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The influence of powders on the final properties of the porous components for MCFC application

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Abstract

A fuel cell life time and its correct working are strongly dependent on its main components characteristics: anode, cathode and matrix. The required performances are directly correlated to two very important parameters: porosity and average pore diameter. In particular the influence of raw powders on MCFC anode porosimetric properties was studied. Ni–Al spherical and non-spherical powders were tested for anode production and the final samples were analysed by mercury porosimetry, scanning electron microscopy (SEM-EDS) and X-ray.

Keywords: MCFC; Anode; Porosimetry

1. Introduction

Porosity and average pore diameter of MCFC porous components have to be included in a specific range to control the electrolyte distribution and to be constant during the cell operation to ensure a good performance.

This goal can be achieved acting on raw material choice, different green fabrication process conditions or the appropriate choice of the thermal treatment parameters (atmosphere and temperature).

The evaluation of raw powders effect on MCFC anode characteristics has been pursued in this work.

Ni–Al has been chosen because of its greater creep resistance as demonstrated by a study carried out on different materials by the same work group [1].

2. Experimental

The characterisation of the starting powders and the final anodes, produced following the same routine, has been performed by mercury porosimetry, SEM and XRD analysis. Tape casting has been the green production technique. The thermal treatment has been divided into two steps: a complete oxidation to NiO and Al_2O_3 and a reduction/sintering at high temperatures, to reduce NiO to Ni, keeping Al_2O_3 strengthening power and obtaining a resistant structure [2].

The compared Ni–Al (4–10%) powders are divided into the spherical shaped (sample A) deriving from gas atomisation (Fig. 1) and the non-spherical shaped (sample B), with irregular granulometry and a coarse surface, obtained from mechanical alloying (Fig. 2).

Rather similar particle size distributions with the most frequent value about 10 μm are displayed in the porosimetric analysis (Figs. 3 and 4).

Differences in composition appear in the XRD analysis (Figs. 5 and 6): powders A pattern confirms the presence as a unique phase of Ni–Al solid solution (lattice parameters are different from the value of pure nickel); sample B contains a small quantity of free Al, too.

The atmosphere and temperatures of the complete oxidation have been fixed.

The reduction/sintering operation conditions are summarised in the Table 1.

Test 1 shows that the spherical powders produce anodes with a bimodal pore size distribution centred at 0.1 and 3.7 μm with a total porosity of about 50%. An increase of the sintering temperature creates a reduction of porosity—in particular it reduces the contribution of the smaller pores—but it lets the most frequent pore sizes unchanged (Fig. 7).

On the contrary, a monomodal distribution characterises the porosimetry of the non-spherical powders-based anode with a greater percentage porosity of about 70% and an average diameter of 5 μm.

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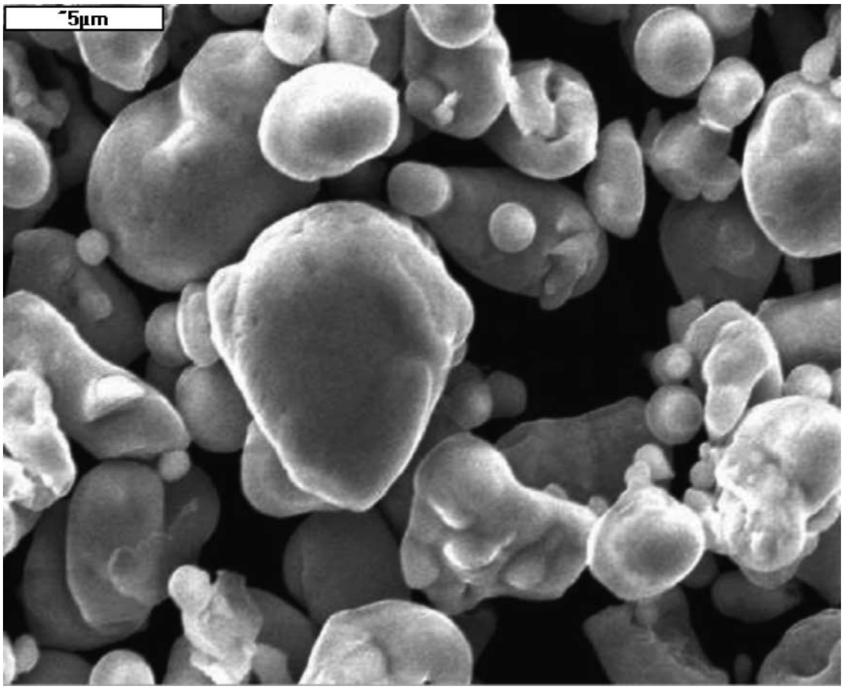

Fig. 1. SEM image of the spherical shape powders identified as sample A (5000×).

In the second test the higher temperature has no notable effect on the final properties (Fig. 8).

The formation of small pores is possible because of a volume change due to Ni oxidation/reduction, according to literature [3] and it is what has been verified with powders A anode. This effect is absent when starting with non-spherical powders which moreover, do not sinter very easily. In fact a reduction of 6% of porosity has been obtained just tripling the sintering time at Ts2.

The above mentioned difference in sintering is visible in the following representative SEM images (Figs. 9 and 10).

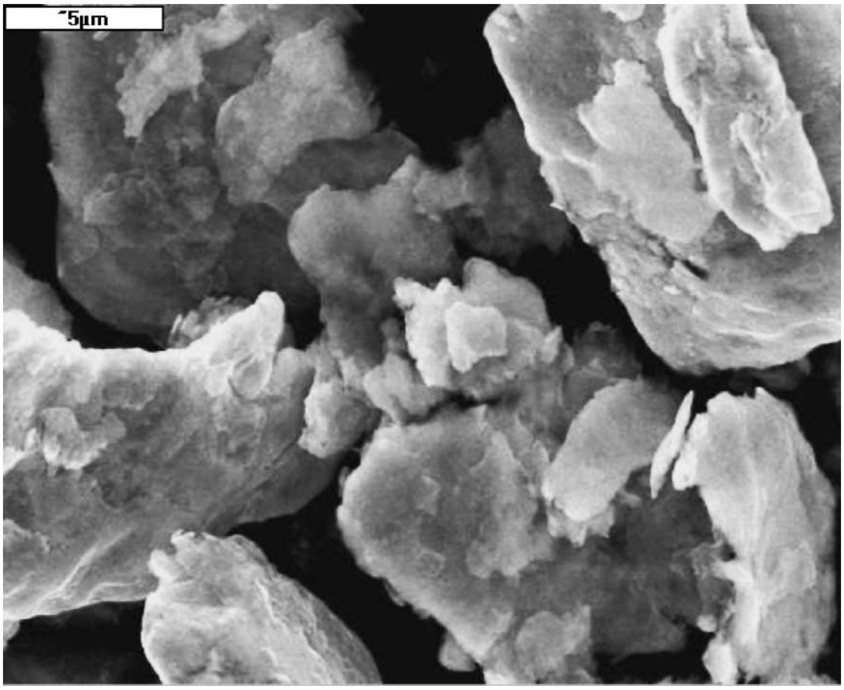

Fig. 2. SEM image of the non-spherical shape identified as sample B (5000×).

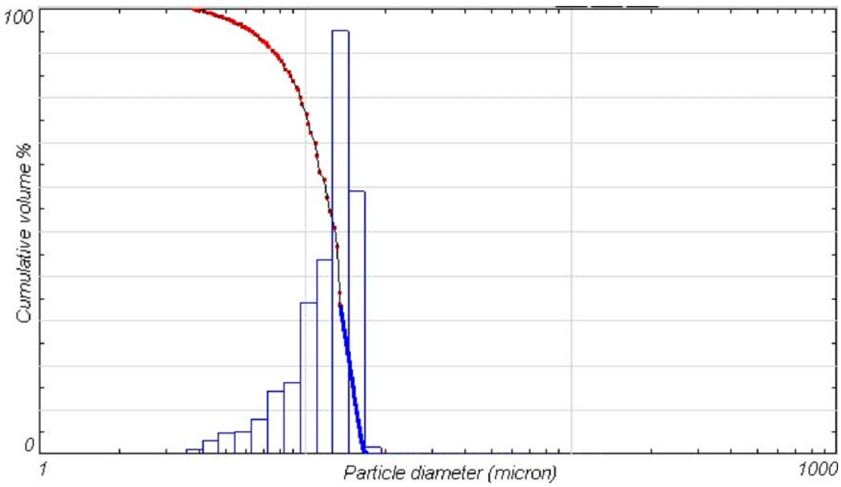

Fig. 3. Spherical powders particle size distribution.

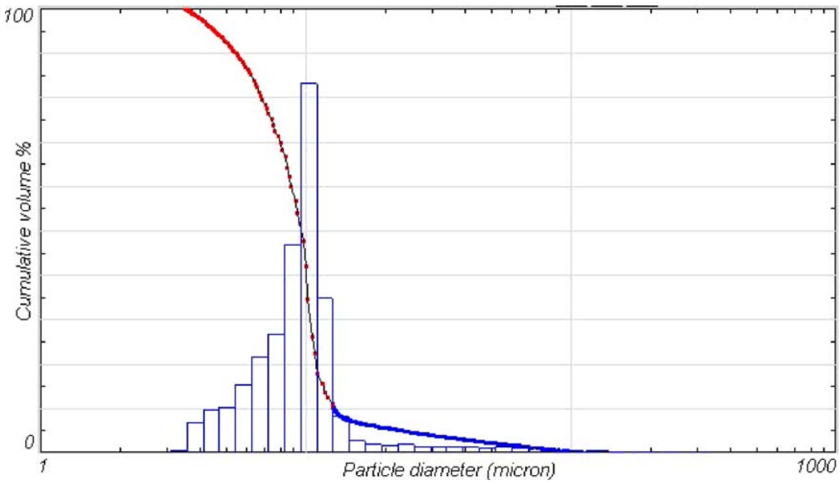

Fig. 4. Non-spherical powders particle size distribution.

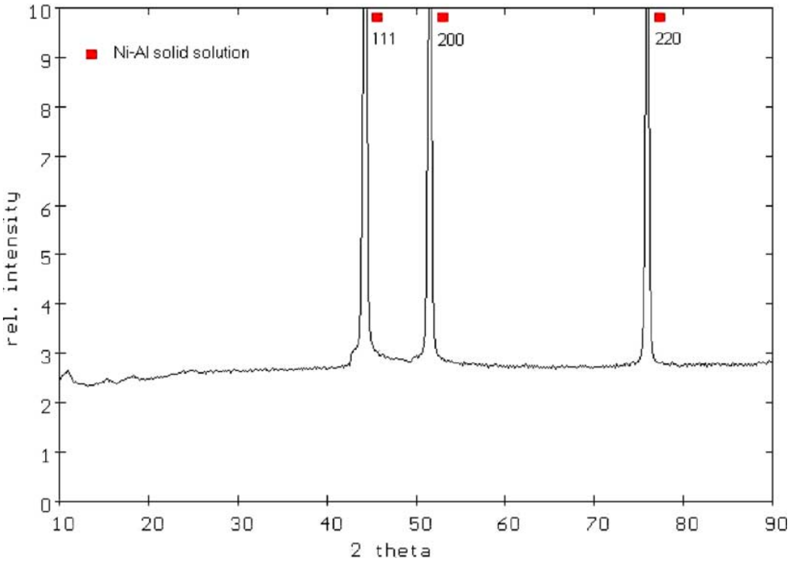

Fig. 5. Spherical powders XRD pattern. Ni–Al solid solution is the unique phase.

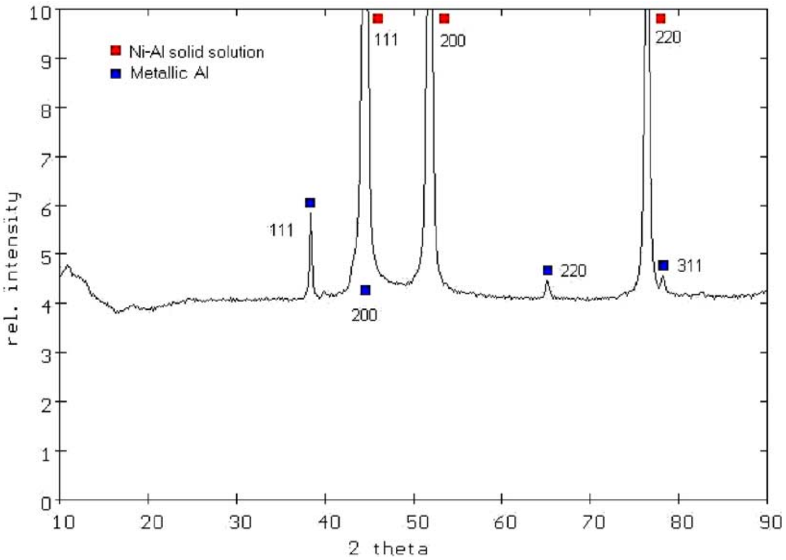

Fig. 6. Non-spherical powders XRD pattern. Ni–Al solid solution and free Al are present.

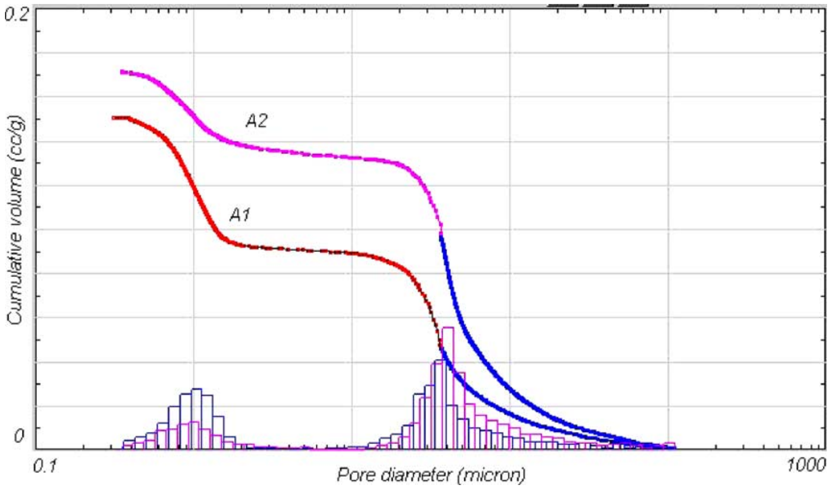

Fig. 7. Pore size distributions of the spherical powders-based anodes; A-2 has been sintered at Ts2 > Ts1.

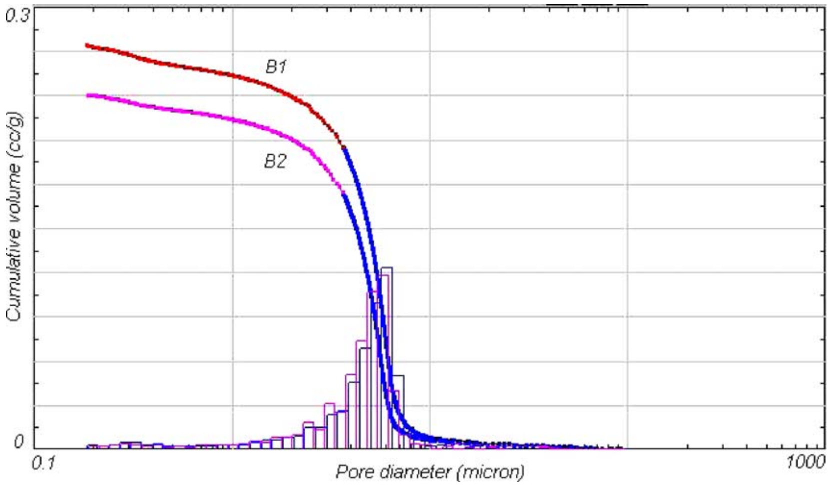

Fig. 8. Pore size distributions of the non-spherical powders-based anodes; B-2 has been sintered at Ts2 > Ts1.

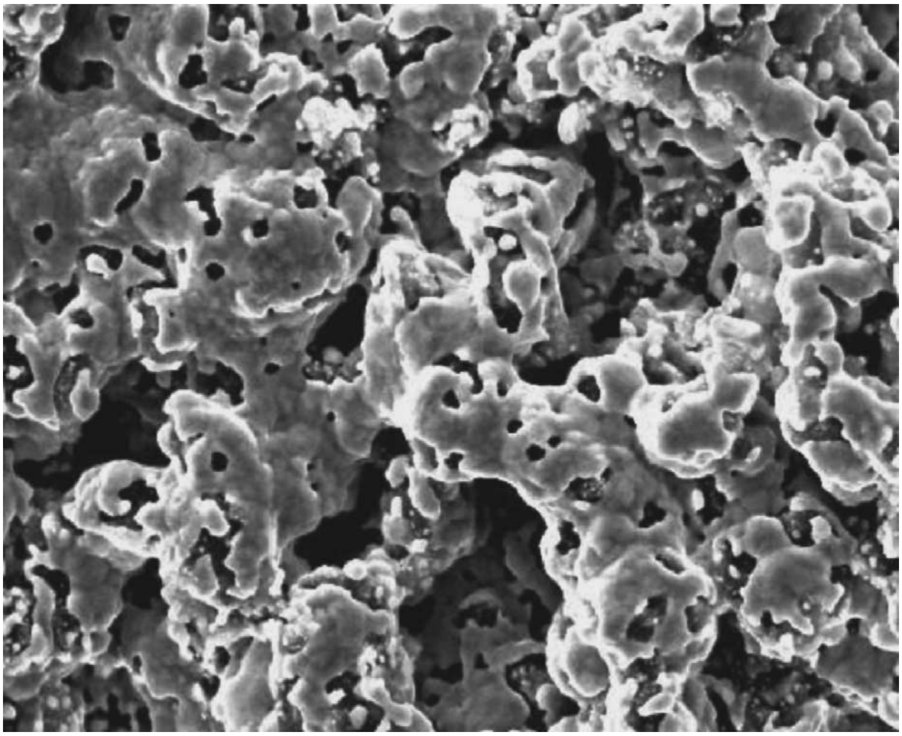

Fig. 9. Spherical powders-based anode SEM image (2000×).

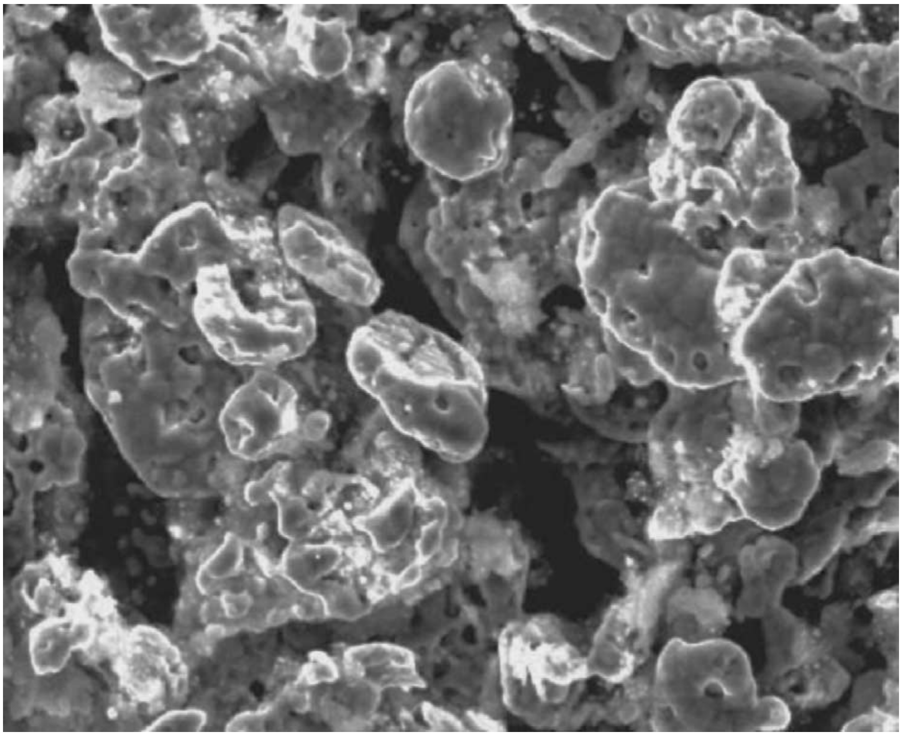

Fig. 10. Non-spherical powders-based anode SEM image (2000×).

Table 1
Thermal treatments (Tr: reduction temperature; Ts: sintering temperature; Ts2 > Ts1)

Sample identity	Thermal treatment	
Sample A		
A-1	Tr for 2 h	Ts1 for 0.5 h
A-2	Tr for 2 h	Ts2 for 0.5 h
Sample B		
B-1	Tr for 2 h	Ts1 for 0.5 h
B-2	Tr for 2 h	Ts2 for 0.5 h

3. Conclusions

For a typical MCFC anode the advised porosity and pore diameter are included in these ranges: 45–70%; 3–6 μm [4]. Making reference to these values, both powders can be used as a raw material, according to the characteristics the anode must have in accordance with the other porous components in the cell.

About the micropore family, it still needs a longer study, in order to take advantage of that or trying by some further treatment to eliminate it.

References

[1] O. Paladino, M. De Francesco, C. Resini, P. Capobianco, A. Sabattini, E. Bergaglio, Performance of Ni/Mg/Fe oxide cathode and Ni/Al anode for MCFCs by the post test analysis of their pore size distribution, poster presentation, Fuel Cell Seminar, 2002.
[2] A. Sabattini, E. Bergaglio, P. Capobianco, A. Torazza, Massive thermal treatment effect on Ni–Al alloy based electrodes final properties, in: Proceedings of the 19th National Meeting on Thermal Treatment, Salsomaggiore, Italy, 2003.
[3] G. Kim, Y. Moon, D. Lee, Preparation of creep resistant Ni–5 wt.% Al anodes for molten carbonate fuel cells, J. Power Sources 84 (2) (2002) 181–189.
[4] Fuel Cell Handbook, fifth ed., EG & G Services Parsons Inc., 2000.