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Screening and optimisation of process parameters for the photocatalytic reduction of CO_2

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Photoreactor design has the potential to maximise light harvesting and limit physical barriers to the catalytic surface reaction. Moreover, to optimise reactor design, it is critical that these process phenomena are well understood. However, there are limited examples of kinetics and comprehensive screening and optimisation of process parameters for the photocatalytic reduction of CO_2. These critical knowledge gaps need to be addressed for this technology to progress towards commercialisation. Accordingly, this study focuses on understanding these two important aspects of the process with the goal of scaling-up CO_2 photoreduction processes. In this work, P-25 TiO_2 was loaded onto stainless steel mesh and photoreduced in the presence of H_2O and UV-light. A novel continuous flow reactor that increased the ratio of illuminated catalyst surface to volume of reacting gas was used. It was observed that increasing reaction temperature resulted in higher yields of CH_4 and CO with a maximum production of 17.9 and 3.03 $\mu mol.g_{cat}^{-1}.hr^{-1}$ recorded respectively at 56.6 °C. Increasing light irradiance gave higher CH_4 and CO values, with a maximum production of 0.72 and 1.04 $\mu mol.g_{cat}^{-1}.hr^{-1}$, respectively at 251 $mW.cm^{-2}$. In addition, a change in selectivity for increasing H_2 production was observed with a maximum production of 1.90 $\mu mol.g_{cat}^{-1}.hr^{-1}$ recorded at 251 $mW.cm^{-2}$. However, blank tests also showed appreciable production of CH_4 and significant increase in CO_2. In addition, under continuous operation with overnight purging of the system with N_2, the GC method used was able to detect the presence of O_2. It is very likely that carbon impurities, introduced during the coating of the support or from the synthesis and handling of the photocatalyst inflated yields. In-situ pre-treatment of the catalyst using UV-light, N_2 and H_2 or H_2O to remove residual carbon impurities are currently under investigation.

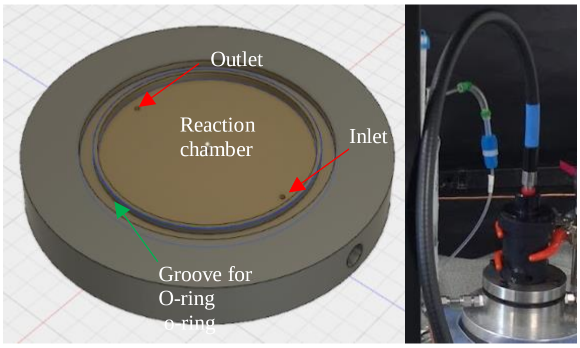

Figure 1. Left – visual representation of reactor design. Right – optical fibre and light focuser placed above actual design

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