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Termite Power

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When I was in graduate school at Texas A&M in the early 90's, I selected chemical engineering Professor Mark Holtzapple as my research advisor. His work was exactly in my area of interest: Biofuels from cellulose. Even then, I was very concerned about the unsustainable lifestyle we were living, and I was hoping to save the world. For a very good overview on what we were doing, see this PowerPoint presentation (note the Hubbert slide) or this article. In brief, what we were doing was searching for naturally occurring biological systems that convert cellulose to organic chemicals.

The primary system we studied was the bovine digestive system. Cattle are very efficient digesters of cellulose. They eat grass, and break it down via microorganisms that live in their digestive systems. So what we did was extract those microorganisms and attempt to convert cellulose in reactors that emulated the chemistry of the cow's stomach. And while we did have success, the conversion was never as efficient as it was inside the cow.

So, I spent time brainstorming other efficient cellulose digesters. It occurred to me that probably the most efficient digester of cellulose in the world is the termite. After all, even cattle can't break down wood. So I discussed it with Professor Holtzapple, and he thought it was a great idea. I searched the literature, and as far as I could determine, nobody had ever done it before. Therefore, I had no guidance at all with what I was attempting.

I arranged a meeting with a termite expert in Texas A&M's Entomology Department. He was very keen on the idea, so he supplied the termites. The next bit was tricky. The cellulose digesters that we were looking at were anaerobic microorganisms. Oxygen would kill them. Therefore we always had to take great care to get them into the reaction system without killing them. For the cows, it was easy. We filled up a bottle with nitrogen, stuck our arm inside a portal into the stomach of a fistulated steer (somewhere there is a picture of me with my arm in a cow's stomach up to my shoulder), extracted about a liter of stomach contents, and poured it into the nitrogen-filled bottle. We then transferred the contents to reactors that were being purged with nitrogen.

But with termites, it wasn't going to be quite so easy. The volume of material I would be extracting would be very small, and therefore it would be tough to extract it without exposing it to air (with the equipment I had to work with). The other problem I had was that there was virtually no information available on the chemistry of the termite gut. How was I going to know what kind of vitamins, salts, etc. to put in the reactor? What should the pH be? The final concern I had was that I didn't know exactly what the product of the reaction would be. I wanted a reaction system that would convert the cellulose to acetic acid or ethanol, and not all the way to carbon

dioxide. But I really had no idea what I would get.

So, what I did was use the same reactor conditions I used for the bovine microorganisms, and I threw in a combination of live termites, termites with their hindguts opened up, and just some extracts from the hindgut. I figured that I had a pretty good chance, given this approach, to have some of those desirable microbes survive the transfer. I then let that combination ferment in the reactor for about a week.

When I tested the contents of the reactor, I was disappointed. I was after acetic acid to turn into ethanol, but what I got was butyric acid (which can be turned into butanol). But I wasn't interested in butanol, and the amounts I got were very small. Since I was nearly at the end of my research, and I didn't really have the facilities nor the time to figure out the termite hindgut chemistry (the real critical piece, in my mind), I abandoned my termite investigation. I still thought it was an excellent idea, and if someone had 3 or 4 years it would have made a great Ph.D. research project. But I had to move on and graduate.

Since that time, I have seen the idea come up on a few occasions. Because of my previous attempt, news of these attempts always catches my attention. I recently saw a new story on this:

Fuel's gold: Termites point way to new dawn of bio-energy

Here is an excerpt, describing this latest line of investigation:

> PARIS (AFP) - A team of US scientists poring over the intestines of a tropical termite have a gut feeling that a breakthrough in the quest for cleaner, renewable petrol is in store.
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> Tucked in the termite's nether regions, they say, is a treasure trove of enzymes that could make next-generation biofuels, replacing fossil fuels that are dirty, pricey or laden with geopolitical risk.
>
> Next-generation biofuels would use non-food cellulose materials, such as wood chips and straw. But these novel processes, hampered by costs and complications, are struggling to reach a commercial scale.
>
> The termite's tummy, though, could make all the difference. **Like cows, termites have a series of intestinal compartments that each nurture a distinct community of microbes.**
>
> Each compartment does a different job in the process to convert woody polymers into the kind of sugars that can then be fermented into biofuel. The US team has now sequenced and analyzed the genetic code of some of these microbes in a key step towards -- hopefully -- **reproducing the termite's miniature bioreactor on an industrial scale**.
>
> "In theory, they could transform an A4-sized sheet of paper into two liters (1.8 pints) of hydrogen," he said.

To be sure, they are well beyond what I was attempting to do. They are sequencing genes, using an entirely different species of termite, and they are attempting to produce hydrogen. But the

core concept is the same: Scale up the internal bioreactor of the termite to produce a desirable end-product.

I guess I was just ahead of my time. :-)