Mode of Action Classification

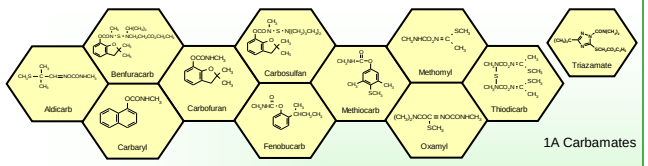
IRAC

Insecticide Resistance Action Committee

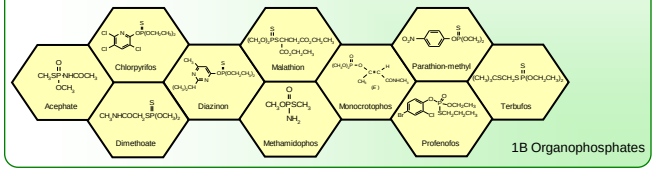
The Key to Resistance Management

More information on IRAC and the Mode of Action Classification is available from:
www.irac-online.org or enquiries@irac-online.org

Group 1: Acetylcholinesterase (AChE) inhibitors (Only major representatives of the groups are shown)



1A Carbamates



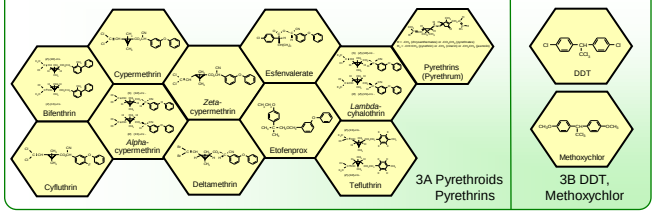
1B Organophosphates

Group 2: GABA-gated chloride channel antagonists

2A Cyclodiene Organochlorines

2B Phenylpyrazoles (Fiproles)

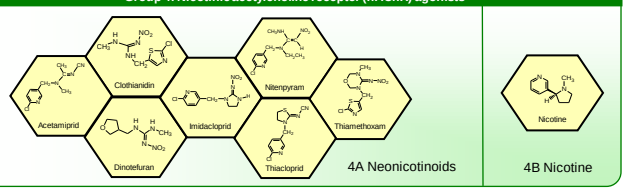
Group 3: Sodium channel modulators (Only major representatives of group 3A are shown)



3A Pyrethroids Pyrethrins

3B DDT, Methoxychlor

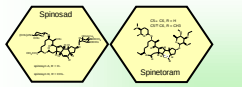
Group 4: Nicotinic acetylcholine receptor (nAChR) agonists



4A Neonicotinoids

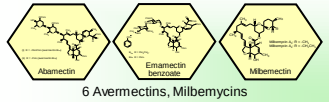
4B Nicotine

Group 5: Nicotinic acetylcholine receptor (nAChR) allosteric modulators



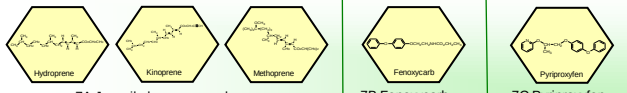
5 Spinosyns

Group 6: Chloride channel activators



6 Avermectins, Milbemycins

Group 7: Juvenile hormone mimics

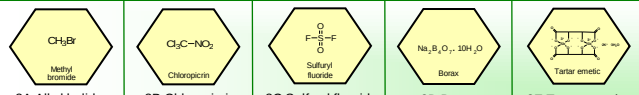


7A Juvenile hormone analogues

7B Fenoxycarb

7C Pyriproxyfen

Group 8: Miscellaneous non-specific (multi-site) inhibitors



8A Alkyl halides

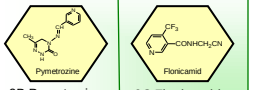
8B Chloropicrin

8C Sulfuryl fluoride

8D Borax

8E Tartar emetic

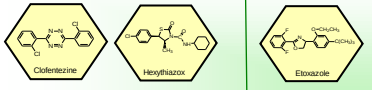
Group 9: Selective homopteran feeding blockers



9B Pymetrozine

9C Flonicamid

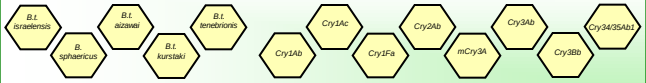
Group 10: Mite growth inhibitors



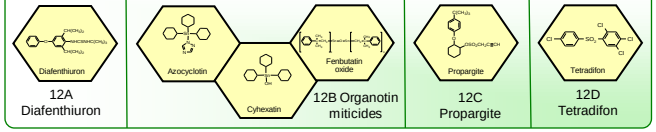
10A Clofentezine, Hexythiazox

10B Etoxazole

Group 11: Microbial disruptors of insect midgut membranes and derived toxins



Group 12: Inhibitors of mitochondrial ATP synthase



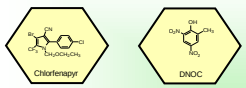
12A Diafenthiuron

12B Organotin miticides

12C Propargite

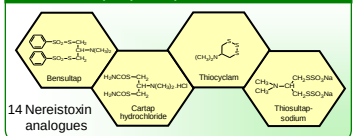
12D Tetradifon

Group 13: Uncouplers of oxidative phosphorylation via disruption of proton gradient



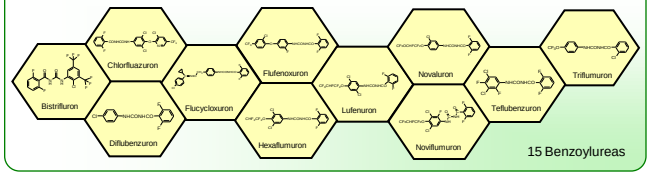
13 Pyrroles, Dinitrophenols

Group 14: Nicotinic acetylcholine receptor (nAChR) channel blockers



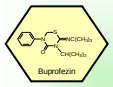
14 Nereistoxin analogues

Group 15: Inhibitors of chitin biosynthesis, type 0



15 Benzoylureas

Group 16: Inhibitors of chitin biosynthesis, type 1

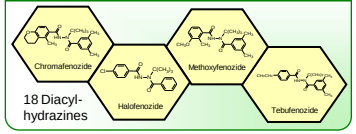


16 Buprofezin

Group 17: Moulting disruptor, Dipteran

17 Cryomazine

Group 18: Ecdysone receptor agonists

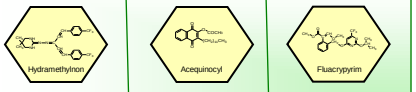


18 Diacylhydrazines

Group 19: Octopamine receptor agonists

19 Amitraz

Group 20: Mitochondrial complex III electron transport inhibitors

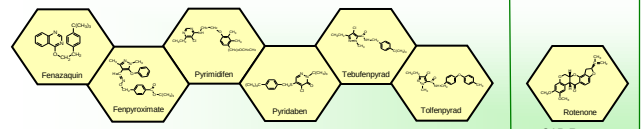


20A Hydramethylnon

20B Acequinocyl

20C Fluacrypyrim

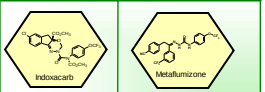
Group 21: Mitochondrial complex I electron transport inhibitors



21A METI acaricides and insecticides

21B Rotenone

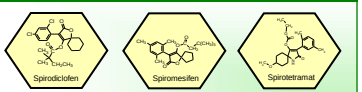
Group 22: Voltage-dependent sodium channel blockers



22A Indoxacarb

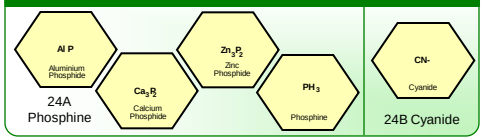
22B Metaflumizone

Group 23: Inhibitors of acetyl CoA carboxylase



23 Tetronic & Tetramic acid derivatives

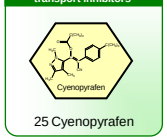
Group 24: Mitochondrial complex IV electron transport inhibitors



24A Phosphine

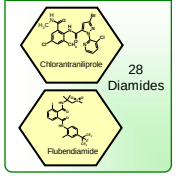
24B Cyanide

Group 25: Mitochondrial complex II electron transport inhibitors



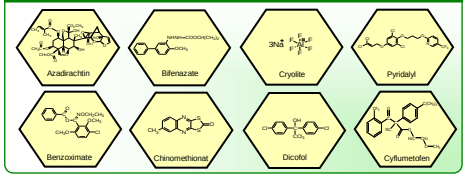
25 Cyenopyrafen

Group 28: Ryanodine receptor modulators



28 Diamides

Group UN: Compounds of unknown or uncertain mode of action



Guidance on the use of Sub-Groups:

- Represent distinct structural classes believed to have the same mode of action.
- Provides differentiation between compounds that may bind at the same target site.
- Are structurally different such that risk of metabolic cross-resistance is lower than for close chemical analogs.
- Are likely to be metabolized by different enzymes - may bind differently enough within the target site that the chance of selection for metabolic/target-site resistance is reduced compared to close analogs.

- In the absence of other alternatives, it may be possible to rotate compounds between sub-groups if it is clear that cross-resistance mechanisms do not exist in the target populations.
- Not all of the current groupings are based on knowledge of a shared target protein. For further information please refer to the IRAC Mode of Action Classification document.
- 1A & 1B - If there are no other alternatives, compounds may be rotated in situations where cross-resistance mechanisms are known to be absent in the insect populations to be treated.

- 3A & 3B - If there are no other alternatives, compounds may be rotated in situations where cross-resistance mechanisms (e.g. kdr) are known to be absent in the insect populations to be treated. DDT is no longer used in agriculture and therefore this is only applicable for the control of human disease vectors such as mosquitoes, because of a lack of alternatives.
- 10A - Clofentezine & Hexythiazox are grouped because they commonly exhibit cross-resistance even though they are structurally distinct, and the target site for neither compound is known.
- 22A & 22B - Although these compounds are believed to have the same target site, they have been sub-grouped because they are chemically distinct, and current evidence indicates that the risk of metabolic cross-resistance is low.

Poster Version 2, October 2009. Based on the Mode of Action Classification - Version 6.3