(587j) Photocatalytic Reforming of Biomass for Hydrogen Production

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Photocatalytic reforming of biomass for hydrogen production

Here, we describe a novel microfluidic device to determine the required bandgap for the photocatalytic reforming of biomass model substrates (ethylene glycol, glycerol, xylose and xylitol) in water. Furthermore, this device is applied to eventually elucidate the reaction mechanism of aqueous photocatalytic reforming, which is currently still a matter of debate.

Combustion of fossil fuels is one of the main causes of the climate change, due to the production of harmful CO_2. As a consequence, significant scientific efforts aim at developing cleaner and more sustainable fuel resources. Hydrogen is a promising alternative, as hydrogen has a high energy density and no harmful products are formed during its combustion. Hydrogen is currently produced from natural gas or coal by gasification, liquefaction or steam reforming [1]. However, these methods are highly energy demanding and they still require natural resources that are not renewable. In contrast, PhotoCatalytic Reforming (PhCR) only uses solar energy to convert aqueous phase biomass waste streams into H_2 and CO_2. [2]

Although PhCR appears to be a clean alternative for hydrogen production, currently used catalysts are relatively inefficient as they only use the UV-band from the entire

electromagnetic spectrum. Only UV-light has sufficient energy to activate the catalyst by means of creating electron-hole pairs. To improve the efficiency of PhCR, new catalysts must be identified that are activated with a wider range of wavelengths. Therefore, we have realized a microfluidic platform to determine electrochemically the minimum required energy potential to perform the photocatalytic reforming of four biomass model substrates, ethylene glycol, glycerol, xylose and xylitol. These compounds were dissolved in water and a small amount of H_2SO_4 was added to ensure enough conductivity of the solution.

The microfluidic device includes electrodes to which a potential (up to 3 Volt) corresponding to the bandgap of a photo catalyst can be applied, mimicking an electrochemical potential. Cyclic voltammetry is used to evaluate the potential at which degradation of the substrate occurs. To study the reaction mechanism, the gases produced at the cathode and the anode sides are kept separate by an array of small channels (length: 50 Î¼m, depth and width: 2 Î¼m, spacing between the channels: 3 Î¼m) as a result of capillary pressure. The gaseous products are next extracted from the aqueous phase by means of a PDMS membrane placed on the outlets and subsequently analysed by inline GC. The liquid phase products are collected from the device and characterized offline by HPLC.

Recorded cyclic voltammograms clearly show that a reaction is taking place for ethylene glycol and xylitol, which is also confirmed by GC and HPLC analysis. Based on the identification of the reaction products, we suspect that both proposed reaction mechanisms in the literature are taking place. [3-5] However, deactivation of the electrode surface was also observed as a result of carbon deposits, as confirmed by SEM and XPS.

In a next step, this device will be applied to help identify the optimal band gap for the photo catalyst, which would significantly improve the efficiency of PhCR.

References

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