Long term stability of TiO_2 templated multilayer films used as high efficiency photoelectrode in liquid DSSCs

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INTRODUCTION

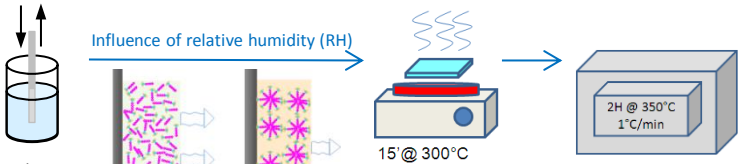
To our knowledge, the stability results reported in the literature only concern cells made from classical doctor-bladed or screen-printed nanoparticles films.

This study focuses on the comparison of the long-term stability of these cells with DSSCs working with templated mesoporous films. Indeed, the increased surface area of templated films could lead to a faster degradation of the resulting cells.

In accordance with IEC:1646:1996 standard tests, light soaking test at 45°C has been applied to determine the cells stability under prolonged illumination. Moreover, thermal stress in the dark has been applied. Unfortunately, due to the sealing material heat resistance, thermal stress test was only performed at 45°C.

TEMPLATED FILMS SYNTHESIS

1. Dip coating — **2. Stabilisation (S)** — **3. Calcination (C)**



Solution:
- Butanol
- $Ti(OiPr)_4$
- PEO-PPO-PEO
- HCl

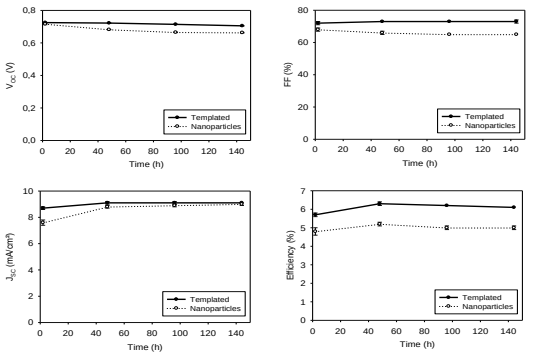
- Evaporation of solvent and volatile species
- Condensation of inorganic network

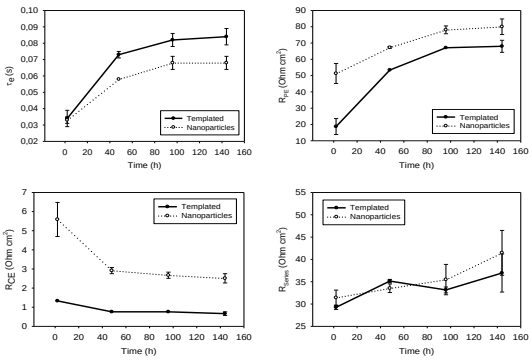
- Thermal decomposition of PEO-PPO-PEO micelles
- Further condensation
- Crystallization

PHOTOVOLTAIC CHARACTERIZATION

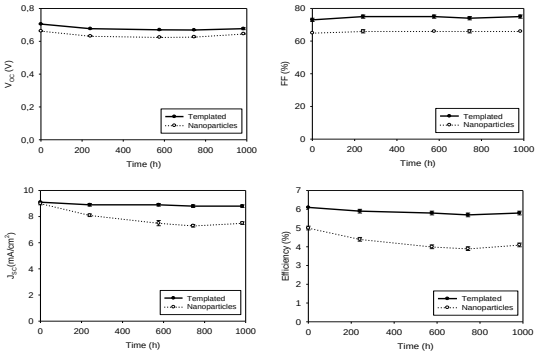
ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY (EIS)

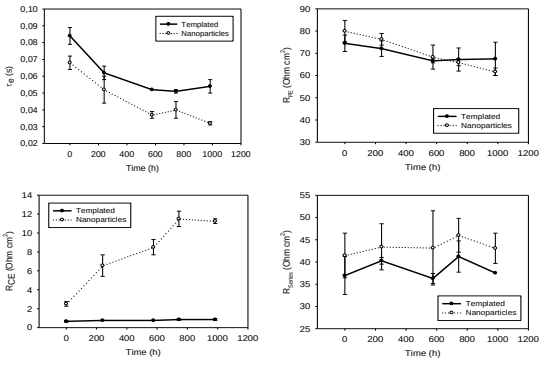
LIGHT SOAKING (0.7SUN illumination, 45°C, 144h)





THERMAL STRESS (dark, 45°C, 1000h)





R_{series} = series resistance, R_{CE} = charge transfer resistance at the counter-electrode, R_{PE} = photoelectrode total resistance, τ_e = electron lifetime in the photoelectrode.

CONCLUSIONS

- Templated samples are stable upon light soaking and thermal stress (45°C). The higher surface area of templated films thus does not promote faster cell degradation, and templated layers are even more stable than nanoparticles films upon thermal stress.
- From EIS characterization, templated samples show lower resistances and longer electron lifetime compared to nanoparticles DSSCs, which leads to the higher photovoltaic efficiency. Templating route improves the crystallites connectivity, the contact between the porous layer and the substrate, which enhances the electron transfers. The use of templated films instead of nanoparticles layers is therefore really promising for DSSC applications.
- Light soaking and thermal stress tests do not affect the cells in the same way. Light soaking leads to an increase of the electron lifetime in the photoelectrode and promotes trap states formation over time whereas thermal stress favors recombinations at the TiO_2/electrolyte interface leading to a decrease of the electron lifetime over time.

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