Accelerating ethylene oxide catalyst innovation through high-throughput testing

High-throughput catalyst testing (HTCT) continues to play a central role in the development of ethylene oxide (EO) catalysts. Despite improvements in EO production, opportunities remain to enhance catalyst performance by reducing side reactions and supporting the transition to more sustainable chemical processes. Avantium has partnered for more than 12 years with a major catalyst supplier to provide HTCT services for EO catalyst development. This includes support of catalyst development efforts to identify more selective and environmentally friendly catalysts, while maintaining high data quality and consistent long-term performance evaluation.

Advancing EO catalyst development

EO continues to be a high-volume chemical with strong global demand. In 2023, the Asia Pacific region led the global EO market with a 50.5% revenue share, driven by China's automotive sector. The automotive product segment held 28.9%, while ethylene glycol was the top application by market share. The global EO market was estimated at 28.0 million tonnes in 2024, with a projected compound annual growth rate (CAGR) of approximately 4.6%, reaching nearly 45.9 million tonnes by 2035 (*ChemAnalyst, 2024* & *Grand View Research, 2024*). In financial terms, the EO market was valued at $36.1 billion in 2023 and is expected to reach $49.1 billion by 2030 (see **Figure 1**).

Considering the scale and projected growth, small enhancements in catalyst performance may lead to notable economic and environmental outcomes. Enhancing the efficiency and selectivity of EO catalysts is critical, as it allows for better suppression of side reactions, thus improving process yields and sustainability (*Kursawe, 2009*). Current research is increasingly focused on greener and more energy-efficient production methods, such as electrochemical EO production powered by renewable electricity, which may offer higher energy efficiency compared to conventional catalytic routes (*Gabardo, 2024*).

Accelerating EO catalyst development

Catalyst optimisation and development for chemical and fuel production involves analysing many variables across thousands or millions of possible combinations. Flowrence high-throughput catalyst testing can operate up to 64 parallel reactors, which significantly increases testing efficiency and reduces time-to-market for new catalyst formulations (*Ortega, 2019*). Researchers can generate thousands of data points in a fraction of the time required by conventional single-reactor systems (*Ramirez, 2024* & *Maxwell, 2003*). The technology is dedicated to oxidation chemistry and offers operational flexibility for EO catalyst screening and deactivation studies. It enables precise control of reaction conditions and ensures high data reproducibility. For instance, carefully regulating the temperature of each reactor regarding its selectivity towards EO provides significant flexibility during deactivation studies.

In addition to EO catalysts screening and deactivation, this unit is designed to operate a broad spectrum of selective oxidation chemistries. This HTCT unit can be used for other oxidation reactions, such as propylene oxidation, a valuable intermediate for polyurethanes and other polymers, and butadiene oxidation, pivotal in manufacturing chemicals like maleic anhydride used in resins and plastics.

This operational flexibility accelerates the screening and optimisation of catalysts for a variety of feedstocks to systematically study catalyst deactivation, regeneration, and stability under diverse process scenarios.

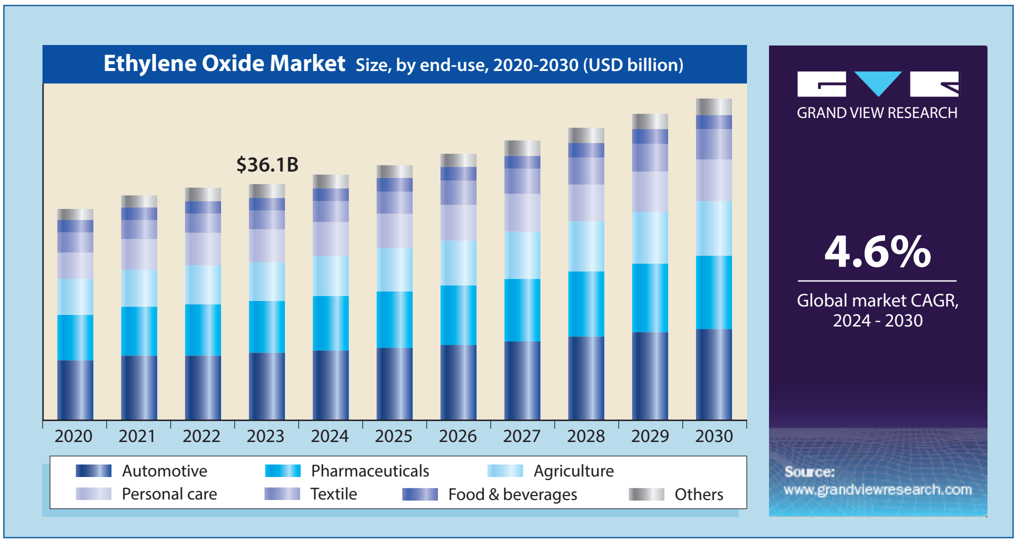

Figure 1 The market growth can be attributed to the robust growth of the automotive industry (*Grand View Research, 2024*)

Avantium supports new catalyst developments while ensuring high data quality and reliable long-term performance evaluation (see **Figure 2**). In practical terms, Flowrence has enabled EO catalyst developers:

- 12 years of continuous collaboration.
- 10k+ unique EO catalysts tested across multiple campaigns.
- 4M data points collected, enabling robust statistical and kinetic analysis.
- 132 experimental campaigns executed with high reproducibility.

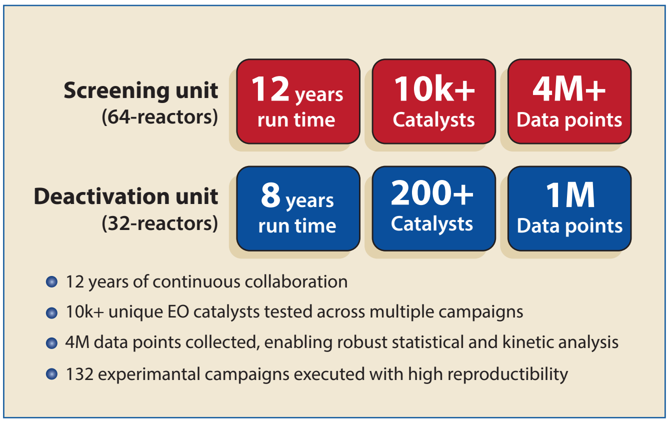

Figure 2 Key points in the enabling of EO catalyst development

The collaboration led to enhanced workflows for catalyst screening and stability testing, which are now standardised procedures for subsequent projects. Overall, this long-term collaboration shows how technology providers and catalyst makers can work together to speed up catalyst development, improve the reliability of test results, shorten development cycles, and stay competitive in a demanding global market.

Future directions

As the demand for more efficient and sustainable EO production increases, the future of EO catalyst development depends on accelerating innovation while maintaining high performance standards. Faster, data-driven decision-making and optimisation of novel catalyst formulations and process conditions will shape the future of HTCT.

One of the most promising directions lies in the integration of advanced data analytics and machine learning with HTCT platforms like Flowrence. By generating large and reliable datasets from parallel HTCT equipment, researchers can identify hidden patterns, optimise reaction conditions, and predict catalyst behaviour under varying process scenarios. The transition from an empirical, trial-and-error methodology to a predictive modelling approach should substantially reduce development timelines and lower innovation costs.

Another key focus area is the development of catalysts tailored for circular and low-carbon EO production. Many clients are actively exploring formulations that enhance selectivity and reduce byproduct formation, thereby improving overall efficiency and environmental performance. These efforts support the industry goals to carbon valorisation chemical manufacturing and meet increasingly strict regulatory standards.

Furthermore, the adaptability of Flowrence technology allows for the exploration of novel feedstocks and reaction pathways towards EO production. In the coming years, EO catalyst development will increasingly rely on collaborations that combine experimental agility and digital intelligence.

Conclusion

The evolution of EO catalyst development is being shaped by an increased need for fast pace, precision, and sustainability. Flowrence technology is the suitable tool for delivering large amounts of robust and reproducible data. The technology empowers catalyst developers to move beyond traditional trial-and-error approaches and embrace data-driven innovation.

Over the past decade, Avantium's collaboration with a major EO catalyst supplier has demonstrated the tangible benefits of this approach, facilitating accelerating developments, improving catalyst performance insights, and reducing risk in commercial deployment.

Integrating machine learning and advanced data mining will further enhance the impact of high-throughput testing. Avantium is dedicated to facilitating catalyst innovation at every stage, from discovery through to deployment, helping developers unlock new levels of performance, efficiency, and environmental responsibility.

Flowrence is a mark of Avantium.

Avantium
Tiago Vilela, Marlene Führer, Elahe Motaee, and Peter Flippo
Email: tiago.vilela@avantium.com

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