TiO_2 templated films used as photoelectrode for solid-state DSSC applications: Study of the solid electrolyte infiltration by Rutherford Backscattering Spectrometry

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INTRODUCTION

In solid-state dye-sensitized solar cells, optimal TiO_2 films thickness is limited to a few microns allowing the adsorption of only a low quantity of photoactive dye and thus leading to poor light harvesting and low conversion efficiency. In order to overcome this limitation, high surface area templated films are investigated as alternative to nanocrystalline films prepared by doctor-blade or screen-printing. In this study, films prepared from different structuring agents are discussed in terms of microstructural properties (pore size, surface area) as well as impact on the dye loading and Spiro-OMeTAD (2,2',7,7'-tetrakis-(N,N-di-p-methoxyphenylamine)9,9'-spirobifluorene) solid electrolyte filling. We report Rutherford Backscattering Spectrometry as an innovative non-destructive tool to characterize the hole transporting materials infiltration. Templated films show dye loading more than two times higher than nanocrystalline films prepared by doctor-blade or screen-printing and solid electrolyte infiltration up to 88%.

SYNTHESIS OF TEMPLATED FILMS

1. Film deposition by dip-coating

2 processes:

Evaporation Induced Self-Assembly (EISA)

Micelles formation after film deposition solvent evaporation

Evaporation Induced Micelles Packing (EIMP)

Pre-existing micelles

Film organisation

2. Stabilisation (S)

15min 300°C

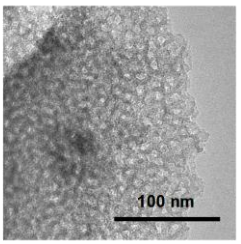
- Evaporation of solvents and volatile species
- Condensation of the inorganic network

3. Calcination (C)

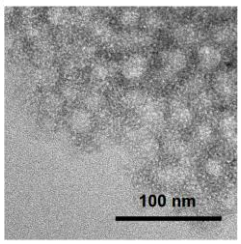
30min 500°C
500°C/h

- Thermal decomposition of the structuring agent
- Further condensation
- Anatase crystallisation

PORE SIZE vs SURFACE AREA



P123 ($PEO_{20}PPO_{70}PEO_{20}$)



PSA (PS(16400)-PEO(36400)

Pore size = 8-10 nm → Pore size = 15-17 nm

Surface area

DYE LOADING

Sample	Dye loading (mol/cm³)
P123	2.4×10^{-4}
PSA	2.0×10^{-4}
Nanoparticles (commercial ref.)	1.0×10^{-4}

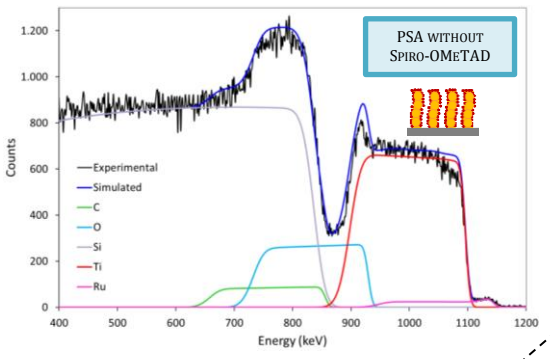
Dye loading 2x higher for templated films

PRELIMINARY PHOTOVOLTAIC TESTS

Cell	Film thickness (μm)	V_{oc} (V)	J_{sc} (mA/cm²)	FF	η (%)
PSA	1.6	0.674	3.3	0.42	1.2
Nanopart. Ref.	1.8	0.650	3.6	0.48	1.4

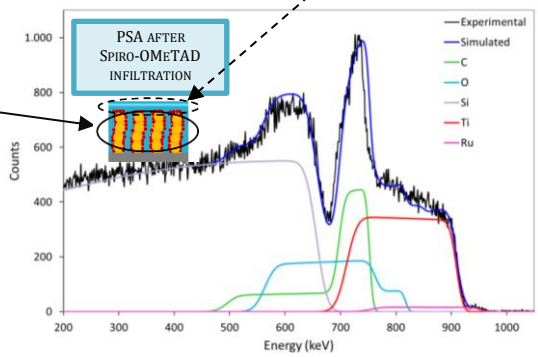
ACKNOWLEDGMENTS:

PORE FILLING OF SPIRO-OMETAD BY RUTHERFORD BACKSCATTERING SPECTROMETRY



Carbon and Oxygen signals: Steps after Spiro infiltration → overlayer of Spiro

Titanium signal: No step, broader, less intense after Spiro infiltration → Homogenous infiltration of Spiro inside the TiO_2 network



PORE FILLING FRACTION EXTRACTED FROM RBS SPECTRA

Sample	Spiro-OMeTAD pore filling fraction	Thickness of Spiro-OMeTAD coverage inside the pores (nm)
P123	88%	2.0
PSA	63%	2.1

- Efficient infiltration of Spiro-OMeTAD, even for pore size of only 8nm
- Spiro-OMeTAD monolayer coverage of the pores (~ 2nm thick) → efficient regeneration of the dye