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Structural Features of Electrodeposited Copper Electrodes for CO_2 Conversion

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Abstract. Direct electrochemical reduction of CO_2 is a process that could contribute to the reduction of the emission of greenhouse gases by using CO_2 as a raw material for fuel production. This paper focuses on voltammetric studies of functionalized electrodes for the electrochemical conversion of CO_2 and reports on its use as a tool for electrode screening and optimization. Nickel substrates modified with copper and ruthenium/copper electrodeposits were studied. Voltammetric experiments indicate that CO_2 electroreduction follows a nickel type mechanism in which this electrochemical reaction occurs simultaneously and in competition with hydrogen evolution. A significant inhibition of hydrogen evolution reaction is observed in nickel modified electrodes. Inhibition characteristics and the onset of carbon dioxide conversion are dependent of the type of electrode functionalization. Voltammetry is thus a powerful tool to evaluate electrode modifications and for tuning electrodes for an optimized electrocatalytic performance.

Introduction

Efforts are continuously being made to reduce the emission of greenhouse gases, especially CO_2. Direct electrochemical reduction of CO_2 is a process that could contribute to the solution of this problem by turning a problematic waste product into useful fuel. In Portugal alone, 27 MTons of CO_2 are released by the ten most polluting Portuguese companies whilst worldwide the emissions amount to 25 billion tonnes of CO_2 / year. The cost of the emissions is currently in the range of 10-20 € per tonne of CO_2. Carbon dioxide is therefore an abundant and cheap raw material. CO_2 sequestration and its use as a raw material for fuel production would represent not only a contribution to compliance with the Kyoto agreement, but would simultaneously provide an opportunity for the realization of the full potential of renewable intermittent sources bringing an increase in the efficiency of installed capacity. The technology would allow the storage of excess energy as fuel during off peak periods and injecting it into the power grid during the peaks of high energy consumption.

Omnidea in collaboration with Research Institutes is developing a technology based upon a regenerative energy storage cycle. In this cycle the recharge system, which is composed of an electrochemical cell, converts CO_2 into hydrocarbons using an external source of power (e.g. solar power), Fig. 1. The discharge system produces electric energy when hydrocarbons and oxygen, from the recharge system, are directly supplied to a Solid Oxide Fuel Cell (SOFC).

The advantages of such a technology are that it is a regenerative system, employs compact and safe equipment and represents a low cost system for producing fuel with a high energy density.

Indirect reduction of CO_2 was reported for the first time by Petrova G. N. *et al.* [2]. A mercury electrode in an aqueous electrolyte at pH 7, containing $TiCl_3$, Na_2MoO_4 and pyrocatechol, yielded a total faradaic efficiency for cathodic hydrocarbon generation of about 0.2% at 7 mA/cm^2, with methane being the major hydrocarbon component.