MINOTAUR EXPLORATION LIMITED
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ASX Release

Carbon Capture Utilising Halloysite-Derived Adsorbent Nanomaterials

Summary

- Testing of halloysite-derived carbon nanomaterials is showing excellent adsorption potential and recyclability for carbon capture and conversion purposes.
- Over 1.1 tonnes CO_2 capture per tonne adsorbent now demonstrated.
- Commercialisation grant application submitted for upscaled, pilot plant facility to demonstrate commercial pathway.
- Successful ARC Linkage Grant outcome for R&D project utilising halloysite-derived nanomaterials for effective removal of microplastics from water.

Minotaur director, Dr. Tony Belperio, stated: 'It is pleasing to see significant research advances through NNT's clear focus on potential commercial outcomes, particularly carbon capture and utilisation.'

Background

Natural Nanotech Pty Ltd (NNT) is a research and commercialisation venture jointly owned (50:50) by Minotaur Exploration Ltd (ASX: MEP, Minotaur) and Andromeda Metals Limited (ASX: ADN, Andromeda), formed to investigate advanced nanotechnology applications for halloysite. NNT is working with the University of Newcastle's Global Innovative Center for Advanced Nanomaterials (GICAN) on high-tech applications for halloysite, natural clay nanotubes, from the Great White Kaolin JV's high-grade kaolin-halloysite deposits in South Australia.

Current Research Projects

Natural Nanotech's projects with GICAN are directed at developing commercially attractive solutions for a range of environmental issues using nano-porous materials synthesised from natural halloysite-kaolin mixtures. Previous research has highlighted outstanding potential for adsorbent-related applications in a broad range of areas including carbon capture and conversion, hydrogen storage and transport, remediation of water and wastewater, energy storage technologies, and antibacterial and agricultural applications. The unique properties of Great White Project halloysite-derived nanomaterials that make them so amenable to these applications are their enormous surface area per unit weight, their porous nature and differential charge capabilities between inner and outer surfaces.

Research activity is currently underway with GICAN under 2 specific research agreements:

1) Halloysite derived nanomaterials for environmental applications (commenced April 2020). This project continues to look at a range of potential high technology applications.

2) Halloysite Based Materials for Carbon Capture and Conversion (commenced April 2021). This project is optimising the processing route and subsequent development of Carbon Capture and Conversion pilot plants.

A number of specific research grant applications are in the pipeline to provide additional funding to accelerate activity in key areas including additional funding to accelerate planned carbon capture and conversion pilot plants.

Carbon Capture

In progressing the ability of halloysite nanomaterials for selective capture of CO_2, the GICAN team continue to optimize adsorption potential as a necessary precursor to larger scale pilot plant design. Outstanding results have been achieved with Great White "run of mine" refined halloysite-kaolin now demonstrating over 1600 m^2/g surface area and 25.7 mmol/g of CO_2 adsorption when converted to engineered porous carbon nanomaterial. These results are significantly superior to current commercial products (Table 1) such as activated carbon, and other materials including mesoporous carbon, carbon nitride and multi-walled carbon nanotubes. The halloysite derived activated porous carbon exhibits the adsorption of 25.7 mmol/g which equates to over 1.1 tonnes CO_2 per tonne of adsorbent and the adsorbed amount is more than six times higher than that of activated carbon. With this exciting result, the GICAN team is actively seeking to increase this further to reach the adsorbed amount of 2 tonnes of CO_2 per tonne of the adsorbent whilst also maximising recyclability of materials. Optimizing the adsorption and recyclability potential are considered critical to commercialisation of this technology.

The exceptional adsorbent performance of activated carbon nanomaterial derived from Great White halloysite-kaolin is due to the 74x increase in surface area generated through surface chemical activation coupled with the higher content of microporosity as compared to that of the unactivated material.

	Surface Area $m^2.g^{-1}$	CO_2 adsorbed (mmol/g) @ 273 K
Halloysite (GW Refined)	22.5	2.17
Carbon nanoflakes derived from Halloysite (GW Refined)	837	13.1
Activated Carbon nanoflakes derived from Halloysite (GW Refined)	**1646**	**25.7**
Mesoporous Carbon nitride (MCN)	232	15.4
Multiwalled Carbon Nanotube	250	5.6
Activated Carbon	747	3.7
CMK-3 (Mesoporous carbon)	1547	24.2

Table 1. *Adsorption potential of refined Great White halloysite-kaolin (GW Refined) and activated carbon nanomaterial derived from halloysite compared to commercially available materials – mesoporous carbon nitride, multiwalled carbon nanotubes, activated carbon and mesoporous carbon.*

Water Treatment Research Award

Minotaur, Andromeda and the GICAN nanotechnology team have been awarded an ARC Linkage Grant to the value of $350,000 for an R&D project under the direction of Professor Jiabao Yi of GICAN, the University of Newcastle, investigating the use of halloysite-derived nanocomposite materials for the removal of microplastics from contaminated water systems. The project aims to develop cheap and environmentally-friendly materials utilizing the high surface area and catalytic activity of halloysite nanotubes and advance next-generation composite materials for water treatment. Formal agreements with the University of Newcastle and Australian Research Council are underway.

Professor Ajayan Vinu, Director of GICAN commented: Optimisation and establishment of the CO_2 pilot plant is underway and this unique facility with the automated CO_2 measurement system will be established at the University of Newcastle over the next few months. GICAN team is actively working on increasing the specific surface area of the activated nanocarbon with the aim of reaching the target of 2 tonnes of CO_2 per tonne of the adsorbent. In addition to the CO_2 adsorption, our team in collaboration with Minotaur, Andromeda and Natural Nanotech, is currently investigating the conversion of the adsorbed CO_2 into fine chemicals, which is quite exciting and will make a huge impact in the field of CO_2 chemistry.

Authorisation

This report is authorised by Mr Andrew Woskett, Managing Director of Minotaur Exploration Ltd.

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