Evaluation of long term storability of (bio)fuels by monitoring CO_2 evolution

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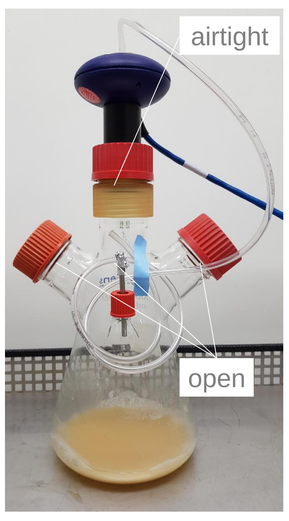
Introduction

- Some biofuels like FAME show reduced storability due to increased microbial degradability [1].
- Microbes degrade fuels to CO_2, so the measurement of CO_2 allows simple and sensitive detection of microbial activity.
- To assess the storability of fuels we use the BCP-CO_2 sensor of BlueSens Gas Sensor GmbH.

Methods

- The off-gas sensor measures absorption of infrared light by CO_2 gas.
- The sensor is insensitive to the test system and can be applied, e.g., on single- and two-phase systems.
- At high microbial degradation rates, hence high CO_2 evolution rates, an aerated reactor can be used.

Results and Discussion



Open single-phase reactor

- Under optimal growth conditions bacteria and yeasts produce CO_2 so fast that the open system (with air exchange) can be applied.
- Samples for off-line analytics like classical growth measurements can be taken.
- CO_2 evolution can be correlated with the growth of microbes (Figure 1).

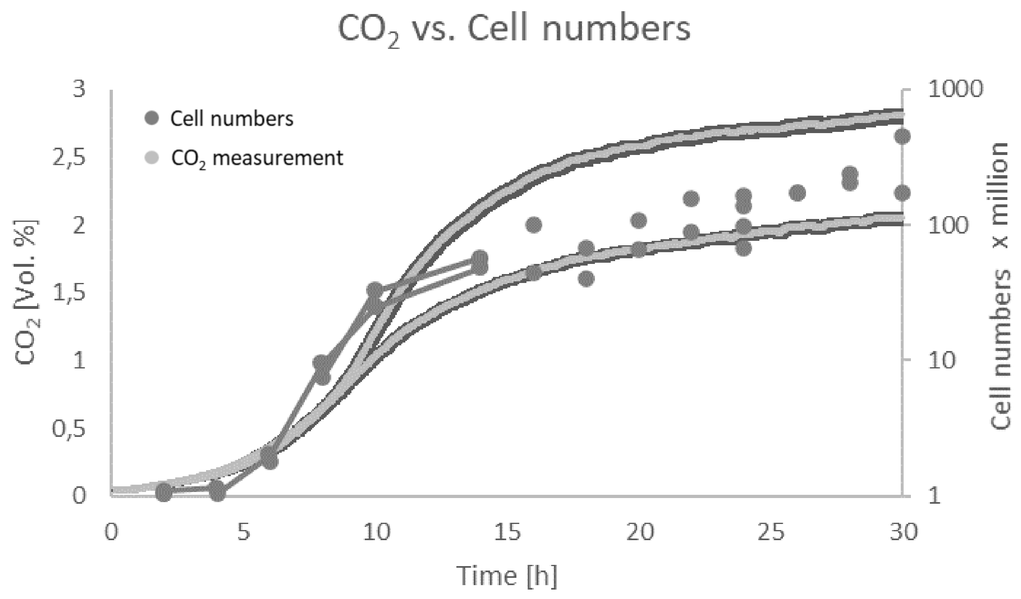


Figure 1: Correlation between growth and CO_2 production of *Y. lipolytica* in an open single-phase system. Growth on YEP medium is shown. Black edges represent the standard deviation of the CO_2 measurement.

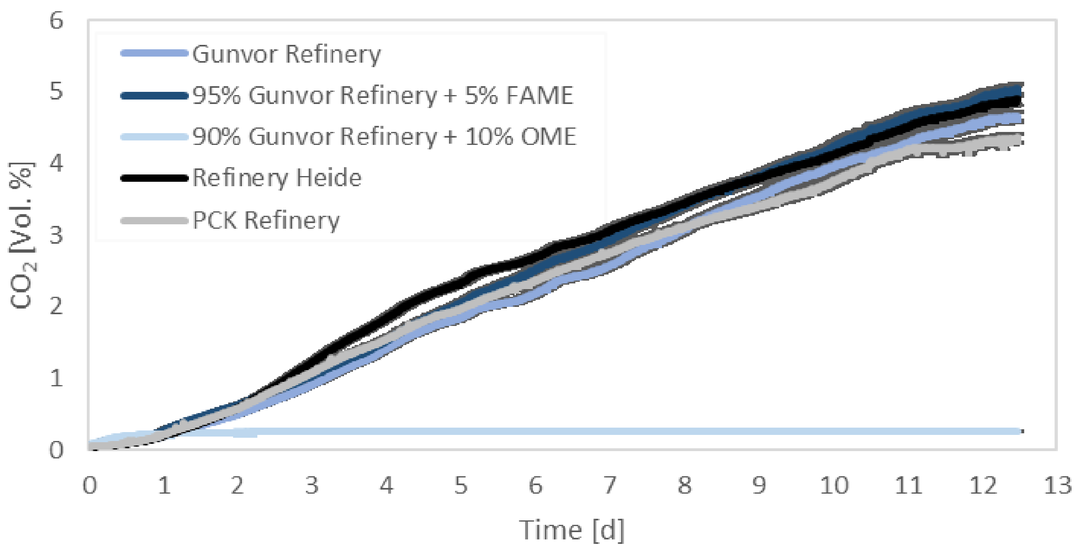
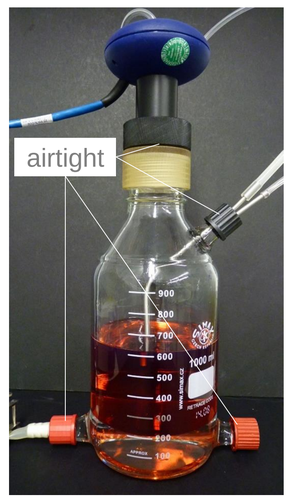


Figure 2: Monitoring of CO_2 evolution by a defined microbial mix [2] using heating oils as sole carbon and energy sources. A closed two-phase system was used. Black edges represent the standard deviation of the CO_2 measurement.

- Using the closed (airtight) two-phase system the oil tank situation can be simulated.
- A free water phase is inoculated with a defined mix of microbes which can be found routinely in regional oil tanks.
- An overlay of heating oil to be tested for storability is applied and the CO_2 production is monitored (Figure 2).



Closed two-phase system

Conclusions

- The formation of CO_2 is a measure for the metabolic activity of present microbes. Allowing air exchange the currently measured CO_2 corresponds to currently present microbes and their metabolic activity. In the open system samples for growth measurement can be taken. The CO_2 evolution correlates with the development of microbial cell numbers under optimal conditions.
- The CO_2 sensor can be used under oil tank conditions, a two-phase system consisting of a contaminated free water phase below an excess of heating oil. For the inoculation of the free water phase a defined mix of microbes is used. This way, the extent of CO_2 evolution and the correlation with microbial growth, depends only on the applied heating oil and the nutritional conditions it offers to the microbes.
- This non-invasive measurement tool allows the evaluation of the storability of heating oils long before problematic signs of microbial contamination like biofilm formation or microbial induced corrosion take place.

References

[1] Leuchtle, B. Mikrobiologische Kontamination von Heizöl - Ursachen und Auswirkungen auf Brennstoff und Tank [dissertation on the internet]. Aachen, Germany: RWTH Aachen University; 2015 [cited 2020, Apr 31].

[2] Leuchtle, B, et al. Defined inoculum for the investigation of microbial contaminations of liquid fuels. Int. Biodeterior. Biodegradation. 2018; 132: 84-93.