SYNFUELS
INTERNATIONAL, INC.

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Technology Information Circular

Synfuels Gas Processing Technology Achieves New Breakthroughs

Synfuels International, Inc. is a Texas corporation which has developed, demonstrated and patented a comprehensive intellectual property portfolio (IP) for the processing of natural gas or its components; C1 methane, C2 ethane, C3 propane, C4 butane and/or C5+ naphtha into any one of the following commercial products; polymer grade ethylene, gasoline blendstock, high specification gasoline or jet fuel.

The Synfuels process is referred to as GTX since it offers customers several process options including; Gas-To-Acetylene (GTA), Gas-To-Ethylene (GTE), Gas-To-Liquids (GTL) and Gas-To-Aromatics (GTB “BTX”). All Synfuels process options utilize the same safe and efficient technology demonstrated in continuous operation at the Synfuels GTX plant in Texas.

The complete Synfuels GTX process consists of 4 process steps; Pyrolysis, Absorption, Liquid Phase Hydrogenation and Oligomerization. The Liquid Phase Hydrogenation step produces ethylene at conversion levels in the 98% range. The oligomerization step produces gasoline blendstock in the 95% range.

Although, Synfuels has continuously demonstrated pyrolysis conversion far above traditional industry performance levels, we have conducted a continuous improvement program which in 2010 has resulted in further significant increases in pyrolysis conversion yields and additional valuable patents.

The practical result of Synfuels breakthrough is even higher profitability levels for customers wishing to monetize low value, stranded or flared natural gas.

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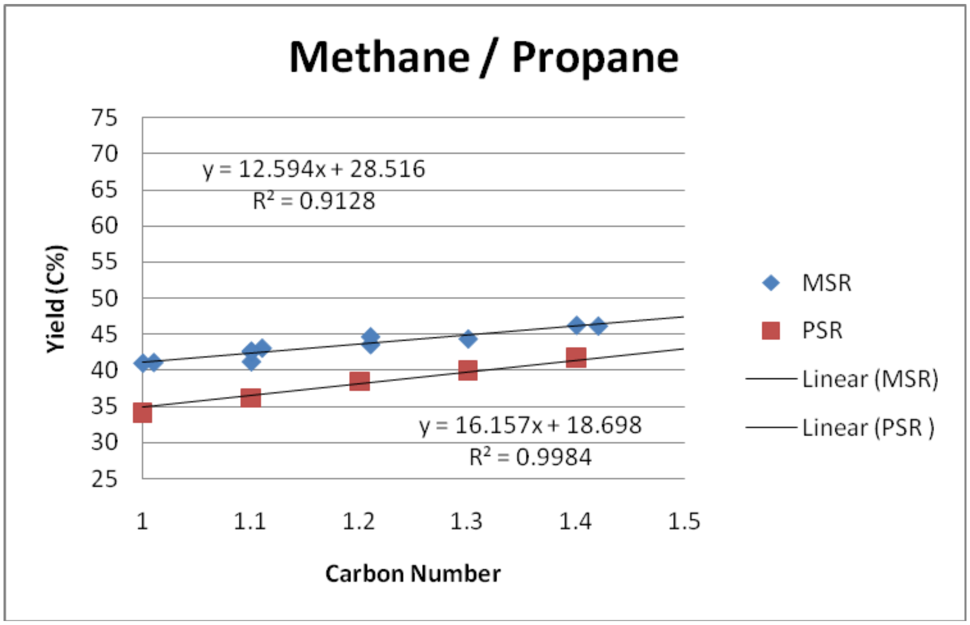
Synfuels Significantly Increases Natural Gas Conversion Yield

BACKGROUND: The Synfuels GTX process is specifically designed to convert a wide range of low molecular weight hydrocarbons into products that include acetylene, ethylene, gasoline, BTX and jet fuel. Hydrocarbons are first converted to acetylene and ethylene in the pyrolysis reactor. The pyrolysis reactor functions by generating a high temperature plasma, then moving that plasma past an injection point where hydrocarbons are mixed with the plasma. The hydrocarbons are converted preferentially to acetylene and ethylene. Methane, the smallest hydrocarbon, converts almost exclusively to acetylene, but requires temperatures in the range of 2000 C for optimum yield. The Synfuels pyrolysis reactor is specially designed to safely and efficiently provide the highest yields of *acetylene and ethylene* (C2=) from gases made primarily of methane.

For natural gas which contains significant amounts of heavier hydrocarbons, the yield of C2= is better than that of pure methane. In early 2009, Synfuels discovered that the yield of a methane/propane blend increased in the mid scale reactor (MSR) from 41% to 46% for a carbon number of 1.4. This clearly demonstrates that for a richer gas, the yield of C2= is better for a rich gas than a lean gas.



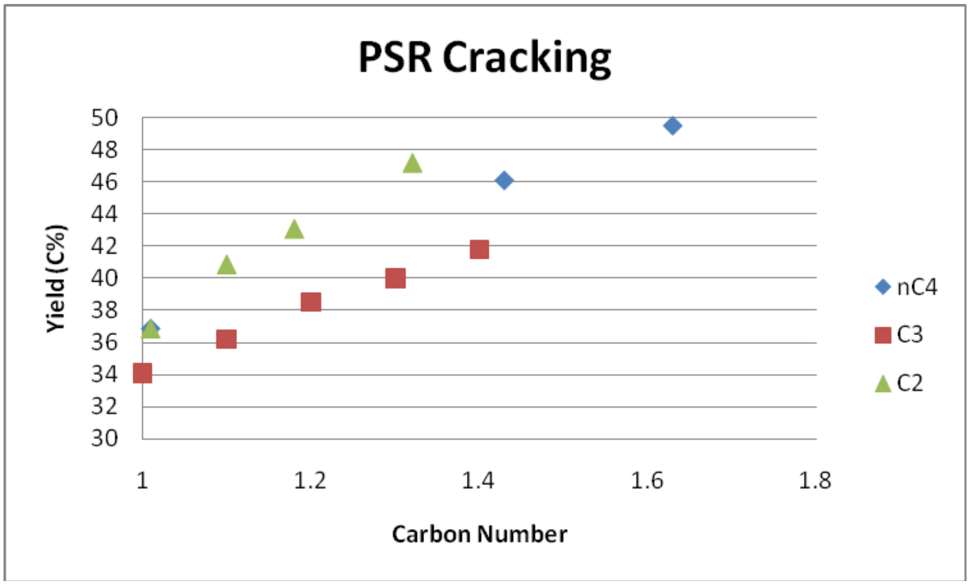
We also tested at that time, the conversion of methane/propane mixtures in the pilot scale reactor (PSR). It showed the same behavior, but consistent with all previous tests, the PSR gives lower optimum yields of C2=.

Reduced yield has been attributed to heat loss. The small size of the PSR allows 40% of the plasma energy to be lost as heat to the walls of the reactor. The MSR, which has a much larger volume to surface ratio than the PSR, only loses about 18% of the plasma energy as heat. Simple calculations show that for the commercial scale reactor heat loss drops to 8% with a corresponding projected increase in yield.

2010 PERFORMANCE IMPROVEMENTS: In 2010, Synfuels tested the ability of their pyrolysis reactor to convert pure heavier hydrocarbons to C2=. The optimum yields from ethane, propane, butane and naphtha are significantly higher than that from methane.

Feed	C#	Yield (C%)
Natural Gas	1.01	36.9
Ethane	2	73.8
Propane	3	67
n-Butane	4	70.2
Naphtha	5.93	68.5

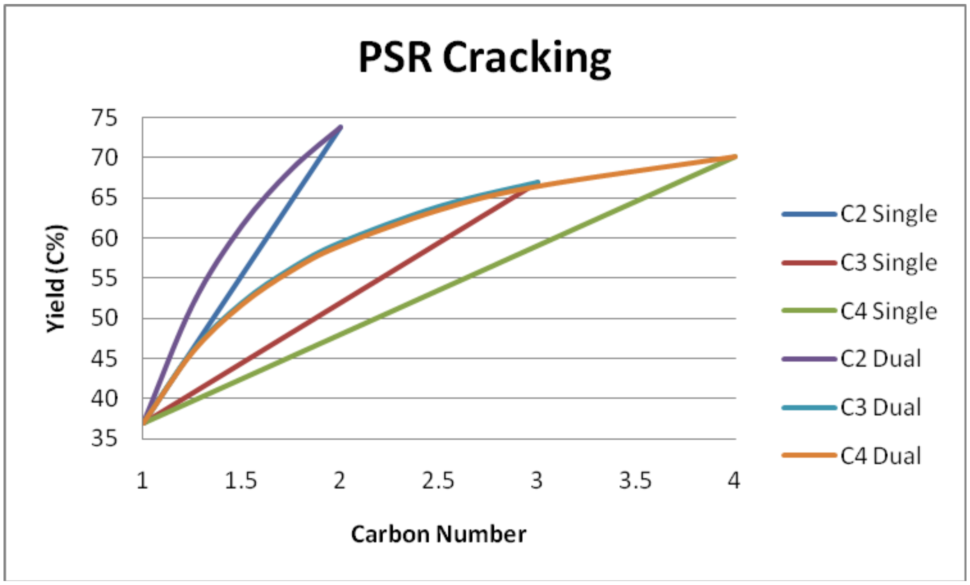
Several tests were then run of mixtures of methane with ethane, propane, or butane in the PSR. The calculated maximum yield based on observed PSR yields for each of these mixtures is shown for comparison.



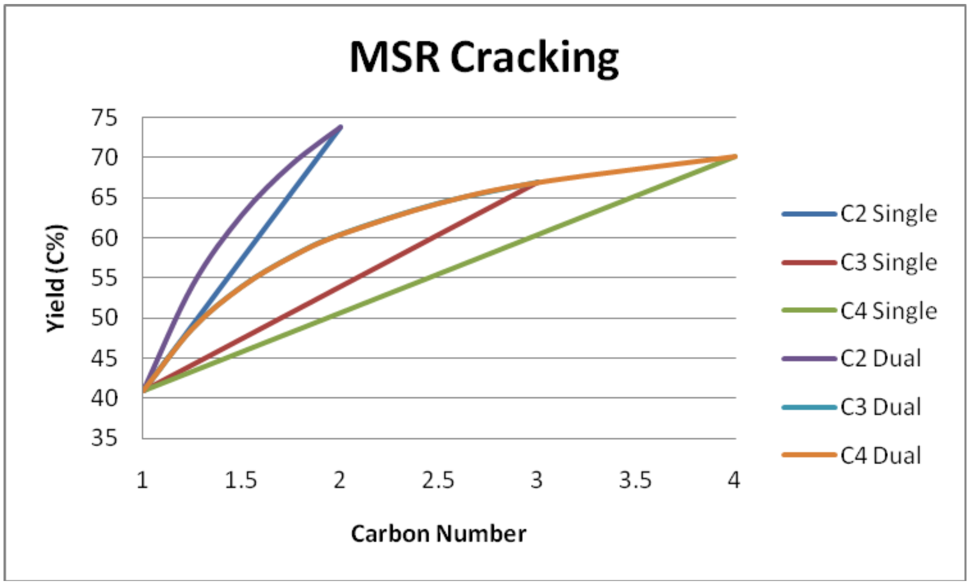
It is clear that although the yield for rich gases is better than that for methane alone, the current single feed design of the pyrolysis reactor does not produce the maximum potential yield of C2=. The early results from our propane testing prompted us to apply for a patent in 2009 that allows the pyrolysis reactor to have multiple feeds in order to maximize yield with a broad range of feedstock profiles.

The reduction in yield in the single feed inlet reactor results from having one “WHSV-temperature” environment where optimum yield is obtained from different “WHSV-temperature” values. Our initial analysis indicates that although the heavier fraction converts 100% in the single feed case, methane conversion, which requires more severe conditions, is depressed. We have also found that the heavier the C2+ component is, the greater the depression in methane conversion for the single feed inlet reactor. This is understandable because the heavier fractions require progressively lower temperature to achieve optimum conversion to C2= products. Separating natural gas feeds into C1 and C2+ fractions has a cost, but in most cases, C3+ can be separated from C1 + C2 affordably. In cases where the C2 fraction is significant, the cost of making the C1/C2+ split may be justified by the increased product yield.

The graph below displays the actual yield results for the various mixtures as a function of compound and carbon number (indicated by the straight lines) along with the calculated maximum yield results that may be possible based on pure component data (indicated by the curved lines). Clearly, the higher the CN is, the greater the opportunity of increased yield using a multi-feed pyrolysis reactor. The results for the dual feed case may not be intuitive. A simple derivation of the effect is provided in Appendix A.



The graph below shows the projected percentage yield of these compositions in the MSR.



For the sake of numerical comparison, the table below shows the performance of the MSR at 1MMSCFD using an average carbon number feed of 1.28 and 1.5 made up of different heavy components. For each component blend, a yield is shown for single and dual feed.

	Carbon Number 1.28		Carbon Number 1.5	
	Single	Dual	Single	Dual
Ethane	50.2	55.4	57.4	62.9
Propane	44.6	49.5	47.5	54.0
Butane	43.7	49.5	45.9	54.0

Appendix A – Derivation of 2-Feed Yields

Given:
C# = carbon number of combined gas
Y1 = yield of methane alone on carbon basis
Yx = yield of heavy heavy component with X carbons on carbon basis

Seeking
Yt = total yield of combined gas on carbon basis

By definition:
C1 = mole fraction of methane
Cx = mole fraction of heavy component
C1 + Cx = 1
C1 + X Cx = C#

C1 = (X-C#) / (X-1)
Fraction of Carbon from Methane = C1 / C# = (X-C#) / (X-1) / C#
Fraction of Carbon from Heavy = 1 – C1/C# = 1 - (X-C#) / (X-1) / C#
Yield from Methane = Y1 (X-C#)/(X-1)C#
Yield from Heavy = Yx (1-(X-C#)/(X-1)C#)
Total Yield = Yx-(Yx-Y1)(X-C#)/(X-1)C#