Looking up: Andrew Kincannon, head of Evonik's hydroprocessing catalyst technology center, on his way to check on the production process in Little Rock, Arkansas.

FOUNTAIN OF YOUTH FOR CATALYSTS

A new technology could help transform the energy industry and contribute to a circular economy. Invented by Porocel—now part of Evonik—this technology reduces waste and greenhouse gas emissions by rejuvenating catalysts for a broad range of oil refining applications. Biofuels might be next.

TEXT **NORBERT KULS**

Little Rock has been a catalyst for historical transformation before. In the late 1950s, the capital of Arkansas became the site of a pivotal moment in the American Civil Rights movement. The Little Rock Central High School was one of the first schools to be integrated after the Supreme Court ruled the racial segregation of schools unconstitutional. Nine African American students faced a mob of white supremacists and the Arkansas National Guard, which blocked the school gates. President Eisenhower eventually called in Federal troops for the students' protection. Today, the school is a National Historic Site with a museum dedicated to that struggle. The Little Rock Nine are honored with a bronze sculpture and a plaque facing Little Rock's Capitol building—one of the town's most prominent landmarks. →

The rejuvenator: Jim Seamans, Head of RD&I for the Americas region in Evonik's Catalysts Business Line, is the co-inventor of a new technology that can make a wide range of spent catalysts as good as new.

Spent catalysts are blackened from coke and sulfur. Fresh and rejuvenated catalysts come in a range of different colors.

“It feels good to make a difference with our rejuvenation technology”

ANDREW KINCANNON, HEAD OF THE TECHNOLOGY CENTER IN LITTLE ROCK

In a one-story former warehouse with white siding and a purple Evonik logo, a 15-minute drive from downtown Little Rock, a group of chemical engineers pushes for another historical transformation that could address one of the major challenges of our time: climate change. They have developed a technology that could help transform the energy industry, lead to lower greenhouse gas emissions and pave the way for a circular economy.

The change agent for that latest transformation out of Little Rock are actual catalysts—chemical tools used in refineries to take sulfur or nitrogen out of crude oil products like naphtha, gasoline, or diesel fuel in a process called hydrotreating. Eventually, that technology might be broadly applied to bio-based feedstocks like vegetable oil. “It is all about the energy transition,” says Jim Seamans, Head of RD&I for the Americas region for Evonik’s Catalysts Business Line. Seamans refers to his impressions from the recent AFPM annual meeting, the largest industry conference for American fuel and petrochemical manufacturers. “In the past, conference participants focused on safety and new ways of desulfurization. Now, in light of the public’s expectation that we will control climate change, the question is how we will change an industry based on fossil fuels to use less oil and more renewable feedstocks.”

“Customers can get the same performance as a fresh catalyst for a lower price and with a lower carbon footprint”

GUILLAUME VINCENT, EVONIK’S BUSINESS SEGMENT MANAGER FOR HYDROPROCESSING CATALYSTS

Magic drum: In the impregnation, active metals like Molybdenum that take sulfur out of crude oil are dissolved in a special solution and redistributed on their catalyst “carrier”.

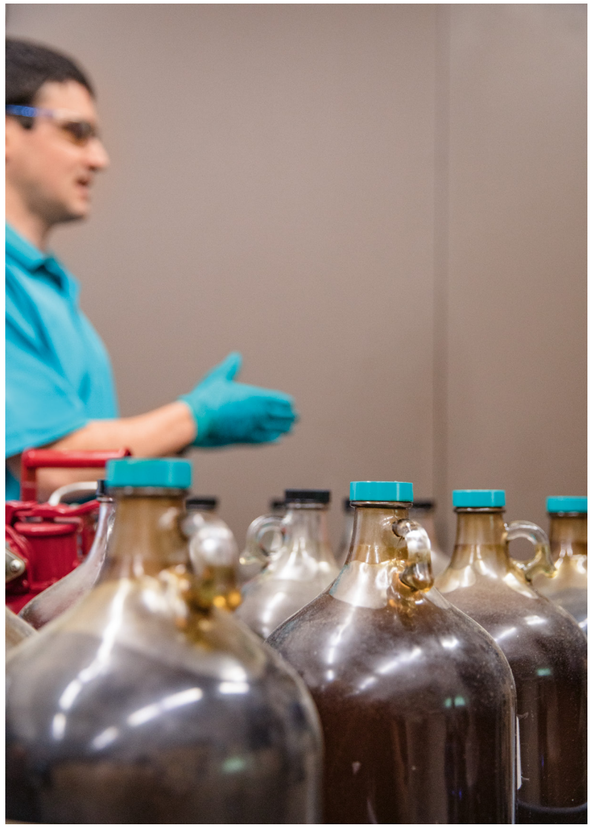
Seamans is a key player in this transition. Together with his colleague Guillaume Vincent, Evonik’s Business Segment Manager for Hydroprocessing (HPC) Catalysts & Services based in Germany, he is the co-inventor of a unique technology that can “rejuvenate” a wide range of different catalysts after they are used up—“spent” in industry jargon. Those catalysts become as good as new and sometimes even better after rejuvenation.

HOW TO REACTIVATE VALUABLE METALS

Seamans and Vincent developed the process at Porocel, a U.S. catalyst specialist acquired by Evonik in November 2020 for 210 million dollars to strengthen its catalyst business. The technology, aptly named Excel® Rejuvenation, helps avoid a recycling process to reclaim the valuable metals inside the catalysts. It also makes the manufacture of new, “fresh” catalysts unnecessary. This significantly reduces the depletion of natural resources, waste, and greenhouse gas emissions. The rejuvenation technology—a fountain of youth of sorts for spent catalysts—could see great demand as the sustainability transformation of the energy industry progresses.

Seamans is part of a group of experienced Porocel veterans now working for Evonik. A chemical engineer with an MBA, he previously worked for the energy giant Shell and had already codeveloped rejuvenation technologies for its catalyst business.

The concept of rejuvenation is not new. Competitors like Albemarle, one of the world’s largest producers of hydroprocessing catalysts, have rejuvenated their products for years. But Evonik’s technology is unique in that it can be applied to a wide range of catalysts from different companies. “We had the idea to develop a fully independent rejuvenation technology,” says Vincent—triggered by customer needs across the globe. →



Product Development Engineer Dan Miskin presenting crude oil jars in the testing center.

New strands of catalysts fall onto a conveyor belt to be dried.

Porocel, founded in 1937 as a joint venture between Atlantic Richfield and Standard Oil of New Jersey, has manufacturing locations to rejuvenate catalysts in Singapore, Luxembourg, Canada, and in the United States, in Lafayette, Louisiana. “It helps to have a regional presence because we are taking the spent catalysts from the refiners in the region. And you can’t easily move spent catalysts around the world,” says Seamans.

A COLORFUL SOLUTION

The former warehouse on the outskirts of Little Rock next to another former Porocel plant is the brain of the business. It is a pilot plant and test center for catalyst rejuvenation. The excitement of being part of a bigger change is palpable. “It feels good to make a difference,” says Andrew Kincannon, a chemical engineer who leads the technology center in Little Rock.

On a tour through the labs, Seamans and Kincannon point out measuring jars and sample containers filled with objects resembling small stones or beads from a craft store: Blue, white, green, black, and beige catalysts, some longer, some shorter. The colorful particles are a mix of “active” metals like Molybdenum or Tungsten and Nickel or Cobalt. The metals sit on a highly porous Alumina “carrier” that resembles a dry sponge to increase its surface (see infographic on p. 49). Eventually, the particles are stacked in layers inside a tube-like reactor on top of a whitish ceramic alumina foundation. This is known as a fixed bed reactor in the industry because the particles don’t move. On top of that layered particle tower are other bead-like objects in a trilobe or hollow cylinder shape. Their role is to trap poisons during the refining process: Silicon found in coker naphtha or arsenic found in some crude oil.

Crude-derived products then flow through the tube reactor, and the catalysts remove sulfur and nitrogen. After a while, however, the catalyst loses its luster. Sulfur and carbon-rich petroleum coke collect on the metal sites and block the pores. The distribution, the “dispersion” of the active metals changes as well. “The metals start to bunch up,” says Kincannon. “They agglomerate and the sulfur-containing compounds in the crude can’t reach those active sites anymore.”

WHERE THE “MAGIC” HAPPENS

A refiner then has two options. It can replace the spent catalyst with a fresh one. Or it can opt for rejuvenation and save up to 70 percent of the cost. For a refiner spending half a million dollars on a catalyst, that would translate into savings of 350,000 dollars. The Excel® rejuvenation is a two-step process. In a first step, called “regeneration,” sulfur and carbon deposits are burned off gently. But that tried-and-true method only restores the catalyst to about 65 to 85 percent of its original capacity. “It doesn’t get you back to full activity because it doesn’t redistribute the bunched-up metals,” explains Kincannon.

The second step, the actual rejuvenation, restores the catalyst’s capacity to near fresh activity levels. Here’s how it works: Evonik applies proprietary molecules to the regenerated catalysts. The goal is to redistribute the metals correctly. The “magic,” as they say in Little Rock, happens inside a round steel container that looks like an oversized wine jug and is called impregnation drum. The metals are dissolved in an aqueous, acidic solution that has been sprayed on the alumina carrier and absorbed in its pores. Finally, the treated catalysts are placed in a thin layer on a stainless-steel belt and dried. “It is a little bit like a pizza oven,” says Seamans. This process redistributes the metals close to their original state.

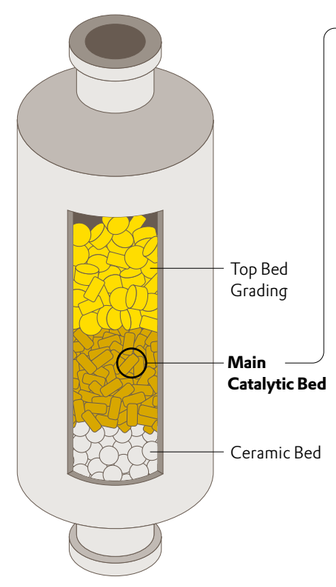
Sometimes, the activity of the rejuvenated catalyst even ends up higher than its original version. That happens when the metal distribution turns out better than the original manufacturer’s. Rejuvenated catalyst particles also tend to be a little shorter. “You get a little bit more catalyst per volume when you load them into the reactor,” explains Seamans.

In an actual refinery, the reactors with catalysts can be several stories high. In Evonik’s Little Rock testing lab, everything happens on a much smaller scale. Kincannon and his team run eight, approximately eight-foot high reactor skids—a mini-refinery. Glass jars filled with dark brown crude rest on the floor, a plastic container with light-yellow →

(ALMOST) AS GOOD AS NEW

How the rejuvenation process helps catalysts to continue their careers.

REACTOR DESIGN



OPERATION AND REACTIVATION

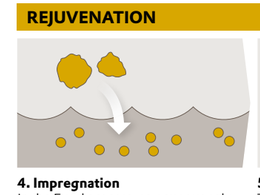
REGENERATION

1. Fresh Catalyst
Metals such as Molybdenum or Tungsten form **active sites** on a porous **aluminum oxide** substrate. The more evenly the sites are dispersed, the better they perform.

2. Spent Catalyst
The active metals ensure that sulfur is removed from the oil that passes through the catalyst. This results in **coke deposits**. The active sites form **clusters** over time, decreasing their performance.

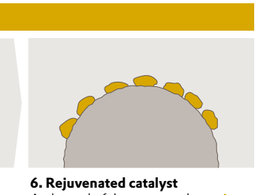
3. Regenerated Catalyst
In the regeneration process, sulfur and coke deposits are burned off gently. The metals, however, remain in **cluster form**. As a result, the regenerated catalyst achieves only 65 to 85 percent of its original activity.

REJUVENATION



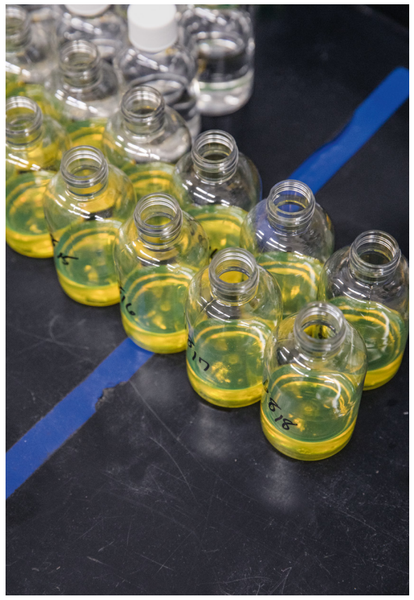
4. Impregnation
In the Excel process, an aqueous solution containing **chelating agents** is spread on the regenerated catalyst to dissolve metal agglomerates and to redisperse active sites.

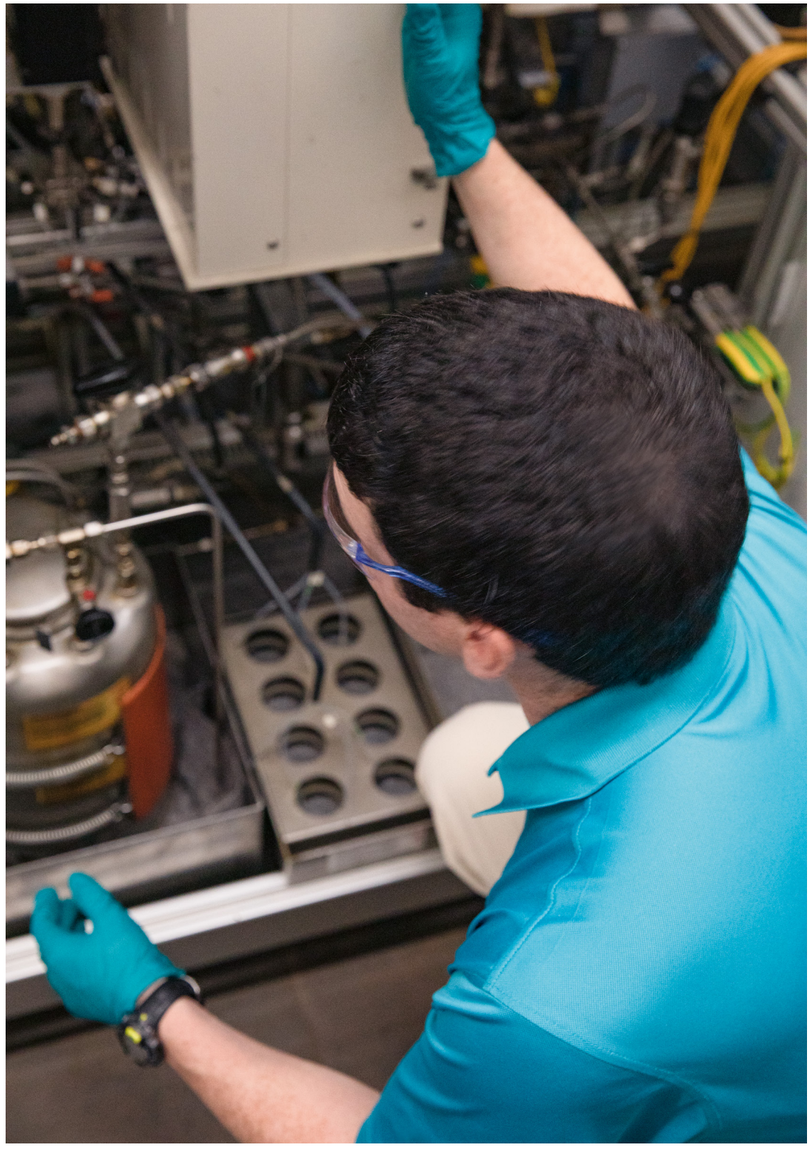
5. Drying
The catalysts are dried to remove some of the **aqueous solution**.



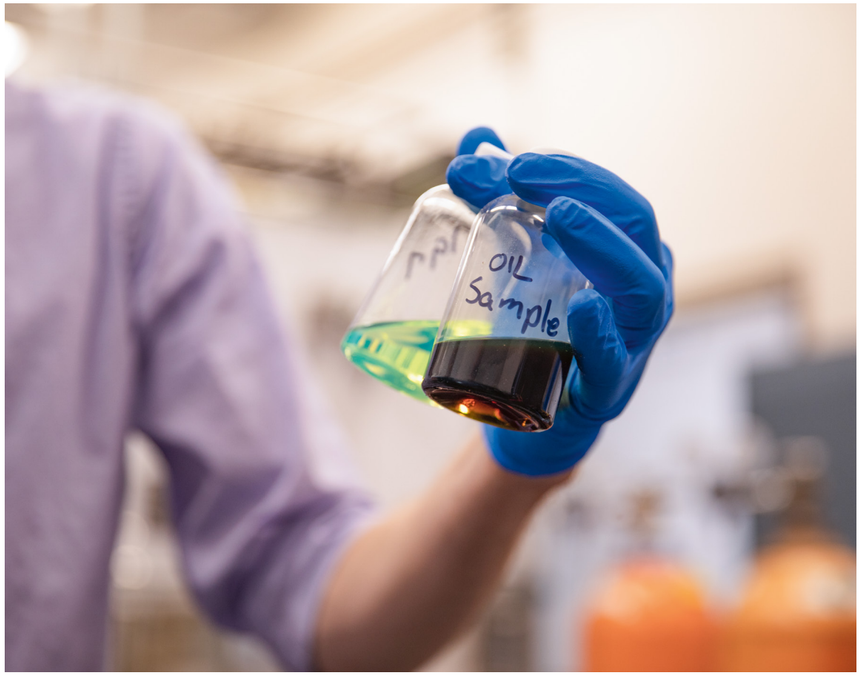
6. Rejuvenated catalyst
At the end of the process, the **active sites** are distributed almost exactly as before. The activity of the treated catalyst is restored to near fresh activity.

Engineer Dan Miskin is checking on a reactor skid—a mini-refinery—in the testing center (r.). Bottles with desulfurized fuel after crude oil got the catalyst treatment.





Crude awakening: Tech Center head Andrew Kincannon with samples of dark crude oil and refined, desulfurized fuel.



Diesel No. 2 and small bottles with clear liquid sit on a cabinet. Numbers are scribbled on the glass with a black marker. Similar bottles sit on the bottom of the mini reactors. They collect the desulfurized, clear fuel after it has moved through the stacked catalyst inside a slim 4-foot cylinder covered with aluminum foil and insulation.

The process is carefully controlled and monitored from a command center next door. It takes exact data, consistent testing, and patience to convince the notoriously conservative oil industry to adopt the technology broadly. The Excel® technology was introduced in the market only five years ago—a short time in the industry. “There is a very steep resistance to new technologies that are not proven,” observes Seamans, who is based in The Woodlands, a suburb of the U.S. energy capital Houston. A refinery will not risk an expensive shutdown because a catalyst might not work. “We have over 100 successful refinery sales, but are still in the phase of convincing customers that our technology is viable and dependable,” he says.

For Guillaume Vincent, it is a matter of perception and attitude. “It is like buying a new car versus a car with low mileage that drives just as well and costs less. Some customers just don’t want a used car—even though they could get the same performance as a fresh catalyst for a lower price and with a lower carbon footprint.” But not everyone is skeptical. For one existing European customer, Excel® is already a big part of the strategy to reduce greenhouse gas emissions. Europeans generally seem to have embraced the idea earlier. “It is an easier sell,” says Technical Manager Mike Martinez, also from Houston. Martinez collects data, does performance modeling, and presents at conferences. “We have started to build a track record,” he says. “Every refinery in the world is on our radar.”

AMBITIOUS PLANS FOR THE FUTURE

Potential clients are not just the big multinational refiners like TotalEnergies, BP, Phillips 66, or Repsol. Excel is also an option for smaller, independent refiners that usually operate in one country only. The third potential customer base are the government-run, public refiners in the Middle East, India, and other parts of Asia. This year, Seamans and his team also want to publicly share data that validates the performance of the Excel rejuvenation technology in different, more severe operating conditions in terms of temperature, pressure, or type of feedstock.

The future for Excel® not only includes fossil fuels. Andrew Kincannon points out a plastic container that looks like it holds yellowish diesel. But it is vegetable oil—the next frontier for Evonik’s catalyst experts. Crude oil refiners seem to be moving aggressively from petroleum towards renewables. U.S. refiner Phillips 66 plans to convert a crude oil refinery in California into a renewable fuels plant using cooking oil and food wastes beginning in 2024. Competitors like Valero, TotalEnergies, Repsol, Chevron, or Marathon have also announced investments in biofuel refining.

“The opportunity from bio-based feedstocks is still fairly small because most fuels are still made with petroleum-based materials,” says Americas RD&I Head Seamans. But the share of renewable fuels is increasing. Seamans estimates that by 2030 up to 20 percent of fuels could be bio-based. “It is definitely a growth market. But even with oil-based feedstocks, we have a lot of growth potential that we haven’t been able to fully realize yet.” —

Norbert Kuls is Evonik’s Communications Manager in North America and a former U.S. correspondent for German newspapers.