

Continuous bio-ethanol production by means of yeast

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One example for applying the BlueSens technology at the Biochemical Engineering Laboratory is the gas online-monitoring for the continuous bio-ethanol production in the field of the biotechnological production of alternative fuels (so-called biofuels). Yeast is able to metabolize under anaerobic conditions several carbon sources (particularly sucrose and glucose) into carbon dioxide and ethanol, conventionally in a batch or fed batch mode. However, if the ethanol concentration exceeds the concentration threshold – ca. 115 g/l, depending on the strain – an inhibition of the metabolism is initiated: ethanol becomes a toxic substance and the maximum product concentration achieves a biological limit. Keeping the product content under the tolerance limit of the cells will allow increasing the bio-ethanol-yield to its maximum.



Figure 1: Stirred unit reactor with connected CO₂, O₂ and ethanol sensors

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The continuous bio-ethanol production by means of in sodium alginate entrapped *Saccharomyces cerevisiae* (ATCC 7752) was successfully carried out at 40°C in a stirred bioreactor with an operating volume of 600 ml by continuous substrate feed over a period of five days.

The sensors were connected gastight, allowing quantitative online records on gases (carbon dioxide, ethanol and oxygen) present in the headspace of the bioreactor (see figure 1). By using a suitable calibrated ethanol sensor a direct calculation of the ethanol content in the liquid phase could be made based on the ethanol content in the gaseous phase; those results were validated by comparative analysis using high performance liquid chromatography.

The measurement of the unavoidable metabolite CO₂ in the bioreactor and the oxygen content in the flue gas stream provided the expected results (see figure 2): the CO₂ concentration increased up to 90 Vol.-% and stabilized at that value as no ambient air could enter the bioreactor. The oxygen content stagnated after reaching

its minimum (approx. 0 Vol.-%), as only CO₂ and ethanol were discharged from the system. The ethanol concentration remained almost constant after the first 60 operating hours. However, the tolerance limit for yeast with respect to ethanol was by no means reached, as it was solely intended to show that such a system could be operated over a longer period of time.

The proposed measurement method offers the advantage that the analysis is not influenced by further media components and metabolites (e.g. organic acids). Strik-

ingly, this demonstrates the potential that the arrangement used to determine online ethanol concentrations can be applied to limit the ethanol content in the medium due to an adequate adjustment.

Actual works dealing with the continuous production process of bio-butanol (under anaerobic conditions) and biotensides (rhamnolipids) extend the field of application of the BlueSens technology for the gas online-monitoring in biotechnological processes.

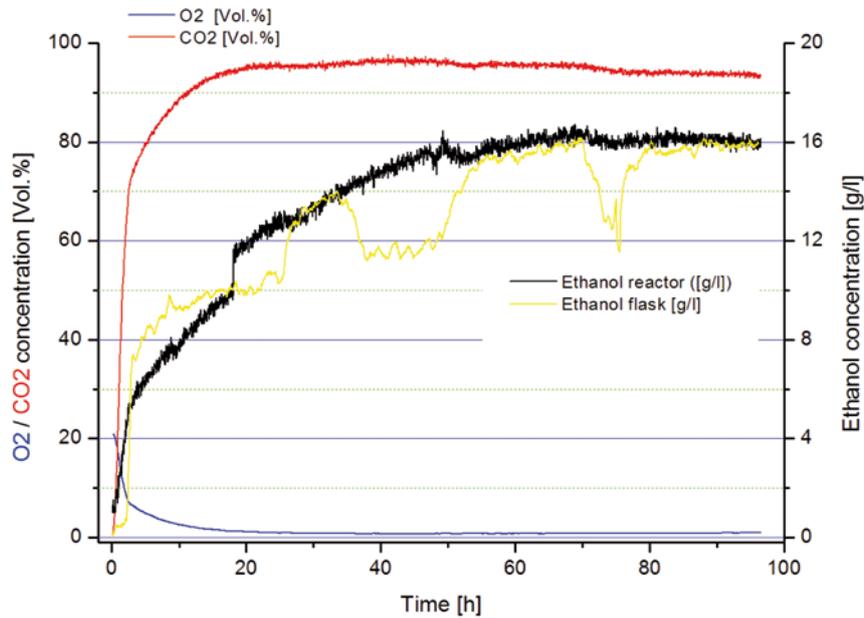


Figure 2: Gas online-monitoring of the bio-ethanol production process by continuous feed of 40 g glucose/l