MethodsX 2 (2015) 204–210

Contents lists available at ScienceDirect

MethodsX

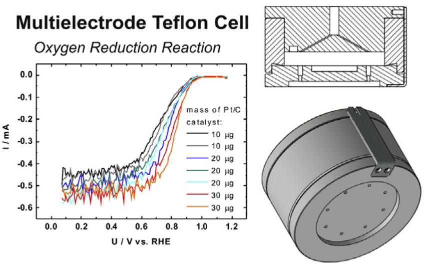
journal homepage: www.elsevier.com/locate/mex

Multielectrode Teflon electrochemical nanocatalyst investigation system

Nejc Hodnik [a,b,*]

[a] Max-Planck-Institut für Eisenforschung GmbH, Max-Planck Str. 1, 40237 Düsseldorf, Germany
[b] National Institute of Chemistry, Hajdrihova 19, 1000 Ljubljana, Slovenia

GRAPHICAL ABSTRACT



ABSTRACT

The most common approach in the search for the optimal low temperature fuel cell catalyst remains “trial and error”. Therefore, large numbers of different potential catalytic materials need to be screened. The well-established and most commonly used method for testing catalytic electrochemical activity under well-defined hydrodynamics is still thin film rotating disc electrode (TF-RDE). Typically this method is very time consuming and is subjected to impurity problems. In order to avoid these issues a new multielectrode electrochemical cell design is presented, where 8 different electrocatalysts can be measured simultaneously at identical conditions.

The major advantages over TF-RDE method are:

- Faster catalyst screening times.
- Greater impurity tolerance.
- The option of internal standard.

* Correspondence to: National Institute of Chemistry, Hajdrihova 19, 1000 Ljubljana, Slovenia. Tel.: +386 14760373; fax: +386 14760300.

E-mail addresses: hodnik@mpie.de, nejc.hodnik@ki.si (N. Hodnik).

http://dx.doi.org/10.1016/j.mex.2015.04.004

A R T I C L E I N F O
Method name: Multielectrode Teflon electrochemical nanocatalyst investigation system
Keywords: Electrocatalysis, Electrochemical cell, Multielectrode electrochemical cell, Oxygen reduction reaction, Platinum activity
Article history: Received 2 February 2015; Accepted 21 April 2015; Available online 22 April 2015

Method details

Background information

There are two methods commonly used to investigate low temperature fuel cell catalyst activity. First one is membrane electrode assembly (MEA) method which is actually an essential part of a real proton exchange membrane fuel cell (PEM-FC). It is a sandwich (composite) of a proton exchange membrane (nafion), catalyst layer and a gas diffusion layer. The main practical problems associated with this method are high costs, large consumption of electrocatalyst, excessive waste of time due to assembling of the MEA and complex interpretation of results due to the large number of parameters that influence a fuel cell performance (water management, membrane thickness, catalyst porosity, etc.). This makes MEA method very unpractical for fast screening of new materials. With the thin film rotating disc electrode (TF-RDE) the number of parameters reduces significantly. The catalyst is deposited on a glassy carbon electrode in a form of a thin film and then measured with classical 3 electrode electrochemical setup under defined mass transport conditions [1,2]. In addition to much easier and less complex interpretation compared to MEA it also consumes significantly less time and catalyst [3]. RDE has been proven to produce results that are in accordance with MEA activity measurements. This method is used in almost every laboratory testing electrocatalysts. Frequently studied reactions are oxygen reduction, methanol or ethanol oxidation, hydrogen oxidation, oxygen evolution, nitrous oxide reduction, and more [4]. Still, this method has some potential problems, which are related mainly to the impurities that can alter the real kinetic of reactions like ORR [5]. This is especially important in alkaline electrolyte [6]. In addition, typical electrochemical characterization experiment of a single sample takes approximately 2–3 h, which is also suitable for fast screening of electrocatalysts. One alternative is to use carbon microfiber as a working electrode (WE) [7]. However in that case it is difficult to control the amount of a deposited catalyst, therefore, only specific activity (without mass activity) can be obtained.

In this study we propose a new design of an electrochemical cell that enables 8 electrochemical evaluations at the same time. Compared to the multi potentiostat systems that have multiple counter (CE) and reference electrodes (RE), commonly used in battery research, our approach is to utilise only one reference and one counter electrode. Therefore we can use only one potentiostat with addition of special module enabling simultaneous control over potentials of 8 working electrodes. This is another important factor that brings down the costs. Control over mass transport of reactive species to the electrode surface (hydrodynamics) is achieved with magnetic stirrer. This is a clear advantage over similar commercial systems [8].

Advantages of multielectrode Teflon cell over TF-RDE glass cell

- Roughly 8 times faster sample characterisation.
- Identical iR drop for all WE; same distance between WE and CE and RE for all 8 electrodes.
- Identical conditions for all samples; same electrolyte, temperature, impurities and reactant concentration.
- The option of internal benchmark standard with known activity parameters provides the information and control over the measurements conditions like pH, impurities, temperature, reactant concentration, etc.