PROPER APPLICATION OF FORMIC ACID FOR *VARROA* MITE CONTROL

ACID VAPOR BATHS IN THE BEEHIVE

It's an irritating affair for the Varroa mites: Formic acid is popular among beekeepers to protect their honey bees from these dangerous parasites. But if it's applied incorrectly, the acid can also harm the bees. A new study sheds light on the process.

AT A GLANCE

// Formic acid is an important tool for beekeepers to fight the *Varroa* mite.
// Bayer researchers investigated how the acid can be applied in an optimal way.

In diffusion studies the researchers tested how much formic acid finds its way through the brood cell caps.

When late summer comes around, it's time for beekeepers to undertake the painstaking task of getting their beehives ready for overwintering. This is crucial to ensure that sufficient numbers of honey bees survive the cold months of the year, thus enabling a strong colony to develop again in the spring. An extremely important part of this process is ridding the colony of deadly *Varroa* mites. The tiny parasites and the battle waged against them dictate the daily activities of nearly all beekeepers around the world. In this fight, a large number of European apiarists prefer to use formic acid. This liquid control substance offers many advantages, as it evaporates in the beehive. "Formic acid begins to act in the gas phase. That's how it's capable of penetrating into the sealed brood cells and killing off the mites feeding there," says Dr Ralf Nauen, an insect toxicologist and Bayer CropScience Research Fellow.

What's more, the mites are unlikely to develop resistance against the highly volatile organic acid after repeated treatment. This is because formic acid is not affected by metabolic enzymes conferring insecticide resistance. Compared to other acaricides it also bears a low risk of being accumulated, so residues are unlikely. Formic acid also controls *Varroa* mite populations which are known to be resistant to synthetic acaricides, such as pyrethroids.

However, formic acid can also have harmful side effects on honey bees, if the acid concentration during the treatment exceeds a certain level. On the other hand, if not enough formic acid evaporates, the mites are not affected. "The therapeutic window, in other words the concentration range between killing mites and damaging bees is very narrow," Dr Nauen explains. "It is therefore important that beekeepers know what concentration of formic acid to apply." But how the formic acid vapors are released also depends on the type of evaporator used and on the temperature. This prompted Dr Nauen together with Manuel Tritschler, at that time working as a bee expert and beekeeper at the Bayer Bee Care Center, to accurately test two different kinds of Nassenheider evaporators. Both devices are filled with 65 percent liquid formic acid that drops onto a mat, where it evaporates. However, the so-called vertical evaporator and the horizontal device differ in the rate the acid drops.

In collaboration with a master beekeeper, the researchers treated four honey bee colonies in August – two of each with one of the evaporators and at different temperatures. They then measured the dispersal of the formic acid vapor in the hive, while also regularly monitoring the concentration of the chemical in the air and how this changed over time. "We discovered some differences," says Dr Nauen,

To find out how formic acid distributes in the beehive, the researchers drilled holes into the chest and measured the acid concentration at different locations inside.

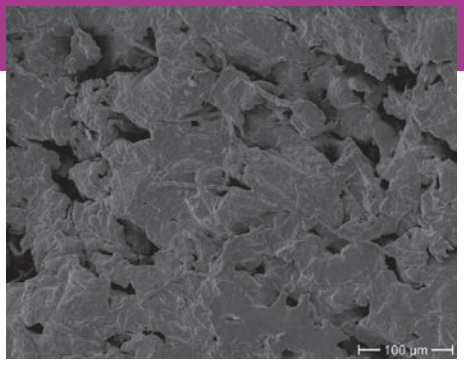
summing up the findings of the study. "Over a period of three days, the horizontal evaporator provided not only a fairly consistent concentration of formic acid but, most importantly, a sufficiently high level." Also the vertical device managed to achieve this concentration, but in a less consistent manner, which means it was a bit slower in effectively protecting the bees from the *Varroa* mites.

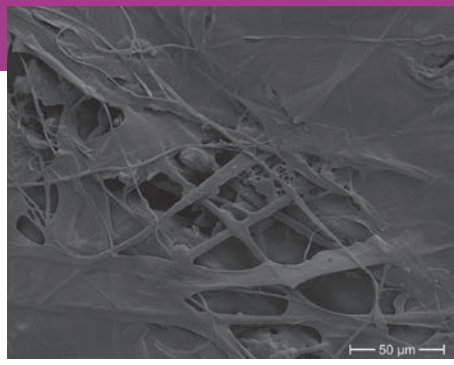
Another finding: The higher the temperature, the better the chemical can vaporize and disperse throughout the hive.

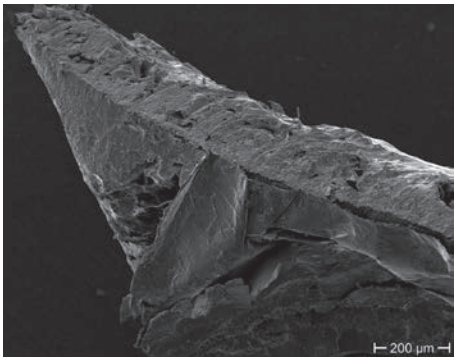
"Beekeepers should avoid using these evaporators at low morning temperatures such as 15°C. Under laboratory conditions, temperatures of 25 to 30°C resulted in an ideal evaporation pattern," says Dr Nauen. The findings of the study give beekeepers important data that can help them treat their hives more effectively – while also ensuring that they are well-prepared to combat the *Varroa* mites in the late summer to fall.

Nature's weapon

Formic acid not only protects against mites; the chemical, which was first extracted by scientists from some ants species, is produced naturally and used by the ants as a defense spray to ward off their enemies. The larvae of the puss moth can also squirt formic acid up to 30 centimeters when it feels threatened. Other creatures such as jellyfish, scorpions and beetles employ the substance to defend themselves, too. Even plants exploit the power of the chemical: The urticating hairs of stinging nettles also contain formic acid.







The close inspection under the electron microscope reveals: The sealed brood cells of a honeycomb are not air-tight. Formic acid can still diffuse through the caps, killing off *Varroa* mites inside.