

Short communication

Research and development on porous components for MCFC applications[☆]

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Abstract

A fuel cell is a complex system in which every single part must have optimal and long lasting characteristics to assure a good performance. Our research group has focused on a specific section of a cell, the porous components, the elements that directly come into play and more strongly influence the working and performance.

Attention has been focused on matrix, in particular trying to improve it by intervening in the first step of raw powder choice.

α -LiAlO₂ has been considered a new interesting and promising material to test. The purpose of this work is the study of the possibility of producing an α -LiAlO₂-based matrix with suitable properties for a MCFC cell. The subsequent steps of powder characterisation, tape preparation and final product analysis are presented as well as the various application techniques.

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1. Introduction

A fuel cell is an electrochemical device which turns chemical energy directly in to electrical energy without the intervention of a thermal cycle and with a reduced environmental impact. Fig. 1 shows a scheme for a molten carbonate fuel cell and in Fig. 2 a cross-section of a fuel cell is described. Two electrodes, anode and cathode, work as catalytic sites for the chemical reactions consuming hydrogen and oxygen/carbon dioxide and producing water and electrical energy. In MCFC technology, the electrolyte, that is the ion conductor, is a mix of alkaline salts, molten at the operating temperatures and held in a ceramic porous support called matrix. This is one of the most critical components because it allows the ionic conductivity between anode and cathode, acting at the same

time as both a gas barrier and an electronic insulation layer between the two parts of the cell. For this purpose, the matrix must have a retention capacity, which is controlled by its porosimetric structure.

γ -LiAlO₂ powders are the most common materials in use for matrix production in a molten carbonate fuel cell. Their disadvantage is the limitation of matrix durability because of some phenomena that occurs during long-term cell operation [1]. Particle growth and pore coarsening lead to specific surface area reduction with consequent electrolyte loss from the matrix since the capillary force regulating molten carbonates allocation is reduced [2]. Moreover, many tests have shown that γ -LiAlO₂ is subjected to the allotropic transformation to the alpha phase (α -LiAlO₂) [3]; as these two phases have different densities, this transformation can cause a change in the pore size distribution and so the filling of the matrix with molten carbonates.

These considerations together with researches on α -LiAlO₂ stability [4,5] led to an increasing interest in using directly this as a raw material.

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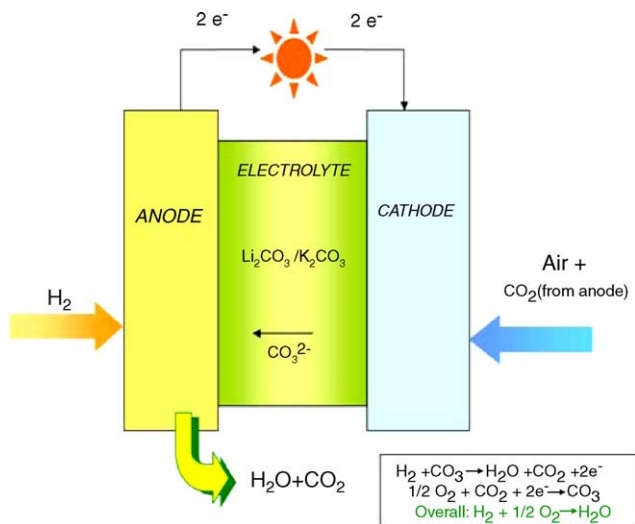


Fig. 1. A scheme of a molten carbonate fuel cell working.

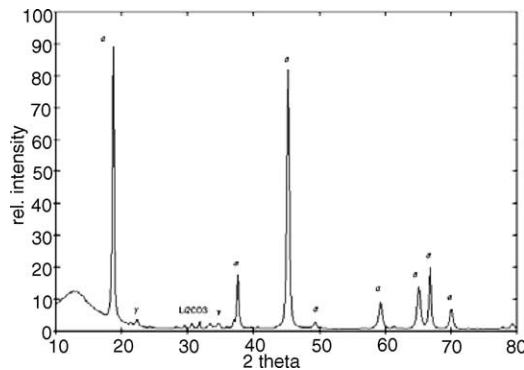


Fig. 4. Sample B XRD analysis.

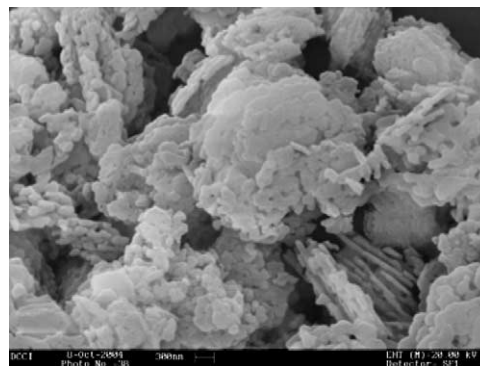


Fig. 5. Powder A SEM image.

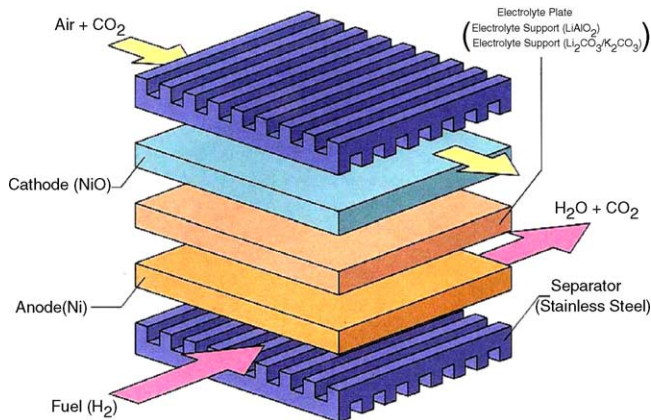


Fig. 2. A typical single cell cross-section.

2. Experimental

Granulometry, BET and X-ray analysis have been the first techniques applied to characterise two different kinds of commercial powders, identified as sample A and sample B. In fact,

particle size distribution and specific surface area (BET) have been considered as the first reference parameters, because they settle the quantity of binders in slurry formation and the final pore size distribution which is very important for the electrolyte allocation.

The introduction of extraneous substances and the consequent damaging effects have been evaluated by controlling the powder pureness degree.

The material characterisation has underlined some peculiar aspects. Regarding particle surface area, the two samples have comparable data, around 10 m²/g, but sample B supplier provides a narrower range of BET values, which gives

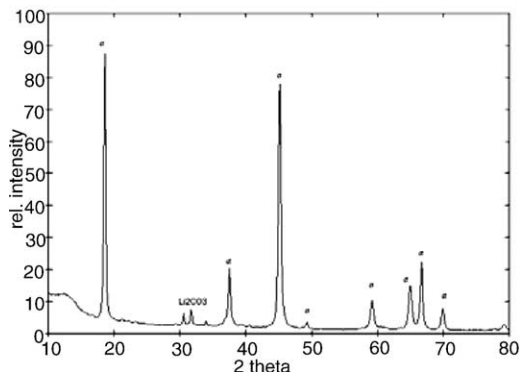


Fig. 3. Sample A XRD analysis.

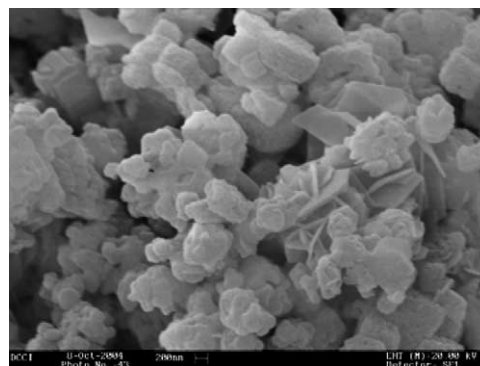


Fig. 6. Powder B SEM image.

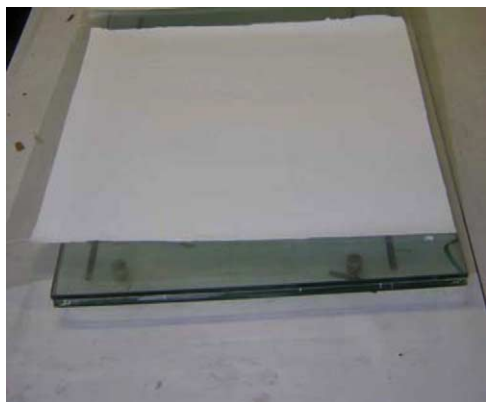


Fig. 7. Example of an α -LiAlO₂ (sample B)-based matrix green tape.

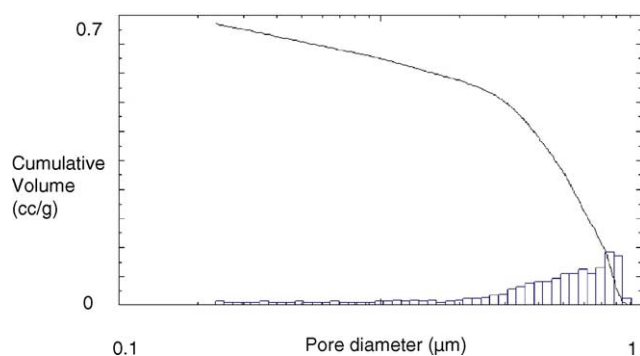


Fig. 8. Example of a suitable pore size distribution of a sample A-based matrix after burn-out.

a certain reproducibility on the slurry formulation. Even the particle size distributions are very similar.

From a pureness point of view the two powders are rather different. Fig. 3 shows the almost absolute absence of extraneous substances in powders A: small intensity peaks are attributable to Li₂CO₃, a residue of production. Fig. 4 shows sample B X-ray diffraction: it shows the presence of Li₂CO₃ and γ -LiAlO₂ too. Even in reduced percentage assessable at 2–3%, the presence of γ -LiAlO₂ could generate problems related to the allotropic transformation whose effects are unwelcome.

The SEM images show some characteristic morphological aspects of each kind of powder (Figs. 5 and 6).

This study of the feasibility of α -LiAlO₂ powders comprises slurry preparation to verify their ease of casting. After different tests the optimisation of binder, plasticizer, dispersant and powder ratios has led to flexible tapes with an almost defect free surfaces for both the two powders. Fig. 7 shows an example of an α -LiAlO₂ (sample B)-based matrix green tape.

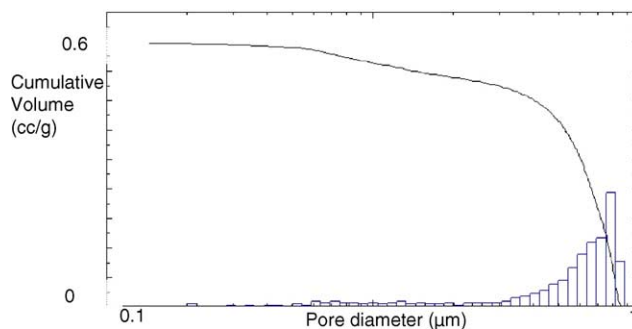


Fig. 9. Example of a suitable pore size distribution of a sample B-based matrix after burn-out.

Afterwards mercury porosimetry has been used to give the final validation to the alpha lithium aluminate application by checking the matrix pore size distribution. Good values have been obtained from the analysis and Figs. 8 and 9 give some examples of the experimental pore size distributions which are suitable for an MCFC application.

3. Conclusions

Studies confirming the greater stability of α -LiAlO₂ compared with γ -LiAlO₂ in molten carbonates focussed the research activity on the alpha phase as a material for MCFC matrix production. Characterisation of commercial powders has been carried out; casting tests and analysis of the final results have demonstrated the possibility of producing a matrix with optimal characteristics which are totally comparable to the qualities of a γ -LiAlO₂-based matrix.

References

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