

CARBON CAPTURE & RECYCLING (CCR) USING NANOSTRUCTURED PHOTOCATALYSTS SUPPORTED ON SILICA NANOSPRINGS™

M. Grant NORTON^{1,2}, Tejasvi PRAKASH¹, Oscar G. MARIN-FLORES¹, Timothy CANTRELL¹, David N. MCILROY^{1,3}, and Giancarlo CORTI¹

¹GoNano Technologies, Inc., Moscow, ID 83843, U.S.A.

²Washington State University, Pullman, WA 99164, U.S.A.

³University of Idaho, Moscow, ID 83844, U.S.A.

E-mail: Norton@GoNano-9.com

Mitigation of anthropogenic greenhouse gas emissions, such as carbon dioxide, is seen as a necessity by the international community. Carbon capture, (separation), and storage (CCS) is the most commonly evaluated method for dealing with CO₂, in which it is used for oil and gas recovery, coal bed methane production, or storage in saline formations. GoNano Technologies Inc. is currently developing Carbon Capture & Recycling (CCR) technology as an alternative and/or a complement to CCS. CCR involves the photocatalytic conversion of CO₂ into useful chemical feedstock products such as formic acid, formaldehyde or formic acid. The CCR system is designed to require minimal modification to actual industry and power plant emission stacks to reduce the cost of implementation. In addition, the use of solar radiation or high-energy-efficiency UV LEDs enables the photocatalytic process to occur with lower parasitic loads compared to other utilization and storage methods.

GoNano Technologies' approach is to use TiO₂ nanoparticles – a known photocatalyst [1] – immobilized on silica Nanospring™ substrates [2]. The Nanosprings have a high degree of accessible surface area (BET; ~ 350 m²/g). The formation of anatase or mixed anatase/rutile TiO₂ coatings by atomic layer deposition produces an overall surface area of 250 m²/g, which is approximately 4 times that of commercially available Degussa P25 nanoparticles. The CCR system

utilizes a solar panel-like reactor that has the photocatalyst mat inside and a quartz window to allow irradiation by UV light. The assessment of the CO₂ conversion is performed using two types of reaction:

(A) CO₂ Reduction into Methanol. A flow of CO₂ dissolved in water at RTP is introduced into the reactor (solution flow rate into the reactor ~ 0.5 ml/hr). UV light (50 W solar simulator Hg lamp; AM 1.5) is incident through a quartz window. Samples (~0.1 ml) from the outlet are analyzed by a flame ionization detector (150°C with He Carrier gas at 30 ml/min) on a HP5890 Series II gas chromatograph. Conversion efficiencies in the range 3-5% of dissolved CO₂ being converted into methanol, after 3 h of irradiation of the photocatalyst have been observed. The space time yield is 4.21 mmol/(g cat.h) which is high compared to μmol/(g cat.h) ranges from commercially available Degussa P25 [3].

(B) CO₂ Reduction into Formaldehyde and Formic Acid in the Presence of Methanol. Keeping all the reaction conditions the same as (A), the addition of 1% methanol into the reaction mixture, allows for dissolved CO₂ conversion efficiencies of 12% into formaldehyde (72.3%) and formic acid (27.7%).

These initial results indicate that the CCR technology is capable of selectively reducing CO₂ into useful C1 products. Enhancing the conversion efficiencies with interface engineering of the photocatalyst is now being pursued.

References

- [1] T. Inoue, et al., *Nature* 1979, 277, 637
- [2] D.N. McIlroy, et al., *J. Phys.: Condens. Matter* 2004, 16, R415
- [3] I. Tseng, et al., *Appl. Catal. B: Environmental* 2002, 37, 37