

Sustainable noble-metal free fuel cell catalysts for automotive heavy-duty applications

Public report

Author: Volvo Technology AB and Celcibus AB
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1 Summary

In this project, Volvo Technology AB and Celcibus AB collaborated to explore non-platinum group metal (non-PGM) catalyst materials as a promising alternative to address the challenges associated with the high cost and limited supply of noble metals—particularly platinum (Pt)—used in conventional fuel cell catalysts. These constraints pose a barrier to the global scalability and long-term viability of fuel cell technology, especially in the context of heavy-duty automotive applications.

2 Background

All life forms depend on a specific temperature range to thrive. However, global warming poses a significant threat to the survival of many species, potentially leading to imbalances within the ecological pyramid and disrupting ecosystems as we know them. One of the primary contributors to global warming is the emission of greenhouse gases, particularly carbon dioxide (CO₂).

In the European Union, trucks, buses, and coaches are responsible for approximately 25% of CO₂ emissions from road transport. To address this, new regulations mandate a 15% reduction in emissions by 2025 and a 30% reduction by 2030, relative to the EU average during the reference period of 1 July 2019 to 30 June 2020.

In alignment with its commitment to a sustainable, carbon-neutral future and the vision of cleaner, quieter, and emission-free urban environments, Volvo Technology AB is actively exploring fuel cell systems (FCS) as a viable electric transport solution. A key challenge with current FCS technology lies in the high cost and limited availability of platinum-based catalysts. Additionally, extending the operational lifetime of fuel cells remains a critical hurdle.

Celcibus AB, a pioneering start-up, is addressing these challenges by developing and manufacturing platinum group metal (PGM)-free catalysts and membrane electrode assemblies (MEAs). These innovations offer a more cost-effective and environmentally sustainable alternative to conventional platinum-based configurations.

3 Purpose, research question and method

The objective of the project was to assess the potential of Celcibus AB's platinum group metal-free (PGM-free) catalyst as a sustainable, durable, and cost-effective alternative to conventional platinum-based fuel cell catalysts.

The primary goal was to evaluate the feasibility of this technology for heavy-duty vehicle applications, focusing on performance and durability, while identifying key knowledge gaps that must be addressed to enable further development.

To support this effort, Volvo Technology AB and Celcibus AB planned a series of technical meetings to align on validation test conditions and to review results collaboratively. Celcibus AB was responsible for optimizing the cathode layer to enhance performance and durability, while Volvo Technology AB undertook validation of the samples under real-world fuel cell testing conditions.

4 Objectives

- Assess the potential of Celcibus technology in terms of catalytic activity, stability, and performance degradation, benchmarked against clearly defined and measurable targets at the laboratory scale.
- Evaluate the relevance and applicability of the catalyst for heavy-duty automotive applications.
- Identify existing knowledge gaps and contribute to the development of foundational knowledge within this technological domain.

5 Result and goal achievement

In the initial phase of the project, Volvo Technology AB and Celcibus AB jointly developed and agreed upon test protocols for evaluating Celcibus membrane electrode assemblies (MEAs) at both organizations—Volvo focusing on large-area MEAs and Celcibus on smaller-area MEAs.

Preliminary testing conducted by Celcibus, which compared various loadings of the PGM-free catalyst, demonstrated that optimal catalyst loading significantly improved not only initial power output but, more importantly, durability. When benchmarked against a low-loaded platinum-based MEA, the Celcibus MEA exhibited higher power density at higher voltages. However, at lower voltages, the platinum-based MEA outperformed it, offering valuable insights into areas where the Celcibus MEA could be further enhanced to better compete with platinum-based alternatives.

Throughout the project, Celcibus continued to refine its catalyst through iterative cycles of composition adjustments, synthesis process optimization, and subsequent fuel cell testing. These efforts culminated in the development of a new-generation catalyst that delivered substantial improvements in both power density and durability.

Unfortunately, due to extended lead times from an external MEA supplier, this new-generation catalyst could not be evaluated by Volvo in large-area cell testing. Nevertheless, Volvo's testing of other non-PGM-based MEAs within the project confirmed that scaling Celcibus's non-PGM technology from laboratory scale to real-world dimensions is feasible—while maintaining both performance and durability.

6 Dissemination and publication

6.1 Knowledge and result dissemination

How is/planned the project result to be used and disseminated?	Mark with X	Comment
Increase knowledge within the area	x	The project has led to a better understanding and knowledge of how the components of the MEA could be adjusted to further improve the fuel cell performance and durability. Also, realization of fuel cell performance with PGM-free catalysts in a larger area cell shows future possibility.
Carry forward to other advanced technical development projects		
Carry forward to product development projects		
Introduced to the market		
Used in investigations/regulations/permit cases/political decisions		

6.2 Publications

No publications available

7 Conclusion and further research

It can be concluded that the project goals were fulfilled. The summary given below concludes the key outcome of the project.

- As part of the project, the non-PGM cathode catalysts were further optimized, resulting in improved MEAs that demonstrated higher power density at elevated potentials compared to low-platinum cathode MEAs.
- The exploration of this unconventional PGM-free cathode catalyst for heavy-duty vehicle fuel cell applications proved valuable. Testing on larger-area cells confirmed that the performance and durability of the samples were maintained, underscoring the technology's scalability.
- While the tested non-PGM samples have not yet reached the performance levels of conventional platinum-based catalysts for heavy-duty automotive use, they show promising potential for auxiliary power unit (APU) applications in such vehicles.

8 Participating parties

Celcibus AB

Volvo Technology AB

