LIFT-OFF—THANKS TO HYDROGEN PEROXIDE

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At the end of the countdown an ear-splitting roar fills the air and the space rocket shoots skyward. Huge driving forces are needed to bring the multi-ton device into orbit. For this, Russian Soyuz rockets rely on a product of Evonik: hydrogen peroxide. It is even being viewed as a potential fuel for the next stage in the evolution of rocket technology.

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"The Soyuz rocket is the workhorse of space travel," according to Dr. Philipp Christ. And he should know; as the manager of the global process laboratory of the Active Oxygens business line in Hanau near Frankfurt, his work focuses on space travel, among other things. While the Russian rocket technology is not new, it is regarded as extremely reliable and relatively inexpensive. Following the closure of the Space Shuttle Program, Soyuz is currently the only rocket allowing safe manned rocket

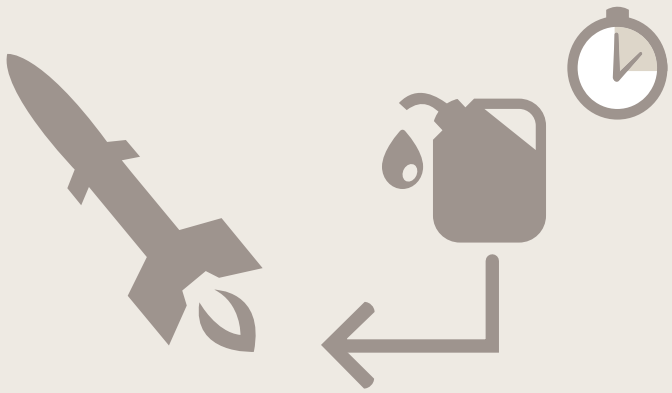
The sky's the limit! The highly concentrated hydrogen peroxide - 82.5 percent - drives the turbo pumps that force the actual fuels – kerosene and liquid oxygen – into the combustion chambers.

launches. In 2011 a Soyuz-ST carrier rocket was launched from the European spaceport Kourou in French Guyana for the first time with PROPULSE®, the hydrogen peroxide developed by Evonik for propulsion systems. "And even today our hydrogen peroxide is used in the turbopumps to transport the actual fuels, jet fuel and liquid oxygen, into the combustors under high pressure," says the 35-year-old chemist. In a sense, then, hydrogen peroxide supplies the energy to feed the huge rocket with fuel. A few metric tons are needed to send the 300-ton Soyuz rocket into orbit.

AN EARLY SUBJECT OF INVESTIGATION IN ROCKET TECHNOLOGY

Hydrogen peroxide is not new in rocket technology. Research into its use as a fuel for rocket propulsion began way back in the 1930s, and it was in fact specially produced for this purpose. While the Russians never lost sight of the product and, before the use of Evonik's hydrogen peroxide, relied on their own production, the Europeans and Americans gave up their efforts and found an alternative with the development of a decomposition catalyst for hydrazine and hydrazine derivatives.

THE CHALLENGE



... is to ensure that rockets are supplied with kerosine fast enough during the take-off and thus can overcome gravity on their way into space.

UP TO 30,000 REVOLUTIONS PER MINUTE

The process is actually quite simple. H_2O_2 is brought into contact with a manganese-containing catalyst in the fuel pump. The oxidant then decomposes, with high generation of heat, into its constituents, water vapor and gaseous oxygen. Both of these ensure, as a result of the volume expansion, that the fuel pump drives the liquid oxygen and jet fuel at up to 30,000 revolutions per minute into the combustors, where the necessary thrust for the rocket launch is generated. By the time the Soyuz is in space, the hydrogen peroxide on board has been almost completely consumed.

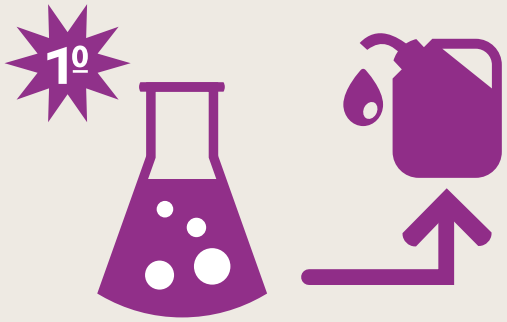
Incidentally, the product is manufactured at the Rheinfelden site, where hydrogen peroxide has already been produced for over 100 years. "From there we dispatch the highly concentrated solutions to all parts of the world in specially manufactured ther-

mal containers," says Christ. "These have a pressure release system as well as temperature and GPS monitoring."

GREEN ROCKETRY

The use of hydrogen peroxide as a fuel for hybrid rockets appears increasingly likely because, compared with conventional fuels, it is far more environmentally compatible. "Everyone's seen in news footage the gigantic brown clouds generated when a space rocket is launched," remarks Christ. This releases huge quantities of nitrogen oxides. Moreover, the hydrazine that is also used as fuel is carcinogenic, which is why the EU is considering banning it. H_2O_2, on the other hand, has none of these negative side effects. "Hydrogen peroxide represents 'green rocketry' because in the decomposition process it does not release any substance that is harmful to man or nature," says Christ.

THE SOLUTION



Highly concentrated hydrogen peroxide which explosively drives the turbo pumps in a rocket: that way sufficient kerosine and liquid oxygen are transported into the combustors.

With a self-developed process, Evonik is able to produce H_2O_2 with a concentration of up to 98 percent.
Thus, hydrogen peroxide would be excellently suited for the propulsion of minisattelites and smaller rockets as the sole fuel.

H_2O_2 AS A FUEL WITH MANY DIFFERENT ADVANTAGES

Despite its high energy density, H_2O_2 is easy to handle and readily initiates the decomposition processes needed for propulsion technology. Over the last few years the HYPROGEO project funded by the European Union has been explicitly studying hydrogen peroxide as a powerful, safe, and environmentally friendly fuel for space travel. The aqueous solution would then not only start up the turbopump but, along with a second fuel, be responsible for the propulsion of the entire rocket. "Propulsion is almost always produced by a combustion, and that needs oxygen; this can be supplied by H_2O_2 in its decomposition process," says Christ. "The result would be hybrid rockets, relying on hydrogen peroxide and, for example, polyethylene as fuels. The latter is a simple plastic, used for example to make shopping bags."

BRIGHT PROSPECTS FOR SMALLER ROCKETS AND MINISATELLITES

Christ sees yet another reason why hydrogen peroxide has a future in space travel.

"The entire market is now ready for the next evolutionary step, the trend being toward smaller rockets and microsatellites. Thanks to its ease of handling, H_2O_2 will play an important role here as a fuel; it allows even relatively small companies to build rockets with simple means." Already today a number of startups all over the world are using hydrogen peroxide as a green fuel in the latest rocket generations.

98 PERCENT H_2O_2

So for the Active Oxygens Business Line, which possesses decades of expertise in hydrogen peroxide and is a world leader when it comes to global availability and transportation know-how, the prospects look bright —all the more so as the concentrations required are high. "For rockets, concentrations of at least 80 percent by weight are needed. This means that one kilogram of solution consists of 800 grams of pure hydrogen peroxide and 200 grams of water. The higher the concentration, the higher is the energy content and therefore the better it is for propulsion rockets," says Christ. "The regular production process results in concentrations of 40 to 50 percent. To enrich the product to higher than 80 percent special production processes are used in which, for example, water is successively distilled off. We're already in a position to produce a 98 percent solution."

This was an important development in the course of the above-mentioned HYPROGEO project. In 2017 Evonik's hydrogen peroxide solution, with the highest H_2O_2 concentration ever achieved, proved itself in practice, giving impressive results in tests of a recently developed engine for hybrid rockets.

SUITABLE FOR SATELLITE NAVIGATION

The 98 percent solution would also be excellently suited for satellite propulsion, for example, because every extra kilogram that must be launched into space also costs more. In 98 percent hydrogen peroxide, the solution carries an enormous amount of energy and contains hardly any water, which is mere ballast. This would be advantageous for satellites using H_2O_2 as the only fuel, when performing steering maneuvers in space: The decomposing hydrogen peroxide alone would suffice. So hydrogen peroxide has the potential to take space-travel and satellite technology to the next level.