

# Cultivation of Human CAP<sup>®</sup> Cells: Evaluation of Scale-Down Capabilities using Single-Use Bioreactors

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## Abstract

Increasing process complexity coupled with rising cost pressures and rapidly evolving regulatory requirements makes today's process development efforts a special challenge. The pressure of achieving faster time-to-market for new and innovative biotechnological products has led to the need to optimize every element of the total development workflow.

The following application note illustrates how the DASbox<sup>®</sup> Mini Bioreactor System combined with the BioBLU<sup>®</sup> 0.3c single-use vessels supports bioprocess development in human cell culture. Scale-down capabilities were investigated by comparison of 500 mL cultures in a DASGIP<sup>®</sup> Parallel Bioreactor System with 170 mL cultures in the DASbox using the BioBLU 0.3c single-use vessel.

## Introduction

Initial bioprocess development involves cell line optimization, clone selection, and screening for media, feed components and strategies, and other process conditions. Shake flasks, the most common vessels used in early cell and microbial work, have served the biotechnology industry well over the decades but their limitations for optimizing cell culture or fermentation conditions are well known. Equipment used during screening should mimic the physical and mechanical characteristics of production-scale bioreactors to the highest degree possible in order to assure consistency throughout development phases. Ideally, these best practices will support the aims of QbD: that quality measures initiated during development are carried forward and manifested in product quality. DASGIP Parallel Bioreactor Systems have the potential to address process consistency and harmonization of unit operations between development and production. Today's state-of-the-art benchtop systems use sensors and information technology to control, monitor, and record critical process parameters such as temperature,

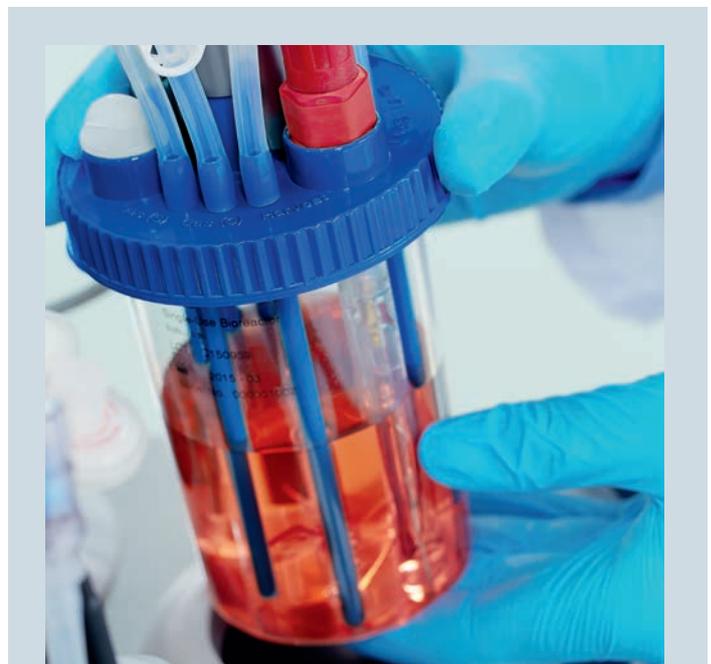


Figure 1: BioBLU<sup>®</sup> 0.3c Single-Use Bioreactor for cell culture

pH, dissolved oxygen, and agitation. As in production-scale bioreactors, gassing and feeding proceed according to defined settings.

CEVEC® Pharmaceuticals GmbH (Cologne, Germany), a global solution provider focussing on the development of top notch human expression systems with highest ethical standards, has established a master cell bank (MCB) of CAP® cells growing in suspension, tested and certified according to ICH guidelines and European Pharmacopeia. The platform expression technologies CAP and CAP-T are based on specific, amniocyte-derived human cell lines. CAP and CAP-T were designed for stable and transient protein production and achieve highest protein yields with authentic human glycosylation patterns. Simple and reliable protocols allow for the fast generation of customized producer cell lines for pharmaceutically relevant proteins based on the parental permanent CAP cells under controlled and optimized conditions. For the required human cell line screening as well as for media optimization, the small working volumes of 100 – 250 mL make the extendable 4-fold DASbox and the BioBLU 0.3c single-use vessel a perfect fit. Bioprocesses are controlled as precise and effectively as they are in larger scale bioreactors while cell material, media and supplements as well as lab space are saved.

Several experiments were carried out aiming at verifying the scale-down capabilities from the DASGIP Parallel Bioreactor System, which CEVEC generally uses in process development, to the Mini Bioreactor System DASbox. To overcome the risk of cross-contamination and to reduce time for cleaning, sterilization and assembly they evaluated the novel developed BioBLU 0.3c single-use vessel. Which comes with a magnetic coupled stirrer and pitched blade impeller and holds several short and long dip-tubes as well as two standard PG13.5 ports facilitating full industry standard instrumentation. A specifically designed port including

a gas permeable membrane allows for DO measurement using a reusable probe which can be plugged easily in directly on the bench. Recuperation of liquid from exhaust gas is carried out via a novel liquid-free operated condenser.

## Materials and Methods

To evaluate the scale-down capability of the new DASbox Mini Bioreactor System and the usability of the BioBLU 0.3c single-use vessel experimental series with two different systems were carried out and compared. A 4-fold Parallel Bioreactor System for cell culture was used in 500 mL scale experiments (PBS). The corresponding small-scale approaches were carried out in a (parallel) DASbox system using single-use vessels with 170 mL (DASbox SU).

The recombinant human CAP cells producing a pharmaceutically relevant protein were batch cultivated for 7 d (170 h) in CEVEC's serum-free, chemically defined CAP medium supplemented with 40 mM glucose and 6 mM glutamine at 37 °C. Initial viable cell density was  $3 \times 10^5$  cells/mL. The DO set-point of 40 % was maintained by a constant stirrer speed and the oxygen concentration in the inlet gas. Stirrer speed was adjusted to 160 rpm (PBS) and 150 rpm (DASbox SU). The pH value was regulated to 7.1 by addition of 1 M Na<sub>2</sub>CO<sub>3</sub> (feeding, speed rate regulated) and CO<sub>2</sub> (submerged gassing). Inlet gas (air, O<sub>2</sub>, CO<sub>2</sub> and N<sub>2</sub>) was mixed continuously mass flow-controlled. The bioreactors were equipped with pitched blade impellers and liquid-free operated exhaust gas condensers. The pre-cultures were cultivated in 125 mL Erlenmeyer flasks (Corning) with 25 mL working volume using a shaker incubator (37 °C, 5 % CO<sub>2</sub>) agitating at 185 rpm (Multitron 2, Infors AG). The cells were expanded up to a viable cell density of  $3 \times 10^6$  cells/mL in the same medium used for bioreactor runs.

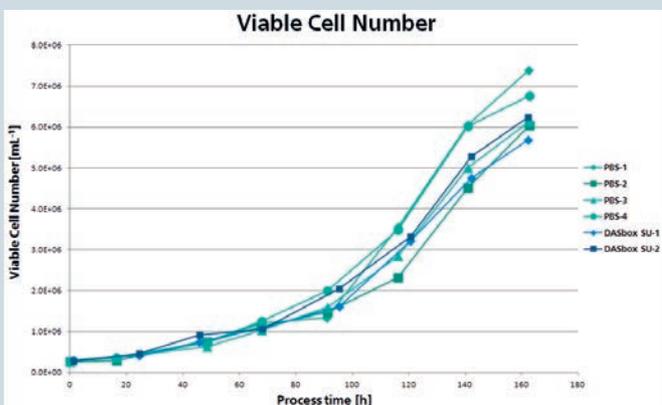


Figure 2: Viable Cell numbers of all experiments with DASGIP Parallel Bioreactor Systems (PBS) and BioBLU 0.3c vessels with average growth rate of 0.02 h<sup>-1</sup>.

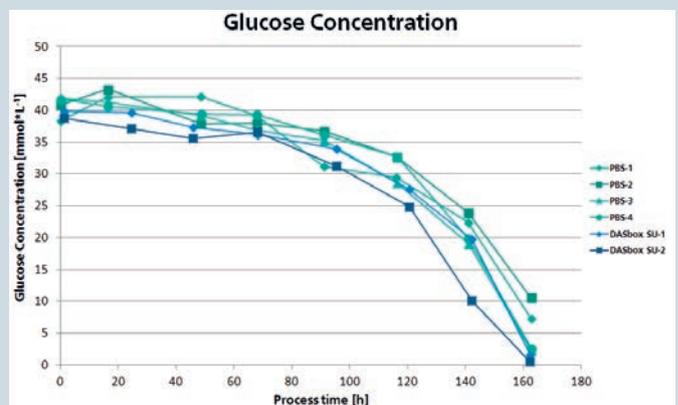


Figure 3: Comparison of metabolic activity by glucose consumption.

The critical process parameters were monitored, controlled and visualized online while additionally offline parameters were added manually for collective analysis and storage in a joint database. Daily samples were taken in place. Viable cell numbers, the concentrations of glucose as well as the target protein were determined via semi-automated trypan blue cell counting (Cedex XS, Roche Innovatis), an automated glucose biosensor (YSI 7100 MBS, YSI Life Sciences) and ELISA, respectively.

## Results and Discussion

The highly comparable results shown in figures 2 and 3 prove the reliability of the process control in both independent experimental series.

The viable cell density increases exponentially within all cultivation studies in a reproducible manner with an average growth rate of 0.02 h<sup>-1</sup>. The corresponding anti-cyclic glucose consumption thereby illustrates the similar metabolism of the different cultures. Cell viabilities ranged in between 90 – 95 % for each sample. As shown in figure 4 the final product yield reached 80 – 121 % in respect to the average protein concentration gained with the Parallel Bioreactor System (PBS) commonly used at CEVEC. No differences in cell growth, metabolic activity and protein expression could be observed using the BioBLU 0.3 c single-use vessels. The results show the successful scale-down from a 500 mL (PBS) to 170 mL (DASbox SU) bioreactor working volume.

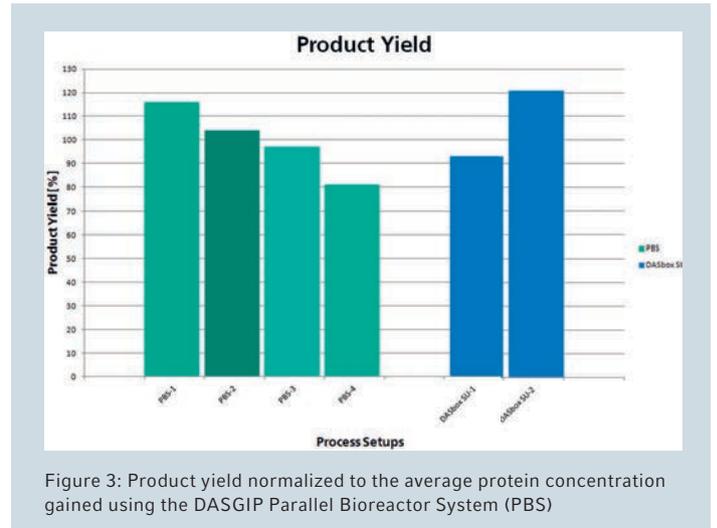


Figure 3: Product yield normalized to the average protein concentration gained using the DASGIP Parallel Bioreactor System (PBS)

## Conclusion

Summarized, the presented results give direct evidence to the scale-down capability of the DASbox Mini Bioreactor System used with single-use vessels. This proves the DASbox to be a superior tool for process development with human cell cultures. The small working volumes save material and consumable costs while utilizing single-use vessels drastically reduce turnover-times and thereby labour costs and development times.

**Ordering information**

<b>Ordering information</b>	<b>Order no.</b>
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8-fold system for single-use vessels	76DX08CCSU
16-fold system for single-use vessels	76DX16CCSU
24-fold system for single-use vessels	76DX24CCSU
<b>BioBLU® 0.3c Single-Use Vessel</b> , cell culture	
4 pack, pre-sterilized	78903508

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