Gregor Schaub, associate division director for biodiesel at BDI-BioEnergy International, discusses future areas of application for waste oil-based feedstock and the necessity of selecting the suitable technology

Cargill's biodiesel plant

What fits the process

Traditionally vegetable oils of different quality and refined stages were used for first generation biodiesel and HVO (hydrotreated vegetable oil) production.

The business and its growth was supported by governmental measurements and subsidies.

These measurements were stopped in most cases as new incentives were created, increasingly for waste-based feedstock only called advanced feedstock.

These changes were logically part of the development of overall carbon reduction that came into focus.

Even though technologies to process advanced feedstock have been available for many years, the main focus has only recently shifted to waste-based feedstocks due to political decisions.

Political situation

The current political landscape and the expected future development has led to the conclusion that the industry has a greater interest in increasing the use of waste-based raw materials for biofuel production.

These incentives include the Renewable Energy Directive (RED III) in Europe and measures like the carbon intensity score in the US.

The RED III directive sets a common target for the share of renewable energy consumption of 42.5% by 2030 and encourages member states to further increase this share by 2.5% by the same year.

In summary, advanced feedstock types will be pushed further into the market by national politics or tax incentives.

When biodiesel producers shift to waste-based material as feedstock, the first choice is often used cooking oil (UCO).

The main reason is that UCO's feedstock parameters are close enough to that of vegetable oil.

The result is that there are no, or only minimal changes, to the processes involved.

To incorporate low-quality waste oils as feedstock, significant alterations to the current process are necessary, leading to increased investment requirements. In certain instances, a completely fresh process design will be essential, which could involve retrofit units such as additional washing steps or distillation, the establishment of a parallel production line, or the creation of an entirely new standalone production process.

Technology

Yet, for producers of renewable diesel and sustainable aviation fuel (SAF), progress in utilising waste-based feedstock is advancing at a slower pace due to the diverse array of impurities present in the feedstock, posing challenges for downstream processing.

Typically, processes involving hydration (such as HVO and SAF) necessitate higher feedstock purity requirements because the catalysts utilised in these processes are sensitive to common catalyst poisons

like phosphorus and metals.

Therefore, the typical input specification for HVO or SAF process plants are quite restrictive when compared with biodiesel production facilities.

Well-known technologies for HVO have limits in phosphors in the single digit ppm range as well as for metals group one and two.

In addition, existing facilities for co-processing might not fulfil corrosion protection necessities, which also strictly limits chlorides and acid values in the feedstock.

For biodiesel production, these parameters in waste-based feedstock are not that crucial because most of the production plants are equipped with a final purification step – a biodiesel distillation unit.

In this unit, the problematic impurities end up in the distillation bottom and not in the distilled product.

A general overview of the different kinds of feedstock are listed here.

Apart from UCO, the most common feedstock is animal fat or waste and residue streams from palm oil production.

Feedstock types, which are rarer on the market include trap greases from oil separation systems and acids oils from soap stock splitting processes from large-scale vegetable oil refining.

Generally, these types of feedstock can be categorised into different qualities, listed below from typically favourable to typically inferior.

Argent's biodiesel plant

Each feedstock is accompanied by its most crucial and characteristic parameter, which is discussed briefly, regardless of its intended use in biodiesel or SAF production.

Feedstock types

UCO is a common advanced feedstock for renewable fuel producers, as already discussed.

Relevant feedstock parameters include, for example, free fatty acids (FFA), water content and solid impurities.

The typical range of FFA in "classic" UCO spans from 0.5% to 5%. The water content varies between 0.2 to 2% and solids from 0.1 to 3%.

Furthermore, a high polymerised triglycerides content is expected – up to 10% – from the deep frying process.

Since UCO can be a complex mix of vegetable oils and animal fats, typical contents like phosphorous can be up to 50 ppm. Metal content, sodium chloride and other cooking ingredients in UCO can be on the high side.

Animal fat has a range of between 5 to 45% FFA depending on the source and time of storage.

The longer the storage time the higher the degradation of the fat, which also increases the sulphur content drastically.

Additionally, a significant concern with animal fat is the presence of polymer-type plastics such as polyethylene. The polyethylene often comes from the ear tags of livestock. In addition, the phosphorus content can be very high, but in most cases this is not a critical factor as it comes from the bone meal, which can be separated by a washing step.

Residues and byproducts from the palm oil industry like palm oil mill effluent (POME) and palm fatty acid distillate (PFAD) are also listed as feedstock for fuel production.

Offering a range of typical feedstock parameters would not be feasible due to the significant fluctuations in the various parameters of POME.

Water content, metal, sulphur and other parameters can vary a lot depending on origin and storage conditions of the sourced material.

However, a typical parameter for POME is the FFA content – 50% and above. However, even with this parameter, unexpected qualities (FFA < 25%) have recently appeared on the market.

PFAD is usually a clean high FFA feedstock and has little fluctuation in the quality parameters, but it is likely to be priced higher when compared with POME.

Greases are known by various names and classifications, including yellow, brown, black, and trap grease.

For instance, yellow grease is often synonymous with UCO. Generally, these greases comprise a blend of other waste oils and fats, residues sourced from various

A range of biodiesel types

origins such as fat separation in wastewater systems.

Due to their diverse sources, they tend to have high levels of moisture, impurities, and insoluble substances (MIU), and the triglycerides within the fats and oils can undergo significant chemical degradation. These characteristics collectively render greases as low-quality feedstock, often lacking reliable availability in substantial quantities.

Acid oils are derived from soap stock, a byproduct of large-scale vegetable oil production, particularly from the degumming process.

To recover the oil residue from soap stock, a process known as soap stock splitting is employed, often involving the addition of sulfuric acid.

These acid oils are characterised by high levels of FFA reaching up to 90%, and phosphorus levels as high as 2000 ppm, concentrated from the vegetable oil refining process.

Despite the daunting parameters associated with even the high-quality waste oils mentioned earlier, numerous state-of-the-art technologies exist for converting such waste oils into valuable biofuel products.

Among these technologies are the BDI RepCAT process, which produces biodiesel, and the BDI Advanced PreTreatment, which prepares the feedstock for subsequent use in SAF production through co-processing or hydration.

Purification

As described above, the pre-requirements for feedstock used in SAF and HVO production are very strict.

A multistage purification process is necessary to prepare the waste oils for their use in this sector.

One example for such a purification process is BDI's Advanced PreTreatment unit.

This consists of multiple washing steps combined with a feedstock drying unit, adsorption and filtration processes.

The process reliably reduces selected parameters like MIU, sulphur, phosphorus, chlorides and metals.

The effort and associated cost of cleaning the feedstock increases in proportion to the level of impurities, which are typically more abundant in low-quality feedstock such as animal fat, greases, and acid oils.

This limitation narrows down the range of economically feasible feedstock qualities that can be cleaned up for SAF and HVO production.

Essentially, all types of feedstock listed above are suitable for the BDI RepCAT process.

From the producer's perspective, the preferred feedstock will be of lower quality, which implies a lower asking price for the feedstock and, thus, higher margins when selling biodiesel as a product.

The technology was specifically developed to process materials with a high proportion of free fatty acids (up to 99% FFA) and is insensitive to typical impurities.

The design of the RepCAT technology makes it a robust choice when producers aim for the lowest quality of feedstock, like acids oils.

"The current political landscape and the expected future development has led to the conclusion that the industry has a greater interest in increasing the use of waste-based raw materials for biofuel production"

A Tricanter Pretreatment plant

The main process steps of the RepCAT plant are a pre-purification step followed by a two-stage continuous trans-esterification process under higher temperature and pressure conditions.

As a final production step, the biodiesel and glycerin are distilled in an optimised distillation column.

The products are biodiesel according the required norm (ASTM or EN14214) and is an absolutely salt-free glycerin of distilled quality.

The bottom product of the distillation, which contains the heterogenic catalyst, is partly recycled to the upstream process.

This step gives the technology its name – RepCAT – repeatable catalyst.

Conclusion

As political pressure for advanced feedstock and biofuels overall is increasing, so does the general demand for bio-based feedstock.

This leads to the conclusion that in the near future all feedstock qualities – whether good or bad – will be a valuable addition to the global feedstock mix for renewable fuel production.

Due to the disproportionate demand for SAF and HVO, coupled with the increased effort required for thorough feedstock purification, higher-quality feedstock such as virgin vegetable oil, UCO, and others will be largely absorbed by this market.

Consequently, biodiesel producers will primarily have access to lower-quality feedstock types that are generally unsuitable for SAF/HVO production. This evolving landscape in the feedstock market places added pressure on biodiesel producers to adapt their processes, integrate new lines with appropriate technologies, and maintain profitability while striving to regain a competitive edge. ●

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