CASE STUDY

The Alchemy of Biofuels Research: Q&A with Dr. David Bressler

Anyone looking for reasons for the explosion of interest in biofuels need look no further than the adverse effects of our dependence on fossil fuels. Climate change, the increase of pollutants in our air and water, the high cost of conventional fuels, and the desire to reduce dependence on foreign energy sources are just some of the reasons we're seeing exponential growth in biofuels research.

That's why we asked Will Soutter, editor in chief at AZoNetwork, to sit down with Dr. David Bressler, professor in the Agricultural, Life & Environmental Sciences department at the University of Alberta, where he is also an associate dean, for a wide-ranging discussion around the present and future of biofuels research. The two discussed such topics as the food-versus-fuel controversy, the importance of biofuels to the future of sustainable aviation, the scale-up challenges facing the industry, and the importance of gas chromatography in driving the research forward. And they even took time to explore experimental biofuels research into . . . spent restaurant cooking grease?

Q **Will Soutter: Welcome, Dr. Bressler. To start, can you briefly describe your research into biofuel production from lipids?**

A **David Bressler:** At our general laboratory, we're working on biorefining in the sustainable economy. Over the last 20 years, we've been developing technology that can convert oils and fats directly to hydrocarbon fuels. In the first generation of biofuels, people were looking at ethanol through fermentation, or making methyl esters from fatty acid resources, to make biodiesel. Alternatively, we're using approaches similar to those in the oil sands sector in Alberta that uses high-temperature, free-radical chemistry to convert oils and fats into hydrocarbon fuels. These fuels are "drop-in" for naphtha distillate, which is more equivalent to gasoline and diesel fuel.

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Q WS: How did you get into this field? How did you get started?

A **DB:** I came from life sciences. There's a lot of microbiology, chemistry in my undergraduate degrees. I spent a couple of years working in chemical engineering, with an office at Syncrude. One day a week I worked in the oil sands space, on their upgrading research, which is where the foundations for this idea come from. At the University of Alberta, I moved into the Agricultural Life Environmental Sciences faculty, which includes research that looks at the interface between agriculture and forestry. I work in the bioresource technology space, which studies how we create value from the byproducts and coproducts of that industry. It's a 20-year research program interfacing with industry to find solutions.

Q WS: How do the processes you've worked on differ from other biofuel technologies?

A **DB:** In the traditional pathways of fats and oils, the first generation used transesterification, which pulls the fatty acid off the triglyceride, substituting a methanol, which caps off the polarity. It makes it compatible with the hydrocarbon world, but it's not exactly a hydrocarbon itself. It still has oxygen in it, and it has some polarity. It blended well enough, and it works, but there were some issues with cloud points and other physical properties.

Q WS: What was the next generation, then?

A **DB:** The next generation was when the hydrocarbon industry got involved – they looked to hydrogen and catalysts to really knock out that oxygen and convert fats and oils directly into the hydrocarbons. That started the creation of drop-in fuels that go right into the fuel supply. The upside is, it's a better, cleaner burning fuel than the petroleum base. For the first time, they're making a renewable fuel that has *better* physical and combustion properties than the incumbent fossil fuels.

Q WS: Was there a downside?

A **DB:** Well, you needed really clean resources, because of the catalysts and the hydrogen they were using. It also required economies of scale to make it cost effective. We then developed the high-temperature, pyrolytic systems that convert oils and fats to the same fuels. A very similar output, but it doesn't require hydrogen. The feed stocks we now use don't have to be very clean, as we don’t use catalysts that could be activated, such as brown grease, spent restaurant grease, undefined tallow. Off-grade canola works well, but we could also use the cheaper resources that were a little bit dirtier!

We can spend a lot less capital for a single plant, because we don’t have the requirement for hydrogen generation. As such, we’re able to go capital-light. You can also scale the size of the operation to align to the scale of the resource available. You get substantial cost benefits doing it that way, and you're getting the same product. Since then, we've been working on expanding past naphtha and distillate, or gasoline-diesel equivalents, into aviation fuels and sustainable bio-jet fuels.

Q WS: How do the benefits of drop-in biofuels compare to biofuels we're used to seeing, like ethanol additives, or to alternate fuel systems such as liquid petroleum gas?

A **DB:** Great question. The first- and second-generation ethanol or biodiesel technologies blend into the fuel, but they're not the same molecules. They don't behave the same, and there are limits to how much you can blend in. Even with ethanol, if you get too high a blend, you start having different requirements on the engine to handle that change.

Biodiesel, again, there's a limit to how much you can blend into the diesel resource without having problems with solubility and cloud points and so on. The fuels we're looking at are more compatible, they're hydrocarbons coming from the petroleum world. When hydrocarbons blend in, they improve the product quality in terms of particulate emissions.

Q WS: How does the food-versus-fuel controversy play out here?

A **DB:** The first-generation fuels used food-grade materials, but with the second generation, we moved into more lignocellulosic material – trees and non-food-based agricultural resources, which keeps us out of the food-versus-fuel discussion. And now we're on the pathway to converting them to fuels that are more compatible with the hydrocarbon world.

With time, technologies refine, they get cleaner, and we find that switching to renewables, and the types of fuels that our lipid-to-hydrocarbon technology makes, you get further improvements against those core criteria. The LTH technology we've licensed to forge hydrocarbons is being benchmarked by third parties – we haven't built it fully commercial yet – but we're in the ballpark of a 15% to 20% carbon footprint as compared to a petroleum base.

Q WS: Do you expect to go lower in terms of emissions and particulates with other substances?

A **DB:** Yes. There are a lot of non-food-grade lipids we're talking about. We expect disruptions from oleaginous organisms, the fermentation of single cells that make fats and oils as part of their body composition. And people are talking about growing algae to generate lipids on a large scale. Suddenly, you're talking very large, billions-of-gallon scales becoming available over the next few decades.

Q WS: Can you talk about how you use gas chromatography in this whole process, through research and scale-up?

A **DB:** I'll be very blunt: without gas chromatography, we don't do anything. From the very beginning right up to last week, everything we do is monitored through gas chromatography. Whether it's online or sample taking, whether it's gas phase or the liquid phase, GC is important to characterizing and monitoring what's happening within the reactor. We're looking at the composition, quantitating how much of everything is there. We're coupling that with a mass spectrometer, looking at what's being formed. If it's a new compound, and we're not familiar with it, we need both the analytical information we get from flame ionization detectors, as well as structural information from mass spec.

Q WS: What are some of the challenges that might crop up in the coming years? And what developments might need to come from GC and other techniques?

A **DB:** As we further refine the technology and product compositions, we push the properties of the fuels into more desirable states. Everything we do has to be validated, quantitated, documented. We sometimes need to send it out for third-party validation. From our lab's standpoint, the faster we can monitor and steer what's happening in the instrumentation, or in the reactors, the better. We've been very fortunate to have great partners, great support. For example, we've been able to deploy a GC with a flame ionization detector coupled with a mass spectrometer, and that cuts our analytical time down considerably.

What's exciting to me is some of the new capabilities we have with GC-VUV and being able to add in some of those detectors as well, giving us further segregation and separation, and being able to look at more complex mixtures. The push on the research side will be what we call integrated biorefining: how do we use these same resources and start going after very valuable side products, solvents, precursors for the specialty chemical space?

Q WS: Bigger picture then, what's the environmental and industrial impact this could potentially have?

A **DB:** This is a long, 20-year "overnight" success, in some ways. We started the basic research in 2003, applied research through the end of that decade. This decade, we've been working with industry partners, and we're now at the stage where we're going to start construction of the first commercial facility in Sombra, Ontario, with forge hydrocarbons. Over the next year or two, we're trying to accelerate bio-jet sustainable aviation technology and potentially bring two, three, maybe four new plants online within a 10-year timeframe.

It's taken a long time to get where we are in the scaling and the optimization, and it's about to go primetime over the next couple of years. It's an exciting time for us.

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