Chemical Products

Not all insecticides are suited for use as ixodicides, stability as well as residual effect are important.

Because of the diluents and stabilisers that are incorporated a commercial preparation is generally superior to a simple dilution of the active agent. It is absolutely indispensable to strictly follow the instructions of the manufacturer that are on the label and/or package insert.

Pesticide Formulations

1. Dusting powders: These are used mainly on pets but occasionally also on larger animals. The active ingredient is diluted with an inactive powder.
2. Soluble powders: Arsenic is the only example.
3. Wettable powders (W.P.): These form suspensions in water and some of the dipping compounds are formulated as wettable powders.
4. Emulsifiable concentrates (E.C.): Are concentrated formulations which form emulsions in water, most dips are formulated in this way.
5. Impregnated strips: Absorbent strips are impregnated with insecticides which are liberated either in gaseous or crystalline form. Tick and flea collars and fly strips are examples.
6. Aerosols: The pesticide is incorporated in a vapour under high pressure. Household aerosols and acaricidal aerosols for patch or hand treatment are examples.
7. Oral formulations: These frequently also have anthelmintic properties.
8. Parenteral formulations.
10. Pour-on.

The acaricide formulations most commonly encountered are:

- on one hand the wettable powders (acaricide in very fine powder + non-active solvent + wetting agent, which allows the dust to be suspended in water $\rightarrow$ suspension in water), and
- on the other hand the emulsifiable concentrates (an acaricide dissolved in an organic solvent + an emulsifier = a surface-active-agent used to stabilize a mixture of one liquid suspended in a larger amount of a second liquid $\rightarrow$ emulsion in water).

The wettable powders seem to be the most stable formulations though not always the most efficient ones. They are less susceptible to stripping (the impoverishment when the acaricide concentration of the liquid that streams down from the animal is lower than the concentration in the pool) and they are usually less...
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dangerous to handle since they are less easily absorbed by the skin. This formulation is particularly indicated for the dipping tank. It is useful to first prepare a paste with the acaricide powder and a bit of water before adding this paste to the bulk of water.

The use of emulsions is to be preferred in spray races. Emulsions have the advantage of not blocking up the nozzles as easily as the wettable powders do. They are directly added to the water and thoroughly mixed.

Never use phytopharmaceutical products! Although the acaricidal effects of many different plant extracts have been demonstrated (mostly in vitro), these have not been sufficiently standardised or tested for safety and efficacy to be commercially viable.

Take into account that in most countries the cost of acaricides includes a significant foreign exchange component!

Arsenicals

Arsenic was introduced as an acaricide around 1900. For almost 40 years it was the only product used and resistance did not appear until towards the end of that period. The product was marketed as a liquid concentrate of arsenic trioxide (As$_2$O$_3$).

Arsenic had the advantages of being inexpensive, stable and the concentration could be accurately determined and replenished in a simple way. Arsenical compounds cannot be used in a spray race as the mist resulting from spraying contaminates the surroundings and particularly the vegetation with arsenic. Arsenic is very toxic and an extremely irritating and caustic product, especially for the gastrointestinal tract. The safety margin of the prepared ready to use liquid (0.08 to 0.2% depending on whether the intervals between dips are short or long) is very slight (concentrations of 0.24% can already cause skin irritation). Animals brought to the dipping tank over long distances have to be rested and cool down before they can be dipped. Animals dying of acute intoxication may not be consumed. Antidote in case of intoxication: B.A.L 5 mg/kg 4 times a day. The product rapidly degrades in the dips. Moreover, arsenic protects against ticks for not more than 12 hours and its efficacy is lower than that of the modern ixodicides. Because of these drawbacks, the product was replaced with synthetic organic insecticides after World War II.

The organochlorinates

These chlorinated hydrocarbons are very stable products and their persistence on the skin and the hide lasts from one to two weeks. In recent years, the use of organochlorinates was banned in most countries because of their polluting (accumulation of these persistent molecules in the food chain) and carcinogenic effects.

Despite the presence of stabilizers in suspensions and emulsions, the active ingredients (especially in plunge dips) rapidly disintegrate. Thus the use of organochlorinates for dipping requires a chemical analysis service in order to check the active agent content in the dipwash. Based on the results the dipwash will be adjusted every 7, 15 or 30 days. Resistance to chlorinated hydrocarbons appeared rapidly: after 18 months
for HCH (Hexachlorocyclohexane), 6 years for DDT and 4 years for Toxaphene. It is thought that the rapidly occurring resistance is partly due to the long residual effect of these products. Cross-resistance to all organochlorines has been observed in *R. microplus*, *R. decoloratus* and *R. appendiculatus*.

**DDT**

DDT affects voltage dependent sodium channels. Recognised as dangerous and not very efficient, DDT has fallen into disuse because of its extreme stability and fat solubility leading to bioaccumulation of the product in the environment.
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**Gamma-hexachlorocyclohexane or lindane**

Lindane is a chloride channel-blocking insecticide causing hyperexcitability and convulsions. The binding to the chloride channel blocks its activation by gamma-aminobutyric acid. HCH is also a relatively cheap insecticide, but unlike DDT does not present the same risks of product accumulation in the animal. However, its lower stability was responsible for a fairly rapid disintegration of the product in the dipping baths. It was used at a concentration of 300 to 500 ppm.

**Toxaphene**

Toxaphene is commonly used in Africa and very efficient especially against *Amblyomma* and *Hyalomma* ticks. Very stable in dipping. Residual effect is 4 days for adult ticks, a bit longer for larvae.

Its toxicity for vertebrates is much higher than that of HCH, it is especially dangerous for carnivores. The product is used at a concentration of 0.25 to 0.5%; sometimes it is combined with organophosphates.

**Organophosphorous compounds**

The OP presently used for tick control are very efficient and less dangerous as they are quickly metabolised by the homoeotherms and thus do not accumulate.

However, different authors noticed that young animals lost weight after treatment.

Antidote in case of intoxication: atropine sulphate (doses possibly to be repeated after 1 or 2 hours: man 2 mg I.M; horse or adult bovine: 10 ml of a solution of 1%; calf, sheep, pig and dog: 2 to 5 ml of a solution of 1%).

Never combine organophosphates for tick control with an organophosphate as anthelmintic (cumulative effect). Resistance to organophosphorous compounds appeared firstly in those areas where *Rhipicephalus (Boophilus)* spp. prevailed. First (1963) in Australia and South America (*R. microplus*); and then in 1966 a resistant strain of *R. decoloratus* was found in South Africa. At first sight it was surprising that it occurred at a place where long-interval dips were practised. However, if the animals had been treated once a week, all the
larvae (= the stage most susceptible to acaricides) would probably have been killed, even the most resistant ones.

The OPs react with the enzyme acetylcholinesterase. This inactivates the enzyme and blocks the degradation of the neurotransmitter acetylcholine, which is released by the presynaptic cell subsequent to a nerve impulse (depolarisation). Acetylcholine binds to the postsynaptic nicotinic acetylcholine receptor and activates an intrinsic cation channel resulting in a depolarisation of the postsynaptic cell due to the influx of sodium and calcium ions. If acetylcholine is no longer hydrolysed by acetylcholinesterase, the concentration of the neurotransmitter builds up, leading to hyperexcitation of the central nervous system (CNS). Because OPs often require bioactivation and must penetrate into the CNS, the OPs do not have a rapid action like that of the pyrethroids.

**Coumaphos (Asuntol, Corral, Agridip Garrapatox)**

The product is sold as a 30 to 50% wettable powder or as an emulsion at 16%. The metabolisation of the product is much faster in mammals than it is in arthropods, which means that the product is less toxic in mammals (di50 rat : 56mg/kg). Calves are not affected by a spray or a dip at 5 times the recommended dose. It is a safe and efficient product but expensive. Asuntol is used for dips and sprays as well as for individual washing. Water with any level of dissolved minerals can be used. The product is rather stable and very efficient (residual effect 4 days). Its disintegration results in the formation of the toxic product potasan. However, by reducing the pH (less than 5.5), it is possible to eliminate the disintegration process without losing efficiency. Should rain fall during the dipping efficacy declines against nymphs and adult ticks.

In case of wettable powders, the recommended dose for dipping and spraying of bovines varies between 0.05% (i.e. 1kg wettable powder at 50% for 1,000 l of water) and 0.125%. A solution of 0.1% is used for sheep. When the water is hard or heavily polluted, the higher concentrations are recommended. In dipping tanks the product remains stable for at least one year. Adding 250 g of copper sulphate per 5000 l water prevents the proliferation of algae. In dips the loss of efficiency is proportional to the amount of dirt brought in by the animals; in such a case asuntol is added at concentrations that are proportional to the level of pollution (0.055 to 0.07%). It is best to have the concentration of the active ingredient in the dip analysed regularly.

As for the 16% concentrated emulsion, 1 l liquid Asuntol is used in 800 l water. To readjust the level of the dipwash, after having treated 200 cattle or after having consumed 500 l of dipwash, 1 l Asuntol is used for 400 l water. The residues in treated animals are low and after a few days, they drop below the detection limit. The milk of treated animals can immediately be consumed.
**Dioxathion (Delnav, Bercotox, Tick dip liquid)**

The products developed for dips are concentrated emulsions containing 15 to 30% Delnav. A special formula has been developed for bovines; “Delnav Diluent Free formula” and a mixture of dioxathion 55% and chlorfenvinphos 55% can be used for horses and bovines older than a month (Supramix DFF).

Hand dressing of sheep can be done using grease containing 0.35% dioxathion (tick grease).

The product is stable in water and has quite a long residual effect. It is used at a concentration of 0.05% active agent. When refilling the dip, a quantity of the product slightly higher than the initial one is added (follow the instructions of the manufacturer).

One must wait a week before slaughtering an animal that has been treated with Delnav. It is a product of great value for controlling *R. appendiculatus* in East Africa, especially when applied bi-weekly.

**Diazinon (Neocidor, Nucidol, Topclip, Dazzel etc.)**

There are concentrated emulsions and wettable powders for dips and sprays on the market with a concentration varying between 25 to 60%. Neocidol 5P (5%) is used for local application. Cats and chickens are very susceptible to Diazinon. The product has low persistence and is much more toxic than Coumaphos. It is used in dosages as follows:

- cattle: dip: 0.03 to 0.06% spray: 0.05 to 0.08%
- small mammals: dip and spray: 0.025 to 0.05%. Lambs younger than six weeks must not be treated!
- dogs and horses: 0.05%

One has to wait one or two weeks before slaughtering an animal that has been treated with Diazinon. The milk cannot be consumed for two days after treatment.
**Quinthiophos (Bac dip)**

It is a very stable product in a dip, even if the latter is fouled. It can be used for all domestic animals except cats. The product is quite resistant to the tropical heat and thus there are no storage problems.

Bac dip is sold as a concentrated emulsion at 50% (sometimes 30%).

The dosage for dips and sprays for cattle, sheep and goats is as follows: 1 l for 2500 l of water (0.02%), for readjustment (replenishment) of the dipping bath or spray reservoir level, one uses 1 l per 1600 l of water (0.03%). Animals cannot be slaughtered for consumption during the seven days following the treatment.

Dogs can be treated with 10 ml per 10 l of water (0.05%).

**Bromophos (Nexion, Tidal etc)**

Nexion only contains bromophos, whereas the commercial product Tidal 300 consists of two organophosphates: Bromophos-ethyl 20% and Fenitrothion 10%. These products have little toxicity and leave few residues behind in the body for more than 3 to 4 days after use. The residues in milk do not exceed 0.1 ppm and are rapidly eliminated.

Dosage: Nexion = 0.05%, Tidal 300 = 1 l for 300 to 500 l water.

**Chlorfenvinphos (Supona) (Supramix DFF = Supona + Delnav)**

Stability is reasonable. The product comes as a 20 to 30% emulsion for dips and sprays. The dosage to use is 0.05%.

Toxicity varies according to the species: for dogs, it is very low when taken orally, but for calves it is quite considerable (20 mg/kg). Given subcutaneously, the product is less dangerous.

Withdrawal period: one week.
**Crotoxyphos (Ciodrin)**

Ciodrin is sold in emulsion form (24%).

This is an interesting product to control ticks on dairy cows. It leaves no detectable residues (detection limit : 0.001 ppm.) in milk or meat. This means that the animals can be treated with the recommended doses until they are ready for slaughter. The product, which is unstable, should not be used in plunge dips. The spray at 0.15 – 0.3% must be used the very day of its preparation.

**Chlorpyrifos (Killtick Dip, Dursban)**

This concentrated emulsion of 10 to 20% is used for individual dipping of sheep and lambs (from the age of 4 days onwards) at a concentration of 0.05%. As soon as the level of the dip drops by 25%, it has to be refilled with an emulsion at 0.075%.

The product is not very stable.
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Propetamphos (Blotic, Bostan, Young’s Summer Dip)

These products contain 8 to 35% active ingredient and they are used for both dip and spray at a concentration of 0.03 to 0.035%. For manual spraying and readjustment of the dip, the concentration of 0.05% is used. Lambs under the age of 3 months are not to be treated with this product. Hard water must be softened before use with 1kg soda per 500 l water. The dipwash can only be used for one week. Withdrawal period: 2 weeks for meat, 60 h for milk.

The carbamates

Their mode of action is similar to that of the OPs.

Carbaryl-based wettable powders have been used as a spray at a concentration of 0.1% or 0.15% (Promecarb).

Carbaryl has been used for spraying infested pastures at a dose of 1kg/4 km2.
The amidines

These compounds mimic the action of the neurotransmitter octopamine, which regulates behavioural arousal within the CNS. Octopamine binds to a receptor that elevates levels of the second messenger, cyclic adenosine monophosphate (AMP). Cyclic AMP then initiates processes that give rise to neuronal excitation. Amidines cause an overstimulation of octopaminergic synapses in insects, resulting in tremors, convulsions, and continuous flight behaviour in adult insects. Moreover, they cause anorexia and suppress reproduction in arthropods.

Amidines were developed to control ticks that had developed resistance to organophosphates.

**Amitraz (Taktic, Azaform, triatox)**

This noncyclic amidine is presented as a wettable powder (WP) at 23.75 and 50% and as a concentrated emulsion (CE) at 12.5 and 23.75%. The concentration used for spraying is 0.025% (CE) and for dipping 0.025 (WP) and 0.05% (CE). The product becomes unstable when the pH drops (urine, faeces, and microbes). Before, it was necessary to add an alkaline stabiliser e.g. Ca (OH)2 at a concentration of 0.5-0.7% that would maintain the pH between 10 and 12 (1.25% for the refills). Today there are new formulations, which do not require any stabiliser.

Amitraz causes the ticks to detach rapidly (within 30 min to 8 h). They also lose the ability to cling to another host. Amitraz has ovacide activity, a long-term persistence and is relatively cheap.

Withdrawal period: one week. Amitraz is very toxic to horses and may not be used on these animals!! Sometimes young animals lose weight after treatment.

**Clenpyrin (Bimarit)**

This amidine causes fast-progressing muscular paralysis in ticks and prevents maturation of the eggs in females. The product has a repellent effect on ticks and since it is stable in dips, no stabiliser is needed. After treatment Clenpyren builds up in the fatty tissues, but after two weeks this level will have dropped 10 times.
The Thioureas

The mode of action is similar to that of the formamidines but they are more stable in the dipping tank.

**Chloromethionon (Dipofène 60)**

Put on the market as a flowable consisting of a 60% suspension of extra fine particles in a watery environment (puddinglike consistency). The product is very stable in a dipping tank and doesn’t require a stabilizer. Even a dip that has been out of use for a while retains its product content. The stripping phenomenon doesn’t take place but flowables have the tendency to come out of suspension and settle to the bottom of the tank if they are not constantly agitated. The product has little toxicity for mammals and is active on resistant strains. The duration of effectiveness is 7 days. Residues in animals do not exceed 0.15 ppm in meat and 0.17 ppm in milk. The product is used at a concentration of 0.18%.

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**Long-lasting pyrethrroids**

Pyrethrroids prolong the flow of the current flowing through sodium channels by slowing or preventing the closure of these channels. This has a potent effect on nerve impulse generation within both the central and peripheral nervous systems. Under normal conditions, neurons possess a negative transmembrane voltage of about –60 mV on the inside. The nerve impulse or action potential consists of a transient depolarisation (positive wave) whose upstroke is driven by an influx of sodium ions, followed by a downstroke from the efflux of potassium ions. The action potential is propagated down the axon until it reaches the nerve terminal, where it stimulates the release of chemical transmitters. The duration of modified sodium currents by type 1 compounds last tens of milliseconds, while those of type 2 pyrethrroids last for minutes or longer. Long-lasting pyrethrroids are very efficient against ticks resistant to organophosphates, but in Australia and South Africa cross resistance (Knock Down Resistance - kdr) was observed in *Rhipicephalus* (*Boophilus*) ticks resistant to DDT.

A disadvantage of these products is their rather high price and the fast-developing resistance (especially against permethrin). In some countries combination products of pyrethrroids and organophosphates are available on the market, since a synergistic effect was observed of organophosphates on pyrethroid-resistant ticks.
Flumethrin (Bayticol)

A residual effect of 7 to 9 days against one-host ticks is shown by the effect on the larvae. The effect on two- or three-host ticks will first show in the larvae and the nymphs and next in the adults, which will be killed after a contact of 1 to 8 hours. There is a strong reduction of the number of viable eggs produced by the female ticks that have been in contact with the product, but have not received a lethal dose. The product is on the market as an emulsifiable concentrate at 2.6% or 7.5%. The product is very stable in dips (no stripping) and can be used on animals of any age. The concentration is 0.004% (40 ppm) for a plunge dip and 0.005% for a spray.

A pour-on formula at 1% used at 1 mg/kg also exists, which is very efficient (100% of *R. appendiculatus* controlled during the first six days after treatment).

The product does not leave any detectable residues in the tissues of the animals, neither is there significant secretion through the milk. However, weight loss was observed in young animals.

Deltamethrin (Decatix)

There are concentrated solutions of deltamethrin available for use in dips and sprays. The concentration used in a dipping tank lies between 0.0025% (25 ppm) and 0.0038% (0.45% for refilling). For spraying, a solution of 0.005% is used. The persistence of the product is long: 15 days in the dry season, 7 days in the rainy season, but the product is not 100% efficacious in eliminating all ticks. Moreover, tick resistance has been detected. Treatment also has a lethal effect on tsetse flies feeding on treated animals,
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**Lambda-cyhalothrine**

This is especially efficient in a spray at a dose of 0.005 to 0.01%.

![Lambda-cyhalothrine](image)

**Phenylpyrazole compounds**

**Fipronyl**

Available as a pour-on formulation for control of ticks in several Latin American countries. Good therapeutic efficacy against *R. microplus* but the product is not very stable under field conditions. The product has an effect on oocyte development and causes salivary gland degeneration.

![Fipronyl](image)
Benzoyl phenyl ureas

Fluazuron

This chitin synthesis inhibitor is efficacious against *Rhipicephalus* (*Boophilus*) ticks. The pour-on formulation does not prevent the tick feeding but during a period of almost 12 weeks reduces the fecundity and fertility of engorged females to close to zero and causes significant mortality among immature ticks because they are unable to moult to the next instar. Because of its binding to fat, fluazuron is excreted in milk and it is thus unnecessary to treat calves suckling on treated cows. Long withholding time: six weeks after treatment.

Spynosins

Spinosad

Spinosad is a fermentation metabolite of an actinomycete and disrupts the binding of acetylcholine in postsynaptic nicotinic acetylcholine receptors. It has persistent efficacy against larval reinfestations with *R. microplus* for two weeks after treatment. Efficacy is greater against nymphaal and larval ticks than against adults.

Synergists

These compounds are not in themselves toxic or insecticidal, but used with insecticides, enhance their activity. They are used extensively in household sprays (aerosols) containing pyrethrin, and are also used in some (but not all) organophosphates, organochlorines, carbamates as well as some plant-derived insecticides. Their mode of action is their binding to oxidative enzymes that would otherwise degrade the insecticide. Examples are: Sesamex, piperonyl butoxide, sulfoxide and MGK 264.
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Macrocyclic Lactones

The macrocyclic lactones (avermectins and milbemycins) are products, or chemical derivatives thereof, of soil microorganisms belonging to the genus *Streptomyces*. The avermectins in commercial use are ivermectin, abamectin, doramectin, eprinomectin, and selamectin. Commercially available milbemycins are milbemycin oxime and moxidectin. The macrocyclic lactones have a potent, broad antiparasitic spectrum at low dose levels. They are active against many immature nematodes (including hypobiotic larvae) and arthropods. The published literature contains reports of use to treat infections of >300 species of endo- and ectoparasites in a wide range of hosts. Moreover, a single therapeutic dose can persist in concentrations sufficient to be effective against incumbent nematode infections for prolonged periods after treatment.

The macrocyclic lactones are well absorbed when administered per os (PO), parenterally, or as pour-on formulations. Regardless of the route of administration, macrocyclic lactones are extensively distributed throughout the body and concentrate particularly in adipose tissue. However, the route of administration and formulation may affect disposition. The residence time of macrocyclic lactones administered subcutaneously (SC) may also be influenced by the body condition of the animal.

Examples: Ivermectin, Doramectin, Moxidectin