

# TDB-DST SUPPORTS INDO-SINGAPORE COLLABORATIVE PROJECT FOR AI-INTEGRATED PLASMA SYSTEM FOR CLEAN HYDROGEN AND ADVANCED CARBON MATERIALS

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In line with India's commitment to advancing clean energy technologies and fostering international technology collaborations, the Technology Development Board (TDB), Department of Science & Technology (DST), Government of India, has extended support to APCHEMI Private Limited under the Indo-Singapore Call for Proposals for the project titled "*AI-Integrated Microwave Plasma System for Controlled Synthesis of Functional Carbon Nanostructures and Diamond-Graphene Hybrid Materials.*" The initiative aims to develop an advanced plasma-based technology platform for the simultaneous production of CO<sub>2</sub>-free hydrogen and high-value carbon nanomaterials, supporting the global transition toward sustainable energy systems.

The project focuses on the development of an AI-integrated microwave plasma reactor capable of efficiently converting methane into hydrogen and advanced carbon materials without carbon dioxide emissions. The system incorporates custom-designed swirling vortex nozzles to maximize microwave energy absorption, enabling efficient splitting of methane into hydrogen and carbon radicals. While APCHEMI Private Limited will lead the development of industrial-scale gas separation, quenching, and carbon collection systems, the Singapore-based partner Commsens will contribute advanced real-time plasma diagnostics and AI-driven control systems to optimize reactor performance.

The pilot-scale facility is designed to produce approximately 4 kg per hour of hydrogen while simultaneously generating around 12 kg per hour of high-value carbon materials, including functional carbon nanostructures and diamond-graphene hybrid materials. This integrated approach enables a dual-revenue model, where the commercialization of premium carbon products helps offset the cost of hydrogen production.

The technology is based on microwave plasma pyrolysis, a process that uses high-temperature plasma discharges to split methane and other hydrocarbons into hydrogen and solid carbon without generating CO<sub>2</sub> emissions. Compared to conventional water electrolysis for hydrogen production, plasma pyrolysis offers significant energy advantages, with well-engineered systems requiring substantially lower energy inputs while producing valuable carbon materials such as graphite, carbon black, and graphene.

By integrating artificial intelligence into plasma reactor control, the system continuously monitors parameters such as microwave power, gas feed rates, electron density, and plasma temperature. Machine learning algorithms dynamically optimize reaction pathways to maximize hydrogen yield, enhance energy efficiency, and tailor the structure of carbon materials for applications ranging from battery-grade graphite to advanced nanostructures.

Speaking on the occasion, **Shri Rajesh Kumar Pathak, Secretary, TDB**, highlighted the importance of international technology collaborations in addressing global energy and sustainability challenges. He noted that projects under the Indo–Singapore collaborative framework bring together complementary strengths in advanced manufacturing, artificial intelligence, and clean energy technologies, enabling the development of globally competitive solutions.

Promoters of APChemi Private Limited expressed appreciation for the support extended through the Indo–Singapore partnership and noted that the project will accelerate the commercialization of next-generation plasma technologies for clean hydrogen and advanced carbon materials.



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