TECH OFFER

A Novel Carbon Nanotube Synthesis Method to Capture and Utilise Carbon Dioxide

KEY INFORMATION

TECHNOLOGY CATEGORY:
Sustability - Low Carbon Economy

TECHNOLOGY READINESS LEVEL (TRL): TRL4
COUNTRY: SINGAPORE
ID NUMBER: TO175215

OVERVIEW

Faced with the increasing levels of carbon dioxide, carbon capture, utilisation, and storage (CCUS) technologies have garnered significant attention. However, as most CCUS technologies rely heavily on various forms of monetary support from governments and faced numerous technical and scalability challenges, most of the CCUS facilities developed are unable to achieve financial profitability or even achieve a net reduction of carbon dioxide (CO2) emissions.

The technology proposed herein relates to an electrochemical-based CO2 reduction reaction process, which can directly capture and convert CO2 to carbon nanotubes (CNTs), a high-value material that exhibits unique electrical and thermal properties suited for applications in various sectors, including electronics, energy storage, sensors and medical uses.

In contrast to synthesis methods that involve complex reactions and expensive catalysts, the proposed method uses a molten salt chemistry that can convert CO2 to cathodic solid carbon nanotubes (CNTs) via the electrochemical process. Although high reaction temperature (about 760 degC) is required, this method is highly controllable and uses cost-effective pure iron catalyst, producing high quality CNTs at a relatively high production rate.

Based on preliminary process modeling and technoeconomic analysis, this technology has the potential to be completely CO_2-negative without re-emission, is more scalable, and profitable with high quality CNT materials.

The technology owner is seeking to collaborate with industry partners and research institutions for joint R&D to advance the lab scale technology to pilot or event industrial production scale, as well as to explore applications for the CNTs produced. Upon further development, the system has the potential to be integrated with existing carbon capture systems to improve their financial viability and achieve carbon negative objective.

TECHNOLOGY FEATURES & SPECIFICATIONS

- The molten salt CO_2 reduction reaction enables CO_2 conversion into high value nanostructured CNTs, which captures carbon as a solid and stable material, complementing other processes that convert CO_2 into combustible fuels.
- Provides a highly controllable production method, using cost-effective pure iron (Fe) as a catalyst and lithium carbonate (Li_2CO_3) based electrolyte.
- The electro-reduction reaction and CNTs produced exhibits good graphitization degree (0.24 I_D/I_G intensity ratio), high Faradaic efficiency (~80%), with a high production rate (~58 $g_{CNTs}\ g_{Fe}^{-1}\ h^{-1}$).
- Based on a preliminary process modeling and technoeconomic analysis, the system may potentially achieve a profitable CO_2 utilisation, subject to further scale up and detailed studies.

POTENTIAL APPLICATIONS

- Energy Storage: The high-quality CNTs produced could be utilised in next-generation batteries and supercapacitors, enhancing energy storage capacity and charging speeds.
- Aerospace and Automotive: Lightweight, strong CNT composites could be developed for use in aircraft and vehicle manufacturing, improving fuel efficiency.
- Construction: CNT-reinforced materials (such as CNT-reinforced concrete) could lead to stronger, lighter building materials with improved durability and insulation properties.
- Environmental Remediation: The technology itself serves as a carbon capture solution, potentially deployable near industrial CO_2 emission sources.
- Textiles: CNTs could be incorporated into smart textiles for wearable technology applications.
- Water Purification: CNT-based filters could be developed for advanced water treatment systems.

MARKET TRENDS & OPPORTUNITIES

The carbon nanotube (CNT) market is projected to grow from USD 1.1 Billion in 2023 to USD 2.3 Billion by 2028, at a CAGR of 14.6% between 2023 and 2028.

UNIQUE VALUE PROPOSITION

This proprietary electro-reduction process has the potential to achieve a net reduction of CO_2 emissions without re-emission, offering an efficient and scalable CCUS solution, while producing high value CNTs material for various industrial uses. The process allows for CNTs to be produced with higher purity and quality than was previously possible from CO_2.