

# The Well-Fortified Two-Component Beetle

Two-component mixing systems — like the ones from Sulzer Mixpac — also exist in nature. The bombardier beetle has been mixing two reactive chemical components efficiently for millions of years already.

The bombardier beetle is a subfamily of the ground beetle that is widespread throughout the world. They developed the principle of binary chemical warfare agents and the rocket drive long before humans hit on these ideas. In its subsidiary rear glands, the beetle produces hydroquinone and hydrogen peroxide, and it stores the two chemicals separately in collecting bladders. If the beetle feels threatened, it releases these substances into a large, thin-walled chamber that is surrounded by strong muscles. The chamber is also at the back of the beetle's body. The two components are mixed here. A valve links the mixing chamber to a small, thick-walled chamber also in the rear part of the body — the rocket drive.

## Corrosive and boiling hot

To defend itself, the beetle contracts the muscles of the large chamber to press a portion of the chemical mixture into the small chamber. There, active, oxidative enzymes are waiting, which immediately react with the chemicals. Hydroquinone transforms explosively into benzoquinone, a pungent-smelling chemical agent that causes irritation to the mucous membrane. The hydrogen peroxide, however, is used to form oxyhydrogen gas, the explosion of which propels the foul chemical agent towards the troublemaker through the rear valve of the bombardier beetle's gland. In this way, the animal, which is only between one-half to two centimeters long, can hit its enemies at distances up to half a meter. It does not matter where the enemies appear because the beetle can rotate the tip of its abdomen rapidly in any direction, like a turret. Even large animals immediately spit out a bombardier beetle. The chemical agent not only tastes corrosive but it can also be up to 100°C (212°F) hot through the chemical reaction in the beetle's combustion chamber.

## Fireworks with miniexplosions

In 1990, a group of American biologists published another amazing detail about the bombardier beetle. During the beetle's firework display, observers had not only



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1 The bombardier beetle in action.

seen a small cloud of spray but they had also reported hearing a short puffing sound. Simultaneous sound recordings revealed not a single bang, but a fast series of half a dozen miniexplosions. High-speed film recordings confirmed the acoustic findings: the bombardier beetle can fire its rocket at the extremely high rate of 500 explosions per second.

## Integrated pulse jet engine

So, nature was the first to invent the principle of the pulse jet engine. During the Second World War, the German Third Reich developed the V1 flying bomb, which worked on exactly this principle. As in the V1, the beetle's engine works automatically: the check valve between the two chambers closes or opens depending on the difference between the mixing chamber and the reaction chamber, and sends the two chemical components for combustion in measured portions.

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