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A Solid Catalyst Unlike the Rest

Catilin Inc. is rolling out T300, a solid catalyst that sidesteps the need for a fixed bed. The company is also making progress in nanocatalyst and nanofarming technologies.

by Susanne Retka Schill

The team at Catilin Inc. anticipates that the promise of lower operating costs, ease of use and safety will overcome the challenges of introducing its T300 solid catalyst to the biodiesel industry in these difficult financial times. Catilin's pilot plant where the T300 catalyst validation work is being conducted currently utilizes soy oil as feedstock. The company has manufactured enough of this catalyst, which is based on a nontoxic, common mineral, to supply several large biodiesel plants for one year.

T300 differs from most solid catalysts that require a fixed bed and high temperature or pressure to operate, according to Dave Sams, Catilin's vice president of business development. Describing a fixed bed system, Sams says, "Inside a reactive vessel they put a plate with a mesh. The catalyst is stacked on top of that mesh and the oil flows through." In the petroleum industry, where Sams worked before joining Catilin, fixed bed systems are common but require highly paid engineers to monitor the process. The systems also require reactors designed for the higher temperatures and pressures necessary for the fixed bed catalysts to work efficiently—a costly retrofit that has largely discouraged the biodiesel industry from adopting solid catalysts.

"Our solid catalyst makes it so much easier," says Larry Lenhart, Catilin CEO. "It's safe and nontoxic, and it requires less expense to run. You don't need to do the mixtures with acids and pH balance, and you can eliminate water washing." With fewer steps, potentially 30 percent of the equipment in a standard biodiesel plant can be eliminated, he adds.

Sams describes the T300 as a "drop-in catalyst" that can be used as a direct replacement for the commonly used sodium methoxide catalysts. "We don't need a fixed bed because we mix in the granular powder directly with the oil," he says. The heterogeneous catalyst remains solid, and performs much the same way as the familiar homogeneous catalysts that are liquids in solution. The catalytic activity is similar to sodium methoxide, with a residence time of 40 to 60 minutes.

The biggest difference is in catalyst removal once reaction is complete. "Typically in a plant, they splash water on the biodiesel to wash out the sodium catalyst so the biodiesel is clean," Sams explains. "Because we have a solid catalyst, we don't need to do that. We use a sophisticated filter to keep the catalyst in the reactor and let the products leave the reactor without any of the catalyst in it. That means people can use a dry wash, which is more economical."

The retrofit to use the T300 solid catalyst involves the addition of a hopper and injection system to introduce the catalyst, and a filter to separate the catalyst from the biodiesel and glycerin products. Both components already exist and are off-the-shelf technologies. "The big designers have historically recommended water wash systems," Sams tells Biodiesel Magazine. "They've had to use water wash because the sodium methoxide they've used as the catalyst has to be removed down to 5 parts per million or less in the biodiesel and the water wash does a very good job of that. Those systems are typically expensive to operate because they require a big distillation column. There's a lot of energy required and if you get in places where water is in tight supply, it becomes a real problem," he says.

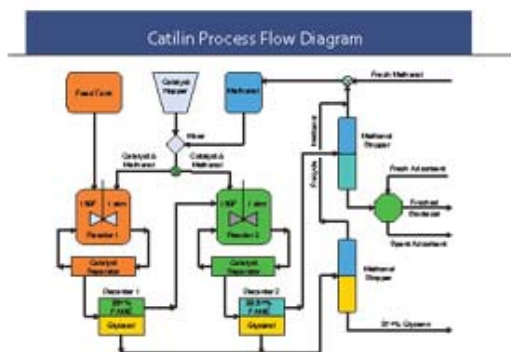
The T300 catalyst is nontoxic, has a long life and can be easily disposed when it is spent, Sams adds. He estimates the cost of retrofitting a 30 MMgy plant to switch to the Catilin catalyst would range between \$300,000 and \$600,000, depending on plant configuration. Initial discussions with potential customers are showing a payback period for the capital investment of about 12 months. The T300 catalyst itself is priced competitively with sodium methoxide.

Catilin received a \$150,000 grant earlier this year to upgrade its pilot plant located at the Biomass Energy Conversion Center near Ames, Iowa. The funds from the Iowa Department of Economic Development were used to convert the pilot plant from batch to continuous flow as the final step in commercializing the technology. A series of runs at the pilot scale has shown consistent results with the soy-based biodiesel, passing both ASTM and European specifications, according to Sams, including the new and somewhat problematic Cold Soak Filtration Test. Catilin is now testing T300 with a number of alternative feedstocks.

Nano-Style Biodiesel

Catilin gets its name from combining the first syllables of catalyst with its founder's last name, Victor Lin, who serves as chief technologist at Catilin. Lin also continues in his joint appointments as an Iowa State University professor of chemistry, and as program director of chemicals and biological sciences at the U.S. DOE Ames Laboratory. His work is being commercialized through Catilin, which is partly owned by ISU with the backing of two California-based venture capitalist firms, Mohr Davidow

Ventures and Leader Ventures. Lenhart and Sams, both of whom come to Catilin with experience in venture-backed development, are based in San Francisco. The rest of the Catilin team is in Ames, Iowa.



SOURCE: CATILIN

The T300 is a bit of detour for Lin. Biodiesel Magazine wrote about his work on developing a nano-style catalyst in October 2007, shortly after Catilin was formed. Lin's research team had completed the first generation development of a new class of biodiesel catalyst. Using nanotechnology principles, they developed synthetic nano particles that vastly increase catalytic surface area while combining acid and basic functionalities in the same catalyst. The goal is a catalyst that converts high free fatty acid (FFA) feedstocks to biodiesel in a single step, eliminating pretreatment.

Two years ago, Lin was facing two challenges in the catalyst development—increasing the reaction time for the process and reducing cost. The initial estimates for the cost of a synthetic nanocatalyst at 30 cents to 40 cents per gallon were too high, Lin recalls. "Biodiesel producers told us to squeeze the cost down to five cents to 10 cents per gallon," he says. "That becomes a challenge for any sort of synthetic." The T300, which is not a nanocatalyst, was developed in the search for economic starting materials from natural minerals and oxides that could be used in place of synthetics. Work on the nanocatalyst parallels T300 development, and pilot-scale tests are ready to go once the final T300 test runs are completed.

The nanocatalyst is being tailored to work in the same process design as the T300, Lin says. The researchers have also developed nanocatalyst manufacturing systems that do not require the pristine environments needed for nanotechnologies used in optical or semiconductor applications. One of Lin's goals has been to find a catalyst that would work not only with higher grades of animal fats with their high FFA content, but with lower grades of poultry fats, recycled waste oil and even algae oil. "In chicken fat, they press the meat and skin, and whatever floats on top is chicken fat," Lin explains. "It can include feathers, blood, proteins and collagens." Cleaning up the lower grade, high FFA feedstocks adds layers of processes and costs. A similar hurdle faces the embryonic algae industry as well.

Nanofarming Algae

Lin likes to describe algae oil as an alphabet soup containing multiple compounds from A to Z. "We only want the ones with the letter B, for biodiesel," he says. Other compounds in the soup have been used in the pharmaceutical or food supplement industries, where much of the work on algae production originated.

Existing systems generally concentrate the algae, grind them and use solvents to extract the oil, which kills the algae in the process and produces oil that contains multiple compounds, including some that can interfere with the biodiesel process.

Lin is turning to nanotechnology in the latest series of experiments he and his colleague Marek Pruski are conducting with algae at the DOE Ames Laboratory. "By combining nanotechnology, chemistry and catalysis, we have been able to find solutions that have not been considered to date," Lin says. Nanoparticles, with their high surface area and porous honeycomb shape, can target pore size to a desired molecule. "We're using this as a tiny sponge to soak up the molecules we want, and filter off what we don't want," Lin says. The most promising aspect of the nanofarming technology is that it doesn't kill the single-celled algae in the process of harvesting the oil. The goal is a system that reduces algae production costs by cutting algae culturing costs, and speeding up the production cycle plus reducing the cost of refining the algae oil before transesterification.

The initial laboratory work has been promising enough that Lin and his team landed DOE support for a \$1.1 million three-year project, funded with \$885,000 from the DOE's Office of Energy Efficiency and Renewable Energy, \$216,000 from Catilin, and \$16,000 from Iowa State University in matching funds. Catilin has signed a Cooperative Research and Development Agreement with the Ames Laboratory, with the goal of bringing the project to commercialization. Phases one and two of the project will cover the culturing and selection of microalgae and the development of the nano-based extraction and catalyst technologies. Phase three will focus on scale-up of the catalyst and pilot scale testing.

Lenhart says, "When we ultimately put this exceptional extraction technology with Catilin's existing solid biodiesel catalyst, we

will dramatically increase the reality of renewable energy.”

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