

Science AMA Series: I'm Dr Neil Stacey, a biofuels researcher at the University of the Witwatersrand. I've shown that the cost of distilling ethanol for fuel use can be reduced by just blending gasoline directly into the ethanol/water mixture. AMA!

DrNeilStacey¹and r/ScienceAMAs¹

¹Affiliation not available

April 17, 2023

Abstract

Purifying ethanol is energy-intensive and expensive. When we're just using it in a fuel blend, it's also unnecessary. The real end-product of ethanol production for fuel use isn't pure ethanol itself but rather a fuel blend which contains ethanol; pure ethanol need not be an intermediate step. Reconsidering the overall flow-sheet in this way opens up a far broader optimization space in which to find energy-efficient separation processes and in a recent Energy and Fuels paper, my colleagues and I demonstrated a more energy-efficient separation process making use of a natural liquid phase split to eliminate water without the addition of further energy for separation. Our process cuts the energy consumption of ethanol production by up to 2MJ per liter and has a lower capital cost than conventional azeotropic distillation. It is, however, just one of many new processes that become possible once you discard the assumption that a pure biofuel is the ultimate end-product. I am here with Shell engineer Ari Hadjitheodorou to talk about the challenges of implementing this concept in the field. Ask us anything! Questions about the violent #FeesMustFall protests on our campus are not off-limits, though we prefer to stick to the science. We will be back at 11 am ET (8 am PT) to answer your questions, ask us anything! Edit: Link to paper. Sadly our currency in South Africa has recently stopped being worth anything, so the university wouldn't fork out the fee for Open Access, so here's a link to a news article that summarizes it. Edit2: It's 7PM over here, so I need to do some real-world stuff (dinner, human contact etc) so I'll be wrapping up for now. I'll stop by again in the morning to answer anything else that's come up. Thanks everyone for the questions and the support and a big thank you to the mods!

[REDDIT](#)

Science AMA Series: I'm Dr Neil Stacey, a biofuels researcher at the University of the Witwatersrand. I've shown that the cost of distilling ethanol for fuel use can be reduced by just blending gasoline directly into the ethanol/water mixture. AMA!

DR_NEIL_STACEY [R/SCIENCE](#)

Purifying ethanol is energy-intensive and expensive. When we're just using it in a fuel blend, it's also unnecessary. The real end-product of ethanol production for fuel use isn't pure ethanol itself but rather a fuel blend which contains ethanol; pure ethanol need not be an intermediate step. Reconsidering the overall flow-sheet in this way opens up a far broader optimization space in which to find energy-efficient separation processes and in a recent Energy and Fuels paper, my colleagues and I demonstrated a more energy-efficient separation process making use of a natural liquid phase split to eliminate water without the addition of further energy for separation.

Our process cuts the energy consumption of ethanol production by up to 2MJ per liter and has a lower capital cost than conventional azeotropic distillation. It is, however, just one of many new processes that become possible once you discard the assumption that a pure biofuel is the ultimate end-product. I am here with Shell engineer Ari Hadjitheodorou to talk about the challenges of implementing this concept in the field. Ask us anything! Questions about the violent #FeesMustFall protests on our campus are not off-limits, though we prefer to stick to the science.

We will be back at 11 am ET (8 am PT) to answer your questions, ask us anything!

[Edit: Link to paper.](#) Sadly our currency in South Africa has recently stopped being worth anything, so the university wouldn't fork out the fee for Open Access, so here's a [link to a news article that summarizes it.](#)

Edit2: It's 7PM over here, so I need to do some real-world stuff (dinner, human contact etc) so I'll be wrapping up for now. I'll stop by again in the morning to answer anything else that's come up. Thanks everyone for the questions and the support and a big thank you to the mods!

[READ REVIEWS](#)

[WRITE A REVIEW](#)

CORRESPONDENCE:

DATE RECEIVED:
October 18, 2016

DOI:
10.15200/winn.147670.05048

ARCHIVED:
October 17, 2016

CITATION:
Dr_Neil_Stacey , r/Science ,
Science AMA Series: I'm Dr
Neil Stacey, a biofuels

I work in a mariculture facility whose goals are algal culture for both feed replacement and biofuels. I've seen how much energy and land area is required to produce usable amounts of algal oil, and it's not an efficient process. Even if we extract the lipids and use the remainder as feed ingredients, the cost is incredible.

My question is, wouldn't it be better to take the land area required to grow these massive biofuel crops, and use them for food, while concentrating on building solar panels over non-arable land to fulfill our energy requirements?

[Southtown85](#)

My experiences with algae have been similarly disappointing. It doesn't grow as well as anyone thinks it should and the separation is a massive headache. I know quite a few people/groups involved in

researcher at the University of the Witwatersrand. I've shown that the cost of distilling ethanol for fuel use can be reduced by just blending gasoline directly into the ethanol/water mixture. AMA!, *The Winnower* 3:e147670.05048 , 2016 , DOI: [10.15200/winn.147670.05048](https://doi.org/10.15200/winn.147670.05048)

© et al. This article is distributed under the terms of the [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and redistribution in any medium, provided that the original author and source are credited.



growing algae and they all get squirrely when it comes to questions like "so can you turn a profit?"

The trouble with replacing biofuel growing with photovoltaics is that what we're after, more often than not, is liquid fuels, rather than electricity so it's not a direct swap. It is possible to go from electricity to fuels, though. You can electrolyze water into Hydrogen, and electrolyze CO₂ into CO, and then use Fischer Tropsch processes to produce fuels.

I also read [\[this article\]](#) just this morning and it offers a direct path from CO₂ to ethanol using electricity. So yeah, it's definitely possible to gradually transition from biofuel crops into photovoltaics over the long-term, with the main pressure to do probably being water. In the medium-term though, biofuels will be a big part of the mix.

How about no ethanol so my equipment doesnt get gummed up by that shit if it sits for a month? Will less pure ethanol cause the fuel to go bad faster than it already does?

[Airdchartdan](#)

Sadly, there's no way to avoid corrosion issues with fuel mixes involving ethanol; it readily soaks up water wherever it goes and that eventually finds its way somewhere you don't want it. Using butanol instead gets around this issue. Butanol happens to work better with our process than ethanol does, so I am as eager as anyone to persuade the biofuels industry to switch over.

The good news, I suppose, is that this process produces, at worst, a water-saturated fuel mixture which is what fuel stations tend to have in their tanks anyway.

Ari (Shell engineer who co-authored with me) will be along a bit later and he can explain some of the practicalities a bit better than I can but what he tells me is that he's never seen a fuel station that didn't have a layer of water at the bottom of their tanks. The short of it is that fuel that gets its ethanol into it through this process will be no worse than fuel that gets it the normal way.

What are your thoughts on the application of this discovery on advanced biofuels like isobutanol. Isobutanol-water is much more difficult to separate due to phase separation, so would adding gasoline to the system help in your opinion?

[stompy33](#)

Butanol (all the isomers) turns out to be a bit easier to separate than ethanol; the phase split actually assists in the separation because you can use hetero-azeotropic distillation to get past the azeotrope without adding an entrainer and an additional distillation column.

That said, butanol is also more soluble in gasoline than ethanol is, and far less soluble in water. This means it's actually far better suited to our process than ethanol is, because it far more readily transfers from the aqueous phase to the fuel phase. Most of our experimental data (which the university won't let us publish) is with processes involving butanol. I can't go into great detail without the university getting mad at me but our findings indicate that a similar process can recover butanol with virtually no additional separation energy. It's also a better fuel molecule in many respects, particularly energy content.

The tricky part is convincing people to *make* the stuff. It's trickier to ferment into and generally produces lower yields than ethanol fermentation.

Why put alcohol in gasoline? Does it release more energy? Does it reduce wear on the motor? Does it

reduce pollution?

[dyin2meetcha](#)

It's to cut fossil fuels usage (and therefore pollution) by replacing a portion of the fuel with a renewable. The US, for instance, has 10% ethanol blends across most of the country. Ethanol also increases octane rating so it's also effectively a replacement for nastier stuff like MTBE, but that's considered more of an incidental benefit.

Good day Dr Stacey,

Do you feel this new separation process could help lower the pressure of biofuel on the food market ? Would you reckon using corn and other resources, compared to solar energy, represent a viable future for this planet ? Thank you for your time.

[Borsenven](#)

Good day [/u/Borsenven](#),

Sadly, making the biofuels production process cheaper means more incentive to produce them which in turn increases pressure on the food market.

As to the other, I'd say that biofuels are not a permanent solution. Population pressure dictates that eventually we'll have to use land and water more efficiently. So I'd say that long-term, we'll have to do something else and bio-fuels are more a medium-term stopgap than a permanent fix.

Can you talk about some of the impurities carried over with the ethanol in your process? How tolerant are modern gasoline engines and fuel/exhaust systems of these impurities and their combustion products?

[pensivebadger](#)

There shouldn't be any surprises for the engine resulting from this approach; we start off with azeotropic ethanol (95% ethanol, 5% water) so it's most of the way purified anyway. Talking ethanol in general, a small amount of it tends to improve combustion properties.

I'm just a layman... however, what are the actual economic benefits on a larger scale (the bigger picture) thanks to this new process? Will these cause the price to be more competitive? Will it make the fuel more ubiquitous? What industries and/or products currently consume the most biofuels?

Thanks in advance if you take the time to respond, and congrats! Better living through chemistry!

[saintpetejackboy](#)

On a larger scale, if this is implemented, it should cut the cost of the ethanol part of fuel by around \$0.50/gallon. Most of the fuel in the US is 10% ethanol, for instance, so one might expect the actual fuel price there to drop by approximately \$0.00/gallon while fuel companies make an extra five cents.

My personal feeling is that the main value of the paper is that it discards a basic assumption that everyone in the field has been making up to this point and opens up a whole new range of ways to approach this process and other processes like it. What we've come up with so far is just one of many possibilities.

Thanks for your AMA Dr Stacey.

I am an agricultural producer in the midwest. Some of our corn will find its way to an ethanol plant. Many people do not understand the importance of DDGS in the economic viability of ethanol. Would your process render a similar amount and quality of DDGS?

[bin-builder](#)

Hi there [/u/bin-builder](#),

This process only picks up the ethanol quite a long way down the processing chain, once it's at an azeotropic mixture. The early stages are unaffected, so there'll be no difference to the production of DDGS.

Thanks for this AMA!

I'm a chemical engineering student in my final year of school and find this topic very interesting. Is there a link where I can view your publication?

[dmbeledo](#)

<http://pubs.acs.org/doi/abs/10.1021/acs.energyfuels.6b01591>

There you go. Sadly our currency here in South Africa has recently stopped being worth anything so the university wouldn't pay the ACS fee to make it open access. You should be able to get it through your university's portal though.

Fast growing bamboo has quite a bit of cellulose and lignin. Is it worth the effort to degrade these complex polymers into fermentable sugars when the energy density of ethanol is so low compared to gasoline? I believe butanol is a worthy successor but it is hard to manufacture from biomass. Do you use synthetic biology techniques to get the ethanol?

[o-rka](#)

I personally have quite limited expertise when it comes to the biological side of things; our tech is focused purely on the separation stages. However, I'll answer as best I can based on the reading I've done. Cellulosic fermentation has come quite a long way and it's generally considered to be a viable option, though the focus on it has generally been on the basis that food crops have cellulosic waste so it's seen as a great value-add for food-growing and the feedstock is effectively free or at least very cheap because it's a waste material.

Growing cellulose-heavy crops like bamboo specifically for fermentation is certainly doable but it's a trickier prospect from a financial standpoint because, as you say, cellulosic fermentation is more difficult. I don't personally know of anyone growing a high cellulose crop specifically for fermentation so I would have to guess that it doesn't work out, economically.

I do know of a company here in SA that's planning to grow bamboo for biomass for gasification --> Fischer Tropsch to produce longer-chain hydrocarbons, some of which they plan to polymerize for use in a building material they've developed that is a bamboo/plastic mix.

Thanks for the response! The agricultural industry produces so much biomass waste to not try and figure out an efficient way to convert it into fuel. I agree, an entire land dedicated to specifically growing biomass for ethanol would probably be ineffective. I was working on the biology side of engineering ethanologenic extremophiles during my masters thesis but I've transitioned to more computationally

stimulating projects . I'm still passionate about the potential impacts biofuels can have on creating a carbon neutral (possibly carbon negative) and hope the engineers, the biologists, and the statisticians keep improving the technology. Great work! We need it!

[o-rka](#)

Honestly it's a good move to switch out of bio experimental work for the Masters; that kind of research often demands a time-frame that's outside of what's reasonable for an MS.

By the way, be sure to get in touch down the line if you're looking to carry on to a PhD, our group is specifically looking for researchers to do computational work.

So, let me get this straight- The wonder "bio" fuel ethanol, which is based on corn, which is grown using intensive amounts of petroleum (fertilizers, pumps for water, planting and harvesting equipment) and produced in coal powered facilities, will be using gasoline in the mix to streamline production? Beyond ridiculous to the sublime.

[drinkingchartreuse](#)

I'm afraid you don't quite have it straight; ethanol and gasoline are already both being produced in large quantities and finding themselves together in fuel tanks. This process gets from the same starting point to the same end point as the existing ones, it just reorders some of the intervening steps to use a bit less energy.

Hello Dr. Stacey,

Thank you for taking the time to do this AMA! I am wondering if you could elaborate on some immediate challenges and what the process might be for implementing this in the field.

More specifically, do challenges stem more from an unwillingness financially or functionally to switch to new machinery, SOPs, materials, etc., or is adoption hindered more by professionals in the field being unaware of these advancements? Based on your stated energy saving potential for this new method, it would seem to be of great interest to incorporate this technique into the overall process.

[DanceMyth](#)

The challenges involved are quite different in different contexts. In Brazil, for instance, the ethanol percentages are too high for our process to work well at all so there's a fundamental technical problem. In the US, where 10% is the norm and our process works reasonably well, there's a general resistance to making capital outlays on new technology because of subsidy structures.

Here in South Africa, legislation mandates 2% ethanol blends and our process works remarkably well but we're in the midst of a multi-year drought, so no-one's making any ethanol to speak of.

In a general sense, though, the biggest challenge is probably that of simply getting multiple large companies to cooperate. This process requires integrating part of the ethanol separation into the fuel distribution chain so it demands the participation both of biofuels manufacturers and fuel companies on the same project. Commercially, our strategy is basically to just sell the patent to a fuel company so we can let someone bigger and nastier deal with that headache.

Do you do a triphasic distillation? Or vacuum? Rotovap triphasic? Do you salt out the ethanol? HOW DOES THIS WORK

[BabiesLOVEclowns](#)

The process in the paper essentially assumes that conventional processes (or exotic processes if need be) have produced an azeotropic mixture (95% ethanol, 5% water). This mixture is then directly blended with gasoline and the last bit of water more or less just falls out. I've edited the original post to have a link to the paper, if that helps.

Hi, Dr. Stacey, first of all, thanks for doing this AMA! I recently went to a summer camp at UCSD and studied biodiesel from algae oils. What place do you think biodiesel will have in the future biofuels market?

[redditlurkernoob776](#)

Bio-diesel is great because it's really easy to make on a small scale. I know that here in South Africa, there are plenty of farmers making their own bio-diesel on-site for their own use. That kind of distributed production model has obvious advantages logistically, so I'd say that bio-diesel is guaranteed a solid niche at a bare minimum.

More than that, though, the ease of production makes bio-diesel easily one of the most appealing renewable energy sources so it's sure to end up with a big share of the market.

It's been long known that you can break the azeotrope with benzene which is obviously present in gasoline, but from reading the op it sounds like your doing a liquid liquid extraction. Could you please comment a bit more on the process itself or perhaps provide the paper? (Doi is fine)

[lasserith](#)

[Link to paper](#)

It is essentially a liquid-liquid extraction, with gasoline as the solvent, except that in this case there's no need to recover the solvent, because the overflow stream is a usable fuel product as is.

Is this something you can patent or will it just be something everybody can do?

[Jupes_Star](#)

The basic concept is way too simple to nail down in a patent, so anyone can go ahead and work on processes using the basic idea. However, Wits University has filed a patent on several aspects of the process that we're commercializing.

I will keep in touch. I think one of the biggest opportunities is looking into elementary mode analysis to figure out which pathways are irrelevant to ethanol synthesis.

[o-rka](#)

It's also worth looking at butanol synthesis; it's a better fuel molecule but the fermentation is less effective so there may well be more space for improvement there.

Is there any way to develop ethanol that doesn't clog up catalytic converters? It's a big problem in states that heavily subsidize ethanol as it ends up in the tanks of a lot of vehicles as it ends up being cheaper than a non 10 or 15% blend.

[barre_chord_reality](#)

The short answer is no. High ethanol content is just damaging to engines not designed for it. The straightforward solution is: either keep the ethanol percentage low enough to not damage engines, or roll out engines that can handle it. My preferred solution to this and other problems is switching from ethanol to butanol, which is far less problematic in this and other ways. Another creative solution is to adopt a blend of the two biofuels. For instance, replacing E15 with something like 8% butanol and 7% ethanol would still give 15% renewable fuel but quite likely without the damaging effects of 15% ethanol and without costing as much as going full-on for butanol.

What is the decolonization FMF are talking about?

[Dark_Messiah](#)

As an engineer I've been more or less oblivious to the decolonization debate. I was pretty sure that it was about reforming curricula in subjects like History and Literature to be more focused on and/or inclusive of the African perspective, which I think most people will agree is a fair request and probably a good thing.

Then I saw [this clip](#) and thought to myself "Maybe I should emigrate."

From everything I'm told, the crazy person in the clip is not at all representative of the movement's actual consensus agenda and that the meeting in its entirety was overall progressive and productive.

Ethanol sucks! Attracts moisture, ruins emissions sensors in vehicles, and makes vehicles use more fuel. Horrible horrible stuff.

[sonofchaos3](#)

I'm one of many advocating a switch to butanol. It's much better as a fuel and it happens to work far better with our process.

What's the estimated net reduction in CO2 emissions (percentage please, not tons/CO2), in global CO2 output, taking into account only countries that use ethanol blends?

[lunchlady55](#)

There is some guesstimation involved here, but this switch cuts the net CO2 emissions of ethanol specifically by about 30%. So in a country with a 10% blend, it'd be around 3% reduction in the emissions from cars.

Cars account for something like 15% of total CO2 emissions, so that brings it down to the order of 0.45% total reduction.

Looked at on a more global scale it reduces still further because not many countries actually use much ethanol.