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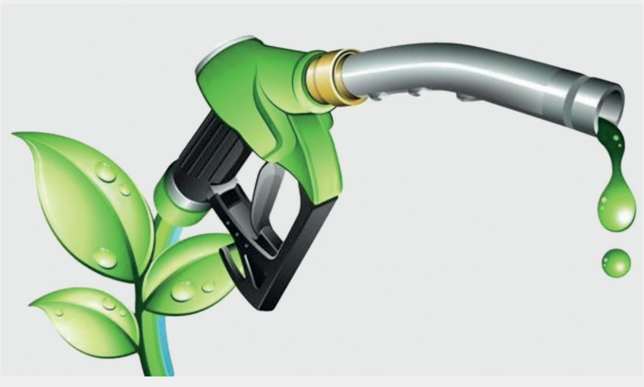
Advancements in Biofuel Production to Limit Carbon Dioxide Emissions & Measuring the Percentage of Biofuel in Fuel Blends



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Introduction

Following the discovery of climate change in the early 19th century, scientists have been researching energy-creating methods that produce less carbon dioxide (CO_2) emissions. Experts have been addressing the conversion of biomass into liquid that is compatible with existing energy infrastructure. There are currently four generations of biofuel advancement. Each is characterized by its source of biomass; the first is edible biomass, the second is non-edible biomass, the third is algal biomass, and the fourth consists of mainly solar fuels. As energy demands increase, it is vital for cleaner fuels to be tested with instrumentation that measure the percentage of biofuel in fuel blends.

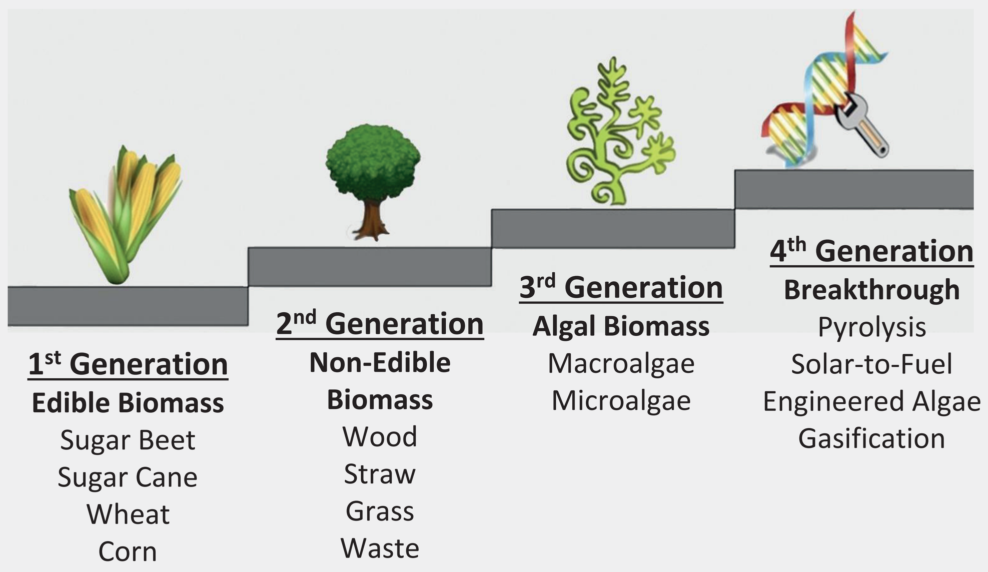

Figure 1: Generations of Biofuels [3]

Research

To combat the issue of high atmospheric CO_2 emissions, researchers throughout the globe have taken advantage of the fact that CO_2 is useful in creating more sustainable fuels. One method involves converting CO_2 to fuel with the use of bacteria. A process at Harvard University uses the bacteria Shewanella in a bacterial reverse fuel cell to directly convert CO_2 to electrofuels. This process is beneficial as the electrofuels produced can perform the same role as most petrol and diesel fuels. Other tactics convert CO_2 into hydrocarbons, such as synthetic methanol, ethanol, or propanol fuels. Scientists from Argonne National Laboratory and Northern Illinois University designed an electrocatalyst that converts CO_2 to ethanol, which is a prevalent fuel source. The catalyst is denoted as highly selective, low cost, and is activated by renewable sources. Such innovative methods tackle rising CO_2 levels.

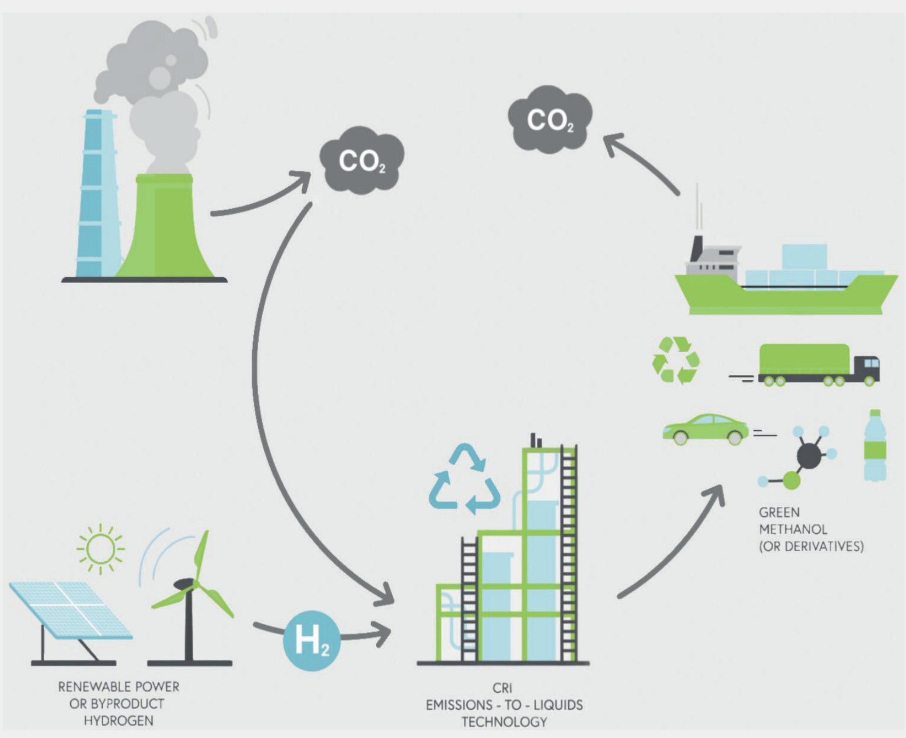

Figure 2: Green methanol production by Carbon Recycling International [6]

Purpose of Biodiesel Testing

There are several applications in which biofuel and biodiesel are being used in new and unexpected ways. For instance, biodiesel in low quantities (2% to 5%) is currently being used in ultra-low sulfur diesel to act as a lubricant. Growth in the United States is also projected to be great due to oil consumption trends and access to ethanol and algae-based biofuels. However, any application of biofuel or biodiesel may become dangerous if not properly regulated. It is also important to note that there are issues with cutting corners on biofuels. In Brazil, this is seen in cost cutting or incomplete conversion of oils. Thus, the growth of biodiesel in many areas of the world coupled with the current problems of cutting corners on biofuels, has resulted in an increased need for monitoring. Putting the necessary regulations in place and establishing adequate field monitoring, has proven more important than the testing method alone.

The Koehler Biodiesel Analyzer

Biodiesel analyzers are devices designed to measure the percent of biodiesel in fuel oil. There are three calibration ranges as given in ASTM D7371: low level blends which contain less than 10% by volume biodiesel, high level blends which contain between 10% and 30%, and biodiesel from 30% to 100% by volume.

Near-infrared spectroscopy (NIR) is a spectroscopic method that operates in the wavelength range of 810 nm to 1045 nm, in which light is readily absorbed by the frequencies of molecular vibration. NIR application offers the benefit of testing gas, diesel, and biodiesel with the same portable device, minimizing equipment, and allowing for faster and more frequent site inspections.

With the use of NIR, Koehler Instrument Company has developed a biodiesel analyzer that measures low (less than 10%) and high (10% to 30%) biodiesel by volume. The handheld field device is designed to take a 200 mL sample, contained in a glass sample holder. It is pre-calibrated for the research octane number, motor octane number, diesel cetane index, and cetane number. The device can also be calibrated to work with samples ranging in temperatures from 5˚C to 38˚C. Near-infrared calibration is done on each device using calibrated lab standards. The device is portable, accurate, fast, and causes no degradation to samples, allowing for field testing to verify concentration and the safety of the content.

Figure 3: Koehler Biodiesel Analyzer [5]

Testing Procedure

Koehler Instrument Company conducted a study on the Biodiesel Analyzer to test biodiesel percentage. In the experiment, room temperature (20˚C) was maintained for consistency. Samples were prepared using diesel fuel as the base and B-100 biofuel as the additive. Samples of 250 mL, in each 1%, 5%, 10%, 15%, 20%, 25%, and 30% by volume biodiesel concentrations were created. The samples were then individually poured into the sample holder of the Koehler Biodiesel Analyzer. Each sample was loaded to the line, run, turned 180˚, and rerun. The double run allowed for any deficiency in the glassware to be negated. Each test was repeated three times. The low biodiesel percent by volume was recorded for all concentrations and high biodiesel percent by volume was recorded for all concentrations above 9%. The device performed NIR analysis as well as the multi linear regression and provided results within three minutes of pouring the sample into the chamber.

Results and Discussion

The low and high percent biodiesel by volume were recorded for each of the three runs, shown in Figure 4. The data was graphed to find the linear best fit line and the calibrated results were compared with the projected results. The low biodiesel calibration was a simple linear line, the R^2 value indicated it was in the 98 percentile, which is a very good fit. The high biodiesel calibration had a lower R^2 value for the linear best fit of only 81%. This does not show the same precision or accuracy as low biodiesel, still it is within an acceptable range.

B-100 Biofuel in Diesel

Concentration	B-100 Biofuel (mL)	Diesel (mL)	Run 1		Run 2		Run 3	
			Low	High	Low	High	Low	High
0%	0	250	4.3		3		3.2	
1%	2.5	247.5	5.1		5.5		3	
5%	12.5	237.5	6.5		7		6.5	
10%	25	225	10.3	30.8	10	31	13	35.2
15%	37.5	212.5	13.8	31.4	14.9	31.9	12.6	34.8
20%	50	200	17.4	39.3	16.6	38	18.3	40.1
25%	62.5	187.5	20.1	39.8	20.1	38.7	20.7	38.3
30%	75	175	22.2	41.2	22.2	42.4	24.8	37.8

Figure 4: The low and high percent biodiesel by volume [5]

Conclusion

Over time, rising levels of CO_2 have proven to be a threat to the environment and society. Scientists have been trying to discover a biofuel extraction process that is inexpensive, time efficient, and sustainable for almost four decades. As biodiesel blends become widespread due to their vast range of uses and applications in the field of diesel, the push to test and enforce regulations is essential. The Koehler Biodiesel Analyzer demonstrated accurate calibration from handmade standards, proving to be an effective NIR testing method. Breakthroughs and innovations encourage strides towards a world powered by clean energy.

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