Abstract: Present invention relates to an insecticidal textile product having at least a first yarn type and second yarn type, said first yarn type comprises an insecticide and the second yarn type does not contain an insecticide, repellent or chemosterilant. Preferred is an insecticidal textile product comprising a first yarn made of polyethylene and a second yarn not containing insecticide and is preferably made of pure HDPE polyethylene and made into a bed net for the prevention of malaria.
TITLE: A strong insecticidal net

FIELD OF THE INVENTION
The present invention relates to an insecticidal textile product comprising at least two yarn types wherein the first yarn type comprises an insecticide, insect repellent or chemosterilant and the second yarn type does not contain an insecticide, insect repellent or chemosterilant, as well as a method to manufacture the textile product of the present invention.

BACKGROUND OF THE INVENTION
Insecticide-treated nets are widely used for the prevention of malaria. Generally these are textile products made of polyester coated with an insecticide or in case of polyethylene or polypropylene the insecticide is incorporated into the polymer composition. There are numerous prior art documents available such as WO0137662 and WO2007085640 which are related to polyester coated with insecticide. For example JP8302080A and WO2008001926, which are related to polyethylene resin compositions with insecticide and US 201 10256198 relates to a polypropylene composition with insecticide. Such resins can be extruded into yarns where from textile products can be made.

Polyethylene compositions can be made from different polyethylene polymers; these may be LDPE, LLDPE, MDPE and HDPE. LLDPE (Linear low-density polyethylene) is a substantially linear polymer (polyethylene), with significant numbers of short branches, commonly made by copolymerization of ethylene with longer-chain olefins.

MDPE is medium-density polyethylene is a substantially linear polymer of polyethylene with shorter chain length than HDPE. HDPE (High-Density PolyEthylene) or PolyEthylene High-Density (PEHD) is a polyethylene thermoplas.

HDPE has little branching, giving it stronger intermolecular forces and tensile strength than lower-density polyethylene. It is also harder and more opaque and can withstand somewhat higher temperatures (120 °C/248 °F for short periods, 110 °C/230 °F continuously). HDPE yarns are stronger than LDPE mixed polyethylene yarns.

LLDPE is linear low-density polyethylene (LLDPE) is a substantially linear polymer (polyethylene), with significant numbers of short branches, commonly made by copolymerization of ethylene with longer-chain olefins. Linear low-density polyethylene differs structurally from convention allow-density polyethylene because of the absence of long chain branching.

These polyethylene compositions (HDPE, LDPE, LLDPE and mixture thereof) are generally used for preparing yarns and polyethylene based textile products such as for example Netprotect.
Netprotect ® is a polyethylene net wherein there is incorporated (formulated in the polyethylene composition as referred to herein) insecticide deltamethrin. This is a typical example of a malaria bed net for the protection of humans. Polypropylene multifilament yarns with insecticide incorporated are also used for bed nets, e.g. LifeNet ® from Bayer.

The incorporation of insecticide into the polymer resin compositions weakens the yarn. This is known in the prior art. US4680328 describes that when insecticide added to thermoplastic compositions, it weakens the tensile strength. For example in section 1 of US4680328 (lines 64 to 68) describing the adverse effect of high content of insecticide on the desirable physical properties of the composition including resistance, creep and stress crack and tensile strengths. Mixtures of HDPE and LDPE were suggested to compensate for such strength losses, thus making use of the stronger HDPE properties and mixing therein a minor amount of LDPE.

The reduced strength of polyethylene yarns has a consequence that in case such weaker yarns are used for the preparation of a textile bed net, holes appear faster in the net and hereby the net looses efficiency as insects (e.g. mosquitoes) easily can find the holes and bite the human hereby transferring the malaria protozoa.

WO201 01 15709 (Ole Skovmand) relates to polyethylene compositions with improved control of release of active ingredient and more stable under storage conditions without mentioning the physical characteristics such as strengths.

Insecticides may be incorporated into the LDPE or LLDPE to form a concentrate, termed Master Batch, to be mixed with the basic polymer (US1 4801 25).

As explained in WO201 01 15709, mixing a minor amount of LDPE/LLDPE into HDPE already results in some loss of tensile strength. The skilled person set to make a polyethylene textile product with insecticide is restricted in the possible amount of LDPE/LLDPE which can be mixed into the HPDE because of the risk of loss of strength. The lower the LDPE/LLDPE amount needed, the more advantageous it is and the less tensile strength will be lost. The problem of losing strength of a yarn containing an insecticide was therein solved by the addition of special waxes, allowing the addition of even lower amounts of LDPE/LLDPE into the resin mixture (HDPE and LDPE). The insecticide is dissolved in the wax and the wax is soluble in the polymer.

Mixtures of HDPE and LDPE are in present invention also termed mixed yarns.

WO2009003468 (Vestergaard Frandsen) discloses an insecticidal thread with a first monofilament and second monofilament. The thread as disclosed therein is having a first and a second cross sectional part. The first part may have an insecticide and the second part being free from
insecticide, both incorporated in polymeric material. First part is a filament may be with insecticide
and second filament without insecticide. Such threads can be used for the preparation of
insecticidal textile products. Figure 1 in WO2009003468 illustrates a thread with two different
filament yarns. As disclosed on page 10 of WO2009003468 (figure 1), the thread (1) contains a
first monofilament (2) and a second filament (3) together forming the thread. Clearly,
WO2009003468 does not disclose a textile product made of two different or separate yarn types.

WO2009003470 relates to an insecticidal textile product with an upper net part and a lower part
made of higher tear strength. However, this ability is not obtained. A product is produced according
to the described patent and was tested in: Strength of bed nets as function of denier, knitting
patterns, texturizing and polymer, Skovmand and Bosselmann, 2011, Malaria J. The article shows
that tear strength was not higher in the lower part though the bursting strength was improved. It
discloses the possibility to have a first yarn with a first concentration (for example higher than
second) and a second yarn with lower insecticide concentration. WO2009003470 does not disclose
an insecticidal textile product where there is combined of an insecticidal yarn and a yarn not
containing insecticide.

WO201 0046348 (Ole Skovmand) discloses a 1st yarn with at least 1st insecticide and 2nd yarn with
2nd insecticide. WO201 0046348 discloses a textile product made of two insecticidal yarn types
AND both comprise an insecticide. The two different insecticidal yarns are made into an insecticidal
textile product and the polymer composition of the yarn type is made as such that the release of
the two insecticides is regulated, so they are simultaneously released, especially useful to make
textile products (e.g. bed nets) in areas where there is high resistance levels of mosquitoes against
insecticides as chosen for the yarn types. WO201 0046348 does not disclose an insecticidal textile
product where there is combined an insecticidal yarn and a yarn not containing insecticide.

WO201 1054825 (Ole Skovmand) discloses an insecticidal textile product with two different yarn
types both comprising insecticide. A first yarn type with first insecticide may be twisted around a
second yarn type with a second insecticide. Such textile products are more effective in killing
resistant insect populations. WO201 1054825 does not disclose an insecticidal textile product
where there is combined of an insecticidal yarn and a yarn not containing insecticide.

discloses a textile product (a net) made of polyester. The polyester net was cut to separate the top
from the four sides and then the top, the four sides or the whole net was impregnated with
insecticide, before the net was sewn back together. Oxborough et al thus investigated a net made
of different pieces of polyester netting; 1) the two sides treated with insecticide and roof not treated,
2) the roof treat with insecticide and the sides not treated, 3) the entire net treated with insecticide
and 4) an entirely not treated net. Oxborough et al does not disclose an insecticidal textile product with two different yarn types, as all the yarn are treated by impregnation.

There is a continuous need to improve polyethylene yarns and textile products, especially to make them more efficacious, stronger, more durable, cheaper and safer for use.

**SUMMARY OF THE INVENTION**

A first object of the present invention is to provide an insecticidal textile product with improved killing efficacy of insects to better protect humans against nuisance insects and diseases transmitted by insects (e.g. malaria carrying mosquitoes).

A second object of the present invention is to provide an insecticidal textile product which is stronger (i.e. a higher bursting strength when measured on the textile product or in case of a yarn a high level of tear strength - tenacity) resulting in an insecticidal textile product which is more durable (stronger) and has a longer life time. In weak nets, holes appear fast, which reduces the nets efficaciousness as insects obviously can enter the net covered area and bite the humans hereby transferring diseases.

The prior art is teaching to mix insecticide into LLDPE or LDPE and thereafter blend that mixture into HPDE forming the polymer composition to make yarns. Mixing LDPE into HDPE is done to obtain sufficiently strong yarns. It is known by the skilled person that, in general, the addition of insecticide such as deltamethrin added to polyethylene weakens the polymer composition resulting in a weak textile product, easily breaking and having causing holes.

It is believed that the insecticide and also generally some additives, make the polyethylene polymer softer as by such addition, the polymer is forced into in a more amorphous state as compared to the more rigid crystalline state when there is no insecticide or additives present.

This is also described in WO2010046348. There are many additives available in the plastic industry also termed plasticisers. These are known additives to the skilled person. Many of these additives as used in the polyethylene industry (plasticisers) may also cause weakening of textile products made thereof. Clearly, today, the skilled person is very restricted in using the available additives also in combination with insecticides in polyethylene compositions.

A third object of the present invention is to provide an insecticidal textile product which is resistant against fire, without losing strength of the textile product or yarn. It is known in the prior art that certain anti-flammability additives can be used and as known are mixed into the polyethylene polymer resin composition. These must normally be added in quite substantial amounts. However, such anti flammability additives, especially in combination with insecticides, even further weakens
the yarns making it impossible today to do make a textile product which has good anti flammability properties. Further, some anti-flammability additives may have a negative impact on the stability of the insecticide i.e. breakdown of the insecticide due to the presence of additives.

This is known for example in the combination of deltamethrin and some Hindered Amin Light Stabilizer (HALS and are derivatives of 2,2,6,6-tetramethyl piperidine) causing severe losses of active deltamethrin due to isomerisation (US20110256198). Deltamethrin may be in the R-isomer form and the S-isomer form. The R-isomer form is not insecticidal active. Addition of some HALS additives increases the amount of R isomer. This then makes the textile product inefficient and for example cannot be used as bed net for the prevention of humans against malaria. Hence, today, some useful plastic additives cannot be directly mixed with insecticide and be present in the same yarn. One of them is an anti-flammability additive preventing polyethylene to burn.

Textile products are often hung in huts and small houses in townships in Africa or Asia. As the total liveable area is not big inside the hut or houses and the polyethylene net hangs close to the kitchen area, this increases the risk of textile nets contacting the stove and may cause polyethylene yarns to burn. When polyethylene in burning, it forms very hot (polyethylene) drops and these may hurt people and causing severe burning damage on the skin.

Therefore, another desired property is an insecticidal textile product which has anti-flammability properties that prevents the drip-off of burning droplets. The problem today is that anti-flammability additives cannot be blended with insecticide as these degrade insecticide (incompatible) and if this incompatibility is to be avoided, the concentrations has to be lowered to a level where it becomes ineffective.

A fourth object of present invention is to decrease the risk of humans to be in direct contact with the insecticide in the insecticidal textile product.

Current insecticidal textile products can easily come into contact with humans. It may happen for example that a human, such as a child, falls asleep against the textile net and has hereby direct skin contact for a long time with the insecticide which is present on the surface of the yarn. There is also often speculated that a baby may even suck for a period of time on the net and hereby ingest insecticide. Indeed, the WHO evaluation program for bed nets stipulates such a scenario. Long lasting impregnated or insecticidal incorporated polyethylene nets expose humans to insecticides (inhalation or intake).

A fifth object of the present invention is to prevent that rats are eating or biting holes into the textile product. This is a known problem especially at storage locations. Textile nets are often stored for
longer time before distribution and they may be stored away in a corner during the day. Rats are often present in storage areas and cause damage and losses of textile nets as they bite holes into the nets or eat the plastic. The present insecticide dosage is not killing the rats. Therefore it is desirable to incorporate into the polyethylene yarn an additive which rats dislike. Such an additive is Capsaicin. Capsaicin and several related compounds are called capsaicinoids (phenolic amide C18H27NO3) and are produced as a secondary metabolite by chili peppers, probably as deterrents against certain herbivores and fungi. It is an irritant for mammals, including humans, and produces a sensation of burning in any tissue with which it comes into contact.

As nets are made today, the skilled person is faced with the same problem namely that such additives cannot be mixed into polyethylene in presence of insecticide as it weakens the yarn and/or causes the insecticide to breakdown due to increased isomerisation as described above.

Today, all textile products (e.g. bed nets) available on the market have yarns wherein humans are exposed to insecticides from both sides of the textile product, such as net. A textile product basically always has a first side and a second side which are on opposite sides of the textile product.

Accordingly, a first aspect of the present invention is an insecticidal textile product comprising a first yarn type and second yarn type, said first yarn type comprises an insecticide, insect repellent or chemosterilant and the second yarn type does not contain an insecticide, insect repellent or chemosterilant.

A second aspect of present invention is a method to manufacture an insecticidal textile product comprising a first yarn type and second yarn type, said first yarn type comprises an insecticide insect repellent or chemosterilant and the second yarn type does not contain an insecticide, insect repellent or chemosterilant, using a weaving or knitting apparatus having a first and a second roll comprising the following steps:

i) prepare the first yarn type comprising an insecticide, insect repellent or chemosterilant,
ii) prepare the second yarn type,
iii) place the first yarns type on the first roll and place the second yarn type on the second roll,
iv) knit or weave by mixing the first and the second yarn types by feeding the first yarn type and feeding the second yarn type to the knitting or weaving machine,
v) obtain the textile product ready for cutting, sewing and shaping, and
vii) optionally, cutting, sewing and shaping the textile product to a specific textile product ready for use.
DEFINITIONS
The term "Denier (D)" represents the weight (g) of 9,000 metre yarn.

The term "LLIN" denotes "long lasting insecticidal net".

The term "Raschel knitted textiles" as used herein is intended to have the meaning as described in US5732573 and such textile may be produced by Raschel Machines as produced by the company Karl Mayer, Liba or Kokett.


The term "matrix" as used herein is denoted as the composite polymer with other additives than the active ingredient (insecticide or biocide) as defined in WO201 015709.

The term "mixed yarns" as used herein denotes synthetic textiles such as mixtures of one or more of polyester, Aramid, acrylic, Nylon, polyurethane, olefin, polylactide, polyethylene mixtures of HDPE and LDPE, polypropylene and polypropylene copolymers and reference is made to WO201 0012671 on page 4.

The term "polymer" as used herein is denoted as polymers as for example olefins and phthalates as referred in WO201 015709. Such polymers are used for making textile products and may without limitation be selected from polyethylene, polyester and polypropylene.

DETAILED DESCRIPTION OF THE INVENTION

An insecticidal textile product
An insecticidal textile product is a textile product comprising an insecticide, insect repellent or chemosterilant for killing, repelling or sterilizing of insects. Such insecticidal textile product herein may be knitted or woven and is basically consisting of a network of yarns. Such textile products are shaped into maybe different forms depending on the uses; curtains, clothing, carpeting, nets, screens, wall decoration. Miscellaneous uses include tents, nets cleaning devices, geotextiles and netting as disclosed in WO03003827 and in WO06024304. Examples of prior art insecticidal textile products are nets such as Netprotect ®, Permanet ®, and Olyset ®.
As disclosed in present invention, the skilled person may chose many possible insecticides and incorporate them into polyethylene and/or polypropylene compositions thereafter preparing yarns for the textile product of the present invention, such as mosquito nets. Insecticides are for example listed in WO201 0046348.

A typical embodiment of present invention is a net, more preferred a mosquito bed net. Other preferred embodiments are for example a curtain, a cushion, a wall covering textile, a tarpaulin, a cloth, an agriculture net and a window/door screen. In particular, the insecticidal textile product is a bed net for the prevention of malaria.

A first yarn type and a second yarn type

According to the present invention, there is used at least a first yarn type comprising an insecticide, insect repellent or chemosterilant and a second yarn that does not contain insecticide, insect repellent and/or chemosterilant. It should be understood that more than one first yarn may be present and may contain an insecticide, insect repellent or chemosterilant, as long as there is at least one second yarn that does not contain an insecticide, insect repellent or chemosterilant. Typically, there is one first yarn type comprising an insecticide, insect repellent or chemosterilant and one second yarn that does not contain insecticide, insect repellent and/or chemosterilant.

The present invention is improved over the prior art in that the textile product is stronger and also has a higher killing effect for insects as disclosed herein.

Said first yarn type may be prepared by known methods such as the incorporation of chosen insecticide into a suitable polymer composition as described in JP8302080 and thereafter making yarns.

The second yarn type herein disclosed is a yarn made of basically any suitable polymer material, such as without limitation polyethylene, polypropylene, polyester, nylon (polyamides). Important herein is that the second yarn type does not contain any insecticide, insect repellent and/or chemosterilant.

Due to that the first yarn type comprises insecticide, insect repellent or chemosterilant and it is typically made of a polyethylene or polypropylene polymer composition comprising low density polyethylene (LDPE), LLDPE, HDPE or low and high melting polypropylene or LLDPE/LDPE mixed into polypropylene and/or mixture thereof, it is a weaker yarn as known in the prior art and also described herein. A LLDPE may be LLDPE-B from the company Formosa Plastics - named Formolene LLDPE or LLDPE from the company Westlake Polymers LLC.
An embodiment is an insecticidal textile product according to present invention, where the first yarn comprises a mixture of polyethylene polymers.

5 A further embodiment is an insecticidal textile product according to present invention, where the second yarn comprises a polymer composition selected from the group consisting of HDPE (high density polyethylene), LDPE (low density polyethylene), mixtures of HDPE and LDPE, polyamide, polypropylene and polyester.

10 A still further embodiment is an insecticidal textile product according to present invention, wherein the first yarn comprises a mixture of HDPE and LDPE and optionally waxes.

The total amount of insecticide needed to obtain a textile product which effectively kills insects according to the WHOPES protocol (WHO/CDS/WHOPES/GCD PP/2005 guidelines) may be regulated by adding the suitable amount of insecticide into the first yarn type of present invention.

In a further embodiment of the insecticidal textile product of the present invention, the first yarn comprises an insecticide in an amount sufficient to kill mosquitoes after at least 15 washes according WHO/CDS/WHOPES/GCD PP/2005 guidelines.

In the textile product of the present invention the total dosage of insecticide per square meter may be the same as in a prior art insecticidal textile product but the total amount of insecticide needed may be concentrated in fewer yarns (e.g. in the first yarn).

As for prior art textile products, the biological effect (e.g. killing of insects such as mosquitoes) has been attributed to dosage of insecticide (mg) per square meter or g/kg net. For example, Netprotect claims to have 2 grams of the insecticide deltamethrin/kg net or 68 mg/m². Other long lasting nets such as impregnated polyester nets comprise 54 mg deltamethrin/square meter. This amount may vary according to the properties of the polymer matrix used or type of polymer composition chosen by the skilled person.

In an embodiment of the present invention, the dosage per square meter was kept constant (e.g. 68 mg deltamethrin per square meter) but two different yarns were used in the present invention, i.e. a first yarn type comprising insecticide, insect repellent or chemosterilant and a second yarn type not containing an insecticide, insect repellent or chemosterilant.

In a further embodiment of the present invention the first and second yarns were made into a textile product (such as bed net) using 70% of the total used meters in length of first yarn type in the
textile product comprising deltamethrin and 30% of the total used meters in length of a second yarn type not containing an insecticide, insect repellent or chemosterilant.

Typically, knitting was done with known methods such as warp knitting as described in Journal of Textile and Apparel, Technology and Management, Volume 4, Issue 4, 2005. Knitted mesh using Raschel knitting is described in US2992550.

The present inventor has realized that while keeping the total insecticide dosage per square meter or per kg textile constant and concentrate the insecticide in one yarn type and keeping at least one second yarn type free of insecticide results in a higher killing effect of the insecticide textile product as compared to using equal yarn (two yarns each comprising an insecticide) as done in the prior art today.

A further embodiment is an insecticidal textile net of the present invention comprising a first yarn comprising an insecticide, insect repellent or chemosterilant and a second yarn not containing an insecticide, insect repellent or chemosterilant wherein 30% of the total meters of yarns used is from the first yarn and 70% from the second yarn.

The skilled person reading present work may now choose any first and second yarn ratio depending on the insecticide chosen, polymer matrix chosen and additives chosen (e.g. fireproof additives that often have to be dosed highly for sufficient efficacy).

**Second yarn type**

The second yarn type may be made of pure polymer composition such as HDPE, LDPE, polypropylene, polyamide or mixtures thereof.

A preferred embodiment is an insecticidal textile product according to present invention comprising a second yarn type made of pure HDPE. It is chosen because pure HDPE is the strongest and most rigid polyethylene composition. When a polyethylene polymer comprising only HDPE is made into the second yarn type and used in an insecticidal textile product (e.g. a net) of present invention, the insecticidal textile product becomes very strong.

A further embodiment of the second yarn type is polypropylene.

By present invention it is now possible to make a stronger net typically, but not limited by using pure polyethylene polymer compositions (such as HDPE pure) or any suitable other materials (nylon, polyester or polypropylene).
An insecticide, insect repellent or chemosterilant

**Insecticides**

Preferred insecticides may belong to the group pyrethroid compounds such as ethofenprox: 2-(4-ethoxyphenyl)-2-methylpropyl-3-phenoxybenzyl ether; Fenvalerate: (RS)-alpha-cyano-3-phenoxybenzyl (RS)-2-(4-chlorophenyl)-3 methylbutyrate; Esfenvalerate: (S)-alpha-cyano-3-phenoxybenzyl (S)-2-(4-chlorophenyl)-3-methylbutyrate; Fenpropofol: (RS)-alpha-cyano-3-phenoxybenzyl 2,2,3,3-tetramethylcyclopropanecarboxylate; Cypermethrin: (RS)-alpha-cyano-3-phenoxybenzyl (1 RS)-cis, trans-3-(2,2,2-dichlorovinyl)-2,2- dimethylcyclopropanecarboxylate;

Permethrin: 3-phenoxybenzyl (1 RS)-cis, trans-3-(2,2,2-dichlorovinyl)-2,2- dimethylcyclopropanecarboxylate; Cyhalothrin: (RS)-alpha-cyano-3-phenoxybenzyl (Z)-(1 RS)-cis-3-(2-chloro-3,3,3-trifluoroprop-1-yl)-2,2-dimethylcyclopropanecarboxylate; Deltamethrin: (S)-alpha-cyano-3-phenoxybenzyl (1R)-cis-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropanecarboxylate; Cycloprothrin: (RS)-alpha-cyano-3-phenoxybenzyl (RS)-2,2-dichloro-1-(4-ethoxyphenyl)cyclopropanecarboxylate; Fluvalinate (alpha-cyano-3-phenoxybenzyl N-(2-chloro-alpha,alpha,alpha-trifluoro-p-tolyl)-D-valinate); Bifenthrin: (2-methylbiphenyl-3-ylmethyl)0(Z)-(1 RS)-cis-3-(2-chloro-3,3,3-trifluoromethyl)-2,2-dimethylcyclopropanecarboxylate; 2-methyl-2-(4-bromodifluoromethoxyphenyl)propyl (3-phenoxybenzyl) ether; Tralomethrin: (S)-alpha-cyano-3-phenoxybenzyl ((1 R)-cis)-3((1 RS)(1',2',2',2'-tetrabromoethyl))-2,2-dimethylcyclopropanecarboxylate; D-limonene: (1RS)-cis, trans-3-(2-2-dichlorovinyl)-2,2- dimethylcyclopropanecarboxylate; Tetramethrin: 3,4,5,6-tetrahydrophthalimido-methyl (1RS)-cis, trans-chrysanthemate; Allethin: (RS)-3-allyl-2-methyl-4-oxocyclopent-2-enoic acid; Deltamethrin: (1RS)-cis, trans-chrysanthemate; Cyphenothrin: (RS)-alpha-cyano-3-phenoxybenzyl (1R)-cis, trans-chrysanthemate, or (5RS)-9-ethyl-10,11-dihydro-5H-di-2,4-oxazepin-2-one; Pyrethroids: These compounds are used as insecticides, insect repellents, or other chemicals; A typical embodiment is a first yarn comprising deltamethrin and a second yarn not containing an insecticide, insect repellent or chemosterilant.
The choice of insecticide and type of textile nets (net, ground cover, film) is dependent on the country (type of climate), insects (climate zones), which targets (malaria insects or food damaging insects) and which type of resistance these insects already have.

5 Insects are capable of developing resistance, and mosquitoes and other biting insects have already been observed to develop resistance to pyrethroids. In such cases, it may be advantageous to replace the pyrethroid with another insecticide with a low mammalian toxicity or to impregnate a part of the material net with a pyrethroid and a part of it with another insecticide. Such a combination may also be used in general as a strategy to delay resistance development.

10 Care should be taken to combine insecticides that have little or no chance to develop cross resistance, e.g. where the development of resistance to one of them also confer resistance to the other even the two insecticides are of different type. Such alternative or supplemental insecticides may be compounds such as organophosphorous compounds organophosphorous compounds such as: Fenitrothion: 0,0-di methyl (4-nitro-m-tolylo) phosphorothioate; Diazinon: 0,0-diethyl-0-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate; Pyridaphenthion: 0,1,6-dihydro-6-oxo-1-phenyl(pyrazin-3-yl) 0,0-diethyl phosphorothioate.; Pirimiphos-Ethyl: 0,0-diethyl 0-(2-(diethylamino) 6-methyl-pyrimidinyl) phosphorothioate; Pirimiphos-Methyl: 0-[2-(diethylamino)-6-methyl-4pyrimidinyl] 0,0-dimethyl phosphorothioate; Etrimphos: 0,6-ethoxy-2-ethyl-pyrimidin-4-yl-0,0-dimethyl-phosphorothioate, Fenthion: 0,0-dimethyl-0-[3-methyl-4-(methylthio) phenyl phosphorothioate, Phoxim: 2-(3-diethoxyphosphinothoxyoxyimino)-2-phenylacetonitrile; Chlorpyrifos: 0,0-diethyl-0-(3,5,6-trichloro-2-pyridinyl) phosphorothioate; Chlorpyriphos-methyl: 0,0-dimethyl 0-(3,5,6-trichloro-2-pyridinyl) phosphorothioate; Cyanophos: 0,0-dimethyl 0-(4cyanophenyl) phosphorothioate; Pyraclfos: (R,S)[4-chlorophenyl]-pyrazol-4-yl]-O-ethyl-S-n-propyl phosphorothioate; Acephate: 0,S-dimethyl acetylphosphoroamidothioate; Azamethiphos: S-(6-chloro-2,3-dihydro-oxo-1,3-oxazolo [4,5-b] pyridin-3-yl)methyl phosphorothioate; Malathion: 0,0-dimethyl phosphorodithioate ester of diethyl mercaptosuccinate; Temephos: (0,0′,4′-dimethyl-4-biphenyl) 0,0,0,0-tetramethyl phosphorodithioate, Dimethoate: ((0,0-dimethyl S-(n-methylcarbamoylmethyl) phosphorodithioate, Formothion: S[2-formylmethylamino]-2-oxoethyl]-0,0-dimethyl phosphorodithioate; Phenthoate: 0,0-dimethyl S-(alpha-ethoxycarbonylbenzyl)-phosphorodithioate.

Furthermore, carbamate compounds may be applied including compounds such as: Alanycarb: S-methyl-N,N-methyl-N-[N-benzyl-N(2-ethoxy-carbonyl)dimethylcarbamate]; Carbaryl (1-naphthyl N-methylcarbamate); Isopropcarb: 2-(1-methylethyl) phenyl methylcarbamate; Carbosulfan: 2,3 dihydro-2,2-dimethyl-7-benzofuranyl [(dibutylamino)thio] methylcarbamate; Fenoxycarb: Ethyl[2-(4-phenoxyphenoxy)ethyl] carbamate; Indoxacarb: Methyl-7-chloro-2,3,4a,5-tetrahydro-2-{methoxy carbonyl (-4-trifluoromethoxyphenyl)}; Propoxur: 2-isopropoxyphenol methylcarbamate; Pirimicarb: 2-dimethylamino-5,6-dimethyl-4-pyrimidinyl-
dimethylcarbamate; Thidiocarb: Dimethyl N,N'(thiobis((methylimino)carbonoyloxy)bisethanimidiothioate); Methomyl: S-methyl N-(methylcarbamoyl)oxythioacetamidate; Ethiofencarb: 2-((ethylthio)methyl)phenyl methylcarbamate; Fenothiocarb: S-(4-phenoxybutyl)-N,N-dimethyl thiocarbamate; Cartap: S,S'-(2-5dimethylamino)trimethylene)bis(mercapto)ethane; Cartap: S,S'-(2-5dimethylamino)trimethylene)bis(mercapto)ethane; XMC: 3,5-dimethylphenyl-methyl carbamate; Xylylcarb: 3,4-dimethylphenylmethylcarbamate.

Newer insecticides with lower mammalian toxicity at use dosage are interesting alternatives, especially because vector insects rarely have developed resistance to these. Such new groups of insecticides are pyrimidialmines (Pyrimidifen), Pyrazoles (Fipronil and Fenpyroximate), Pyrrols (clorfenapyr), dicloproamid. Chlorfenapyr is especially interesting since it has been used experimentally (Rowland et al, 2005) and shown interesting, though slow effect.

Where nets and other impregnated materials are used in mass campaigns, the alternative or supplemental insecticide may also be an insecticide with a sterilizing effect thus to sterilize the mosquitoes and avoid the next generation of mosquitoes. Such insecticides can be of the benzoyl urea group such as 1-(alpha-4-(chloro-alpha-cyclopropylbenzylidenoxy)-p-tolyl)-3-(2,6-diflourobenzoyl)urea, Diflubenzuron: N-(((3,5-dichloro-4-(1,1,2,2-tetrafluoroethoxy)phenylamino)carbonyl)2,6 diflouro benzamid, Triflumuron: 2-Chloro-N-(((4(trifluoromethoxy) phenyl)-amino-carbonyl) benzamide, or a triazin such as N-cyclopropyl-1,3,5-triazine-2,4,6-triamin or other insecticides with a sterilizing effect on adult mosquitoes.

Insecticides as listed herein may be chosen to be incorporate into the first yarn, and each one is considered an individual embodiment of the present invention.

According to present invention, insecticides may be selected from the group consisting of pyrethroids (deltamethrin, Alphacypermethrin, permethrin), organophosphates, carbamates and neonicotinoids (Chlorphenapyr) or mixtures thereof.

A typical embodiment is a first yarn comprising an insecticide, such as selected from the group consisting of pyrethroids; carbamates. In particular the insecticide is deltamethrin.

A still further embodiment is a first yarn comprising an insecticide selected from the group consisting of Chlorfenapyr, Permethrin and Alphacypermethrin.

Another typical embodiment is a first yarn comprising an insecticide such as selected from the group consisting of pyrethroids, organophosphates, carbamates, neonicotinoids, pyrrols, pyrimidiamin or pyrazoles or mixtures thereof.
A particular example of pyrazole is fipronil, an example of pyrrols is chlorfenapyr or imidaclorpid, an example of pyrimidin is pyridaben.

As it concerns the insecticide "permethrin", the amounts needed are much higher (as compared to using deltamethrin or Alphacypermethrin in polyethylene) in order to obtain sufficient bio-efficacy (to fulfill the WHO testing protocol as referred herein).

Olyset, a polyethylene net comprising permethrin comprises 2% w/w. A product as Netprotect (also polyethylene) contains 0.2 % w/w of insecticide deltamethrin.

Olyset may therefore be considerably as weaker and as a result looses a lot of strength due to the higher levels of the insecticide. As discussed herein, to compensate for such strength losses, the skilled person may use thicker yarn to compensate for strength losses at the higher cost of price and higher total weight of the textile.

By present invention, one can now improve this prior art net Olyset, by incorporating sufficient amount of permethrin into the first yarn and using a second yarn type not containing insecticide, insect repellent or chemosterilant. One may now use a yarn type which will be the second yarn type for example made of pure HDPE not containing insecticide, insect repellent or chemosterilant and as disclosed herein may comprise for example 70% of the total length of yarns used in the insecticidal textile product where 30% of the total length is used a first yarn type comprising 2 % w/w insecticide or higher. Such improved Olyset net will now be approximately as disclosed herein 10-50% stronger and will kill also more effectively insects and is cheaper (light weight by using for example pure HDPE yarn).

Insect repellent

Suitable examples of an insect repellent is a insect repellent selected from the group consisting of DEET (N, N-diethyl-m-toluamide), essential oil of the lemon eucalyptus and its active ingredient p-menthane-3,8-diol (PM D), Icaridin, citronella oil, soybean oil and neem oil.

Chemosterilant

A chemosterilant may be a sterilant that prevent the mosquito to contribute to the next generation and thus also has a mass effect, but no transmission effect.

A chemosterilant, any chemical compound used to control economically destructive or disease-causing pests (usually insects) by causing temporary or permanent sterility of one or both of the sexes or preventing maturation of the young to a sexually functional adult stage. The mating of sterilized insects with fertile insects produces no offspring, and if the number of sterile insects is kept constant, the percentage of sterile insects will increase, and fewer young will be produced in
each successive generation. Chemosterilants can be grouped into two types of compounds, depending on their action. Antimetabolites such as amethopterin and aminopterin cause sterility in female insects by preventing egg formation. In some species, certain doses may stop eggs from hatching or larvae from maturing. Alkylating agents such as tepa, metepa, and apholate cause changes in genetic material and chromosomal damage in both male and female reproductive cells.

A first side and a second side
Traditional knitting always results in a textile product with two sides; herein denoted a first side and a second side.

The insecticidal textile product of present invention has a first side and a second side characterized in that the first yarn is predominantly located on the first side and the second yarn is predominantly located on the second side.

The textile product of present invention as said comprises a first and a second yarn. The total amount of yarns expressed in meters as used in the final textile product may be expressed in the sum of the amount of meters of the first yarn and the amount of meters of the second yarn as used in the knitting or weaving process.

The total amount of yarns in the textile product may for example be 100 meters in length; where 30 meters is a first yarn of present invention and 70 meters of a second yarn, or the other way; 70 meters of a first yarn and 30 meters of a second yarn.

A typical embodiment is an insecticidal textile product where the second yarn type not containing an insecticide, insect repellent or chemosterilant is from 50-80% of the total used yarn meters in length present in the textile product, more preferred from 55-75% and most preferred 70%. The preference percentage of the first and the second yarn is based on insecticide, insect repellent or chemosterilant dosage needed, and of the final use of the textile.

A typical embodiment is the insecticidal textile product of present invention, wherein the ration in length meters between the first yarn and the second yarn type is from 1/99 to 99/1.

A typical embodiment is 30 % of the first yarn and 70 % of the second yarn.

According to the present invention as disclosed herein because of the disproportional release of the insecticide, wherein all the release of insecticide, insect repellent or chemosterilant comes from the first yarn type, one obtains an improved insecticidal textile product which is killing insects more effectively as compared to prior art nets which are using a first yarn comprising an insecticide and
a second yarn also comprising an insecticide, having both yarn type spread over the textile
product.

According to the present invention it is now possible to make an insecticidal textile product which
has higher killing efficacy as compared to a prior art net.

A finished knitted or woven textile net contains meshes. These can be of different sizes; for example a 136 mesh or a 200 mesh depending on the size of the insect which needs to be stopped or prevented from entering areas. This is described in US2992550.

A typical embodiment is an insecticidal textile product wherein the insecticidal textile product has a first side and a second side characterized in that the first yarn is predominantly located on the first side and the second yarn is predominantly located on the second side.

Methods to make textile products with a first side and a second side are known to the skilled person. For example is described in US7634819 a head wrap knitted from two types of yarn. A 50 denier 36 filament bright polyester yarn is used in the knitting to be predominantly on the outer side of the fabric to make that surface relatively slippery against another fabric and a 50 denier 36 filament textured polyester yarn is used in the knitting to be predominantly on the back or head side of the fabric wrap to make that surface relatively rougher against wearer's hair.

The result is one layer material with two distinct, different sides. A known double knit machine may be used to knit the insecticidal textile product of the present invention. Other machines to make knitting warp raschel knitting pattern may be also be used to produce the insecticidal textile product of the present invention.

A typical method of making an insecticidal textile product according to present invention is the use of warp knitting.

Amount of insecticide, insect repellent or chemosterilant.

A typical embodiment is an insecticidal textile product of the present invention, wherein the insecticide in the first yarn is from 1.0 to 100 gram insecticide per kg textile.

A further embodiment is an insecticidal textile product of the present invention, wherein the insect repellent in the first yarn is from 1.0 to 100 gram insect repellent per kg textile.

A typical embodiment is an insecticidal textile product of present invention, wherein the first yarn comprises an EVA polymer (ethylene vinyl acetate) and an insect repellent in an amount from 1.0 to 100 gram insect repellent per kg textile.
A still further embodiment is an insecticidal textile product of the present invention, wherein the chemosterilant in the first yarn is from 1.0 to 100 gram chemosterilant per kg textile.

**Sufficient to kill after washes**

Insecticidal textile products such as nets recommended by WHO (WHOPES scheme) need to pass the test protocol as described in WHO/CDS/WHOPES/GCD PP/2005 guidelines.

A further embodiment is an insecticidal textile product of the present invention, wherein the first yarn comprising an insecticide in an amount sufficient to kill mosquitoes after at least 15 washes according WHO/CDS/WHOPES/GCD PP/2005 guidelines, (see example 4 herein).

The amount sufficient to kill mosquitoes after at least 15 washes depends on the type of insecticide chosen. For example in case of permethrin this may be 25 g permethrin per kg textile and in case deltamethrin it may be 2-4 g/kg.

**Stronger textile product**

As shown in the examples hereinafter, although 70% of the total length of yarns in the textile product is a first yarn comprising an insecticide and is a mixed yarn made of HDPE and LDPE and only 30% of total length of yarns used in the textile product is made of pure polyethylene HDPE yarn (second yarn type), the tensile strength improved significantly. Increasing tensile strength is a direct measure for the strength of the textile product.

In accordance with the present invention it is now possible to make an insecticidal textile product wherein the insecticidal textile product has a first side and a second side characterized in that the first yarn is predominantly located on the first side and the second yarn is predominantly located on the second side. Such net is stronger and also has improved bio efficacy.

A typical embodiment is an insecticidal textile product according present invention, wherein the textile product has a bursting strength value of at least 5 to 70% higher as compared to an insecticidal textile product comprising a first yarn with insecticide, insect repellent or chemosterilant and a second yarn with insecticide, insect repellent or chemosterilant.

A typical embodiment is an insecticidal textile product having at least a first yarn type made of a mixture HDPE and LDPE and a second yarn type made of nylon, wherein the first and the second yarn are knitted together. Such a textile product has a very light weight (due to the presence of nylon and not polyethylene), which is an advantage in order to reduce the transportation cost of such net and also due to the presence of nylon such net is at least 5-50% stronger.
A most preferred embodiment is an insecticidal textile product which is 25-50% stronger as compared to prior art insecticidal textile product.

Cheaper textile product

Prior art nets today use mixed yarn types, e.g. HDPE and LDPE or LLDPE polymer matrix wherein there is mixed insecticide (Netprotect ®, Olyset ®). Such mix yarns are prepared by standard methods known in the art. The skilled person may buy ready masterbatch, denoted as the chosen HDPE and LDPE or other mixtures already comprising insecticide which are thereafter extruded to make yarns. The company Alok (India), manufacture many different types of masterbatches (e.g. polyethylene masterbatches). Such masterbatches may be used in injection molding, blow molding, film extrusion, sheet extrusion, polypropylene and polyethylene woven sack extrusion, roto moulding, polypropylene and polyethylene mono filaments and pipe extrusion.

A first yarn comprising an insecticide is much more expensive as compared to pure HDPE. According to the present invention it is now possible to significantly reduce cost and make cheaper insecticidal textile products. This is possible by using a first yarn comprising an insecticide, insect repellent or chemosterilant and a second yarn not containing an insecticide, insect repellent or chemosterilant. In the first yarn, there is incorporated according to present invention, the insecticide, insect repellent or chemosterilant needed to obtain a net which fulfils current requirements to obtain the WHOPES approval.

Method to measure the strength of an insecticidal textile product is measured as explained in detail in example 1 described herein.

A textile product can be made asymmetric by all known methods used to make textile product such as knitting, weaving and 3-dimension knitting in general. Knitting and weaving techniques are known to the skilled person. One particular most used method relevant for the invention herein is for example warp knitting which is also used for making insecticidal textile products such as a malaria mosquito bed net.

There are new choices possible of choosing cheaper and stronger materials. For example one may use nylon yarns as the second yarn type. Nylon yarns are more expensive, but also lighter for the same tenacity as obtained with a HDPE yarn. As second yarn type, the nylon will not contain an insecticide, insect repellent or chemosterilant and may be used to make the net in such a way that it is made asymmetrically, i.e. most of the nylon will be on the second side (2) of the textile product and the yarn comprising insecticide, insect repellent or chemosterilant made of polyethylene (e.g LDPE, mixtures of HDPE and LDPE) and known to the skilled person will predominately be on the first side (1). In such a way, a very strong net is obtained. As known to the skilled person, adding an insecticide to the polymer matrix (e.g HPPE, LDPE and mixtures thereof) softens the
polyethylene polymer and is the cause that polyethylene nets are not strong enough (typically holes appear after a while).

A further embodiment is an insecticidal textile product where the second yarn type is made of nylon.

A still further embodiment is an insecticidal textile product where the second yarn type is made of pure HDPE or pure polypropylene.

Although as exemplified herein 70% of textile expressed in length in meters of yarn of the total textile product is made of the first yarn type comprising insecticide, insect repellent and chemosterilant and only 30% as expressed in length in meters of yarn of the total textile product was the second yarn type not containing insecticide, insect repellent and chemosterilant, it is surprisingly found that the strength increased dramatically. See example 3 herein.

Agriculture nets for greenhouses
Nets are often used in agriculture and in some areas like the Mediterranean. These nets are untreated, i.e. there is no insecticide in the textile product (net) as bees are very sensitive to the used insecticide as for example deltamethrin.

Bees need to be protected from contacting the insecticide. Bees are useful beneficial insects and are introduced into greenhouses for pollination. In this case, no killing is desired on the inside of the greenhouse (the side facing the plants, e.g. plant growing area) and a high killing effect is desired on the outer side, the side facing away from the plants (separated by screen, glass or untreated nets), typically facing the outside where from insects are flying in from the nature.

A typical embodiment is an insecticidal textile product comprising at least a first yarn type and second yarn type, said first yarn type comprises an insecticide, insect repellent or chemosterilant and the second yarn type does not contain an insecticide, insect repellent or chemosterilant in a method for growing plants in glass or greenhouses.

According to the present invention, agricultural nets may be prepared and used in greenhouses or plant growing houses where the entire structure is made of net and where a first side is facing away from the plant growing area and the second side (not comprising an insecticide) facing the plants. Bees touching the second side will not be killed as the first yarn comprises the insecticide. This is clearly an improvement over prior art net as for example described in EP1411764B1 wherein bees are killed at contacting the net as described therein.

Flexibility to incorporate any additive in the second yarn not contain the insecticide
According to the present invention, the skilled person is not limited to select additives and tests these in combination with the chosen insecticide.

According to the present invention, known additives may be chosen and incorporated into the second yarn type not containing insecticide, and not weakening the strength of the second yarn. By making a textile product of the present invention, a stronger, anti-flammable and more bio efficacious net is obtained. Below, is a list of possible additives which may be chosen and these are all known to the skilled person.

A further embodiment is an insecticidal textile product of the present invention, wherein the second yarn comprises a plasticizer additive which is not compatible with the insecticide as present in the first yarn type.

**Additives (plasticizers)**

There are additives belonging to the group of anti-oxidants. Anti-oxidants include oxygen-radical scavengers, HALS ( Hindered Amin Light Stabilizer) and NOR-HALS (Alkyloxamin Hindered Amin Light Stabilizer) molecules. Such plasticizers or additives are produced by e.g. the company BASF under trade names such as but not limited to CHIMASSORB® 81, TINUVIN 494 and IRGANOX or by the company Songtom under similar tradenames as Songnox.

For example CHIMASSORB® 81 is a solid-form UV absorber of the 2-hydroxy-benzophenone class imparting good light stability when used in combination with HALS of the Chimassorb or Tinuvin range. It shows good compatibility with polyolefin and plasticized PVC.

Other additives are light stabilisers, anti-oxidants and UV absorbers. References can be found in US791 0642, US200301 09599 and US6828364.

**Flammability retardants**

Flame retardants are chemicals used in thermoplastics, thermosets, textiles and coatings that inhibit or resist the spread of fire. Flammability retardants are known compounds to the skilled person. Suitable for present invention may be PE68 and Dyneon MM5935. These may be mixed into the second yarn of pure HDPE and hereby protect the textile product of present invention against fire and the forming of hot polyethylene droplets. In prior art nets (i.e. net with only yarns containing an insecticide), flammability retardants destroy the insecticide making the net ineffective and not killing insects. Also, the amount needed for effective flame retardants or anti dripping effect during burning, is not compatible with a yarn with sufficient tenacity to be used for making nets. Such additives also named flame retardant additives.
A typical embodiment is an insecticidal textile of the present invention, wherein the second yarn comprises additive chosen from the group consisting of fire retarding additives, colour additives, UV filters, light remitting additives, Capsaicin, rat poison, rat repellent and other plasticizer stabilizing additives which break down the insecticide in presence of the polyethylene polymer.

Capsaicin
As explained above, Capsaicin and several related compounds are called capsaicinoids (phenolic amide C18H27NO3) and are produced as a secondary metabolite by chili peppers, probably as deterrents against certain herbivores and fungi. It is an irritant for mammals, including humans, and produces a sensation of burning in any tissue with which it comes into contact.

Pure Capsaicin may be bought in a crystal form and is widely available in the trade.

A typical embodiment is a first yarn comprising an insecticide and a second yarn containing a rat poison. An example of a suitable rat poison is Difenacoum or Warfarin. Warfarin (also known under the brand names Coumadin, Jantoven, Marevan, Lawarin, Waran, and Warfant) is an anticoagulant. Such known pesticides against rats may be chosen by the skilled person.

A typical embodiment is a first yarn comprising an insecticide and a second yarn containing Capsaicin. Other suitable rat repellents are additives from Capsicum annun extracts.

A typical embodiment is a first yarn comprising an insecticide and a second yarn containing a rat repellent.

EXAMPLES

Example 1: Method to measure the strength of an insecticidal textile product

Bursting strength and tenacity are measured according to the method as described in Skovmand and Bosselmann Malaria Journal 2011, 10:87 describing measurements of bursting strength and tension strengths in the two directions. Tension strength measured in the length and width directions of the net using one hook and one clamp.

Bursting strength was measured according to European Norm International Standards Organization (EN ISO) 13938-2. This test uses pneumatic pressure method for determining bursting strength and distension of textile fabrics before bursting.
Tensile strength with grabs was measured according to test standard ISO 13934-2 (tensile strength - grab method). This test determines the maximum force of textile fabrics using a grab method. The fabric specimen is gripped in its centre part by jaws of specified dimensions and is extended at constant rate until rupture. The maximum force was recorded. Tensile strength with hook is an adaptation of the grab test, where a hook is positioned in one clamp. During the test the hook is inserted in a mesh of the net. When the net is pulled, the hook will cause rupture in the net. It thus determines the force necessary to tear a hole in the net.

**Example 2:** Method to measure killing or knock down of mosquitoes in vivo with a sufficient insecticide dosage: (according to WHO, World Health Organization).

The term "sufficient dosage" herein is defined by: 50, 3-4 days old female mosquitoes are exposed to textile (net) under standard WHO cones, 5 in each cone, for 3 min. The net must be able to kill at least 80% of mosquitoes of a susceptible (no insecticide resistance) strain of mosquitoes after 24 hours or to paralyze (called knocked down) at least 95% within 60 min. Mosquitoes are hold in cups with sugar water available for the 24 hr, at 25±2°C and 75±10% RH.

Alternatively, 5-8 days old adult female mosquitoes are released in a tunnel (square section 25x25 cm) made of glass, 60 cm length. At each end of the tunnel, a 25 square cm cages is fitted (extension) and covered with polyester netting. At one third of the length, a disposable cardboard frame is placed with the netting sample. The surface of the netting available to mosquitoes is 400 cm² (20x20 cm), with none holes each 1 cm diameter: one hole is located at the centre of the square; the other eight are equidistant and located at 5 cm from the border. In the shorter section of the tunnel, bait (guinea pig for Anopheles gambiae) is placed, unable to move. In the cage at the end of the longer section of the tunnel, 100 females are introduced at 18:00. Females are free to fly in the tunnel, but have to make contact with the net and locate holes before passing trough to reach the bait. The following morning 9:00, mosquitoes are removed and counted from each section and immediate mortality and blood feeding status is recorded. Delayed mortality is recorded on live mosquitoes transferred to cups with sugar water and after 24 hr. Mortality must be at least 80% and blood feeding inhibition at least 90% for a textile (net) still sufficient active. (Guidelines for laboratory and field testing of long lasting insecticidal mosquito nets, WHO/CDS/WHOPES/GCDPP/2005. 11).
Example 3: Bursting strength of insecticidal textile product (e.g. a net) with 70% polymer mix (HDPE and LDPE) also termed mixed yarn (herein first yarn type) and 30% pure HDPE yarn (herein second yarn type).

<table>
<thead>
<tr>
<th>Insecticidal Textile</th>
<th>Weight/m²-Gram</th>
<th>Bursting strength (kPa at mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRODUCT A: A Net with only mixed insecticidal HDPE/LLPE yarns (prior art net)</td>
<td>38</td>
<td>450</td>
</tr>
<tr>
<td>PRODUCT B: A Net with Pure HDPE yarns (no insecticide) knitted with a mixed insecticidal HDPE/LLDPE Yarns (this work)</td>
<td>38</td>
<td>650</td>
</tr>
</tbody>
</table>

Table 1: Two different insecticidal textile products were prepared; product A made of mixed yarns (HDPE and LDPE as prior art) and product B (this work) using a first yarn (mixed yarn HDPE and LDPE with insecticide) and a pure HDPE yarn not containing insecticide.

Conclusion example 1: Stronger net
The insecticidal product as made and tested in example 1 is prepared by traditional Raschel knitting method. As explained above, such by using method, yarns are fed from for example two different roles (there can be many roles on such machine). Herein 70% is fed from the first role (second yarn not containing insecticide) and 30% (first yarn comprising insecticide) from another role. The bursting strength of the insecticidal textile product has increased from 450 to 650 kPa at mm (a 50% increase) keeping the total weight of the textile product constant. Prior art may of course teach that to obtain an increase in bursting strength, the skilled person may simply increase the thickness of the yarn, however, this will increase the weight of the textile significantly resulting in high cost of transportation of such textile products.

In other words, the increase in bursting strengths has been achieved by using a first yarn comprising an insecticide and a second yarn not containing an insecticide.
Example 4: Bioassay (Bio-efficacy) of prior art net versus a first yarn comprising insecticide (mixed yarn HDPE/LDPE) and a yarn not comprising insecticide (pure HDPE) warp knitted into textile insecticidal product.

<table>
<thead>
<tr>
<th>Polymer compositions Yarns</th>
<th>5 washes KD</th>
<th>5 washes Mortality</th>
<th>15 washes KD</th>
<th>15 washes Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>461 prior art net</td>
<td>51</td>
<td>56</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>462 prior art net</td>
<td>25</td>
<td>26</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>462 this work</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>463 prior art net</td>
<td>13</td>
<td>14</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>463 this work</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 2: Insecticidal textile products were tested for bio-efficacy according to protocol WHO (WHO/CDS/WHOPES/GCD PP/2005 guidelines) and killing effect was measured (KD and mortality). Polymer compositions of insecticidal product 461 and 462 are identical. Insecticidal product termed "Polymer 463" is a different polymer composition as compared to 461 and 462.

From the polymer compositions 461, 462 and 463, insecticidal textile products were prepared either according to the prior art using warp knitting in a ration of 70% of the first yarn comprising deltamethrin and 30% of the second yarn not containing an insecticide, insect repellent or chemosterilant.

Conclusion: Example 4 clearly shows that bio-efficacy is improved. The killing values (either knock down measured or mortality after 5 and 15 washes according to WHOPES test protocol) shows 100% (all insects dead) kill effect as compared to much lower values with prior art textile nets (25-51% KD and 26-56% mortality) after 5 washes. The test was stopped after 5 washes as 25-51% KD and 26-56% mortality is already below the allowed level of minimum 80% killing as described as the minimum allowed level for an insecticidal product to be approved according to the WHOPES testing schedule. Below 80% such a product is not approved as prevention tool for the protection of humans against malaria.
Example 5: Bioassay (Bio-efficacy) of prior art net versus a first yarn comprising insecticide (mixed yarn HDPE/LDPE) and a yarn not comprising insecticide (pure HDPE) warp knitted into textile insecticidal product.

<table>
<thead>
<tr>
<th>Insecticidal textile net</th>
<th>5 washes % kill 60 min KD</th>
<th>5 washes % kill 24 hours death</th>
<th>7 washes % kill 60 min KD</th>
<th>7 washes % kill 24 hours death</th>
<th>10 washes % kill 60 min KD</th>
<th>10 washes % 24 hours death</th>
<th>15 washes % kill 60 min death</th>
<th>15 washes % kill 24 hours death</th>
</tr>
</thead>
<tbody>
<tr>
<td>461A-1</td>
<td>22</td>
<td>20</td>
<td>6</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>461B-1</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>462A-2</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>462B-2</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>463A-2</td>
<td>ND</td>
<td>ND</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>463B-2</td>
<td>ND</td>
<td>ND</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3: The efficacy of 3 different insecticidal textile products was tested according to the WHO WHO/CDS/WHOPES/GCD PP/2005 guidelines. The polymer composition of 461 and 462 were the same and the polymer composition of 463 was different from 461 and 462 (additives added). ND denotes "not determined". The insecticidal product was given A for one side and B for the second side.

Insecticidal products from table 3 tested:
461A-1 and 461 B-1: as the prior art teaches; a first yarn with polymer compositions 461 comprising an insecticide and second yarn also comprising an insecticide and knitted to an insecticidal textile product according to the known methods in the prior art (warp knitting). As mixed yarn was used LDPE polymer and was mixed with HDPE as known in the prior art.

462A-2 and 462B-2: this work; first yarn comprising an insecticide and the second yarn does not contain an insecticide, are knitted together to an insecticidal textile product using a ratio 70% of mixed yarn; which is the first yarn type comprising and insecticide (this work deltamethrin) and the second yarn type not containing an insecticide.
463A-2 and 463B-2: this work; first yarn comprising an insecticide and the second yarn does not contain an insecticide are knitted together to an insecticidal textile product using a ratio 70% first yarn type and 30% second yarn type.

462 and 463 are textile products with a first yarn comprising an insecticide and a second yarn not containing an insecticide. The total concentration of insecticide per square meter is 68 grams/m². The total amount of 68 grams/m² is important to be able to keep constant as this is the total allowed amount of a prior art insecticidal textile product approved for the use of prevention of malaria.

As one yarn of the two yarns in present invention, does not contain an insecticide, one must compensate for the amount of insecticide i.e. the concentration of insecticide in the first yarn is increased 1.5 to 2 times.

The amount of insecticide present in the first yarn may vary and depends on the type of insecticide to be used in the yarn. The skilled person may choose an insecticide where there is needed high amount; such as up to 100 grams per kg textile. The amount is determined by the LC 50 value of the insecticide of interest. Malathion is for example used at a level of 20-40 gram per kg textile, e.g. such chosen amount is directly related to the efficacy of the insecticide to kill mosquitoes.

An embodiment is a first yarn comprising from 1.0 to 100 grams insecticide. Another embodiment is a first yarn comprising from 1.0 to 85 grams insecticide or from 1.0 to 80 grams insecticide, from 1.0 to 75 grams insecticide, or from 1.0 to 70 grams insecticide, from 1.0 to 60 grams insecticide, from 1.0 to 50 grams insecticide, from 1.0 to 45 grams insecticide, from 1.0 to 40 grams insecticide, from 1.0 to 35 grams insecticide, from 1.0 to 30 grams insecticide, from 1.0 to 25 grams insecticide, from 1.0 to 20 grams insecticide, from 1.0 to 15 grams insecticide, from 1.0 to 10 grams insecticide, from 1.0 to 5.0 grams insecticide and from 1.0 to 2.0 grams insecticide.

A further embodiment is a first yarn comprising from 1.0 to 5.0 grams deltamethrin insecticide, more typical from 2-3 grams insecticide and most typical 2.6 gram insecticide per kg textile.

At concentrations from 2-3 grams of insecticide only present in the first yarn (and no insecticide in the second yarn), the surface concentration is very high explaining the high killing effect as observed and disclosed herein. Based on this, the skilled person can now chose, a first yarn type comprising an insecticide and the second not containing insecticide.

Prior art net: total amount of 1.8 gram deltamethrin per kg textile. Present invention: first yarn 2.571 gram deltamethrin per kg textile and a second yarn with 0.0 gram insecticide.
From the first yarn is used 70% of first yarn expressed as % of the total weight of the finished textile product and 30% of the second yarn. Thus, 70% of 2.571 gram deltamethrin is 1.799 gram deltamethrin per kg textile product which is the same as the prior art specification 1.8 gram per kg textile product.

5  
Conclusion example 5:  
Keeping the total weight of the textile product constant and keeping the total amount of insecticide constant by using a first yarn comprising an insecticide and a second yarn not containing an insecticide knitting the two yarns to a textile product, one obtains a stronger net and a net with improved killing efficacy.

The skilled person may now simply chose the amount of insecticide needed, chose the ratio of the first yarn and the second yarn to obtain a textile product with desired strength and bio-efficacy tested according to the WHO reference protocol.

A stronger insecticidal textile product (e.g. a net)  
Example 6: Bursting strengths of prior art net

<table>
<thead>
<tr>
<th>Code</th>
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<th>030</th>
<th>031</th>
<th>032</th>
<th>034</th>
<th>028</th>
<th>033</th>
<th>035A</th>
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<td>136</td>
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<td>479</td>
<td>474</td>
<td>479</td>
<td>536</td>
<td>463</td>
</tr>
</tbody>
</table>

Table 4: Measurement of bursting strength of prior art insecticidal textile products (net); for mesh 136, the bursting strength is minimum 400 kPa and for mesh 200 the bursting strengths is minimum 500 kPa. Average production bursting strength of prior art net is 450 kPa.

Example 7: Bursting strength of insecticidal textile product of present invention

<table>
<thead>
<tr>
<th>Code (this work)</th>
<th>Bursting strength (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F.1</td>
<td>662</td>
</tr>
<tr>
<td>F.2 (26 m/m)</td>
<td>738</td>
</tr>
<tr>
<td>F.2 (48 m/m)</td>
<td>657</td>
</tr>
</tbody>
</table>

Table 5: Bursting strength measurements on insecticidal net of present invention (this work).

Conclusion:
Insecticidal textile product of present invention is much stronger; average prior art net has a bursting strength of 450 kPa as compared to average net of present invention is 686 kPa. This is a 34% improvement in strength. By present invention such nets will not break that easy and the chance that holes will appear is reduced.

Less costly
Insecticidal textile nets made as disclosed herein (first yarn with insecticide, and maybe a mixed composition of HDPE and LDPE) and a second yarn made of pure HDPE are cheaper to produce because the second yarn made of pure HDPE is less costly than the first yarn (made of mixture of HDPE and LDPE).

More safe for the user
As the total amount of second yarn not containing an insecticide (this example 80%) is present in a much higher proportion of the total amount of yarns used in the insecticidal product, and may be knitted by for example the raschel knitting method, such insecticidal product have a first side (1) and a second side (2). The first side (1) has a low dosage insecticide and a second part (2) with a much higher dosage insecticide. By present invention it is now possible to make an insecticidal textile product where the first side (1) (also inner side) is used and facing the human (e.g. a person sleeping under a bed net) and the second side (2) is the opposite side, the outer side. This way the person is less exposed to the insecticide. Such first side (1) and second side (2) may also be used for window screen, where the first side (1) with lower insecticide dosage faces towards the inside of the house and the second side (2) faces the outside of the house. Insects trying to enter the house via the window screen will first contact the second side (2) on which they land and will get killed.

In another more safe use it is insecticidal textile products for agricultural use. Textile nets are often used in greenhouses as part of the walls or forming side and roof. Insecticidal textile products can be used but have to be attached to exiting textile nets not containing any insecticide due to the risk of honey bees, bumble bees or other beneficial insects getting killed. Bees and bumble bees are beneficial insects as they are used to pollinate the plants for example in the production of tomatoes. Other beneficial insects may be parasitoids.

According to the present invention, an insecticidal textile product (net) can be set up without the risk of bees getting killed as the minor part of insecticide will face the first side (1) - inner side (plant house or greenhouse) and the second side (2) with higher insecticide dosage facing the outer side.

Clearly, the present invention offer many new advantages to the skilled person who is interested in making insecticidal textile products.
Bio-efficacy

Bioassays confirm that an insecticidal product of present invention more efficacious. This may be explained by that mosquitoes are exposed to a higher dose of the yarns comprising insecticide. This may also be advantageous to control insects which are resistant (e.g. insects resistant to deltamethrin, these are termed KDR resistant mosquitoes may be killed as they are exposed to higher concentrations of deltamethrin).
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CLAIMS

1. An insecticidal textile product comprising a first yarn type and second yarn type, said first yarn type comprises an insecticide, insect repellent or chemosterilant and the second yarn type does not contain an insecticide, insect repellent or chemosterilant.

2. The textile product of claim 1, where the first yarn comprises a mixture of polyethylene polymers and the second yarn comprises a polymer composition selected from the group consisting of HDPE (high density polyethylene), LDPE (low density polyethylene), mixtures of HDPE and LDPE, polyamide, polypropylene and polyester.

3. The textile product of claim 1 or 2, wherein the first yarn comprises a mixture of HDPE and LDPE and optionally waxes.

4. The insecticidal textile product of any one of the preceding claims, wherein the insecticidal textile product has a first side and a second side characterized in that the first yarn is predominantly located on the first side and the second yarn is predominantly located on the second side.

5. The insecticidal textile product of any one of the preceding claims, wherein the insecticide in the first yarn is from 1.0 to 100 gram insecticide per kg textile.

6. The insecticidal textile product of any one of the preceding claims, wherein the ration in length between the first yarn and the second yarn type is from 1/99 to 99/1.

7. The insecticidal textile product of any one of the preceding claims, wherein the first yarn comprising an insecticide in an amount sufficient to kill mosquitoes after at least 15 washes according WHO/CDS/WHOPES/GCD PP/2005 guidelines.

8. The insecticidal textile product of any one of the preceding claims, wherein the second yarn comprises a plasticizer additive which is not compatible with the insecticide as present in the first yarn type.

9. The insecticidal textile product of claim 8 wherein the additive is chosen from the group consisting of fire retarding additives, colour additives, UV filters, light remitting additives, Capsaicin rat poison, rat repellent and other plasticizer stabilizing additives which break down the insecticide in presence of the polyethylene polymer.
10. The textile product of any one of the preceding claims, selected from the group consisting of a net, a mosquito bed net, a curtain, a cushion, a wall covering textile, a tarpaulin, a cloth, an agriculture net and a window/door screen.

11. The insecticidal textile product of claim 10, wherein the insecticidal textile product is a bed net for the prevention of malaria.

12. The textile product of any one of the preceding claims, wherein the insecticide is selected from the group consisting of pyrethroids, organophosphates, carbamates, neonicotinoids, pyrrols, pyramidiamin or pyrazoles or mixtures thereof.

13. The insecticidal textile product of any one of the preceding claims, wherein the textile product has a bursting strength value of at least 5 to 70% higher as compared to an insecticidal textile product comprising a first yarn with insecticide, insect repellent or chemosterilant and a second yarn with insecticide, insect repellent or chemosterilant.

14. A method to manufacture an insecticidal textile product comprising a first yarn type and second yarn type, said first yarn type comprises an insecticide insect repellent or chemosterilant and the second yarn type does not contain an insecticide, insect repellent or chemosterilant, using a weaving or knitting apparatus having a first and a second roll comprising the following steps:
   i) prepare the first yarn type comprising an insecticide insect repellent or chemosterilant,
   ii) prepare the second yarn type,
   iii) place the first yarns type on the first roll and place the second yarn type on the second roll,
   iv) knit or weave by mixing the first and the second yarn types by feeding the first yarn type and feeding the second yarn type to the knitting or weaving machine,
   vi) obtain the textile product ready for cutting, sewing and shaping into insecticidal textile products and
   vii) optionally, cutting, sewing and shaping the textile product to a specific textile product ready for use.

15. The method of claim 14, wherein the knitting is warp knitting.