Sustainable Production of Carbon Nanotubes via CO_2 - Free Methane Decomposition Enabling Hydrogen Generation

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Carbon nanotubes (CNTs) are strategic nanomaterials with rapidly expanding applications in polymers, electronics, energy storage, and advanced manufacturing. However, large-scale deployment of CNT technologies remains constrained by energy-intensive synthesis routes, high production costs, and significant environmental footprints. Developing sustainable, scalable, and economically viable CNT growth technologies is therefore critical for establishing a robust domestic carbon nanomaterials ecosystem in India.

In this work, we present a sustainable production technology for CO_2-free CNT synthesis via methane-rich feedstock decomposition, developed by Hindustan Petroleum Corporation Limited. The process employs a low-cost proprietary catalyst, enabling efficient catalytic methane decomposition at atmospheric pressure and mild operating temperatures. The technology is compatible with multiple feedstocks including compressed natural gas (CNG), and compressed biogas (CBG), offering flexibility for integration with existing infrastructure.

The process uniquely integrates simultaneous CNT growth and hydrogen generation, avoiding carbon dioxide formation and eliminating water consumption associated with conventional hydrogen production pathways. Multi-walled carbon nanotubes are generated as solid carbon products with desirable structural characteristics for downstream industrial applications, while the hydrogen-rich gas stream is blended to produce hydrogen - enriched compressed natural gas (HCNG). Reactor operation is demonstrated in lead-and-lag configuration, supporting continuous synthesis and process stability.

The technology has progressed from laboratory scale to demonstration scale at ~25 kg per day, achieving TRL-7 readiness. This integrated synthesis route not only addresses sustainability challenges in CNT production but also valorizes carbon from methane into high-value nanomaterials while enabling cleaner gaseous fuels. The co-production approach enhances overall process economics and supports scalable deployment. This technology represents a transformative pathway toward sustainable carbon nanomaterial manufacturing in India. The platform establishes a foundation for domestic CNT supply chains while reinforcing the role of methane-derived resources in a low-carbon, materials-integrated energy future.

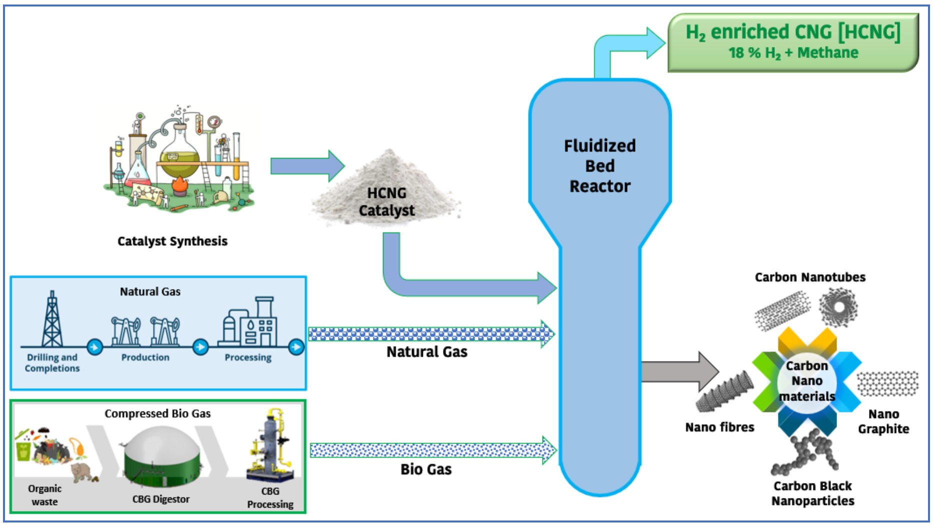

Fig 1 - Process Technology Schematic