textiles - Domestic washing and drying procedures for textile testing.

ISO 5077:2007 - Textiles - Determination of dimensional change in washing and drying.

ISO 13938-2:1999 - Textiles - Bursting properties of fabrics - Part 2: Pneumatic method for determination of bursting strength and bursting distension

EN 1102:2016 - Textiles and textile products. Burning behaviour. Curtains and drapes. Detailed procedure to determine the flame spread of vertically oriented specimens.

Figure 1 Recommended positions from which 5 pieces of netting should be taken from a made up bed net and combined to form a representative sample.



PART TWO
EVALUATION REPORTS

ALPHA-CYPERMETHRIN + CHLORFENAPYR

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WHO SPECIFICATIONS FOR PUBLIC HEALTH PESTICIDES

ALPHA-CYPERMETHRIN + CHLORFENAPYR FAO/WHO EVALUATION REPORT 454+570/2019

Recommendations

The Meeting recommended the following.

The specification for alpha-cypermethrin + chlorfenapyr long-lasting (coated onto filaments) insecticidal net, proposed by BASF, and as amended, should be adopted by WHO.

Appraisal

A draft specification and supporting data for alpha-cypermethrin + chlorfenapyr long-lasting (coated onto filaments) insecticidal net (LN), provided by BASF, were considered by the Meeting for development of a new WHO specification. The data and test reports provided by the manufacturer to support this specification were generated by the manufacturer as well as by independent laboratories. The proposed specification was broadly in agreement with the LN specification guideline of the FAO/WHO Manual on pesticides specifications (FAO/WHO 2016).

The LN under consideration (Interceptor® G2) is a poly-filament polyester fibre of 75 denier or 100 denier coated with alpha-cypermethrin SC and chlorfenapyr SC. The intention is to combine two insecticides with different modes of action (alpha-cypermethrin, a sodium channel modulator and chlorfenapyr, an uncoupler of oxidative phosphorylation), to better control resistant strains of malaria vectors. The Meeting agreed to develop a single specification for this formulation containing a mixture of two active ingredients.

WHO specifications are published for alpha-cypermethrin TC and SC (454/TC, January 2013 and 454/SC, February 2015) and for chlorfenapyr TC and SC (570/TC and 570/SC, December 2017).

The alpha-cypermethrin + chlorfenapyr (coated onto filaments) LN produced by this manufacturer was tested and evaluated by WHOPES and a time-limited interim recommendation for its use in malaria prevention and control was issued in 2017 (WHO 2017). The recommendation is based on the efficacy studied in the WHOPES trials, and assessment of the safety of the net. When considering the safety, the WHOPES working group also considered the possible interaction of the two active ingredients, alpha-cypermethrin and chlorfenapyr, and noted that even applying the conservative, IPCS-recommended approach of dose-additivity¹, the Interceptor G2 long-lasting insecticidal nets do not pose undue hazards to people while sleeping under them and handling them for washing.

¹ Assessment of combined exposures to multiple chemicals: report of a WHO/IPCS international workshop on aggregate/cumulative risk assessment, WHO 2009.

Description

Whereas one active ingredient - alpha-cypermethrin - is a well known compound with WHO specifications and WHOPEs recommendation for a number of products - including several LNs - chlorfenapyr might have potential in areas with high pyrethroid resistant malaria vectors (WHO 2017). The product under evaluation is a mixed product of these two active ingredients aiming at better control of resistant strains of malaria vectors. Coating is done by mixing alpha-cypermethrin SC and chlorfenapyr SC with a polymeric binder, any necessary stabilizers, plasticizers and other formulants.

Active ingredients

The nominal content of alpha-cypermethrin on the 75 and 100 denier netting is 3.2 and 2.4 g/kg, whereas the content of chlorfenapyr is 6.4 and 4.8 g/kg, respectively, with a tolerance of $\pm 25\%$. This difference in active ingredients content for the two fabric weights when expressed in g/kg was proposed by the manufacturer in order to keep the same active ingredients content of 100 mg/m² and 200 mg/m², respectively for alpha-cypermethrin and chlorfenapyr.

The CIPAC methods for chlorfenapyr content in TC and SC (570/TC/M/3 and 570/SC/M/3, CIPAC Handbook O) uses reverse phase HPLC with UV detection. For Interceptor® G2, the manufacturer initially proposed an extension of the CIPAC method 454/LN/M/3.1 for alpha-cypermethrin content in coated LN, for the simultaneous determination of alpha-cypermethrin and chlorfenapyr using a single procedure for both extraction and chromatographic determination. The content of alpha-cypermethrin and chlorfenapyr are determined by capillary gas chromatography using flame ionisation detection (GC-FID) and dioctyl phthalate as internal standard, after extraction by refluxing with tetrahydrofuran. This extended method was successfully validated for alpha-cypermethrin and chlorfenapyr on two samples of Interceptor® G2 of 100 denier on its specificity, linearity of chromatographic response, accuracy and repeatability.

These method validation data as well as a GLP study performed on Interceptor® G2 of 75 and 100 denier showed that the products fully comply with the target doses $\pm 25\%$.

The manufacturer collaborated further with an independent laboratory in order to optimise the single extraction method followed by GC-FID for the simultaneous determination of alpha-cypermethrin and chlorfenapyr. In this optimised method, the content of alpha-cypermethrin and chlorfenapyr are determined by GC-FID and dicyclohexyl phthalate as internal standard after extraction by ultrasonication or shaking with n-heptane and adding of citric acid. This capillary GC-FID method for the determination of alpha-cypermethrin and chlorfenapyr in coated onto polyester LN was accepted as a provisional CIPAC method in 2019 (CRA-W 2019).

A spatial variation study provided by the manufacturer on two samples of Interceptor® G2 of 100 denier (alpha-cypermethrin and chlorfenapyr content on 5 individual net pieces taken from each side and roof of the net) showed an acceptable homogeneity of the distribution of the active ingredients within the net (within-net RSD of 4.0% and 4.2% for alpha-cypermethrin and of 3.4% and 4.0% for chlorfenapyr). This homogeneity was confirmed by the chemical analysis of active ingredients on 3 samples of open netting material each of 75 denier and 100 denier (3 pieces taken from the right, middle and left from the width of the netting) (within-

net RSD ranging from 0.8% to 1.8% for 75 denier yarn and from 7.4% to 13.6% for 100 denier yarn). The manufacturer stated that the results on the 100 denier net leaves room for improvement and will be subject to further production trial.

At the request of the Meeting, the manufacturer provided additional spatial variation data on Interceptor® G2 of 100 denier (alpha-cypermethrin and chlorfenapyr content on 5 individual net pieces taken from each side and roof of the net) showing an acceptable homogeneity of the distribution of the active ingredients within the net (within-net RSD of 3.4% for alpha-cypermethrin and 4.2% for chlorfenapyr). This homogeneity was confirmed by the chemical analysis of active ingredients on 2 samples of open netting material of Interceptor® G2 of 100 denier (3 pieces taken from the right, middle and left from the width of the netting) (within-net RSD of 1.3% and 1.6% for alpha-cypermethrin and of 1.6% and 3.8% for chlorfenapyr).

The WHOPES Phase I testing and evaluation of Interceptor® G2 showed that alpha-cypermethrin and chlorfenapyr content in the LN comply with the target doses $\pm 25\%$, and an acceptable homogeneity of the active ingredients between the nets. The between-net variation, expressed as the relative standard deviation (RSD) of the alpha-cypermethrin and chlorfenapyr content found on 4 different nets, was 8.4% and 8.7% respectively (CRA-W 2016, WHO 2017).

The WHOPES Phase II trials conducted in Côte d'Ivoire and Tanzania showed that Interceptor® G2 complies with the target doses ($\pm 25\%$) and an acceptable homogeneity of the distribution of the active ingredients within the nets. The within-net variation, expressed as the relative standard deviation (RSD) of the alpha-cypermethrin and chlorfenapyr content found on 5 different net pieces cut from each net ranged from 0.3% to 2.1% and from 1.2% to 2.4% respectively (CRA-W 2017, WHO 2017).

Active ingredients wash resistance index

An adequate amount of active ingredients must be present at the surface of the LN, for efficacy reasons, whereas the majority must reside within the coating of the LN, to avoid excessive losses during washing and to provide a reservoir from which the surface is replenished with active ingredient. The depth and properties of coating therefore strongly influence the retention of active ingredients when the LN is subjected to repeated washing. Depletion of total active ingredients content by washing (wash resistance index) is accomplished by analyzing separate washed and unwashed pieces of the same fabric.

The method MT 195 for determination of wash resistance index of LN was adopted as full CIPAC method in 2013 and is now published in the Handbook O. This method is a further standardization of the WHO washing method published in the "WHO Guidelines for laboratory and field testing of long-lasting insecticidal mosquito nets", document WHO/CDS/WHOPES/GCDPP/2005.11 (WHO 2005). Briefly, the wash resistance index is determined by analyzing net samples in triplicate representing wash points 0 and 4 for total active ingredient content and calculating the average wash resistance index per wash using the equation for a free migration stage behaviour. A wash resistance index per wash of 95% indicates that at least 95% of the insecticide present in samples washed 1 to 3 times is still present after an additional wash step. The wash resistance index applies to the average obtained from triplicate tests performed on net pieces removed from the same net or batch of netting (CIPAC 2017).

One of the challenges in combining two active ingredients is to ensure that both compounds show similar wash resistance indexes to prevent drastic changes in one or the other active ingredient in a series of wash steps. The results of MT 195 showed a reasonable agreement between the two wash resistance ranges.

The manufacturer provided data on one batch of the 75 and 100 denier products unwashed and washed 4 times according to the CIPAC method MT 195. The wash resistance index ranged from 97.6% to 100.9% for alpha-cypermethrin and from 93.9% to 95.1% for chlorfenapyr. The manufacturer initially proposed to specify a range from 90% to 101% for both alpha-cypermethrin and chlorfenapyr.

In order to better reflect the release properties of the two active ingredients, the Meeting requested the manufacturer to specify a lower range for chlorfenapyr than for alpha-cypermethrin. Additional data provided by the manufacturer on the wash resistance index of two batches of the 75 and 100 denier products unwashed and washed 4 times according to the CIPAC method MT 195 showed indeed a lower wash resistance index for chlorfenapyr (94.6% to 98.2%) compared to alpha-cypermethrin (98.1% to 100.1%).

The WHOPES Phase I testing results on alpha-cypermethrin and chlorfenapyr content and associated biological efficacy of Interceptor® G2 washed up to 25 times (according to the WHO washing procedure) showed an exponential decay of the alpha-cypermethrin and chlorfenapyr content in function of the number of washes (free-migration stage behaviour). The overall alpha-cypermethrin and chlorfenapyr retention after 20 washes was 45.2% and 16.1% respectively, corresponding to an average retention index per wash of 96.9% and 92.0% respectively, as estimated by the exponential regression curve (CRA-W 2016, WHO 2017), and this is in agreement with the specification tolerances.

The manufacturer proposed to specify a range of 90% to 101% for alpha-cypermethrin and 85% to 99% for chlorfenapyr, and this was agreed by the Meeting.

Relevant impurities

There are no relevant impurities identified in the published WHO specifications 454/TC and SC for alpha-cypermethrin neither in the published WHO specifications 570/TC and SC for chlorfenapyr.

Physical properties

Data provided by the manufacturer on two batches of the 75 and 100 denier products showed:

- a fabric mass per unit area in agreement with the specified limits of 30 g/m² ± 10 % for 75 denier yarn and 40 g/m² ± 10 % for 100 denier yarn.
- an average and minimum number of complete holes / cm² in agreement with the specified minimum limit of 24.
- a dimensional stability to washing in agreement with the specified limit of maximum 5% shrinkage / expansion.
- a bursting strength higher than the minimum limit of 250 kPa for 75 denier yarn and 405 kPa for 100 denier yarn.

The flammability of Interceptor® G2 was tested according to 16 CFR Part 1610 as well as according to EN ISO 1102. Interceptor® G2 can be classified with class 1

(normal flammability). According to EN 1102 the tested samples did not ignite after removing the burner and flame spread did not occur.

Storage stability

The manufacturer provided data on the 75 and 100 denier products (manufacturer's data on 2 batches and independent laboratory's GLP study on 1 batch) showing that, after storage at 54°C for 2 weeks, the average alpha-cypermethrin and chlorfenapyr content (measured individually) are higher than 90% relative to the average content found before storage. This limit of minimum of 90% of the active ingredients content remaining after accelerated storage as proposed by the manufacturer differs from the default limit of 95%, but is rather due to the typical variability of the active ingredients content within coated LNs than to a significant degradation of the active ingredients.

The manufacturer provided also data showing that, after accelerated storage at 54°C for 2 weeks, the 75 and 100 denier products still comply with limits proposed for active ingredients wash resistance index, dimensional stability to washing and bursting strength.

ANNEX 1: REFERENCES

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
5220/m	CRA-W	2019	Alpha-cypermethrin + Chlorfenapyr (454 + 570) in Technical material (TC) and Long Lasting Insecticidal Net (LN). CIPAC method 5220/m. Full scale collaborative trial. Report of the Walloon Agricultural Research Centre, Gembloux, Belgium for BASF and CIPAC, June 2019.
5221/R	CRA-W	2019	Alpha-cypermethrin + Chlorfenapyr. Full scale collaborative trial for the determination of Alpha-cypermethrin and Chlorfenapyr in Technical material (TC) and Long Lasting Insecticidal Net (LN). CIPAC report 5221/R. Report of the Walloon Agricultural Research Centre, Gembloux, Belgium for BASF and CIPAC, June 2019.
RE 23855	CRA-W	2015	Chemical properties and storage stability of Interceptor® G2 (alpha-cypermethrin + chlorfenapyr LN). GLP report BASF / RE 23855 / 2015 / 1/4 of the Walloon Agricultural Research Centre, Gembloux, Belgium for BASF SE, November 05, 2015.
RE/16/U10/24224	CRA-W	2016	Determination of alpha-cypermethrin and chlorfenapyr in net samples from the WHOPEs Phase I study on Interceptor® G2. Report RE/16/U10/24224 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, July 11, 2016.
RE/17/U10/24440/1	CRA-W	2017	Determination of alpha-cypermethrin and chlorfenapyr in net samples from the WHOPEs Phase II study on Interceptor® G2 in Côte d'Ivoire. Report RE/17/U10/24440/1 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, March 18, 2017.
RE/17/U10/24485	CRA-W	2017	Determination of alpha-cypermethrin and chlorfenapyr in net samples from the WHOPEs Phase II study on Interceptor® G2 in Tanzania. Report RE/17/U10/24485 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, August 02, 2017.
	FAO/WHO	2016	Manual on development and use of FAO and WHO specifications for pesticides. Second revision of the 1 st edition. FAO, Rome and WHO, Geneva, March 2016 (internet publications).
2014/1233853	Förster Rolf & al.	2014	Long Lasting Insecticidal Net (LN) Interceptor® G2. Determination of the spatial variation of the concentration of alpha-cypermethrin and chlorfenapyr on the net. Report 2014/123853 of BASF SE, September 23, 2014.
2014/1217856	Förster Rolf & al.	2014	Long Lasting Insecticidal Net (LN) Interceptor® G2. Quantitative determination of the total content of alpha-cypermethrin and chlorfenapyr. Report 2014/1217856 of BASF SE, October 2014.
2014/1217855	Förster Rolf & al.	2014	Long Lasting Insecticidal Net (LN) Interceptor® G2. Determination of the retention index or wash resistance index of alpha-cypermethrin and chlorfenapyr. Report 2014/1217855 of BASF SE, October 08, 2014.
2015/1158431	Förster Rolf & al.	2015	Long Lasting Insecticidal Net (LN) Interceptor® G2. Determination of the spatial variation of the concentration of alpha-cypermethrin and chlorfenapyr on the net. Additional data. Report 2015/1158431 of BASF SE, June 23, 2015.

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
2015/1314766	Förster Rolf & al.	2015	Long Lasting Insecticidal Net (LN) Interceptor® G2. Accelerated Storage Stability up to 2 weeks at 54°C. Determination of the Total Content of alpha-cypermethrin and chlorfenapyr. Report 2015/1314766 of BASF SE, February 15, 2015.
2014/1217852	Kröhl Thomas & al.	2014	Physical properties of BASF' Interceptor® G2 Long Lasting Insecticidal Net (LN) containing alpha-cypermethrin and chlorfenapyr. Draft report 2014/1217852 of BASF SE, 2014.
2015/1179301	Kröhl Thomas & al.	2015	Physical properties of BASF' Interceptor® G2 Long Lasting Insecticidal Net (LN) containing alpha-cypermethrin and chlorfenapyr. Report 2015/1179301 of BASF SE, August 26, 2015.
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2016/1231516	Müller Holger & al.	2016	Draft specification for BASF' Interceptor® G2 Long Lasting Insecticidal Net (LN) containing alpha-cypermethrin and chlorfenapyr. Revision 2016. Report 2016/1109526 of BASF SE, August 22, 2016.
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	WHO	2014	Report of the 17 th WHOPES Working Group Meeting, WHO/HQ, Geneva, 15-19 September 2014. WHO, Geneva, document WHO/HTM/NTD/WHOPES/2014.3 (ISBN 978 92 4 150803 2).
	WHO	2015	Determination of fabric strength of long-lasting insecticidal nets. Report of a WHO consultation, Geneva, 20-22 August 2014, document WHO/HTM/NTD/WHOPES/2015.1.
	WHO	2017	Report of the 20 th WHOPES Working Group Meeting, WHO/HQ, Geneva, 20-24 March 2017, document WHO/HTM/NTD/WHOPES/2017.04