Process Intensification of CO_2 Photocatalytic Reduction

Abdullahi Adamu (a.adamu2@ncl.ac.uk), Fernando Russo Abegão, Kamelia Boodhoo

School of Engineering, Newcastle University, Newcastle Upon Tyne, NE1 7RU, United Kingdom.

The development of photocatalysts that harness the visible range of irradiant solar energy and design of efficient photoreactors remain the biggest challenges of CO_2 photoreduction processes. Addressing these challenges would improve the effectiveness and lower the manufacturing cost of the process. The conventional batch photoreactors reported to have been used in photocatalytic CO_2 reduction are prone to catalyst deactivation, mass and heat transfer limitations, low selectivity and low photo-illumination efficiency. Microreactors where there is an enhanced mixing improved light penetration, and high surface area to volume ratio can potentially reduce mass and heat transfer limitations. Such systems are a promising approach in improving CO_2 photoreduction efficiency. In this work, the perfomance of a conventional annular photo-reactor operating under batch regime is compared with 3D printed miniaturised continuous flow microreactor as an intensification technology for CO_2 photoreduction.

In the first part of this work, an annular reactor equipped with a 125 W power Hg UV lamp was used to reduce 200 ml of 0.1 M sodium bicarbonate/carbonate solution to formate. The bicarbonate/carbonate ratio was used to adjust the pH and 0.1 g of 5%Cu/TiO_2 catalyst was used. The mixtures was irradiated for 5 hours under continuous stirring. The optimum formate production rate of 180 µmol g_{cat}^{-1} h^{-1} was achieved at pH 11 as depicted in figure 1.

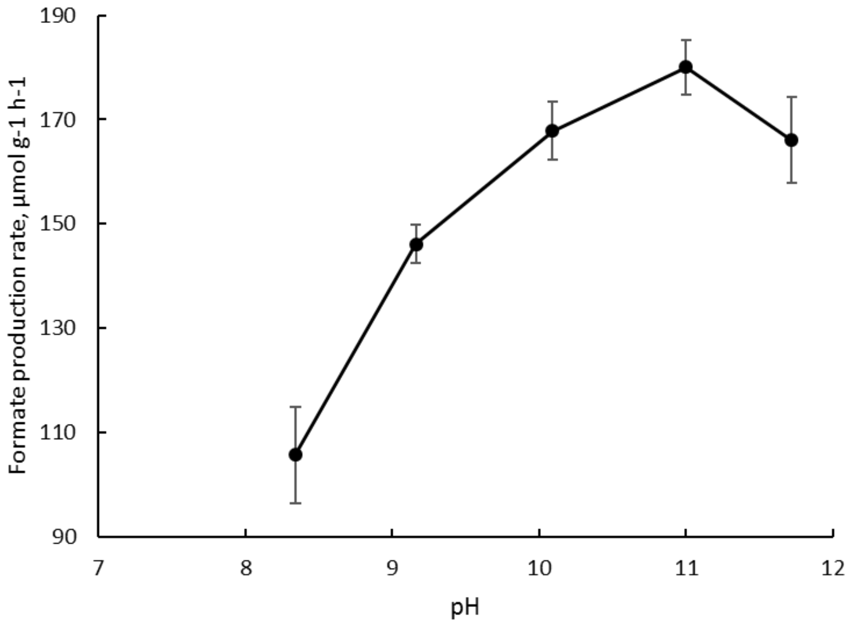

Figure 1: Formate production rate at different pH

In the second part of this work, 3D printed microreactor is being used to intensify the process under the similar operating conditions to the ones in the annular reactor. 3D printing technology is gaining considerable interest among researchers of fluidic flow and provides for easy and fast implementation of chemical reaction while reducing the complex manufacturing processes and tools involved. In the present work, the microreactor system consists of serpentine microchannels of rectangular cross section coupled to a heat exchanging device for temperature control. The system is irradiated through a quartz glass window using unidirectional UV LED lamps for uniformity of irradiation. Experimental data are currently being gathered in the microreactor and will be reported at the conference.