Progression Group

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CyclOx® *for diesel engines*

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Problem

Governments around the world are mandating ever higher concentrations of bio-derived compounds in fossil fuels. Such legislation is a testament of inferior technology and/or too expensive products.

At the same time it is clear that fossil fuels, which will remain dominant for decades to come, are themselves imperfect, giving rise to carcinogenic soot emissions in the case of diesel fuel.

Our goal was to develop a drop-in biofuel with a price-performance ratio that markets will accept without the need for legislation, tax incentives or subsidies. Only then is biofuel truly sustainable.

Approach

We solved this problem in two-step approach:

1. Reverse-engineer - from an engine's (i.e. the customer's) perspective - the chemical composition of the ideal drop-in biofuel with respect to curbing soot.

2. Allocate low-cost renewable feedstocks and develop associated conversion methods to produce this biofuel.

Invention

CyclOx® is an abbreviation for cyclic oxygenates. The combination of a cyclic structure and onboard oxygen improves the fuel-oxygen mixing process before and during combustion, thereby suppressing soot formation.

A technical animation is available on our YouTube page:

http://www.youtube.com/user/ProgressionIndustry

On average, the addition of 10% CyclOx to diesel fuel results in a 50% (best-in-class) decline in soot emissions. This superior soot performance has been documented extensively in the following peer-reviewed papers:

Emission performance of lignin-derived cyclic oxygenates in a heavy-duty diesel engine, *SAE Technical Papers*, 2012-01-1056, 2012.

The effect of the position of oxygen group to the aromatic ring to emission performance in a heavy-duty diesel engine, *SAE International Journal of Fuels and Lubricants*, *5*(3), 2012-01-1697, 2012.

Side effects

- Aforementioned improved mixing conditions lead to a more rapid combustion event, thereby slightly increasing NOx by approximately 1% for every 5% reduction in soot.

- The cyclic structure is more resistant towards auto-ignition which may effect cold start capability.

- The oxygen in the fuel may adversely affect seals and hoses in the fuel circuit.

- Fuel economy in g/kWh is worse due to fuel oxygen, but due to the higher density remains neutral when expressed in ml/kWh (or liters/km).

Feedstocks

Phase 1 (Clean Fossil): extract CyclOx directly from low-value waste streams recoverable from the SMPO process, which produces the base material for Styrofoam™.

Phase 2 (Clean Bio): extract CyclOx via depolymerization of lignin. Lignin is a form of low-value second-generation biomass, currently burnt for process heat in both the paper and cellulosic ethanol industry. With falling gas prices, the value of lignin as a heating fuel is set to drop even further.

Market & pricing strategy

Until a suitable economy of scale is realized in both phase 1 and phase 2, pricing of processed CyclOx will hover around 1000$/ton, well above current diesel prices of 500-700$/ton. At a suggested blend ratio of 10%, this will increase the price of the blended end-product by 5-10%.

Utilization is therefore limited to markets in which:

1. Fuel costs are low against total operational costs, and

2. Clean air is seen as a marketable asset.

Markets currently engaged included power generation at public and private events, and transport in inner-city green zones.

Intellectual property

The use of CyclOx in diesel engines is protected by the following pending patents:

US2010000146 , CN101627104 and EP2115102