WHO SPECIFICATIONS AND EVALUATIONS

FOR PUBLIC HEALTH PESTICIDES

DELTAMETHRIN

LONG-LASTING (INCORPORATED INTO FILAMENTS) INSECTICIDAL NET

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

World Health Organization

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[1] The specification 333/LN/4 was withdrawn by WHO at the request of the applicant.

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.

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[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 WHO Prequalification Unit – Vector Control Product Assessment Team (PQT/VCP) website, https://extranet.who.int/pqweb/vector-control-products

PART ONE

SPECIFICATIONS [1]

DELTAMETHRIN

[1] The specification 333/LN/4 was withdrawn by WHO at the request of the applicant.

DELTAMETHRIN

INFORMATION

ISO common names

Deltamethrin (BSI, draft E-ISO), deltaméthrine ((f) draft F-ISO)

Synonyms

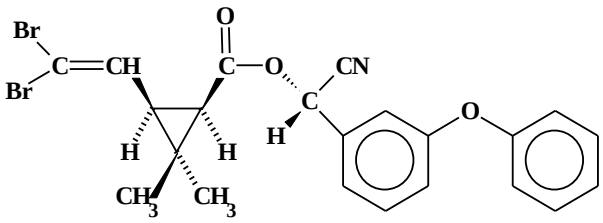
Decamethrin (rejected common name)

Chemical names

IUPAC (*S*)-α-cyano-3-phenoxybenzyl (1*R*,3*R*)-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropane carboxylate

CA [1*R*-[1α(*S**),3α]]-cyano(3-phenoxyphenyl)methyl 3-(2,2-dibromoethenyl)-2,2-dimethylcyclopropanecarboxylate

Structural formula



Empirical formula

$C_{22}H_{19}Br_2NO_3$

Relative molecular mass

505.2 g/mol

CAS Registry number

52918-63-5

CIPAC number

333

EEC number

258-256-6

Identity tests

HPLC retention time; TLC; IR, NMR and mass spectra

DELTAMETHRIN LONG-LASTING (INCORPORATED INTO POLYETHYLENE) INSECTICIDAL NET

WHO specification 333/LN/3 (September 2015*)

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 (333/2015.1). 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 (333/2015.1), 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 120 denier monofilament, high density polyethylene fibres, incorporating technical deltamethrin complying with the requirements of WHO specification 333/TC (January 2015), together with any necessary other formulants. The product shall appear clean, and shall be free from visible extraneous matter (Note 2), 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 it shall be suitable for use as an insecticidal net with long-lasting activity (Notes 3 & 4).

2 Active ingredient

2.1 **Identity tests** (333/LN/(M2)/2, CIPAC Handbook N, p.34, 2012) (Note 5)

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 **Deltamethrin content** (333/LN/(M2)/3, CIPAC Handbook N, p.34, 2012) (Notes 5 & 6)

The deltamethrin content shall be declared (1.8 g/kg) and, when determined, the average content shall not differ from that declared by more than ± 25%.

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* This specification is applicable to long-lasting (incorporated into polyethylene) insecticidal nettings and nets produced by LIFE IDEAS Biological Technology Co. Ltd. and commercialised under the trade name of Panda Net 2.0. The subject of the extension of specifications for LN has been discussed by the JMPS in 2009. The Meeting agreed that - in contrast to other formulations - an extension of a specification to nominally similar LN of other manufacturers was not possible with the data currently available and that the manufacturer and the product should be named in a footnote or in the specification.

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/pqweb/vector-control-products

2.3 **Deltamethrin wash resistance index** (MT 195) (Note 7)

The wash resistance index of deltamethrin from the netting, when determined, shall be within the range 95% to 101%.

3 Physical properties

3.1 **Netting mesh size** (Note 6)

When counted by the method given in Note 8, the average number of complete holes/cm² shall be not less than 18, and the lowest value shall be not less than 18.

3.2 **Dimensional stability of netting to washing** (Notes 6 & 9)

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

3.3 **Bursting strength** (Note 6 & 10)

The minimum bursting strength of the fabric shall be declared (not less than 400 kPa) 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.

4 Storage stability

4.1 **Stability at elevated temperature** (MT 46.3.4) (Note 11)

After storage at 54 ± 2°C for 2 weeks, the determined average active ingredient content shall not be lower than 95%, relative to the determined average content found before storage (Note 12) and the product shall continue to comply with the clauses for:

- wash resistance index (2.3);
- dimensional stability (3.2);
- bursting strength (3.3).

Note 1 The specification applies to manufactured nets and bulk netting, which may be rectangular or conical in design.

Note 2 Occasional short lengths of loose thread present in the netting are not considered to be extraneous matter.

Note 3 Long-lasting insecticidal netting is expected to retain its insecticidal activity during its life span and through a number of washes.

Note 4 Flammability of the product is not part of the specification but it should be measured by the manufacturer, according to 16CFR Part 1610, and the result presented on the package. The linear density (denier) of the fibres cannot be measured in the manufactured net, but should be identified on the packaging.

Note 5 For complete identification and good quantification, deltamethrin which is a single pyrethroid stereoisomer consisting of [α*S*,1*R*,3*R*]-isomer (also known as the *S*-isomer) must be separated from the [α*R*,1*R*,3*R*]-isomer (otherwise known as the *R*-isomer), which is not part of the active ingredient and not a relevant impurity. These diastereomers may be separated by non-chiral techniques as provided in the CIPAC method for deltamethrin.

Note 6 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 selvedges.

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 sun heat) or freezing, and analyzed/tested with minimum delay. Representative portions (sub-samples) for testing should be taken as described in each test method.

Note 7 The method MT 195 for determination of wash resistance index of LN was adopted as full CIPAC MT method in 2013. Prior to its publication in the next Handbook, copies of the method can be obtained through the CIPAC website, http://www.cipac.org/prepubme.htm

The net samples have to be stored at 40°C for 2 days between washings. The content of deltamethrin in the net pieces before and after washing should be determined by the method 333/LN/(M2)/3, CIPAC Handbook N, p.34, 2012. 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 8 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. Before counting, the fabric should be conditioned according to ISO 139 (1973) (4 h, 20ºC, 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 (±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 ≥½ are counted as complete holes, whereas those <½ are not counted. Count 5 replicate squares selected according to Note 5, calculate the average and note the lowest value.

Note 9 Method of preparation, marking and measuring: ISO 3759 (2007). Method of washing: ISO 6330 (2001). Method of calculation: ISO 5077 (1984). 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: ISO type 8A (gentle cycle 30ºC). Fill the washer with dummy load (with fabric as per ISO standard) up to the standard of 2 to 4 kg. Drying: flat drying.

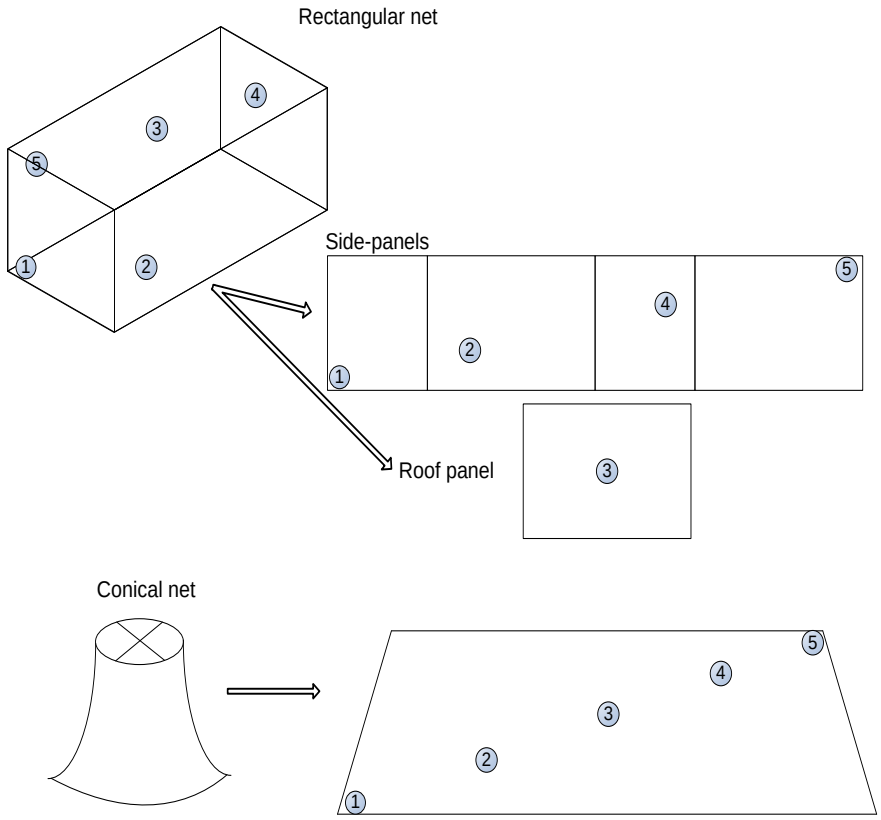
Note 10 Test method: ISO 13938 part 2 (1999), with conditioning of the fabric as specified in the ISO standard. The declared minimum bursting strength, and testing for compliance with it, should be based on tests of 7.3 cm^2 areas of fabric. Five replicate tests should be conducted on samples taken at 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 one produced by conceptually arranging the panels end to end). 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 11 The extension of the scope (CIPAC/4956) of CIPAC method MT 46.3 for the accelerated storage procedure of the LN formulations regarding determination of active ingredient content and wash resistance index was adopted as a provisional CIPAC MT method in 2014. Prior to its publication in the next Handbook, copies of the method can be obtained through the CIPAC website, http://www.cipac.org/prepubme.htm

Note 12 Samples of the product taken before and after the storage stability test should be analyzed concurrently in order to reduce the analytical error.

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.



DELTAMETHRIN LONG-LASTING (INCORPORATED INTO POLYETHYLENE) INSECTICIDAL NET

WHO specification 333/LN/6 (February 2021*)

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 (333/2020.2). 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 (333/2020.2), given in PART TWO, forms an integral part of this publication.

1 **Description** (Note 1)

The product shall be in the form of netting, consisting of 120 denier (Note 2) knitted mono-filament polyethylene fibres, incorporating technical deltamethrin complying with the requirements of WHO specification 333/TC (November 2017), together with any necessary 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/in an insecticidal net with long-lasting activity (Note 4).

2 **Active ingredient**

2.1 **Identity tests** (333/LN/(M2)/2, CIPAC Handbook N, p. 34, 2012) (Note 5)

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 **Deltamethrin content** (333/LN/(M2)/3, CIPAC Handbook N, p. 34, 2012) (Notes 5 & 6)

The deltamethrin content shall be declared (2.5 g/kg) and, when determined, the average content shall not differ from that declared by more than ± 25%.

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* This specification is applicable to long-lasting (incorporated into polyethylene) insecticidal nettings and nets produced by Moon Netting FZCO and commercialised under the trade name of Tsara. The subject of the extension of specifications for LN has been discussed by the JMPS in 2009. The 2009 Meeting agreed that - in contrast to other formulations - an extension of a specification to nominally similar LN of other manufacturers may not be possible with the data currently available and that the manufacturer and the product should be named in a footnote or in the specification.

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/pqweb/vector-control-products

2.3 **Deltamethrin wash resistance index** (MT 195, CIPAC Handbook O, p. 205, 2017) (Note 7)

The wash resistance index of deltamethrin from the netting, when determined, shall be within the range 94% to 101%.

3 **Physical properties** (Notes 6 & 14)

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

The mass per unit area shall be declared (37 g/m²), and when determined, shall not differ from that declared by more than ± 10%.

3.2 **Netting mesh size**

When counted by the method given in Note 8, the average number of complete holes per unit area (holes/cm²) shall be not less than 17 holes/cm² and the lowest value shall be not less than 16 holes/cm².

3.3 **Dimensional stability of netting to washing** (Note 9)

Not more than 5% shrinkage and not more than 5% expansion in both directions.

3.4 **Bursting strength** (ISO 13938:2) (Note 10)

The bursting strength of the fabric shall be declared (not less than 400 kPa) 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 11)

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 150 mm, respectively.

4 **Storage stability**

4.1 **Stability at elevated temperature** (MT 46.4) (Note 12)

After storage at 54 ± 2°C for 14 days, the determined average active ingredient content shall not be lower than 95%, 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 (2.3),
- dimensional stability to washing (3.3),

- bursting strength (3.4).

Note 1 The specification applies to manufactured nets and bulk netting, which may be rectangular or conical in design.

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 lifespan and through a number of washes.

Note 5 For complete identification and good quantification, deltamethrin which is a single pyrethroid stereoisomer consisting of [α*S*,1*R*,3*R*]-isomer (also known as the *S*-isomer) must be separated from the [α*R*,1*R*,3*R*]-isomer (otherwise known as the *R*-isomer), which is not part of the active ingredient and not a relevant impurity. These diastereomers may be separated by non-chiral techniques as provided in the CIPAC method for deltamethrin.

Note 6 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 edges.

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 7 The content of deltamethrin in the net pieces before and after washing should be determined by the CIPAC method 333/LN/(M2)/3, CIPAC Handbook N, p. 34, 2012. Wash resistance index values as low as 94% and up to 101% are acceptable due to the inherent active ingredient content variation known to exist between samples taken from the same net and the measurement uncertainty of the CIPAC method MT 195.

Note 8 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/cm^2. Before counting, the fabric should be conditioned according to ISO 139 (4 h, 20ºC, 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 (±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 ≥ ½ are counted as complete holes, whereas those < ½ 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 9 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: 30ºC 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 10 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 cm^2 areas of fabric. Proposed specifications based on tests of 50 cm^2 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 cm^2 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 11 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 12 MT 46.4 is the harmonized and revised version of MT 46.3 and was accepted as full CIPAC method in 2020. Prior to its publication in a next Handbook, copies of the method can be obtained through the CIPAC website, http://www.cipac.org/index.php/methods-publications/pre-published-methods

Note 13 Samples of the formulation taken before and after the storage stability test may 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.

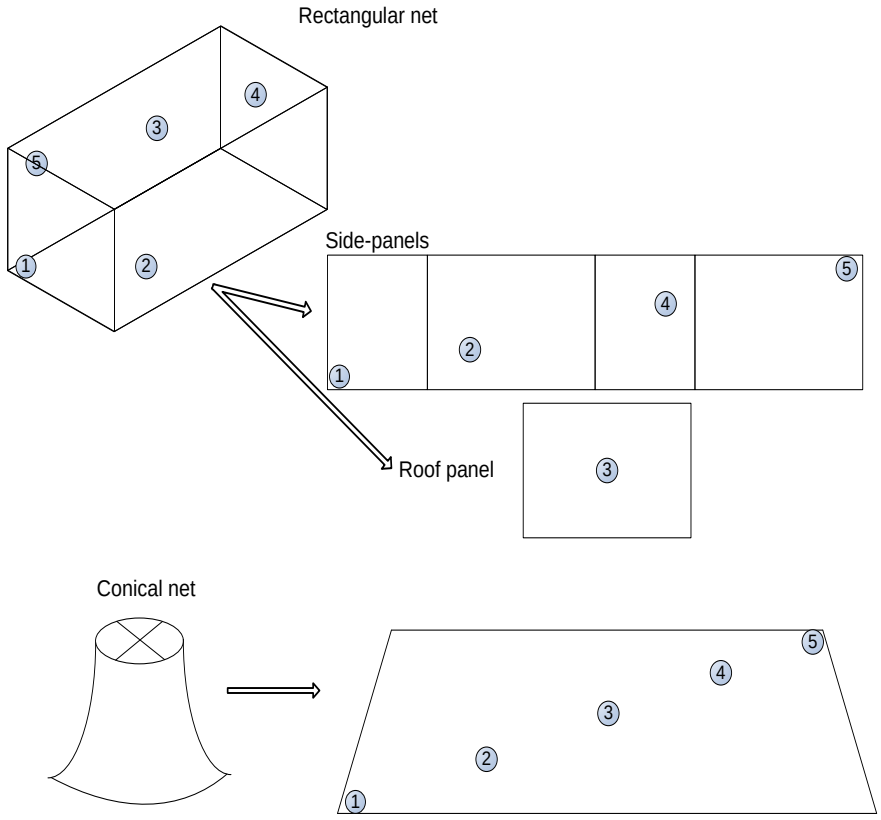
ISO 6330:2012 - Textiles - Domestic washing and drying procedures for textile testing.

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

DELTAMETHRIN

[1] The specification 333/LN/4 was withdrawn by WHO at the request of the applicant.

DELTAMETHRIN

FAO/WHO EVALUATION REPORT 333/2020.2

Recommendations

The Meeting recommended the following:

The new specification 333/LN/6 for deltamethrin (incorporated into polyethylene) LN for the 120 denier Tsara product of Moon Netting FZCO should be adopted by WHO.

Appraisal

A draft specification, supporting data and information for deltamethrin long-lasting (incorporated into polyethylene) insecticidal net (LN), provided by NRS Moon Netting FZE, Dubai, were considered by the Meeting in support of a new WHO specification. The proposed specification was in agreement with the LN specification guideline of the FAO/WHO Manual on pesticides specifications (FAO/WHO 2016).

Subsequently, the applicant informed WHO that the name of the company was changed from NRS Moon Netting FZE to Moon Netting FZCO.

The LN under consideration (Tsara) is in the form of a finished mosquito net consisting of 120 denier mono-filament polyethylene fibres incorporated with deltamethrin at a target dose of 2.5 g/kg. The treatment is performed with deltamethrin TC by combining a deltamethrin masterbatch with polyethylene during the fibre extrusion process. The deltamethrin technical material is from a source compliant with the existing WHO specification for deltamethrin TC.

The data and test reports provided by the manufacturer to support the new specification were generated by an independent laboratory. Data were provided for the analysis of one net in support of all the proposed specification clauses. In addition, data for fabric weight, deltamethrin content, and wash resistance index were provided by a different testing laboratory for a further two nets. The proposer subsequently provided additional data for deltamethrin content and physical and technical properties of samples used in efficacy testing and in quality control tests.

The meeting considered that taking all the data provided into account there was adequate data to support a new specification.

Description

The Meeting concluded that the description of Tsara made of 120 denier mono-filament polyethylene fibres incorporated with deltamethrin broadly complied with the requirements of the Manual.

Active ingredient content

Tsara is produced from 120 denier yarn and the target deltamethrin content is 2.5 g/kg, corresponding to 92.5 mg/m² (fabric weight = 37 g/m²). The CIPAC method 333/LN/(M2)/3 published in Handbook N, was used for the determination of the active substance content. Data provided by the manufacturer for deltamethrin

content for five nets (range 2.2 - 2.6 g/kg, mean 2.4 g/kg) showed that the product complies with the target dose. Data on nets tested in efficacy studies were also provided for eight nets (range 2.2 - 2.6 g/kg, mean 2.4 g/kg).

Additional data on two nets were provided. For these the deltamethrin content was determined using an in-house GC-FID method. No further details for this method were provided. The deltamethrin content was found to be 2.4 g/kg and 2.6 g/kg in the two nets, respectively.

Special attention needs to be paid to control random variations in the distribution of the insecticide throughout the net and between nets. The manufacturer provided spatial variation data on 10 nets (deltamethrin content on 5 individual net pieces taken according to Figure 1 of the specification) showing acceptable within-net homogeneity (RSDs of 0.5 - 1.9%, n = 5 for each net) of the active ingredient.

Relevant impurities

There are no relevant impurities identified in the existing WHO specification for deltamethrin TC. During the manufacturing process of deltamethrin LN, however, epimerization of deltamethrin to the (insecticidally inactive) *R-alpha* isomer may occur. This conversion must be controlled by the manufacturer to avoid losses of active ingredient. This conversion can also occur if the LN is exposed to excessive heat or UV light during storage or use. This epimer is not a relevant impurity but formation of an excessive amount is expected to lead to a reduction of biological activity. Data provided by the manufacturer on 5 nets showed that deltamethrin *R-alpha* isomer content of Tsara was < 0.4% of the deltamethrin content.

The *R-alpha* isomer content is also indirectly specified by the active ingredient content clause in the accelerated storage test, where at least 95% of the initial amount of deltamethrin must be present after the test, thus limiting the epimerization during storage to a maximum of 5%.

Active ingredient wash resistance index

An adequate amount of active ingredient must be present at the surface of the LN, for efficacy reasons, whereas the majority must reside within the LN, to avoid excessive losses during washing and to provide a reservoir from which the surface is replenished with active ingredient. The incorporation process can influence the retention of deltamethrin when the LN is subjected to repeated washing. The monitoring of the depletion of total active ingredient content by washing (wash resistance index) is accomplished by analysing separate washed and unwashed pieces of the same fabric.

The method MT 195 for determination of wash resistance index of LN was adopted as a full CIPAC method in 2013. The manufacturer provided the Meeting with data for two Tsara nets tested using the CIPAC method that showed that the deltamethrin wash resistance index after 4 washes was 97% in both nets.

Data on two further nets was provided; the Method MT 195 was used with the deltamethrin content determined using an in-house GC-FID method. No further details for the in-house method were provided. The wash resistance index was found to be 97.8% and 100.1%, in the two nets, respectively.

The Meeting considered additional data from an analytical report conducted on samples used in efficacy studies, where the deltamethrin content was determined using the CIPAC method. The wash resistance indexes for 4 nets reported in this

study after 1, 3, 5, 10, 20 and 25 washes were calculated and were in the range 95 - 99%.

The manufacturer proposed a specification range of 94% to 101%. The Meeting considered that the additional data from efficacy studies gave weight of evidence to the proposed clause for wash resistance index, and that the specification range is supported.

Physical properties

The manufacturer provided fabric weight data for two nets, determined by ISO 3801 / EN 12127 as the average of 5 x 100 cm² circular samples. The fabric weight was in the range 36.9 - 37.7 g/m^2. Additional data on seven nets were provided determined by ISO 3801 / EN 12127 as the average of 3 pieces of net of 100 cm² each. The fabric weights were in the range 35.7 - 37.9 g/m^2.

The manufacturer provided netting mesh size data for seven nets showing that the average number of complete holes/cm² ranged from 17 - 20 holes/cm² (mean = 18.5 holes/cm²). On this basis the manufacture proposed specification clauses for netting mesh size of not less than 17 holes/ cm² and that the lowest value is not less than 16 holes/ cm². The Meeting considered that this was acceptable.

Test data provided by the manufacturer for six nets showed that the dimensional stability to washing complies with the specified limit of not more than 5% shrinkage and not more than ± 5% expansion in both directions. The bursting strength of seven nets was determined to be in the range 447 - 477 kPa (mean 458 kPa). On this basis the specification clause of 400 kPa was proposed and was considered acceptable by the Meeting.

Flammability was tested using the method described in EN 1102 for two batches of LN. No ignition, propagation of flame or glow was observed. There was no flaming debris and no ignition of the filter paper. The meeting concluded that Tsara complies with the conditions of the test.

Storage stability

The manufacturer provided data for two nets after storage at 54°C for 2 weeks showing that the loss of deltamethrin was less than 5% (deltamethrin content of 2.48 g/kg and 2.50 g/kg after storage) and that the wash resistance index remained within the limits of the proposed specification clause (wash resistance index of 96.8% and 97.6% after storage).

The manufacturer also provided data showing that the dimensional stability of the net to washing and the bursting strength remained essentially unchanged after storage at 54°C for 2 weeks.

The Meeting concluded that the data demonstrated that Tsara could comply with the relevant clauses following storage stability testing at 54°C for 2 weeks.

ANNEX 1: REFERENCES

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
18116	S. Nagachandrudu	2018	Chemical and Physical Analysis of Deltamethrin Long Lasting (Incorporated into polyethylene) Insecticidal net. International Institute of Biotechnology and Toxicology (IIBAT), Tamil Nadu, India, Report of study No. 18116, July 16, 2018. GLP.
RE-18.027.1	H. Nguyen	2018	Test Report on Tsara long lasting insecticidal net. Biolytrics, Vietnam Co. Ltd, Report No RE-18.027.1. Non-GLP.
RE-18.027.2	H. Nguyen	2018	Test Report on Tsara long lasting insecticidal net. Biolytrics, Vietnam Co. Ltd, Report No RE-18.027.2. Non-GLP
FCM1910193 (EN)	Anon.	2018	Test Report on TSARA netting (Manufacturer: SunPack Co., Ltd). DPTC Changzhou Safety Testing Centre for Entry-Exit Industrial & Consumable Products, Report No FCM1910193 (EN). Non-GLP.
FCM1910193	Anon.	2018	Certificate of Quality for TSARA, SunPack Co. Ltd., Certificate No. FCM1910193. Non-GLP.
FPM156961 (EN)	Anon.	2018	Test Report on TSARA (Manufacturer: SunPack Co., Ltd). DPTC Changzhou Safety Testing Centre for Entry-Exit Industrial & Consumable Products, Report No FPM156961 (EN). Non-GLP
FCM1910187 (EN)	Anon.	2019	Test Report on TSARA netting (Manufacturer: SunPack Co., Ltd). DPTC Changzhou Safety Testing Centre for Entry-Exit Industrial & Consumable Products, Report No FCM1910187 (EN). Non-GLP.
FPM166966 (EN)	Anon.	2019	Test Report on TSARA netting (Manufacturer: SunPack Co., Ltd). DPTC Changzhou Safety Testing Centre for Entry-Exit Industrial & Consumable Products, Report No FPM166966 (EN). Non-GLP.
FCM1910211	Anon.	2019	Certificate of Quality for TSARA, SunPack Co. Ltd., Certificate No. FCM1910211. Non-GLP.
19247	Ch. Rajasekharam	2019	Physical-Chemical Analysis of Tsara net (Deltamethrin 2.5 g/kg - White) Long Lasting (incorporated into polyethylene) insecticidal net). International Institute of Biotechnology and Toxicology (IIBAT), Tamil Nadu, India, Report of study No. 19247, October 25, 2019. GLP.
18227	S. Nagachandrudu	2019	Active Content Analysis of Deltamethrin LN Samples Following the Phase I and Phase II Laboratory Studies at four locations (Phase-I Benin, Burkina Faso and Phase-II Tanzania, Benin). International Institute of Biotechnology and Toxicology (IIBAT), Tamil Nadu, India, Report of study No. 18227, October 23, 2019. GLP.
COQ191008	Anon.	2019	Certificate of Quality for TSARA, SunPack Co. Ltd., Certificate No. COQ191008. Non-GLP.

DELTAMETHRIN

FAO/WHO EVALUATION REPORT 333/2015.2

Recommendations

The Meeting recommended the following:

(i) The wash resistance index tolerance of the existing WHO interim specification 333/LN/4 for deltamethrin long-lasting (incorporated into polypropylene) insecticidal net (LN) using the new CIPAC washing method MT 195 should be revised to the range of 74% to 99%.

(ii) The revised specification should keep the status of interim WHO specification.

Appraisal

The method MT 195 for determination of wash resistance index of LN was adopted as full CIPAC MT method in 2013. 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, Geneva, 2005 (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 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 2012 and 2013).

The Meeting requested Bayer CropScience producing deltamethrin long-lasting (incorporated into polypropylene) insecticidal net (LN) (LifeNet) to generate wash resistance index data using the new CIPAC washing method MT 195 and to propose a revised wash resistance index clause based on these data.

The manufacturer provided the Meeting with wash resistance index data from an inter-laboratory study conducted in four different laboratories using the CIPAC method MT 195. The nets tested were from 3 different batches produced in July, August and September 2013. These nets were stored in Thailand for 6 to 8 months and were therefore representative of nets which would reach the market. From each batch, 2 sets of 9 net pieces were sent to each laboratory for determination of wash resistance index (3 pieces at wash 0, 3 pieces at wash 1 and 3 pieces at wash 4). Analytical methods used to determine deltamethrin content in the unwashed and washed net pieces was either the Bayer HPLC-DAD method used for internal quality control, either the CIPAC method 333/LN/M2/3 (HPLC-DAD). The wash resistance index at wash 4 measured in the 4 laboratories for the different nets from 3 different batches varied from 73.6% to 91.2%, with a mean value of 83.5%. The inter-laboratory relative standard deviation at wash 4 ranged from 4.8% to 6.1%, indicating an acceptable reproducibility of the CIPAC method MT 195.

Based on these results integrating several sources of variation, the manufacturer proposed to specify a range of 74% to 99% for deltamethrin wash resistance index, the higher limit being kept in order to encompass nets controlled right after production.

The Meeting questioned the manufacturer about the low retention index values obtained by the 4 laboratories, and particularly about the lower value of the wash resistance index range (74%). The wash resistance was indeed lower compared to this obtained in the WHOPES Phase I study using the old WHO washing method (wash resistance index ranging from 95.9% to 98.2% for washes 1 to 35, WHO 2011) and this obtained in the CIPAC small scale trial using the new CIPAC washing method (wash resistance index ranging from 88.2% to 96.7% at wash 4, CIPAC 2012). These results indicate an excessive bleeding rate of the active ingredient which could compromise the bio-efficacy of the product after 20 washes. The Meeting asked also the manufacturer to provide clarification on the batches of LifeNet used in the inter-laboratory study.

The manufacturer confirmed that the nets tested in the inter-laboratory study were from the same production than those currently being tested in the WHOPES Phase III trials. The bio-efficacy of 5 nets produced in April 2013 in the same conditions than those used in the inter-laboratory study was evaluated using the CIPAC method MT 195 for washing and WHO cone bioassay for testing according to the WHO guideline. Results indicated that all nets tested were highly above the WHO threshold (knockdown ≥ 95%, mortality ≥ 80%) for at least 35 washes (NENTWIG, 2013).

The Meeting agreed with this explanation and the proposed range of 74% to 99% for the wash resistance index, but recommended to keep the specification as an interim one awaiting the efficacy results associated with chemical analysis of LifeNet in the WHOPES Phase III trials. The Meeting proposed also that the manufacturer should carefully control their manufacturing process in order to avoid an excessive bleeding of the active ingredient which may compromise the bio-efficacy of their product.

The Meeting agreed also:

- to refer only to the standard pneumatic method (EN ISO 13938-2) for bursting strength, as recommended in the report of the WHO consultation of August 2014 on fabric strength of LNs.
- to refer to the method MT 46.3.4 adopted as full CIPAC MT method in 2015 for accelerated storage procedure and to update some footnotes of the existing specification to be in line with the current CIPAC methods and the draft specification guideline for LN of the November 2010 - second revision of the first edition of the FAO/WHO Manual.

ANNEX 1: REFERENCES

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
	CIPAC	2012	MT 19X. Wash resistance index of LN, CIPAC method 4827/m.
	CIPAC	2012	MT 19X. Wash resistance index of LN, small scale collaborative trial, CIPAC report 4828/R.
	CIPAC	2013	MT 195. Wash resistance index of LN, available at http://www.cipac.org/cipacpub.htm
	CIPAC	2013	Wash resistance index of LN - Validation of the new CIPAC Washing Method, CIPAC report 4909/R.
NE-MÜ130703	Nentwig Guenther	2013	Evaluation of the bio-efficacy of 5 LifeNets produced in 2013 under controlled conditions against the Malaria mosquito *Anopheles gambiae* (Deltamethrin susceptible strain RDL-H), up-to 35 washes. Report NE-MÜ130703, Bayer CropScience, September 03, 2013.
	Patty Laurent	2014	Wash resistance index data generated according to method CIPAC MT 195. Revised WRI clause proposed for WHO specification (333/LN/4). Bayer CropScience, June 2014.
	Patty Laurent	2015	Wash resistance index data generated according to method CIPAC MT 195. Revised WRI clause proposed for WHO specification (333/LN/4). Bayer CropScience, Revised version July 2015.
	WHO	2011	Report of the Fourteen WHOPES Working Group Meeting, WHO/HQ, Geneva, 11-15 April 2011. WHO, Geneva, document WHO/HTM/NTD/WHOPES/2011.7
	WHO	2015	Determination of fabric strength of long-lasting insecticidal nets. Report of a WHO consultation, Geneva, 20-22 August 2014. WHO, Geneva, document WHO/HTM/NTD/WHOPES/2015.1.

DELTAMETHRIN

FAO/WHO EVALUATION REPORT 333/2015.1

Recommendations

The Meeting recommended the following:

(i) The specification for deltamethrin long-lasting (incorporated into polyethylene) insecticidal net, proposed by LIFE IDEAS Biological Technology Co. Ltd., and as amended, should be adopted by WHO.

(ii) The existing WHO interim specification 333/LN/3 (August 2010) for deltamethrin long-lasting (incorporated into polyethylene) insecticidal net should be withdrawn.

Appraisal

Supporting data and information for deltamethrin long-lasting (incorporated into polyethylene) insecticidal net (LN), provided by LIFE IDEAS Biological Technology Co. Ltd. were considered by the Meeting for development of a new WHO specification.

The manufacturer had initially requested the equivalence of their product with the existing WHO interim specification 333/LN/3 (August 2010). However the 16th WHOPES Working Group Meeting concluded that evidence was not sufficient to grant full recommendation to the LN covered by the existing specification (Netprotect). The WHOPES Working Group Meeting recommended that until more evidence on performance of the product is available from large-scale studies, the WHO interim recommendation on the use of Netprotect should be withdrawn (WHO 2013). The JMPS Meeting therefore agreed that the existing WHO interim specification 333/LN/3 (August 2010) for deltamethrin long-lasting (incorporated into polyethylene) insecticidal net should be withdrawn and that the LN manufactured by LIFE IDEAS Biological Technology Co. Ltd. should be the object of a new WHO specification.

The data and test reports provided by the manufacturer to support this new specification were generated by independent laboratories as well as by the manufacturer.

The LN under consideration (Panda Net 2.0) is a warp knitted fabric netting material made from 120 denier monofilament high density polyethylene yarn incorporating technical deltamethrin at the target dose of 1.8 g/kg. The manufacturer provided a written confirmation that the deltamethrin technical material incorporated into the LN is from a source having a WHO specification for deltamethrin TC (Tagros).

The Meeting was provided with bio-efficacy data on Panda Net 2.0 showing a good efficacy (KD at 60 minutes and mortality at 24 hours) against mosquitoes also after 30 standard WHO washes.

The deltamethrin (incorporated into 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 2015 (WHO 2015).

Description

The Meeting agreed that the specification should be applied to netting, in bulk, and to finished rectangular or conical bed nets, made from 120 denier mono-filament polyethylene fibres.

Active ingredient content

The declared deltamethrin content of Panda Net 2.0 is 1.8 g per kg of netting material with a tolerance of ± 25%. Data provided by the manufacturer for deltamethrin content on 6 batches of Panda Net 2.0 showed that the product complies with this limit.

The CIPAC methods 333/LN/(M2)/2 & 3, published in Handbook N, were used in the study reports provided by the manufacturer and are applicable for identification and determination of deltamethrin content in Panda Net 2.0. The content of deltamethrin is determined by normal phase high performance liquid chromatography using UV detection at 254 nm (HPLC-DAD) and dibutyl phthalate as internal standard, after extraction by refluxing with xylene and solvent exchange to the mobile phase.

Special attention needs to be paid to control random variations in the distribution of the insecticide within the net and between nets. The spatial variation data provided by the manufacturer on one batch of Panda Net 2.0 (deltamethrin content on 5 individual net pieces taken according to the Figure 1 of the specification) showed a good homogeneity of the active ingredient content within the net (within-net RSD = 0.3%, n = 5).

The WHOPES Phase I testing and evaluation of Panda Net 2.0 showed that deltamethrin content in the unwashed nets fully comply with the target dose of 1.8 g/kg (± 25%), and a good homogeneity of the active ingredient within and between the nets. The between-net variation, expressed as the relative standard deviation (RSD) of the content found on 4 different net pieces from 4 different nets ranged from 0.9% to 1.5% (CRA-W 2013, WHO 2015).

The WHOPES Phase II trials conducted in Thailand, Tanzania and Côte d'Ivoire showed that Panda Net 2.0 comply with the target dose of 1.8 g/kg ± 25% (n = 7) and a good homogeneity of the distribution of deltamethrin within the nets. The within-net variation, expressed as the relative standard deviation (RSD) of the deltamethrin content found on 5 different net pieces cut from each 7 nets ranged from 1.0% to 7.2% (CRA-W 2015, WHO 2015).

Active ingredient wash resistance index

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

Where the active ingredient is incorporated into filaments, rapid loss of active ingredient is not likely to occur during washing but, if re-equilibration to the surface is

too slow, the product may be ineffective for an unacceptable period of time after washing. Alternatively, if the re-equilibration is too rapid, the surface concentration could become higher than expected, leading to higher losses of active ingredient during washing and possibly increased user exposure to the active ingredient.

The method MT 195 for determination of wash resistance index of LN was adopted as full CIPAC method in 2013. 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 behavior. 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 2013).

The WHOPES Phase I evaluation of Panda Net 2.0 concluded that a regeneration time of 3 days at 30°C (WHO 2015) is required to restore an acceptable biological efficacy. The Meeting agreed therefore to specify in a footnote that net samples have to be stored at 40°C for 2 days between washings. Otherwise, unrealistically high wash resistances would result in MT 195.

Data provided by the manufacturer on one sample of Panda Net 2.0, washed 1, 3 and 5 times according to the WHO washing method but with a storage period of 46 ± 2 hours at 40°C between washings to allow a complete regeneration of the net, showed that the deltamethrin wash resistance index ranges from 98.0% to 98.8%.

The WHOPES Phase I testing results on deltamethrin content and associated biological efficacy of Panda Net 2.0 washed up to 25 times (according to the WHO washing method) showed an exponential decay of the deltamethrin content in function of the number of washes (free-migration stage behaviour). The overall deltamethrin retention after 20 washes was 91.1%, corresponding to an average wash resistance index of 99.5% (CRA-W 2013, WHO 2015).

Additional wash resistance index data provided by the manufacturer on 3 different nets of Panda Net 2.0 using the CIPAC method MT 195 showed a wash resistance index ranging from 98.8% to 99.8%, and therefore similar to this obtained with the WHO washing method (CRA-W 2014).

Considering the uncertainty of measurement of the CIPAC method MT 195 and the potential inter-laboratory variation, the Manufacturer and the Meeting agreed to specify a range of 95% to 101% for the wash resistance index.

Relevant impurities

There are no relevant impurities identified in the existing WHO specification for deltamethrin TC. During the manufacturing process, storage and use of deltamethrin LN, heat and base-catalyzed epimerization of deltamethrin to the (insecticidally inactive) *R*-alpha isomer may occur. This conversion must be controlled by the manufacturer to avoid significant losses of active ingredient. Data provided by the manufacturer as well as WHOPES Phase I testing and evaluation of Panda Net 2.0 showed that the content of deltamethrin *R*-alpha isomer in Panda Net 2.0 is lower

than 2% of the deltamethrin content and that this amount does not increase in the LN washed up to 25 times (CRA-W 2011, CRA-W 2013, WHO 2015).

Physical properties

Initially, the data provided by the manufacturer on one sample of Panda Net 2.0 showed that the average number of complete holes/cm² was less than 20 which was the specified limit. Data showed also that the bursting strength was lower than 400 kPa for the fabric and that the dimensional stability to washing was higher than 5%. The manufacturer provided additional netting mesh size data on 5 nets showing that the average number of complete holes/cm^2 is higher than 20. He provided also additional data showing that the dimensional stability to washing and bursting strength comply with the specified limits of minimum 400 kPa for bursting strength and maximum 5% shrinkage / expansion for dimensional stability to washing. The manufacturer and the Meeting finally agreed to specify a limit of minimum 18 complete holes / cm² for netting mesh size.

Storage stability

The manufacturer provided data after storage at 54°C for 2 weeks and at 40°C for 8 weeks showing that the loss of deltamethrin is very low (less than 1%) and that the wash resistance index ranges from 98.9% to 99.5% and from 96.8% to 98.9% respectively. He provided also data showing that the dimensional stability to washing and bursting strength remains unchanged after accelerated storage.

ANNEX 1: REFERENCES

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
(5212) 010-0047	Bureau Veritas	2012	Physical tests on Panda Net 2. Report (5212) 010-0047 of Bureau Veritas for LIFE IDEAS Biological Technology Co. Ltd., January 12, 2012.
	CIPAC	2013	MT 195. Wash resistance index of LN, available at http://www.cipac.org/prepubme.htm
2670/2011-1	CITEVE	2011	Physical tests on Panda Net 2. Report 2670/2011-1 of CITEVE, Portugal for the Walloon Agricultural Research Centre, Gembloux, Belgium, April 28, 2011.
3696/2011-1	CITEVE	2011	Physical tests on Panda Net 2. Report 3696/2011-1 of CITEVE, Portugal for the Walloon Agricultural Research Centre, Gembloux, Belgium, June 06, 2011.
8437/2012-1	CITEVE	2012	Physical tests on Panda Net 2. Report 8437/2012-1 of CITEVE, Portugal for LIFE IDEAS Biological Technology Co. Ltd., November 12, 2012.
1599/2013-1	CITEVE	2012	Mesh count of Panda Net 2. Report 1599/2013-1 of CITEVE, Portugal for LIFE IDEAS Biological Technology Co. Ltd., March 01, 2013.
22503	CRA-W	2011	Physical and chemical properties and accelerated storage stability tests for Panda Net 2. Report Life Ideas / RE 22503 / 2011 of the Walloon Agricultural Research Centre, Gembloux, Belgium for LIFE IDEAS Biological Technology Co. Ltd., August 03, 2011.
23671	CRA-W	2014	Deltamethrin wash resistance index for Panda Net 2. Test report RE/14/U10/23671 of the Walloon Agricultural Research Centre, Gembloux, Belgium for LIFE IDEAS Biological Technology Co. Ltd., August 07, 2014.
RE/13/U10/ 23257	CRA-W	2013	Determination of deltamethrin in Panda Net 2.0 from the WHOPES Phase I testing and evaluation of Panda Net 2.0. Test report RE/13/U10/23257 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, July 17, 2013.
RE/14/U10/ 23709/1	CRA-W	2015	Determination of deltamethrin in Panda Net 2.0 from the WHOPES Phase II testing and evaluation of Panda Net 2.0 in Thailand. Test report RE/14/U10/23709/1 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, June 26, 2015.
RE/14/U10/ 23709/2	CRA-W	2015	Determination of deltamethrin in Panda Net 2.0 from the WHOPES Phase II testing and evaluation of Panda Net 2.0 in Tanzania. Test report RE/14/U10/23709/2 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, March 30, 2015.
RE/14/U10/ 23709/3	CRA-W	2015	Determination of deltamethrin in Panda Net 2.0 from the WHOPES Phase II testing and evaluation of Panda Net 2.0 in Côte d'Ivoire. Test report RE/14/U10/23709/3 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, March 30, 2015.
D12024E D12028E D12007E D12014E D12017E	DPTC	2012	Deltamethrin content in Panda Net 2. Reports D12024E, D12028E, D12007E, D12014E and D12017E of the Changzhou testing and technical center for dangerous goods and packaging for Life Ideas Textiles Co., Ltd., May - September 2012.

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
	FAO/WHO	2010	Manual on development and use of FAO and WHO specifications for pesticides. Second revision of the 1st edition. FAO, Rome and WHO, Geneva, November 2010 (internet publications).
	Paton William	2012	Draft specification and supporting data for Panda Net 2. JMPS data package. LIFE IDEAS Biological Technology Co. Ltd., November, 2012.
1442b/0411	T.E.C. Laboratory	2012	Assessment of the insecticide efficacy of an anti-mosquito impregnated bed net (Panda Net 2). Report 1442b/0411 of T.E.C. Laboratory, France for LIFE IDEAS Biological Technology Co. Ltd., February 13, 2012.
	WHO	2005	Guidelines for laboratory and field testing of long-lasting insecticidal mosquito nets. Document WHO/CDS/WHOPES/GCDPP/2005.11. WHO, Geneva, 2005.
	WHO	2013	Report of the Sixteenth WHOPES Working Group Meeting, WHO/HQ, Geneva, 22-30 July 2013. WHO, Geneva, document WHO/HTM/NTD/WHOPES/2013.6 (ISBN 978 92 4 150630 4).
	WHO	2015	Report of the Eighteenth WHOPES Working Group Meeting, WHO/HQ, Geneva, 29 June - 1 July 2015.

DELTAMETHRIN

FAO/WHO EVALUATION REPORT 333/2011

Recommendations

The Meeting recommended the following.

A time-limited interim specification (until September 2014) for deltamethrin long-lasting (incorporated into polypropylene) insecticidal net, proposed by Bayer CropScience and as amended, should be adopted by WHO.

Appraisal

Supporting data and draft specifications for deltamethrin long-lasting (incorporated into polypropylene) insecticidal net (LN), provided by Bayer CropScience, were considered by the Meeting for development of a new WHO specification. Appropriate clauses, limits and methods of testing for certain parameters of this new type of formulation were developed by the company and scientific institutes.

The deltamethrin (incorporated into filaments) LN produced by this manufacturer was tested and evaluated by WHOPES and a time-limited interim recommendation for their use in malaria prevention and control was issued in 2011 (WHO 2011).

The diversity of LN technologies currently requires specification clauses and limits to be tailored to individual products or type of products, as efficacy is strongly dependent on retention / release characteristics of the product. The LN under consideration is a warp knitted fabric in which deltamethrin is incorporated into multi-filament polypropylene fibres of 100 denier at the target dosage of 8.5 g deltamethrin per kg of netting material.

The active ingredient incorporated into the LN is from a source compliant with the existing WHO specification for deltamethrin (Bayer CropScience).

Description clause

The Meeting agreed that the specification should be applied to netting, in bulk, and to finished rectangular and conical bed nets, made from 100 denier multi-filament polypropylene fibers.

Active ingredient content clause

The target dose of deltamethrin (8.5 g/kg) is related to the LN technology and the specific insecticidal activity of the active ingredient, in order to achieve a satisfactory biological activity. The target dose on a fabric area basis (340 mg/m^2) is calculated from measurements of g/kg and fabric density in g/m^2. The Meeting agreed that the declared and tolerance values should be based on g/kg, with the corresponding mg/m^2 value being defined in a Note to the specification.

The extension of the CIPAC method 333/LN/(M)/3 (CIPAC/4673/m) for determination of deltamethrin in incorporated into polyethylene LN by high performance liquid chromatography with UV detection (HPLC-UV) was accepted as a provisional CIPAC method in 2009. This method was additionally validated for determination of deltamethrin in incorporated into polypropylene LN (CIPAC/4797/m, as referenced in the specification) and was accepted as provisional CIPAC method in 2011. Bayer CropScience provided also the Meeting with a new method involving extraction by refluxing with xylene, precipitation of the polymer with 2-propanol, filtration and rinsing with acetonitrile, and chromatographic determination by high performance liquid chromatography with UV detection (HPLC-UV). This method was successfully validated and showed comparable results with the provisional CIPAC method.

Special attention needs to be paid to control random variations in the distribution of the insecticide within the net and between nets. The manufacturer provided spatial variation data on 15 nets showing a good within-net homogeneity of the active ingredient content (n= 5, RSD ranging from 2.81 to 7.15%) and also a low between net variability (n=15, RSD = 1.92%). The WHOPES Phase I and II trials showed also that deltamethrin content complies with the target dose (except for 2 samples which were just below the tolerance lower limit), and that the distribution of deltamethrin within and between nets is homogeneous (WHO 2011).

During the manufacturing process of deltamethrin LN, epimerization of deltamethrin to the (insecticidally inactive) R-alpha isomer may occur. This conversion must be controlled by the manufacturer to avoid losses of active ingredient. This epimer is not a relevant impurity but excessive amount may lead to loss of biological activity. WHOPES Phase I trial and one WHOPES Phase II trial showed that deltamethrin R-alpha isomer is less than 10% of the deltamethrin content. Nevetherless, in two of the WHOPES Phase II trials, the deltamethrin R-alpha isomer content was relatively high (19% of the deltamethrin content) (WHO 2011).

This conversion can also occur if the LN is exposed to excessive heat or UV light during storage or use. The Meeting agreed that the R-alpha isomer should remain designated as a non-relevant impurity and hence remained excluded from the specification. It is however indirectly specified by the content clause in the accelerated storage test, where at least 95% of deltamethrin has still to be present after the test thus limiting the epimerization during storage to a maximum of 5%.

Active ingredient retention index clause

An adequate amount of active ingredient must be present at the surface of the LN, for efficacy, whereas the majority must reside within the LN, to avoid excessive losses during washing and to provide a reservoir from which the surface is replenished with active ingredient. Depletion of total active ingredient content by washing (retention index) is accomplished by analyzing separate washed and unwashed pieces of the same fabric. The manufacturer provided data on deltamethrin content and associated biological efficacy of LifeNet® washed up to 60 times (according to the WHO washing procedure). These data showed an exponential decay of the deltamethrin content in function of the number of washes (free-migration stage behaviour) with the exception of the first wash which removes a higher amount of deltamethrin. The regeneration time is less than 24 hours.

Currently (2011), CIPAC is developing a wash method for the determination of the retention behaviour of long-lasting insecticidal mosquito nets. This method is a

further standardisation 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, World Health Organization, Geneva, 2005. Briefly, the retention index is determined by analyzing net samples in triplicate representing wash points 0 and 4 for total active ingredient content and calculating the average retention index using the equation for a free migration stage behaviour (WHO 2008).

The data provided by the manufacturer showed that a deltamethrin retention index of minimum 80% after the first wash and within the range 0.94 to 0.99 for the subsequent washes is adequately supported. WHOPES Phase I data confirmed also these clauses.

Relevant impurities clause

There are no relevant impurities identified in the existing WHO specifications for deltamethrin TC.

Physical properties clauses

The clauses for dimensional stability to washing and bursting strength specify ISO methods. The test method for netting mesh size does not require standardization.

The ±5 % tolerance for dimensional stability to washing is in agreement with the standard of 5 % given in the LN guideline (FAO/WHO 2010) and was supported by test results.

Storage stability clause

Although deltamethrin in bulk is stable over a very wide temperature range and has very low volatility, in the LN it apparently behaves differently. The manufacturer provided data after storage in a closed glass bottle at 40°C for 8 weeks showing that the determined average deltamethrin content is higher than 95% of the average content found before storage, and that the net still complies with the limit set for the retention index. Moreover the physical properties of the fabric are maintained after the storage stability test. The storage of the LN at 54°C for 14 days showed that the retention index can be lower than the limit specified. The Meeting agreed to include in the specification the testing at 40°C for 8 weeks.

ANNEX 1: REFERENCES

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
AQ 009-10 M-413937-01-1	Broda J.	2010	Accelerated storage stability study for 8 weeks at 40°C for deltamethrin LN 0.85A W [Deltamethrin long lasting (incorporated into polypropylene insecticidal mosquito net (LN)]. Report AQ 009-10. BioGenius GmBH, Bergisch-Gladbach, Germany, March 2010.
22357 M-413938-01-1	CRA-W	2010	Determination of deltamethrin in Lifenet [deltamethrin long-lasting (incorporated into polypropylene) insecticidal net (LN)]. Report WHO / RE 22357 / 2010 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, December 10, 2010.
22402 M-413939-01-1	CRA-W	2011	Determination of deltamethrin and its R-alpha isomer in Lifenet® [deltamethrin long-lasting (incorporated into polypropylene) insecticidal net (LN)] : comparative study of 2 analytical methods (extension of CIPAC method 333/LN/(M)/3 and Bayer CropScience method AM013809MF1). Report BAYER / RE 22402 / 2010 of the Walloon Agricultural Research Centre, Gembloux, Belgium for Bayer CropScience, March 11, 2011.
22472 M-413940-01-1 M-413941-01-1 M-413942-01-1	CRA-W	2011	Determination of deltamethrin in LifeNet (deltamethrin long-lasting (incorporated into polypropylene) insecticidal net (LN)). [WHOPES Phase II testing and evaluation of LifeNet in Benin, India and Tanzania). Reports WHO / RE 22472 / 2011 / 1, 2 & 3 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, May 2011.
22540 M-413943-01-1	CRA-W	2011	Validation of the extension of the CIPAC method 333/LN/(M)/3 (CIPAC/4673/m) for determination of deltamethrin in LifeNet® [deltamethrin long-lasting (incorporated into polypropylene) insecticidal net (LN)]. Report BAYER / RE 22540 / 2011 of the Walloon Agricultural Research Centre, Gembloux, Belgium for Bayer CropScience, June 01, 2011.
	FAO/WHO	2006	Manual on development and use of FAO and WHO specifications for pesticides. March 2006 revision of the 1st edition. FAO, Rome and WHO, Geneva, March 2006 (internet publications).
	FAO/WHO	2010	Manual on development and use of FAO and WHO specifications for pesticides. Second revision of the 1st edition. FAO, Rome and WHO, Geneva, November 2010 (internet publications).
E-0631-Z-10 M-413953-01-1	Haid H. & Wendtlandt	2010	Determination of selected properties of insecticidal nets according to WHO-instruction (March 2006). Report E-0631-Z-10 from the Institut für Textil- und Verfahrenstechnik (ITV), Central laboratory, Denkendorf, Germany.
E-0212-Z-10 M-413944-01-1	Haid H. & Wendtlandt	2010	Determination of selected properties of insecticidal nets according to WHO-instruction (March 2006). Report E-0212-Z-10 from the Institut für Textil- und Verfahrenstechnik (ITV), Central laboratory, Denkendorf, Germany.
CIPAC/4797/m CIPAC/4798/R	Krautstrunk Gerhard	2011	Validation study for the extension of the scope of CIPAC method 333/LN/(M)/3 (CIPAC/4673) for the determination of deltamethrin in LifeNet® [deltamethrin long-lasting (incorporated into polypropylene) insecticidal net (LN)]. 2011 CIPAC Technical Meeting, CIPAC documents 4797/m and 4798/R.

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
AQ 028-11 M-413946-01-1	Manka S.	2011	Determination of the Retention Index for Deltamethrin LN 0.85B W. Report AQ 028-11. BioGenius GmBH, Bergisch-Gladbach, Germany, March 2011.
AQ 040-11 M-413948-01-1	Manka S.	2011	Storage Stability under Accelerated Conditions. Determination of the Content and Retention Index for Deltamethrin LN 0.85B W stored in Glass Bottles. BioGenius GmBH, Bergisch-Gladbach, Germany, July 2011.
M-364693-01-1	Nentwig G.	2010	Wash resistance of LifeNet® : Wash resistance study of LifeNet® against *Anopheles gambiae*, susceptible strain KISUMU, according to WHO protocols. Results after 0-60 washes. Report MÜ090818b, BES-03678, M-364693-01-1. Bayer CropScience AG, Monheim, Germany, February 2010.
M-358969-01-1	Odendahl A. & Zitmann W.	2009	Validation of HPLC-method AM013809MF1 – Determination of deltamethrin and its R-alpha isomer in polypropylene matrices – normal phase method – deltamethrin LN 0/85 (8.5 g/kg). Bayer CropScience AG, Development – Formulation Technology, Monheim – Germany, November 2009.
M-366384-01-1	Patty L & Horn K.	2010	LifeNet®. WHOPES Dossier. Bayer CropScience, March 2010.
M-395535-01-1	Patty L.	2010	LifeNet®. JMPS Dossier. Bayer CropScience, October 2010.
CIPAC/4673/m	Vestergaard-Frandsen	2009	Method extension of CIPAC 333/LN. Determination of deltamethrin in PE by high performance liquid chromatography. 2009 CIPAC Technical Meeting, CIPAC document 4673/m.
CIPAC/4674/R	Vestergaard-Frandsen	2009	Deltamethrin 333/LN. Method extension for polyethylene LN, Validation Data and Statistics. 2009 CIPAC Technical Meeting, CIPAC Document 4674/R.
M-358904-01-1	Zitmann W.	2009	Analytical method AM013809MF1 - Determination of deltamethrin and its R-alpha isomer in polypropylene matrices - Assay HPLC, external standard, normal phase. Bayer CropScience AG, Development – Formulation Technology, Monheim – Germany, November 2009.
	WHO	2005	Guidelines for laboratory and field testing of long-lasting insecticidal mosquito nets. Document WHO/CDS/WHOPES/GCDPP/2005.11. WHO, Geneva, 2005.
	WHO	2005	Technical consultation on specifications and quality control of netting materials for mosquito nets (untreated and treated). 29 November–02 December 2005. WHO Headquarters, Geneva, Switzerland.
	WHO	2008	Report of the Eleventh WHOPES Working Group Meeting, WHO/HQ, Geneva, 10-13 December 2007. WHO, Geneva, document WHO/HTM/NTD/WHOPES/2008.1.
	WHO	2011	Report of the Fourteen WHOPES Working Group Meeting, WHO/HQ, Geneva, 11-15 April 2011. WHO, Geneva, document WHO/HTM/NTD/WHOPES/2011.7

DELTAMETHRIN

FAO/WHO EVALUATION REPORT 333/2010.1

Recommendations

The Meeting recommended the following.

A time-limited interim specification (until August 2013) for deltamethrin long-lasting (incorporated into filaments) insecticidal net, proposed by Intelligent Insect Control and as amended, should be adopted by WHO.

Appraisal

Supporting data and draft specifications for deltamethrin long-lasting (incorporated into filaments) insecticidal net (LN), provided by Intelligent Insect Control, were considered by the Meeting for development of a new WHO specification. Appropriate clauses, limits and methods of testing for certain parameters of this new type of formulation were developed by the company and scientific institutes.

The deltamethrin (incorporated into filaments) LN produced by this manufacturer was tested and evaluated by WHOPES and a time-limited interim recommendation for their use in malaria prevention and control was issued in 2007 (WHO 2008).

A provisional specification guideline for LN formulations was accepted by the JMPS in 2004 and published by WHO. The guideline for LN was subsequently amended, taking into account the recommendations of a WHO consultation on mosquito nets (WHO 2005) and published in the revised manual (FAO/WHO 2006). However, the apparent diversity of LN technologies currently requires specification clauses and limits to be tailored to individual products.

The LN under consideration is a raschel-warp-knitted fabric in which the active ingredient, deltamethrin, is incorporated into the polymer prior to the spinning process. The yarn is a mixture of high, medium and low density polyethylene monofilament. The manufacturer confirmed that the active ingredient incorporated into the LN is from a source compliant with the existing WHO specification for deltamethrin (Tagros).

Description clause

The Meeting agreed that the specification should be applied to white or coloured raschel-warp-knitted fabrics made from 118 denier monofilament spun from a mixture of high, medium and low density polyethylene yarn and that it should apply equally to made up, ready-to-use nets (rectangular and circular) or to netting in bulk. The supporting data show that the incorporation process (mixing of deltamethrin TC with the high, medium and low density polyethylene) and the subsequent melt-spinning process leads to an increase in the αR-isomer at the expense of deltamethrin, which is a single isomer pyrethroid having αS-configuration. The description clause was therefore slightly modified ("complying with the TC specification prior to incorporation") in order to allow for the higher relative content of

αR-isomer, a non-relevant impurity, as compared to the TC. Initially, a limit for αR-isomer was proposed in the draft specification but the Meeting agreed that it was not necessary and the clause for isomer ratio of the active ingredient was removed.

Active ingredient content clause

The target dose of deltamethrin (1.8 g/kg) is related to the LN technology and the specific insecticidal activity of the active ingredient, in order to achieve a satisfactory biological activity. The target dose on a fabric area basis (68.4 mg/m^2) is calculated from measurements of g/kg and fabric density in g/m^2 which has at least 20 complete holes per cm^2. The Meeting agreed that the declared and tolerance values should be based on g/kg, with the corresponding mg/m^2 value being defined in a Note to the specification.

Special attention needs to be paid to control random variations in the distribution of the insecticide over the surface of the net and between nets. The manufacturer provided between- and within-batch data which demonstrated a good homogeneity of the active ingredient content within and between nets (RSD < 5%). The WHOPES Phase I and II data showed also that deltamethrin content complies with the target dose and that the distribution of deltamethrin within and between nets is homogeneous.

Study reports submitted by Intelligent Insect Control to support the specification involved different analytical methods for deltamethrin content. The method involving extraction with hot heptane (existing CIPAC method for permethrin incorporated into filaments) and determination by HPLC with UV detection (existing CIPAC method for deltamethrin coated onto filaments) underestimates the content of insecticide in the LN formulation. Other methods involve extraction by refluxing with xylene and determination by GC-ECD, GC-FID or HPLC-UV or extraction by refluxing with xylene, exchange of solvent to HPLC mobile phase and determination by HPLC-UV. This last method (CIPAC/4673/m) was presented to CIPAC as an extension of the CIPAC method 333/LN/(M)/3 for determination of deltamethrin in incorporated into polyethylene LN by HPLC-UV and was accepted as a provisional CIPAC method in 2009.

Active ingredient retention index clause

An adequate amount of active ingredient must be present on the surface of the LN, for efficacy, whereas the majority must reside within the fibres of the LN, to avoid excessive losses during washing and to provide a reservoir from which the surface is replenished with active ingredient. The nature of the fibre material – a mixture of polyethylenes of different densities – strongly influences the migration of deltamethrin to the surface when the LN is subjected to repeated washing.

Initially the manufacturer provided data for release index which were elaborated with solvent washes using acetone, methanol, hexane or isooctane / dioxane. These data showed release index values (active ingredient surface concentration in the third wash divided by active ingredient surface concentration in the second wash) ranging between 0.75 to 1.02 depending on the solvent used. These results, whatever quite variable due to the method used, indicated nevertheless a quite high retention of deltamethrin in the LN formulation. The Meeting requested the manufacturer to provide retention index data after washing the net with aqueous detergent (instead of solvent) using the WHO/CIPAC method.

Depletion of total active ingredient content by washing (retention index) is now accomplished by analyzing separate washed and unwashed pieces of the same fabric. Currently, CIPAC is developing a wash method for the determination of the retention behaviour of long-lasting insecticidal mosquito nets. This method is a standardisation 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, World Health Organization, Geneva, 2005. Briefly, the retention index is determined by analyzing net samples in triplicate representing wash points 0 and 4 for total active ingredient content and calculating the average retention index using the equation for a free migration stage behaviour.

The manufacturer provided data showing that approximately constant proportions of the remaining deltamethrin are removed from the polymer by successive washings with aqueous detergent (free-migration stage behaviour, WHO 2008). As the diffusion processes in solid materials are significantly slower than in solution, a certain time period (2 days at 40°C) is necessary to re-establish the equilibrium level of the active ingredient on the surface of polymer. Data obtained after 1, 3 and 5 washes showed an average deltamethrin retention index of 0.98 - 0.99 and the Meeting agreed to specify a minimum retention index of 0.95. WHOPES Phase I data supports also this clause.

Relevant impurities clause

There are no relevant impurities identified in the existing WHO specifications for deltamethrin TC. During the manufacturing process of deltamethrin LN, epimerization of deltamethrin to the (insecticidally inactive) αR-isomer may occur. This conversion must be controlled by the manufacturer to avoid losses of active ingredient. Data initially provided by the manufacturer showed that deltamethrin αR isomer content could reach up to 20 % of deltamethrin content. The manufacturer provided further data indicating that the deltamethrin αR-isomer content can be reduced to 10% of the deltamethrin content.

This conversion can also occur if the LN is exposed to excessive heat during storage or use. The Meeting agreed that the αR isomer should remain designated as a non-relevant impurity and hence remain excluded from the specification. It is however indirectly specified by the content clause in the accelerated storage test, where at least 95 % of deltamethrin is still present after the test thus limiting the epimerization to a maximum of 5 %.

Physical properties clauses

The nets are available in the mesh size 20 complete holes per $cm^{2,}$ (136 mesh/$inch^2$). The clauses for dimensional stability to washing and bursting strength specify ISO methods and apply to net in bulk and manufactured nets. The test method for netting mesh size does not require standardization.

The ±5 % tolerance for dimensional stability to washing is in agreement with the standard of 5 % given in the LN guideline (FAO/WHO 2006) and was supported by test results.

Storage stability clause

Deltamethrin is normally stable over a very wide temperature range and has low volatility and thus its incorporation into a polymer should provide additional protection to the active ingredient. However, storage of the net (without packaging) in an oven at 54ºC for 2 weeks led in a study to a measurable loss of deltamethrin (approximately 8%), although the physical properties of the fabric were maintained. The supporting data showed that the loss of deltamethrin occurs mainly through epimerization to the αR-isomer. The manufacturer provided additional data on the net stored at 54°C for 2 weeks indicating the loss of deltamethrin was less than 5 %. The manufacturer and the Meeting finally agreed to include in the specification the standard testing of 54°C for 2 weeks. Data provided for the retention index on the net stored at 54°C for 2 weeks showed a decrease in retention index (average deltamethrin retention index of 0.93-0.97 after 1, 3 and 5 washes), and the Meeting agreed to specify a minimum retention index of 0.90 after the accelerated storage.

ANNEX 1: REFERENCES

Study number	Author(s)	Year	Study title. Study identification number. Report identification number. GLP [if GLP]. Company conducting the study
21353	CRA-W	2006	Determination of deltamethrin in mosquito net samples (32 samples for the WHOPES testing and evaluation of NetProtect. Report WHO / RE 21353 / 2006 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, November 2006.
21469	CRA-W	2007	Deltamethrin content, deltamethrin release characteristics and accelerated storage stability test for NetProtect [deltamethrin long-lasting (incorporated into filaments) mosquito net (LN)]. Report IIC / RE 21469 / 2007 of the Walloon Agricultural Research Centre, Gembloux, Belgium for Intelligent Insect Control, August 2007.
21608	CRA-W	2007	Determination of deltamethrin and deltamethrin R-isomer in NetProtect. Report IIC / RE 21608 / 2007 of the Walloon Agricultural Research Centre, Gembloux, Belgium for Intelligent Insect Control, October 2007.
21609	CRA-W	2007	Determination of deltamethrin in NetProtect (75 samples for the WHOPES testing and evaluation of NetProtect. Report WHO / RE 21609 / 2007 / 1 of the Walloon Agricultural Research Centre, Gembloux, Belgium for WHO, November 2007.
21616	CRA-W	2007	Determination of deltamethrin and deltamethrin R-isomer in NetProtect. Report IIC / RE 21616 / 2007 of the Walloon Agricultural Research Centre, Gembloux, Belgium for Intelligent Insect Control, October 2007.
21672	CRA-W	2008	Determination of deltamethin and deltamethrin R-isomer in NetProtect: comparison of 2 analytical methods. Report IIC / RE 21672 / 2007 of the Walloon Agricultural Research Centre, Gembloux, Belgium for Intelligent Insect Control, March 2008.
21676	CRA-W	2008	Deltamethrin content, deltamethrin R-isomer content and deltamethrin release characteristics for NetProtect® [deltamethrin long-lasting (incorporated into filaments) insecticidal mosquito net (LN)]. Report IIC / RE 21676 / 2007 of the Walloon Agricultural Research Centre, Gembloux, Belgium for Intelligent Insect Control, August 2008.
CIPAC/4682/m	CRA-W	2009	Determination of deltamethrin and/or piperonyl butoxide in Long-Lasting (incorporated into polyethylene) Insecticidal Mosquito Nets. Analytical method by GC-FID. 2009 CIPAC Technical Meeting, CIPAC Document 4682/m.
CIPAC/4683/R	CRA-W	2009	Determination of deltamethrin and/or piperonyl butoxide in Long-Lasting (incorporated into polyethylene) Insecticidal Mosquito Nets. Validation and performance verification of the analytical method by GC-FID. 2009 CIPAC Technical Meeting, CIPAC Document 4683/R.
22094	CRA-W	2009	Deltamethrin content in samples of masterbatches, socks and PE netting. Report IIC / RE 22094 / 2009 of the Walloon Agricultural Research Centre, Gembloux, Belgium for Intelligent Insect Control, December 2009.
22307	CRA-W	2010	Accelerated storage stability study (deltamethrin content and retention / release index) for NetProtect [deltamethrin long-lasting (incorporated into polyethylene) insecticidal mosquito net (LN)]. Report IIC / RE 22307 / 2010 / 1 of the Walloon Agricultural Research Centre, Gembloux, Belgium for Intelligent Insect Control, July 2010.

	FAO/WHO	2006	Manual on development and use of FAO and WHO specifications for pesticides. March 2006 revision of the 1st edition. FAO, Rome and WHO, Geneva, March 2006 (internet publications).
	Intelligent Insect Control	2007	Technical data and draft specification submitted by Intelligent Insect Control to WHO for application for WHO specifications, November 2007.
CH:TX:9420056105	SGS		Bursting strength, dimensional change after washing, tensile strength, weight per unit area for NetProtect. Report CH:TX:9420056105 for Bestnet Europe Ltd., October 2009.
CIPAC/4673/m	Vestergaard-Frandsen	2009	Method extension of CIPAC 333/LN. Determination of deltamethrin in PE by high performance liquid chromatography. 2009 CIPAC Technical Meeting, CIPAC document 4673/m.
CIPAC/4674/R	Vestergaard-Frandsen	2009	Deltamethrin 333/LN. Method extension for polyethylene LN, Validation Data and Statistics. 2009 CIPAC Technical Meeting, CIPAC Document 4674/R.
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	WHO	2005	Technical consultation on specifications and quality control of netting materials for mosquito nets (untreated and treated). 29 November–02 December 2005. WHO Headquarters, Geneva, Switzerland.
	WHO	2008	Report of the Eleventh WHOPES Working Group Meeting, WHO/HQ, Geneva, 10-13 December 2007. WHO, Geneva, document WHO/HTM/NTD/WHOPES/2008.1.