Hydrothermal synthesis of TiO_2 nanostructures on conducting glass: Effect of Time and Temperature on Morphology and Specific surface area towards Improved Light harvesting & Charge Transport in DSSCs

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INTRODUCTION

The importance of TiO_2 nanostructures in sensors, photocatalysis or photovoltaics can't be overemphasized. Hydrothermal method of synthesis offers a process by which TiO_2 can be grown from solution. This method is quite interesting because of the option to use solvents, reagents and Ti compounds of choice. Additives can also be added in addition to free choice of temperature value and reaction time to obtain desired structure. Hydrothermal synthesis is carried out in an autoclave: a closed system.

OBJECTIVE

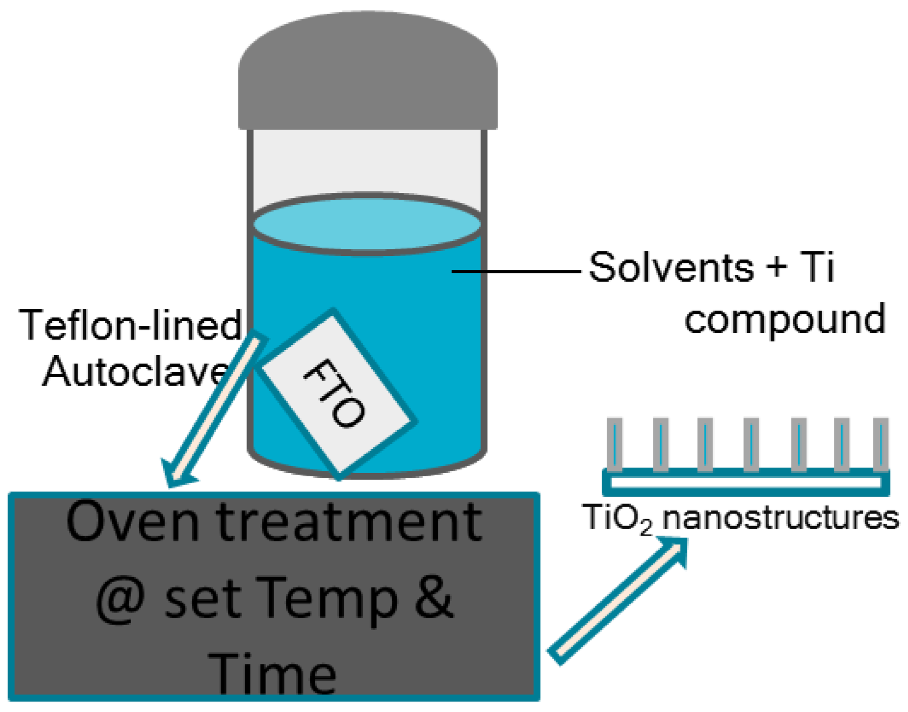
To grow/synthesize TiO_2 nanostructures with optimal active surface area for dye adsorption and electron transport properties to achieve DSSC devices.

EXPERIMENTAL

Substrate (FTO) Preparation

- Cleaning by sonication
- Blocking layer on substrate by dip coating
- Crystallisation

Hydrothermal/Solvothermal Process



$TiCl_4$ Treatment

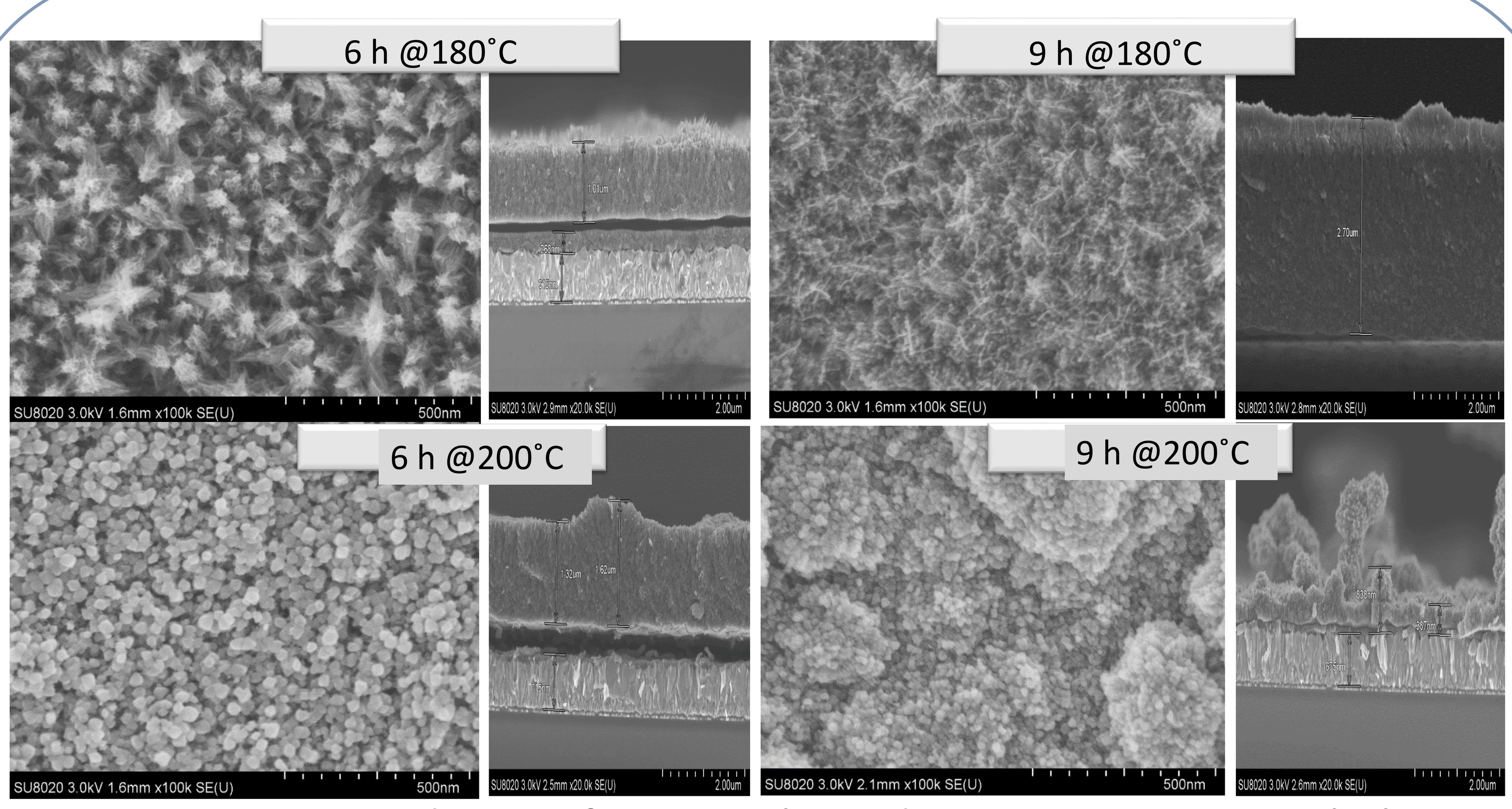
Thermal Treatment

Dye Impregnation

DSSC Assembly and Analysis

- HTM Infiltration
- Deposition of counter electrode
- IV measurements by solar simulator

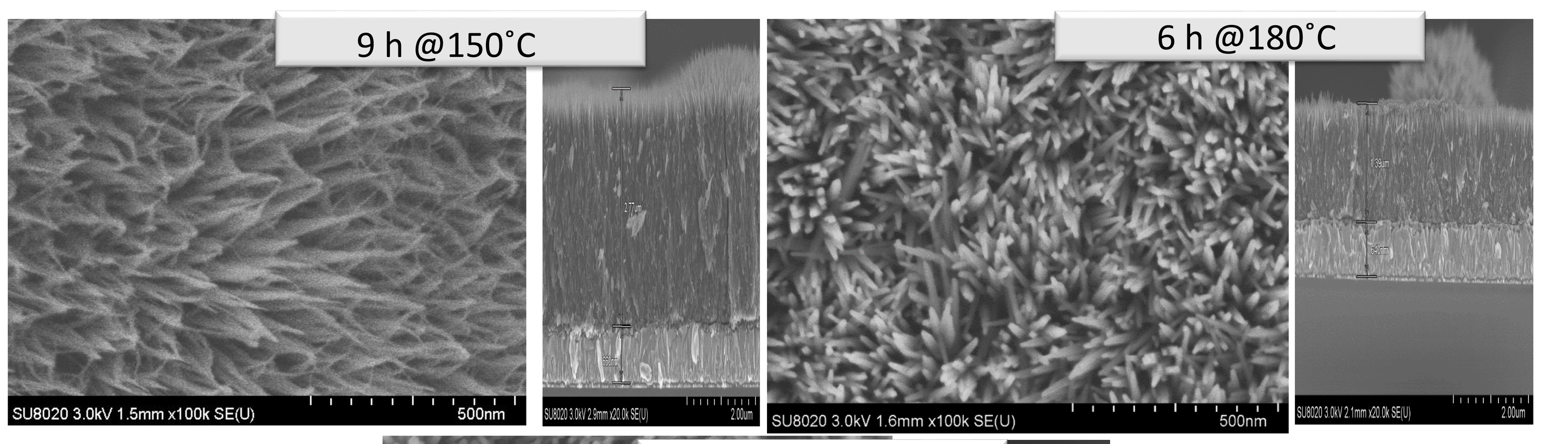
SEM of NS: from Organic + Water



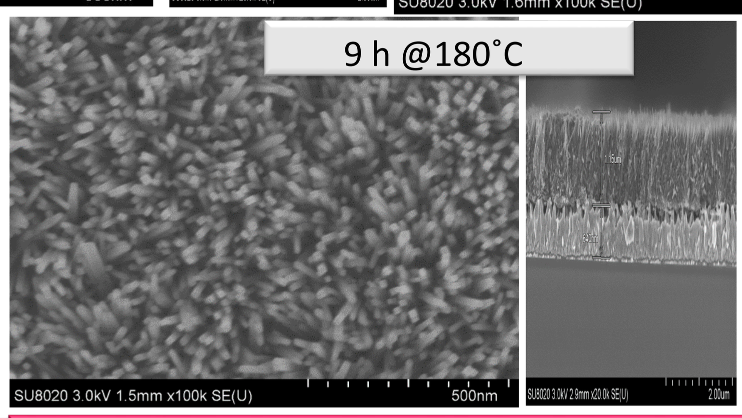
Temperature and time of reaction have direct impact on morphology and thickness.

In general, at high temperatures, after a given time, the thickness of NS begin to reduce by re-dissolving in solution.

SEM of NS: from Organic + Acid



Morphology becomes well defined and stable with relatively high temperature.



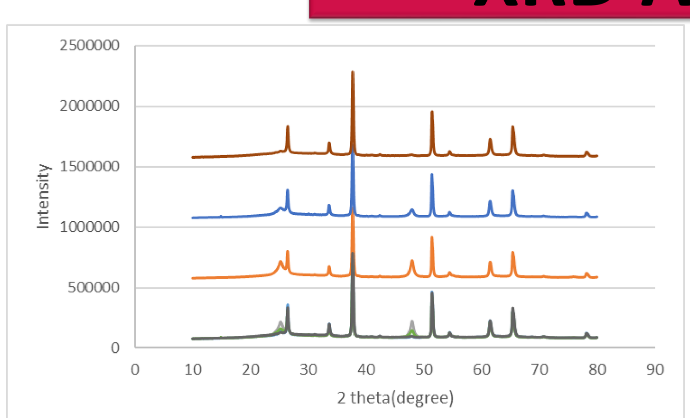
Thickness reduces at prolonged reaction time due to re-dissolving at the interface with solution.

Surface Area Analysis by UV-VIS

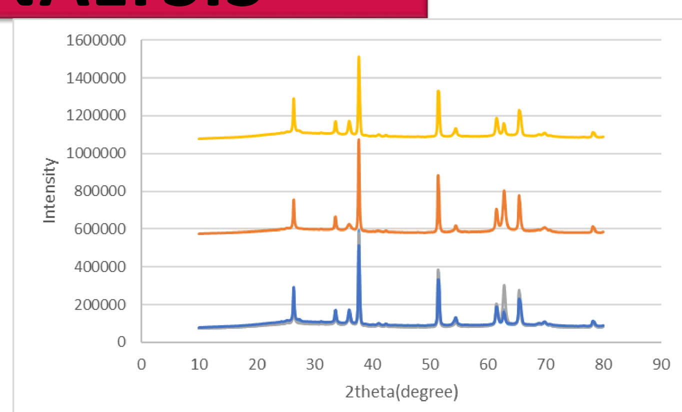
Sample	Thickness (µm)	Surface Area of NS (cm^2)	Specific Surface Area N719/ Vol. TiO_2 (m^2/cm^3)
	2,77	7,20	54,95
B	1,39	6,90	150,51
C	1,15	6,90	146,66
D	1,31	7,20	154,86
E	1,17	6,69	136,43

- NS grown in acid/organic have high specific surface area. This is highly dependent on the temperature and time of hydrothermal synthesis
- NS grown in contact with organic solution have insignificant specific surface area with respect to the ruthenium complex dyes.

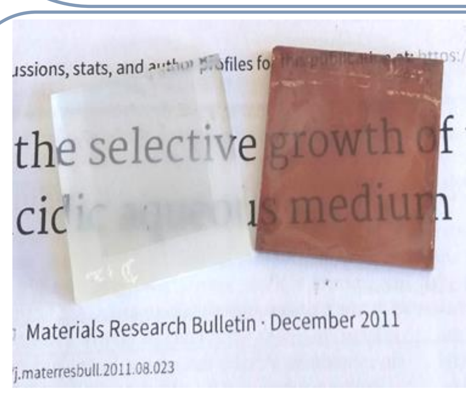
XRD ANALYSIS



XRD analysis revealed anatase polymorph for nanostructures grown in contact with solution in the presence of hydroxyl ions.



XRD analysis revealed rutile polymorph for nanostructures grown in contact with solution in the presence of chloride ions.



Interaction of TiO_2 nanostructures with the dye after impregnation

Solid state DSSC samples.

Conclusion

TiO_2 nanostructures as directly synthesized on conducting glass by hydrothermal method showed increased specific surface area. The conditions of synthesis are to be optimized for improved electron transport properties.

Current Challenges/Work to be done

There is a huge loss of electrons in the solar cells fabricated and this is highly responsible for the low cell efficiency recorded. This is suspected to be at the FTO/blocking layer/NS interface due to the adhesion problems encountered at the early stages of this research hence there is need to ensure direct electron transport at this section of the cell.

Aknowledgement

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