Optimization of the large scale synthesis of the LSF-20 cathode material for SOFCs

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Introduction

Solid oxide fuel cells (SOFCs) have the potential to be one of the cleanest and most efficient energy technologies for direct conversion of chemical fuels to electricity.

Requirements to be economically competitive for commercialization.

Continuous innovation of materials and fabrication processes to enhance system lifetime and reduce cost.

Technologies for synthesis of SOFC materials. These requirements originate from the demands for large scale SOFC industrial production [1].

Solution combustion synthesis (SCS) is a simple and reproducible method used to obtain several types of ceramic oxides for applications [2,3].

Scientific Approach

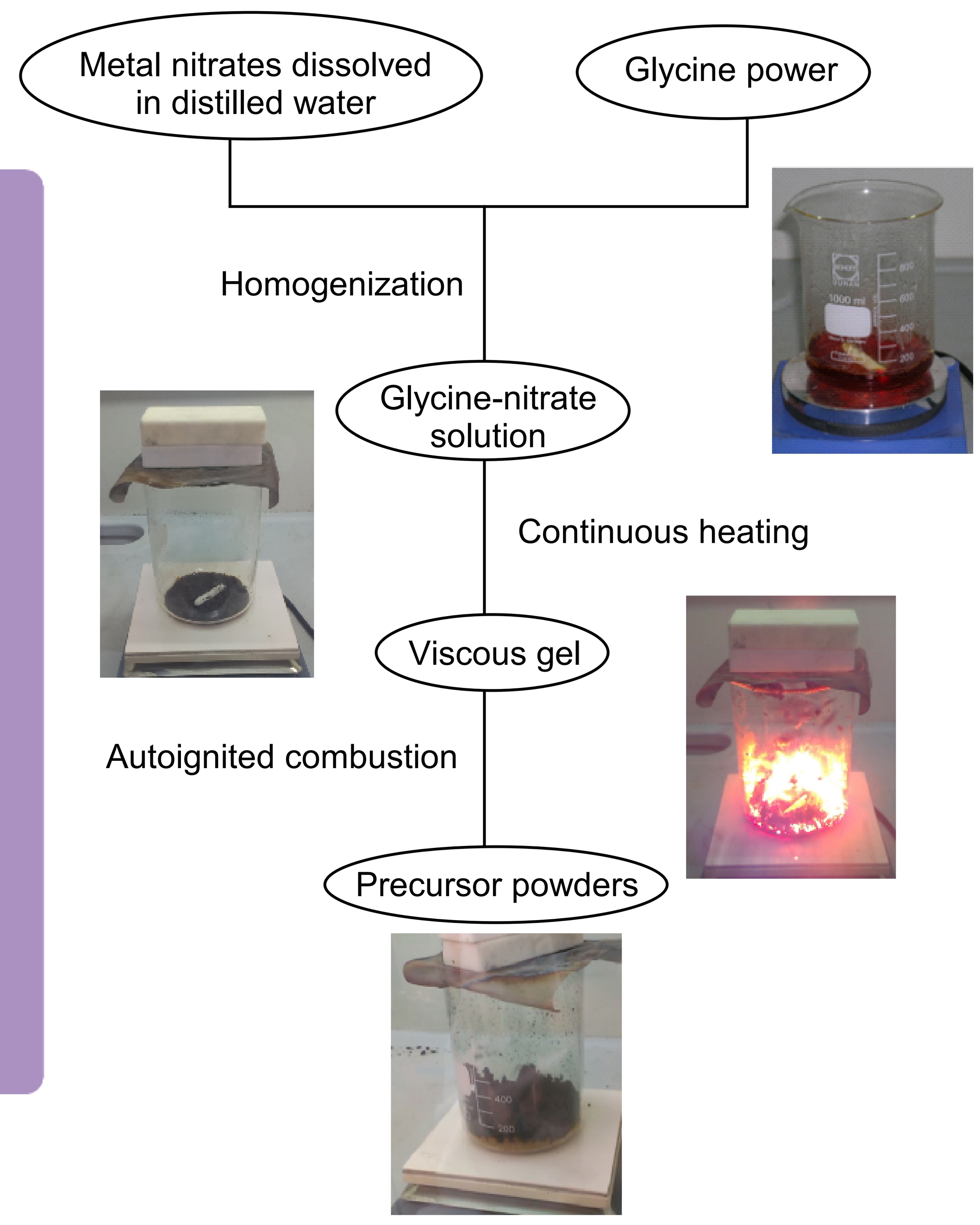
The objective of this work is to obtain, on a large scale, the perovskite-type oxide $La_{0.8}Sr_{0.2}FeO_3$ (LSF-20) that shows promising properties as cathode for SOFC applications.

Synthesis

• Stoichiometric amounts of the metal nitrates, to yield 15 g of the final LSF-20 oxide powder, were dissolved in distilled water. The solutions were mixed in a 1 litre glass beaker, which was placed on a hot plate, under constant stirring, to evaporate the excess water. The synthesis was carried out varying the fuel/oxidizer ratio (G/N = 0.5, 1.0 and 1.5).

• The resulting viscous liquid autoignited after placing the glass beaker directly in a preheated plate (at 450ºC).

• The resulting powders were pelletized and calcined in air between 600 and 850ºC for 5 hours to obtain the pure samples.

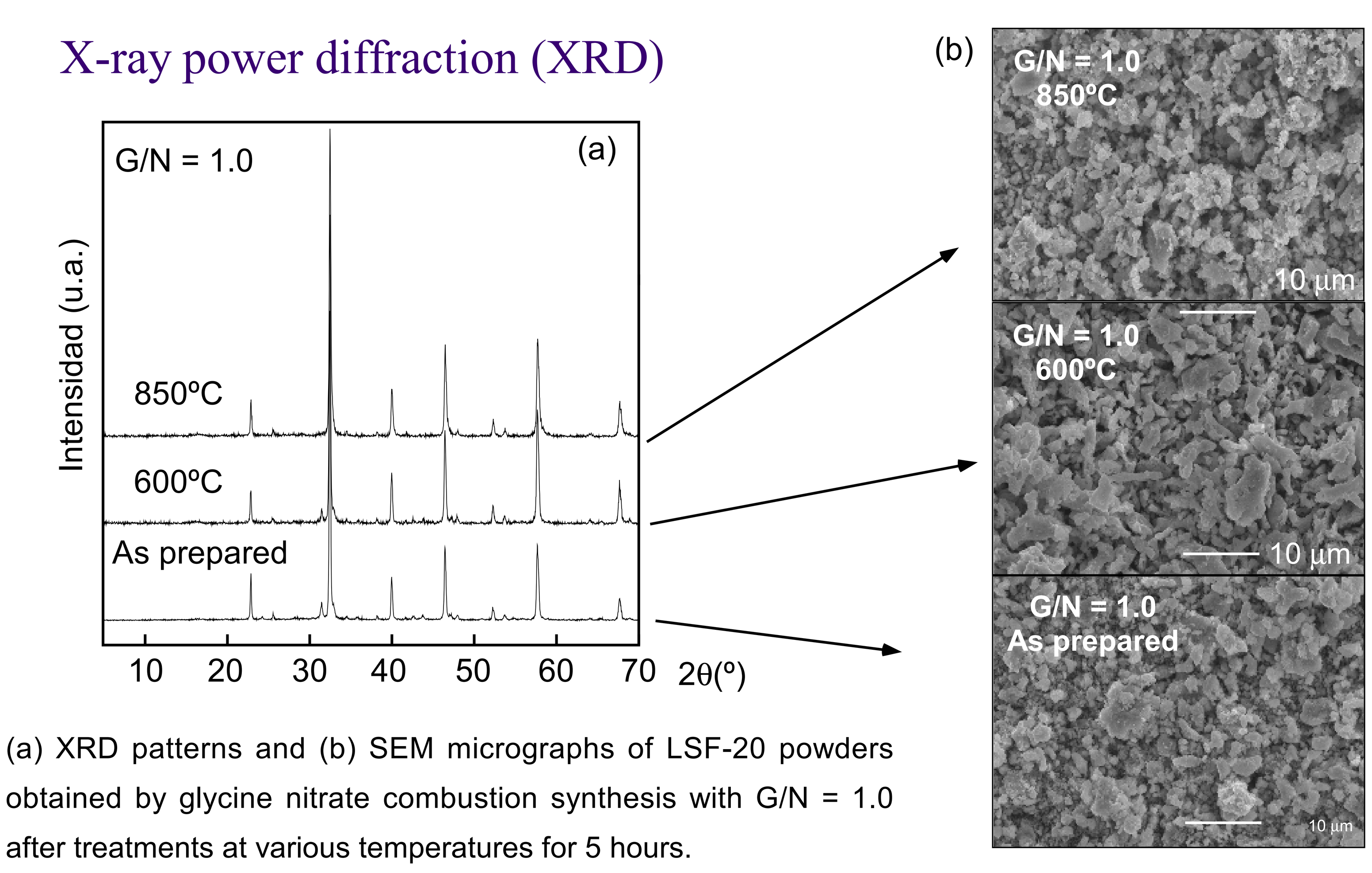


Scheme of glycine nitrate combustion synthesis.

Evolution of Synthesis

X-ray power diffraction (XRD)

Scanning electron microscopy (SEM)



(a) XRD patterns and (b) SEM micrographs of LSF-20 powders obtained by glycine nitrate combustion synthesis with G/N = 1.0 after treatments at various temperatures for 5 hours.

The as-prepared LSF-20 powder shows weak crystallinity of the perovskite phase. Formation of the perovskite phase, $La_{0.8}Sr_{0.2}FeO_{3-\delta}$, is completed above 850°C as observed by XRD results.
The as-prepared powders are highly porous and particles are linked together in agglomerates of different shapes and sizes. Substantial particle growth is observed upon calcination at higher temperatures. The particle size of sample calcined at 850°C increases but the structure remained highly porous, which resembled the typical cathode structure for SOFC.

Characterization

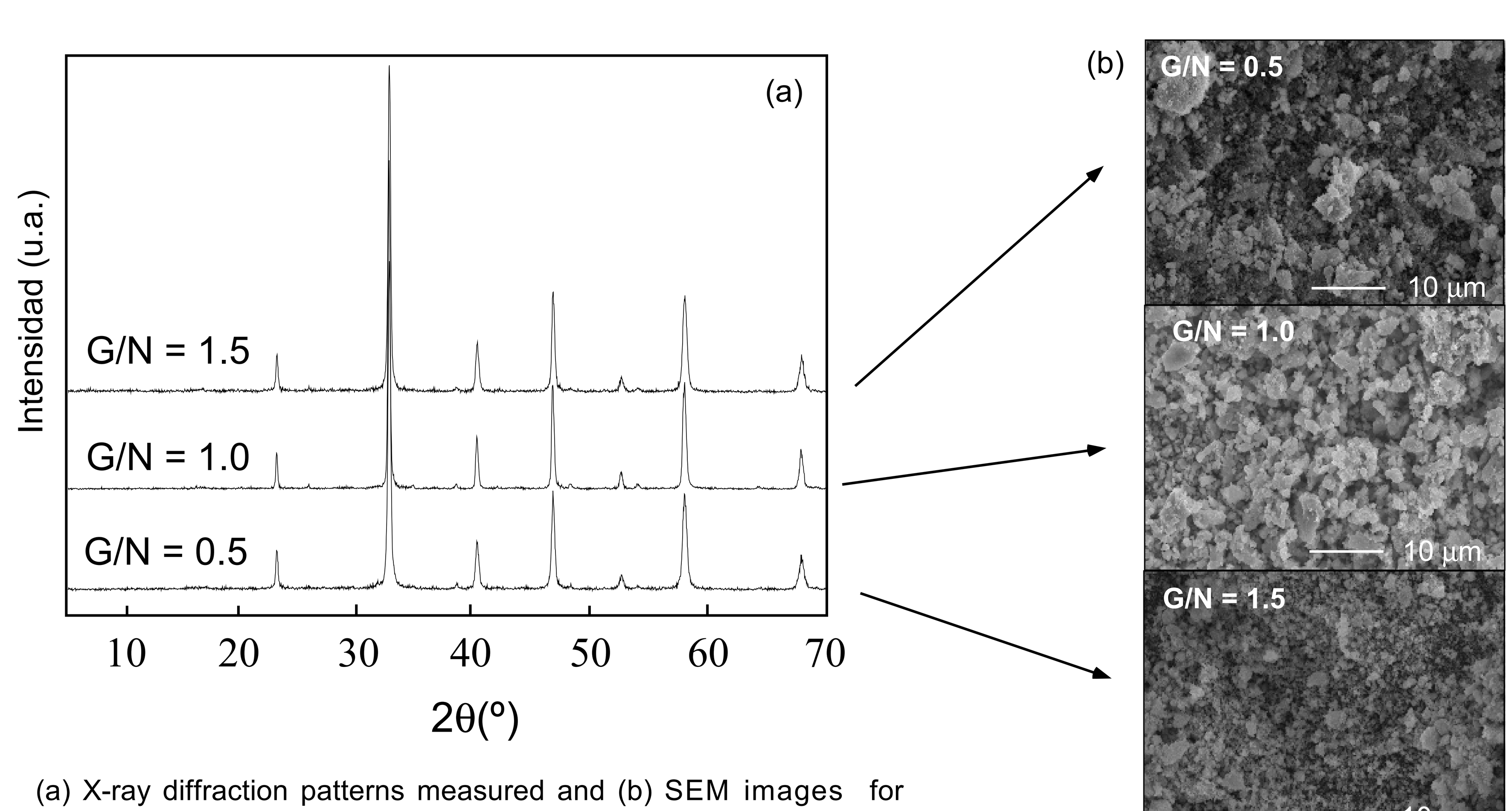
Inductively coupled plasma (ICP)

Summary of the ICP analyses for the samples with nominal composition of $La_{0.8}Sr_{0.2}FeO_3$.

Sample	Experimental composition
G/N = 1.5	$La_{0.78(2)}Sr_{0.20(1)}Fe_{1.00(3)}O_3$
G/N = 1.0	$La_{0.78(2)}Sr_{0.20(1)}Fe_{1.00(3)}O_3$
G/N = 0.5	$La_{0.75(2)}Sr_{0.15(1)}Fe_{1.00(3)}O_3$

X-ray power diffraction (XRD)

Scanning electron microscopy (SEM)



(a) X-ray diffraction patterns measured and (b) SEM images for LSF-20 perovskites obtained at 850ºC by the glycine-nitrate route using different amounts of fuel/oxidizer ratio (G/N = 0.5, 1.0 and 1.5).

SEM images of the perovskite powders calcined at 850ºC.

The samples crystallize as single phase in the orthorhombic space group Pnma.

As observed, no significant differences can be found in the morphology or the average particle size in these samples. The samples are composed of nanosized particles which agglomerate into grains.

Conclusions

15 g of LSF-20 cathode material has been succesfully synthesized by the solution combustion synthesis, varying the fuel/oxidizer ratio, being suitable for scalable synthesis.

The microstructural properties of the samples are appropriate for application as cathode material in SOFCs.

Acknowledgements

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