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Specialized Modalities

A robust system for high-titer, platform-agnostic AAV production in HEK293 cell lines

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Abstract

To maximize the results of viral titer and full capsids, it is necessary for any gene therapy program to undertake systematic process development and optimization of AAV production. Development and optimization strategies have been shown to increase titer and enrich full capsids through screening both components of the production process as well as fine-tuning the stoichiometries and delivery methods of these components. Improving these critical metrics is a multi-parameter problem, spanning all process components.

Choice of cell culture medium is foundational to productivity and efficiency of packaging since this media is the environment in which all upstream steps of AAV production take place. A chemically-defined media that is free from animal origin components is table stakes for further manufacturing (GMP) programs as it supports consistency and regulatory compliance. However there are unique performance characteristics to media that provide research and commercial advantages for the critical quality metrics of titer and full capsids mentioned above:

1. Compatibility with mostly fixed process components such as viral serotype and plasmid/gene of interest
2. Flexibility with variable process components such as cell line, transfection reagents, and enhancers or additives that increase production
3. Baseline (non-optimized) performance that meets or exceeds industry standards

By fulfilling these three key characteristics, it is possible for a cell culture media system to enable multi-fold titer and full capsid gains in AAV production.

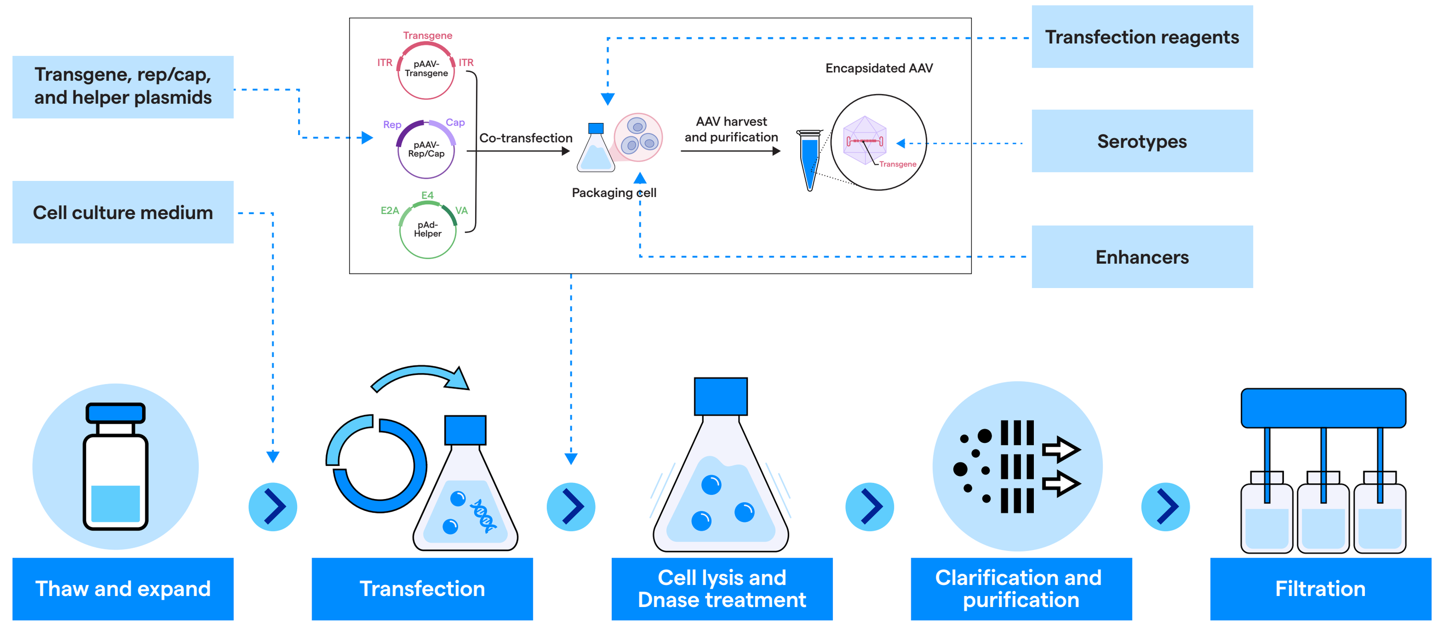


Figure 1.
Schematic representation of AAV production components surveyed in this study.

Materials and methods

Cell culture and scale-up process

Human Embryonic Kidney (HEK) 293 cells were thawed directly into TheraPEAK 293-GT® Medium and cultured in 125 mL shake flasks for at least 3 passages after thaw.

Transfection

TheraPEAK 293-GT® AAV Supplement was added to cell culture within one hour prior to transfection. Research-grade helper plasmids, transfer plasmids and cis plasmids (GFP) were Lonza Xcite® AAV Transient Transfection Plasmids and commercial plasmids.

Commercially available transfection reagents and AAV enhancers were acquired from respective vendors.

Harvest and downstream process

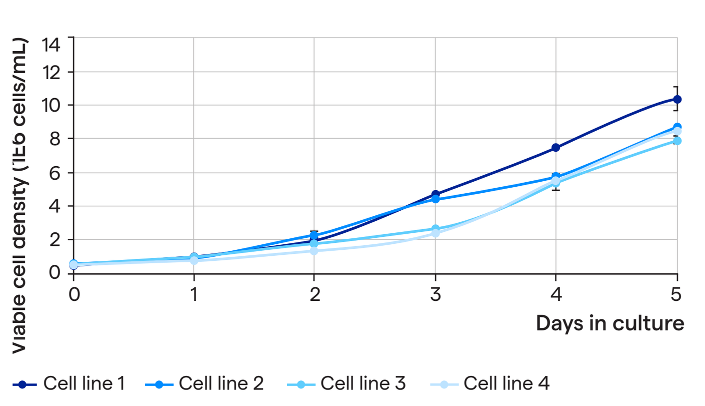
72 ± 2 hours after transfection, cell culture was collected and lysed with lysis buffer prepared in house. After filtration, 25% of total lysate from both bioreactors were pooled for downstream purification followed by capturing chromatography, polishing chromatography and retentate filtration.

AAV titer and full/empty ratio analysis

AAV titer was assessed with droplet-based digital PCR using industry standard protocols through direct quantification of copy numbers of gene of interest (GFP). Full/empty AAV capsid ratio in crude lysate and purified product was quantified with automated immunoassay and mass photometry systems following vendor's recommended protocol.

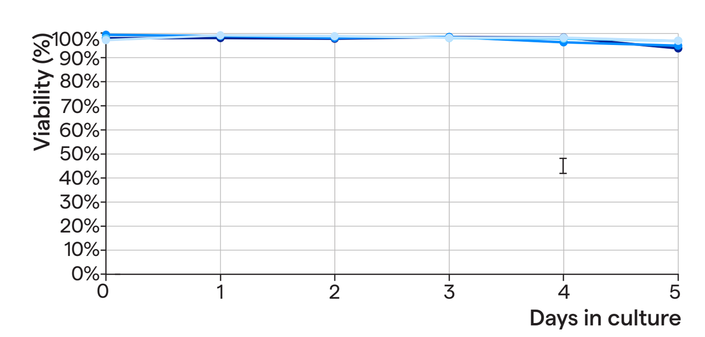
Results

Cell growth



Across four different HEK293 cell lines, Lonza's TheraPEAK 293-GT® Media System supports robust cell growth. Some cell lines experienced up to 59% higher density after 5 days in TheraPEAK 293-GT® Media System than in their cloning/adaptation media (A).

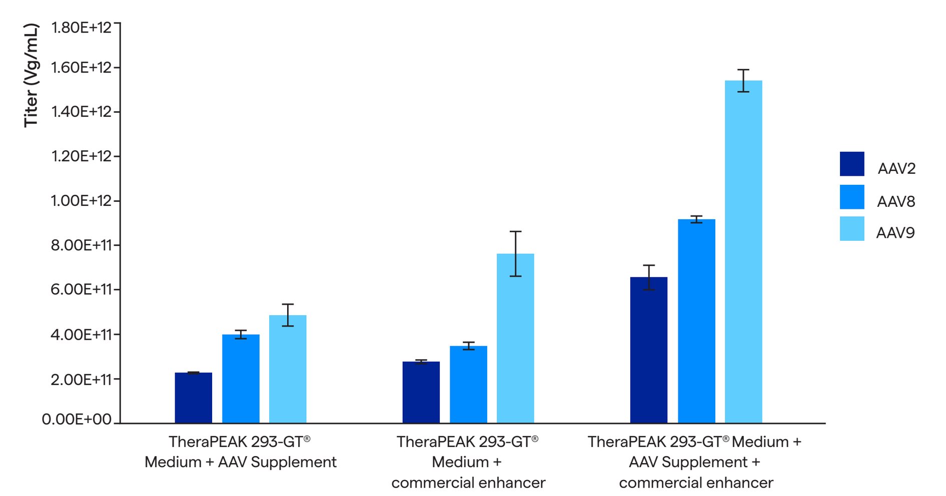
Cell viability



TheraPEAK 293-GT® Media System maintained a high viability of ≥95% across the same four different HEK293 cell lines, demonstrating a superior ability to support proliferation needed for AAV production (B).

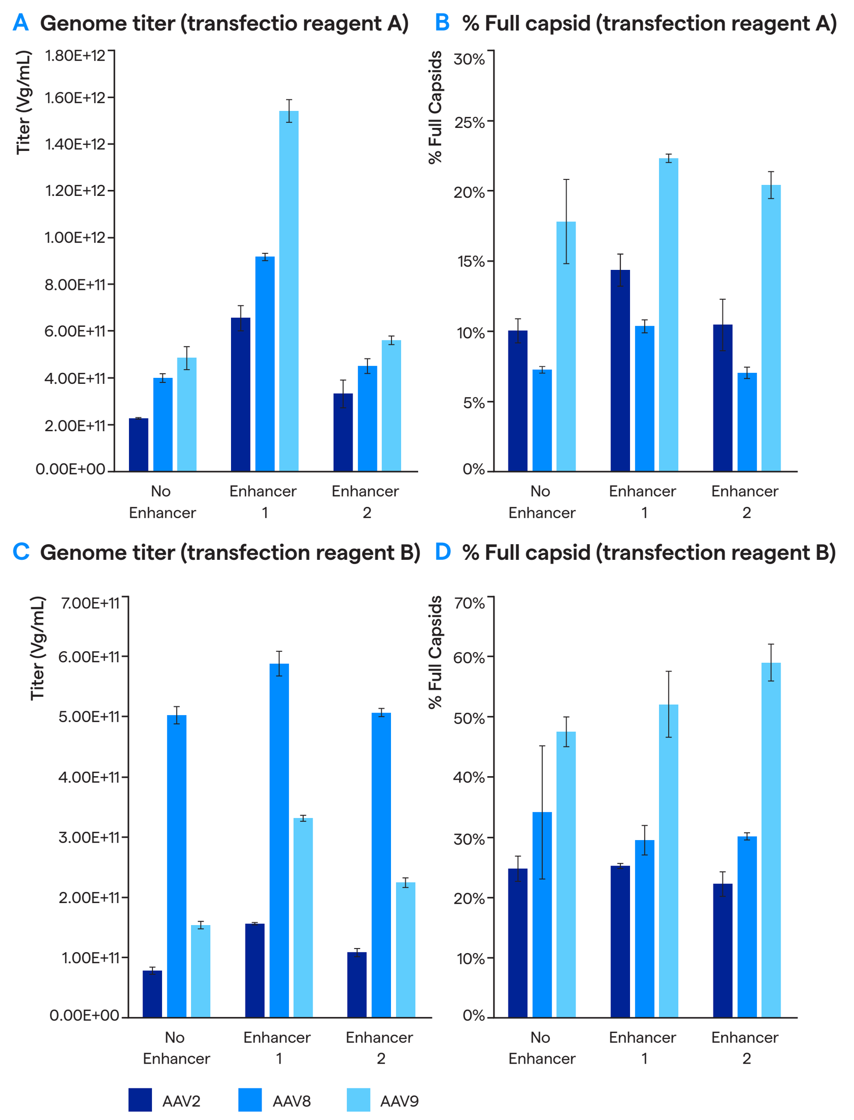
Results

Synergistc effect of AAV supplement



Addition of TheraPEAK 293-GT® AAV Supplement increases AAV titer as compared to using commercial enhancer alone. Here, use of the complete TheraPEAK 293-GT® Media System delivers a ~3x increase in AAV titer.

High performance across process development components

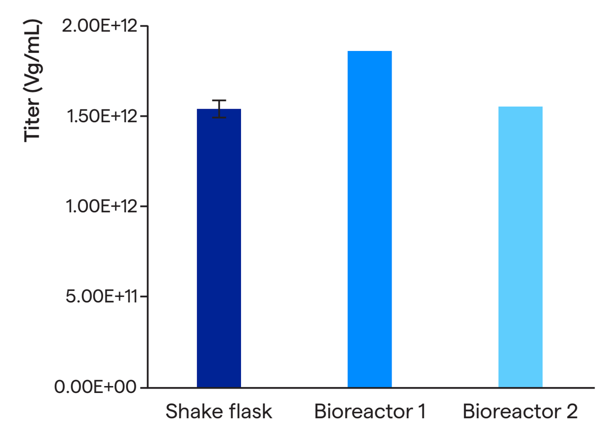


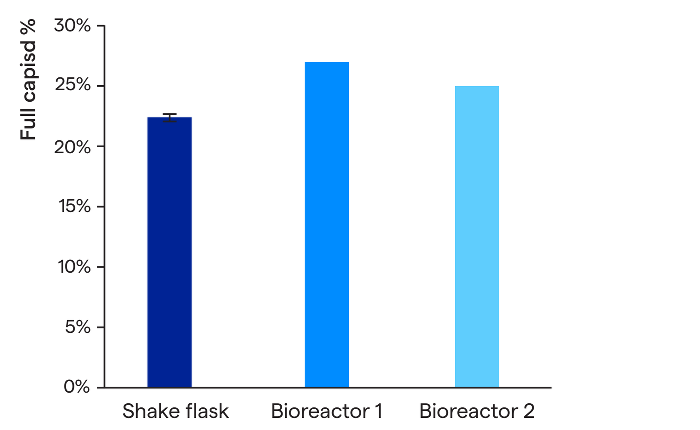
TheraPEAK 293-GT® Media System helps deliver favorable AAV titer (A, C) and favorable full capsid ratios (B, D) across multiple transfection reagents, enhancers, and viral serotypes, making it ideal for commercial AAV production.

This supports the benefits of easy integration into existing workflows, and efficacy for process development for a variety of production platforms

Results

Scalability to bioreactor processes





	AAV9 titer (vg/mL)	% Full capsids
Bioreactor 1 crude lysate	1.86E+12	26.9%
Bioreactor 2 crude lysate	1.55E+12	24.9%
Purified product	5.87E+13	75.4%

Shake flask process was successfully scaled up to 3 L bioreactor runs. Comparable AAV9 titer and % full capsid were observed between the two scales, demonstrating solid scalability of TheraPEAK® 293-GT® Media System.

A downstream purification process was performed to demonstrate complete AAV production process.

Conclusion

TheraPEAK 293-GT® Media System helps enable success for AAV development programs through robust cell expansion, increased titer, and favorable full capsid ratios. This performance has been validated across a survey of viral serotypes, transfection plasmids, transfection reagents, and AAV enhancers, as well as benchmarked against a competitor AAV media and complete production platform. The aforementioned flexibility and performance demonstrate that Lonza's TheraPEAK 293-GT® Media System is ideal for commercial gene therapy process development and cGMP-compliant manufacture.

Learn more.

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