THE DIRECT ROUTE

TEXT **HANNS-J. NEUBERT**

Evonik has developed a new process for the efficient and environmentally friendly production of propylene glycol. In cooperation with the US-based Dow company, the technology is now being brought to market maturity

Sometimes you need to take a backward look before you can really move a project forward. In 2012 Holger Wiederhold, a researcher in the Active Oxygens Business Line at Evonik, came upon a note that had been entered in a database years ago. Bernd Jaeger, who was at that time a Head of Research at Evonik, had recorded his thoughts about the direct synthesis of propylene glycol. He had speculated that this coveted product, which was normally manufactured in several complicated steps via precursor products, could be synthesized in a single step that offered major benefits.

But back then Jaeger had not come up with a practical approach to a solution, so he merely left a note about his project in the in-house database. In this memory bank of ideas, Evonik researchers save suggestions for which they don't yet see a possible technical implementation, but which they hope will someday be found by someone.

While Wiederhold, a chemist, was reading Jaeger's note, he suddenly realized how this chemical synthesis could work. "That was the starting point of HYPROSYN™," he says. The project for developing the cost-effective and sustainable direct synthesis of propylene glycol has been conducted by the Active Oxygens Business Line in the laboratories of process technology since 2013.

The demand for propylene glycol is huge, and it's growing by 2.5 percent annually. This compound is used in antifreeze, lubricants, fiberglass-reinforced plastics, cleaning and washing products, and latex wall paints. It's also indispensable for the food industry. It gives chewing gum the right consistency, makes baked goods soft, and keeps packaged foods moist. Livestock farmers use it to treat metabolic disorders of their dairy cows. "Propylene glycol has developed into an all-round bestseller," says Thomas Bode, who is responsible for HYPROSYN™ technology at Evonik. Today about two million tons of propylene glycol are processed annually worldwide. In order to meet the growing demand, developers have been working for years to find new solutions.

A PRECURSOR PRODUCT FOR MANY APPLICATIONS

At Evonik, a core team of four colleagues set out to develop a new process for synthesizing propylene glycol. "In order to refine this process, we needed the support of additional colleagues from a whole range of different areas," explains Wiederhold. Many colleagues from all over the Group contributed their know-how to this development process.

Previously, the first step in the production of propylene glycol had often been the production of propylene oxide. In order to manufacture this precursor product, Evonik cooperated with thyssenkrupp from 2000 on to develop the HPPO process. This acronym stands for "Hydrogen Peroxide to Propylene Oxide." In 2008 this process was licensed for the first time for a production plant in South Korea, which today is turning out more than 130,000 tons of propylene oxide annually. By contrast to traditional synthesis methods, which require substances such as chlorine or benzene, this process requires only propylene and H_2O_2, which is supplied by Evonik. The only byproduct of the process is water.

The intermediate product propylene oxide is in high demand. One fifth of the total production volume is used to synthesize propylene glycol. Two thirds of →

From veterinary medicine to aeronautics, the applications of propylene glycol are wide-ranging

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OXIDANTS AT EVONIK

the total production volume are processed into polyether polyols, which are then processed via intermediate steps into polyurethane (PU) products such as construction foams and paint bases. The remaining propylene oxide is used as a starting material for producing other valuable chemicals. The demand for propylene oxide has recently grown even faster than that for propylene glycol, by about four percent to approximately 11 million tons.

One way to continue meeting this demand in the future would be to build additional propylene oxide production plants. However, each of these plants would cost hundreds of millions of euros. Alternatively, researchers could search for innovative solutions that simultaneously open up new applications for environmentally friendly hydrogen peroxide. “We considered the second alternative much more attractive,” says Wiederhold, who headed the project.

The key to success, which helped Wiederhold achieve a breakthrough, was a newly developed catalyst system. Thanks to this, it is now possible to generate propylene glycol in a single reaction between propylene and hydrogen peroxide—without the intermediate step of propylene oxide. In general, a catalyst system makes a chemical reaction easier and faster. The special charm of this particular solution is that some of the components of the new catalyst were already used in other chemical processes at Evonik. “The combination of different input materials, together with special technical processes, ensures that the catalyst remains stable over a long period of time,” says Wiederhold. “In addition, it transforms the basic materials propylene and hydrogen peroxide in a process that is especially efficient and energy-conserving.”

EXPERIENCE WITH H_2O_2 PAYS OFF

As a result, the HYPROSYN™ process is not only more cost-efficient than the previously used technology; it also makes a significantly higher yield possible while requiring much less energy. As with HPPO synthesis, except for water there are no other coproducts that would have to be separated out. Now that the process has functioned superbly in the laboratory, it is being scaled up in a pilot plant with a capacity that is 160 times bigger. Instead of the lab’s output of 50 grams of propylene glycol per hour, the pilot plant will produce eight kilograms an hour. Construction of the plant in Hanau will be completed in 2021. “It will then be operated for one year in order to improve the process and verify the results,” says Evonik manager Thomas Bode. HYPROSYN™ is expected to reach market maturity in 2022.

The success of this new product is due in large measure to Evonik’s experience with peroxide chemistry, which goes back for more than a century. H_2O_2 is one of the Group’s most important sales products. It is used in numerous applications. Initially it was mainly used as a bleach for textiles and paper, as well as a disinfectant. Today it is used, among other things, in the electronics industry to clean printed circuit boards and semiconductors for the manufacture of LCD displays. In rockets, hydrogen peroxide drives the turbopumps that force the actual fuel into the combustion chambers. HYPROSYN™ technology is now opening up an additional sales market.

Evonik is a leading supplier of H_2O_2 with 18 production sites and an annual global capacity totaling more than one million metric tons. The Group has established itself primarily as a specialist in the production of highly concentrated hydrogen peroxide. The HPPO synthesis process that has by now become familiar uses 70-percent H_2O_2. Conventional processes use concentrations of 50 percent or less. Evonik can even deliver H_2O_2 at a concentration of 98 percent—a top value in the industrial production of hydrogen peroxide.

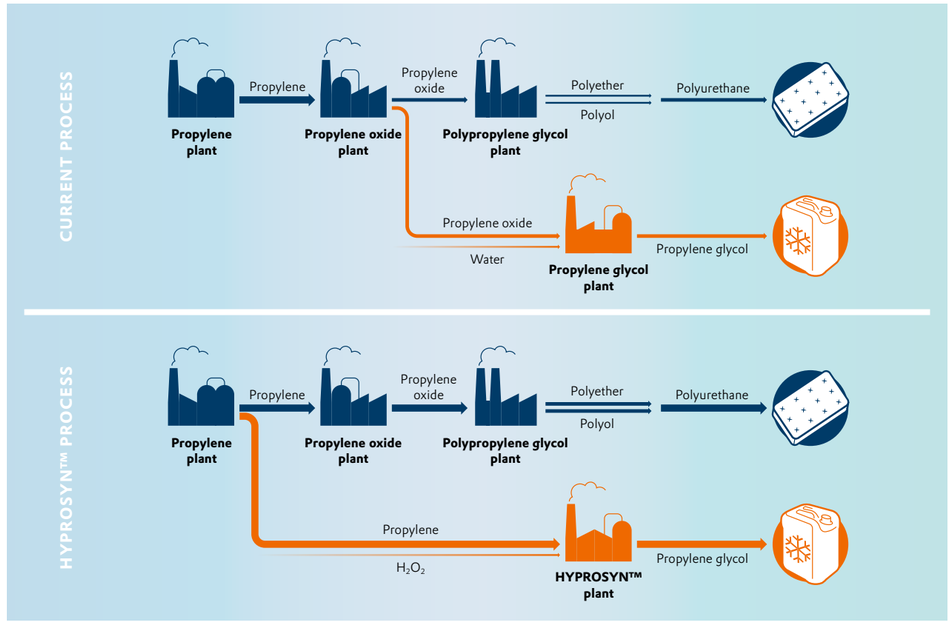
A NEW LIFE FOR OLD PLANTS

But the advantages of this new process go even further. That’s because the chemical reaction of propylene and hydrogen peroxide that has just been described takes place in one single reactor. That makes the previous precursor product, propylene oxide, unnecessary. Through the economical conversion of existing propylene glycol production plants to HYPROSYN™ production, the propylene oxide that was previously needed can now also be used as a basic material for PU products. The new technology can thus be regarded as a smart method for indirectly expanding the capacity of propylene oxide production plants. In addition, the introduction of HYPROSYN™ technology makes it possible to manage the production of propylene glycol and of propylene oxide independently of each other. As a result, the production volumes of these two materials can be more easily adapted to the demand.

Evonik is now working together with Dow to refine the new technology to the point of market maturity. The US company Dow produces propylene glycol and propylene oxide in many plants on four continents and is the global market leader for both products. Michael Träxler, the head of the Active Oxygens Business Line, calls Dow an “ideal partner”—largely because of its expertise in the area of materials science.

“For us, it’s important that the new technology fulfills the stringent quality criteria for medical applications in particular, so that it offers a competitive alternative to existing processes,” says Meinolf Weidenbach, the Technology Leader PO/PG Technology Center at Dow Deutschland. Vincent Lacoste, the Global Business Director at Dow for sales of propylene oxide and propylene glycol, hopes that this partnership will create a competitive advantage for his company’s own products. “Thanks to the HYPROSYN™ process, we can offer a cost-efficient product based on a sustainable and environmentally friendly technology, which will help us to be more flexible as we support our customers,” he says.

Once the HYPROSYN™ process and the associated reactor technology are ready for industrial-scale production, Evonik and Dow also want to license it to third parties all over the world. And that’s how an idea in a database will ultimately become a profitable business.



A lean process
The HYPROSYN™ process frees up facilities that produce propylene oxide