Mirror Image Insecticides

Everything in the world, except perhaps a vampire, has a mirror image. But mirror images are curious things. Imagine that you place a ping-pong ball in front of a mirror. If you could somehow pick up its image from behind the mirror, you would find it to be identical with, and exactly superimposable on the original. But now imagine that you hold your left hand in front of the mirror. The reflection you see is a right hand. Were you able to pick up this mirror image hand, you would not be able to superimpose it on the left hand. What's the difference between the ping pong ball and your hand? The ball is symmetrical, the hand is not. Basically then, any object that is not symmetrical will have a non-superimposable mirror image. That goes for molecules as well. We call such non-superimposable mirror image molecules "enantiomers." As far as standard chemical reactions go, enantiomers behave in an identical fashion, but such is not the case when biological systems are involved. Enantiomers may have different toxicological profiles and different breakdown patterns in the environment. This may be of great interest when it comes to evaluating the risk-benefit profile of some insecticides.

About 25% of currently used insecticides have molecular structures that lack symmetry and therefore can exist as enantiomers. When these substances are synthesized, both enantioners are produced in equal amounts. But they do not necessarily have the same insecticidal properties and do not necessarily degrade the same way in the environment. Hexachlorocyclohexane was once a commonly used insecticide, but is being phased out because of its environmental persistence. It can be found in the fatty tissue of animals, including humans. Interestingly, though, when the brain tissue of seals around Iceland was examined, only one of the enantiomers was found to be present. This means that the other was more rapidly degraded. All of this may sound highly theoretical but there are significant practical applications.

Synthetic pyrethroids and organophosphates are some of the most commonly used insecticides and the commercial preparations are enantiomeric mixtures. It is likely that for any such insecticide the two enantiomers have different biological effects. For example, *Daphnia magna* is a species of flea that lives in freshwater aquatic environments and serves as food for fish. Experiments have shown that individual enantiomers of certain insecticides have dramatically different toxicity effects on this creature. That is important information because one of the fallouts of using insecticides is their effect on non-target species. We may want to spray a field to keep insects away from a food crop but we don't want insecticide residues that wash into nearby waters to affect aquatic life. This may be achievable by separating the enantiomers of a commercial insecticide mixture, a process that is technically feasible, and using only the appropriate one. Just another example of how an understanding of fundamental molecular theory can pay practical dividends. And another reason that organic chemistry students should not complain about struggling with enantiomers.

by Joe Schwarcz