Photoelectrochemical oxidation of methane at a TiO2 nanotubes array photoanode

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Environmental awareness highly motivates the exploitation of natural gas over other fossil resources, thanks to its lower environmental footprint. Unfortunately, methane, which is its primary component, is being wasted due to the lack of an efficient utilization process for its integration in the existing energy infrastructure. Currently, methane is mostly burned in order to use its heat for power generation. In order to utilize methane more efficiently, it may be chemically converted for energy conversion. However, its molecular structure (CH4) has neither a functional group, nor a polar distribution to facilitate chemical interactions, resulting in a low chemical reactivity. Its C-H bond has one of the highest bond energies among hydrocarbons (413kJ/mol). The present research investigates the ambient photoelectrochemical oxidation of methane using a TiO2 nanotubes array photoanode. TiO2 semiconductors generate highly reactive holes upon illumination that can drive the oxidation reaction. In this type of activation, the exploitation of light energy may dramatically reduce the energy required for the oxidation reaction. The nanotubes array structure is prepared via anodization of Ti foils followed by annealing at 500 . This structure, which was characterized by SEM, TEM and XRD, has an efficient exposure to light with high surface area for the photoelectrochemical reaction. Linear sweep voltammetry and chronoamperometry measurements indicate a significant photocurrent response in the presence of methane. Moreover, the results suggest that the current efficiency of methane oxidation is affected by the applied biased potential. Preliminary products characterization using GC and 1H-NMR indicates that CO2, CO, C2H6 and formic acid are produced in the photoelectrochemical reaction.