BETTER CALL TT25

A sensitizer for energy and fuel production

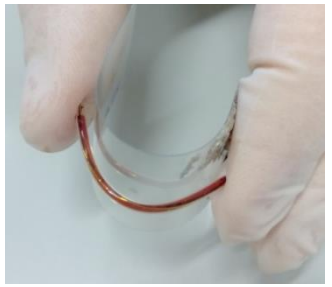
Alessio Dessì

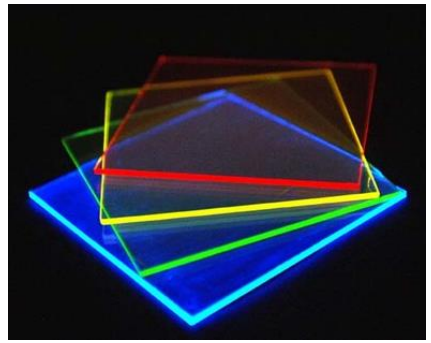
Light-to-Energy and Fuel (LEaF) Lab @CNR-ICCOM

Our Research in "Chemistry and Energy"

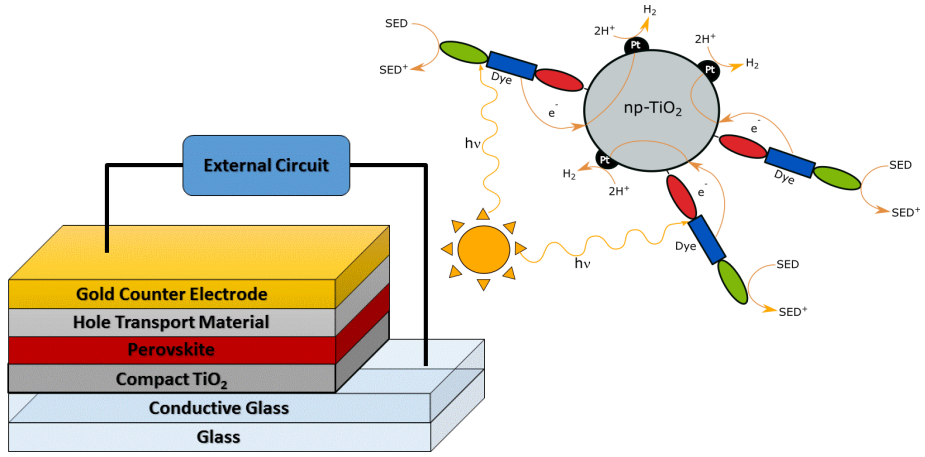
DSSCs
- Design and synthesis of new dyes
- Building-Integrated Photovoltaics
- Fiber-shaped Solar Cells

LSCs
Design and synthesis of new visible light-emitters





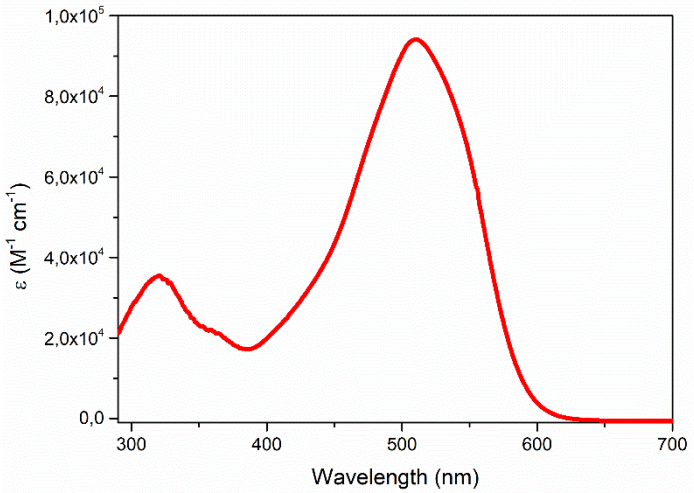
H_2
- New photocatalysts for H_2 production
- Sustainable electron donors
- Alternative TiO_2 polymorhs



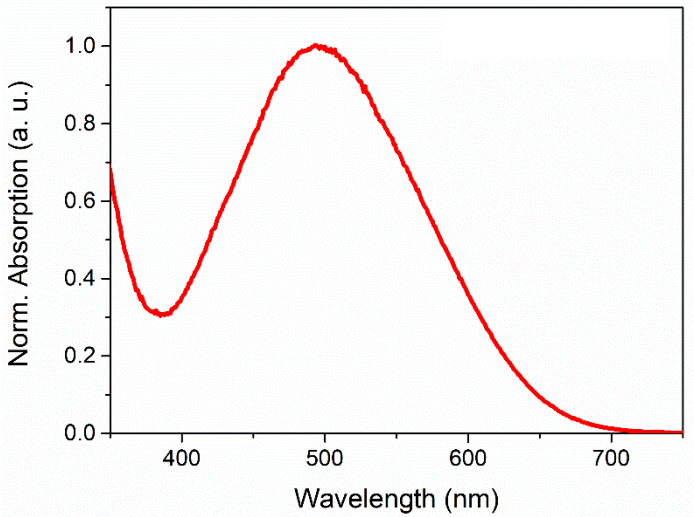
PSCs
Design and synthesis of new hole-transport materials (HTMs)

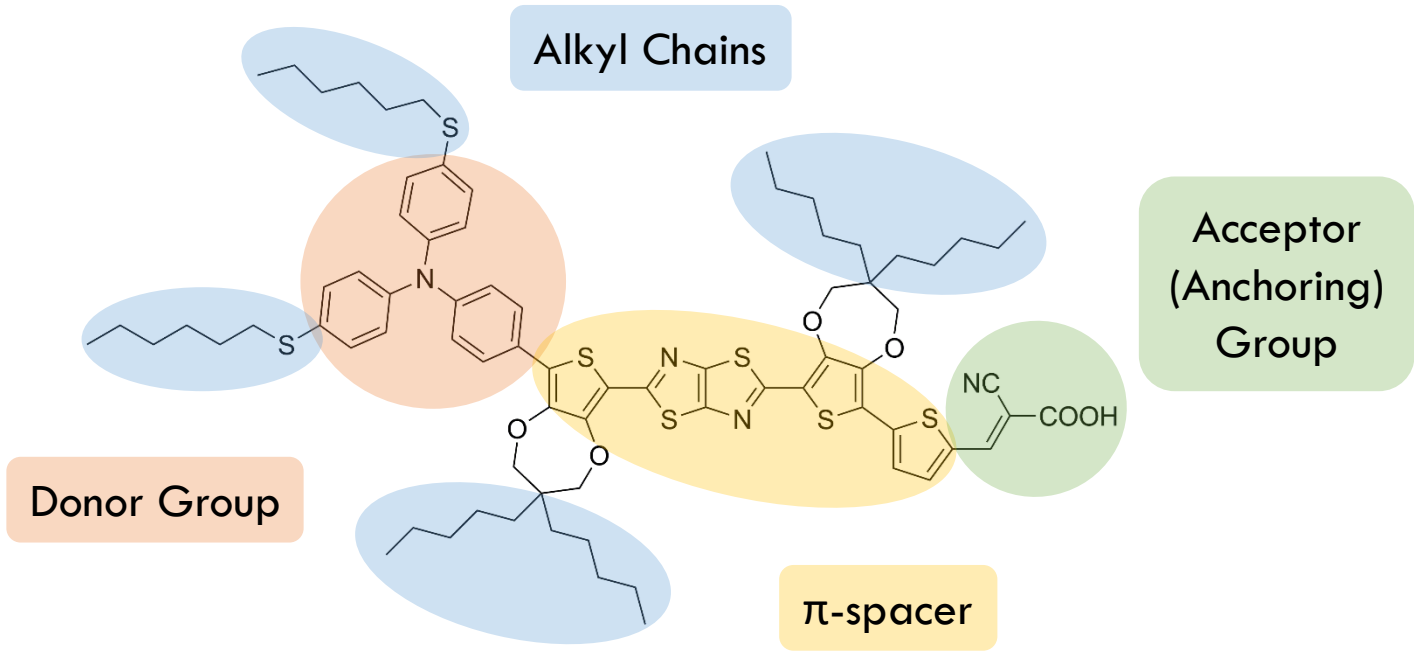
D-π-A Structure

In THF solution



On TiO_2

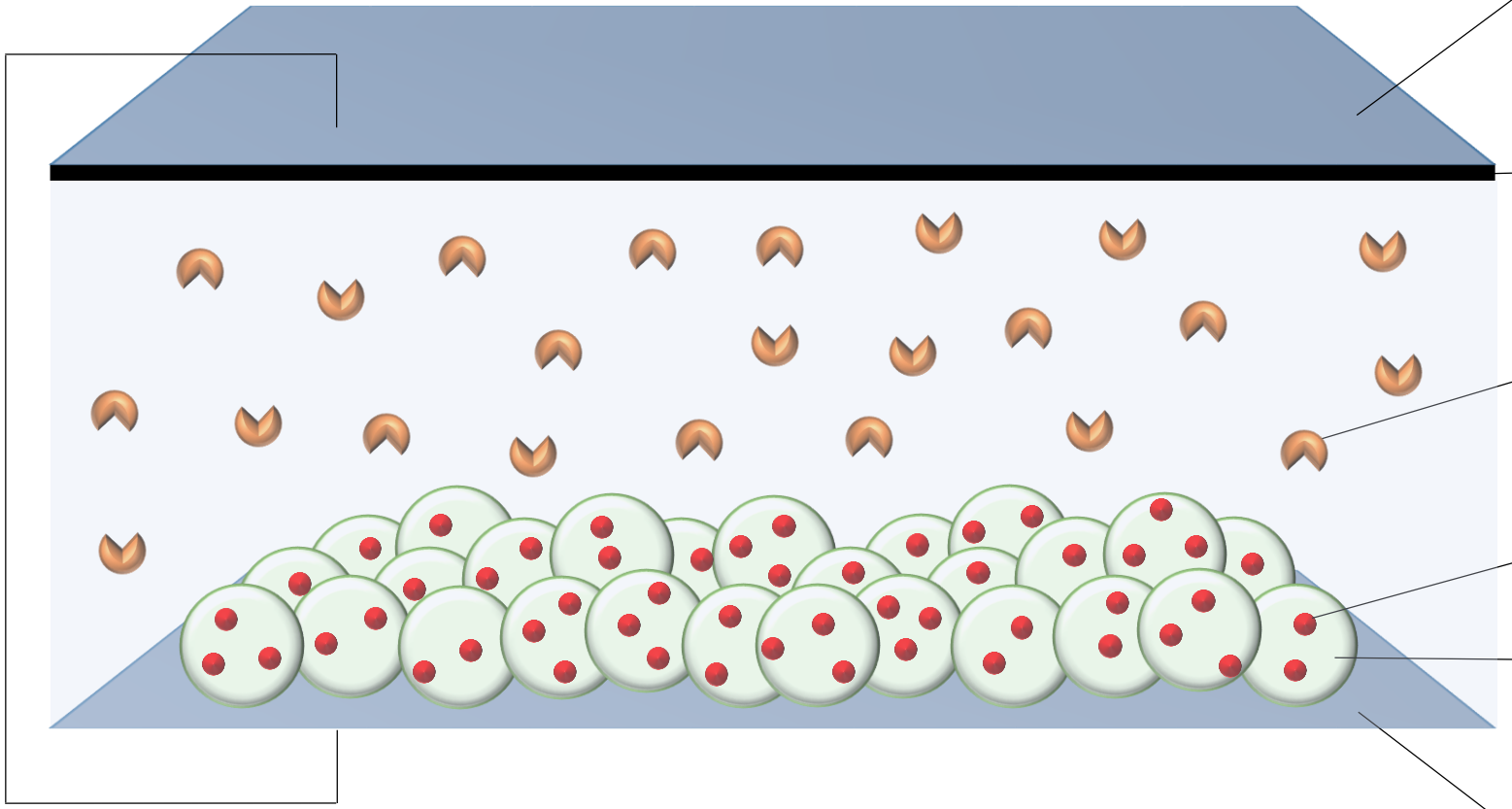




$\lambda_{abs.}$ [nm]	ε (x 10^4) [M^{-1} cm^{-1}]	$\lambda_{abs.}$ on TiO_2 [nm]	$E_{0\text{-}0}$ [eV]	E_{ox} [V][a]	E^*_{ox} [V][a]
510	**9.41**	487	2.24	0.99	– 1.25

[a] vs. NHE

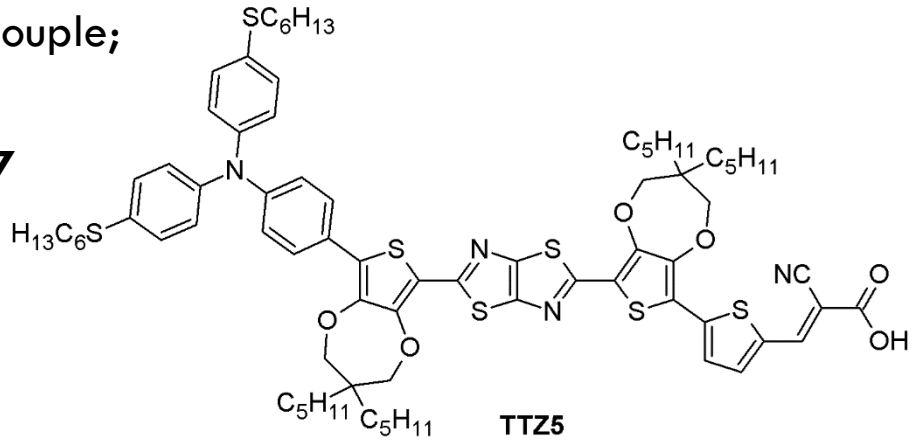
Dye-Sensitized Solar Cells (DSSCs)



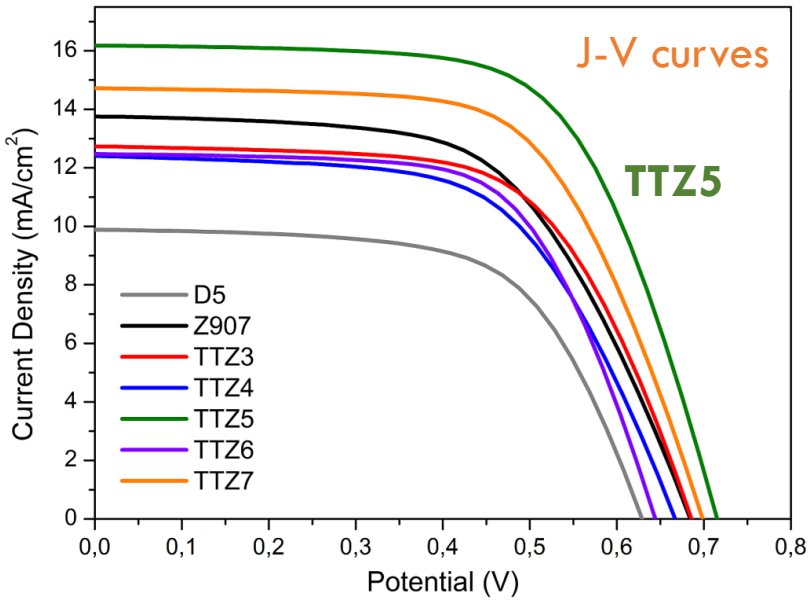
Dye-Sensitized Solar Cells (DSSCs) – Transparent thin-film devices

Simple fabrication: NO $TiCl_4$ treatment, NO scattering layer, I^-/I_3^- redox couple;

- Best result $\eta = 7.71\%$ for **TTZ5**, better than reference dyes **D5** and **Z907**
- Thin TiO_2 films: thickness **5.5 µm** / Surface area: **0.25 cm²**



TTZ5



- J_{sc} = short–circuit photocurrent density
- V_{oc} = open–circuit photovoltage
- *ff* = fill factor
- η = solar energy-to-electricity conversion yield
- P_{in} = power of incident sunlight (generally 100 mW cm^{-2})

$$\eta(\%) = \frac{P_{max.}}{P_{in.}} = \frac{(J_{sc.} * V_{oc.} * ff)}{P_{in.}}$$

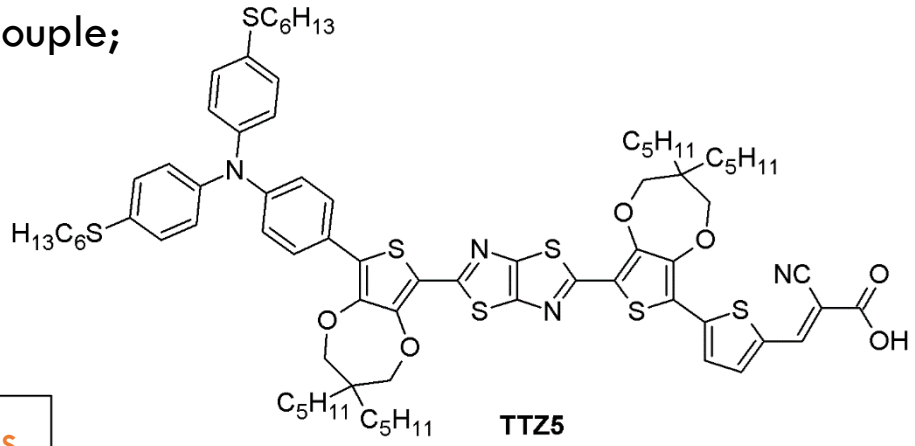
Chem. Commun., **2014**, *50*, 13952; *RSC Adv.*, **2015**, *5*, 32657

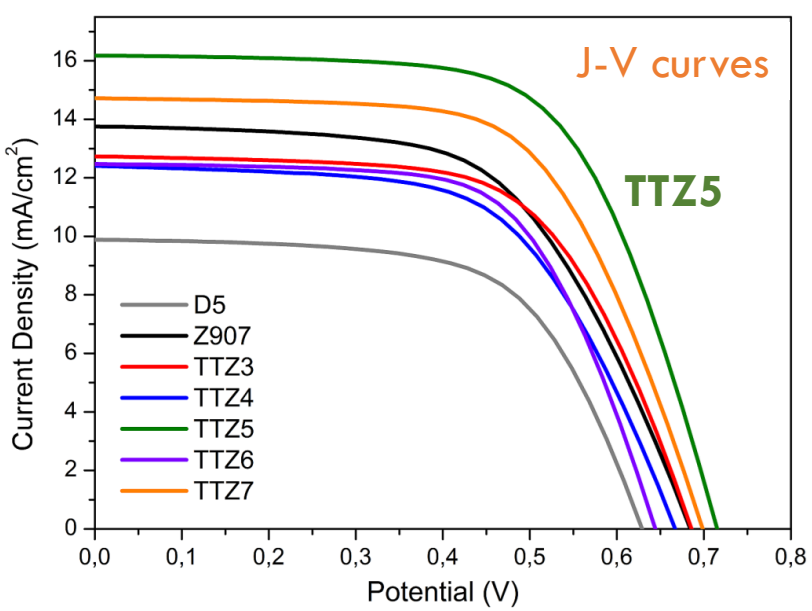
Prof. Aldo Di Carlo and Dr. Daniele Colonna, Center for Hybrid and Organic Solar Energy (C.H.O.S.E.)

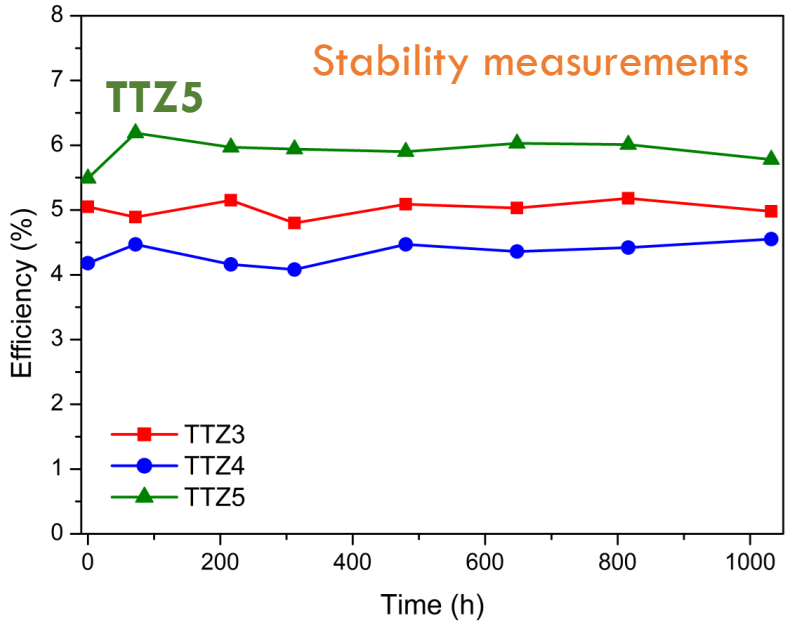
Dye-Sensitized Solar Cells (DSSCs) – Transparent thin-film devices

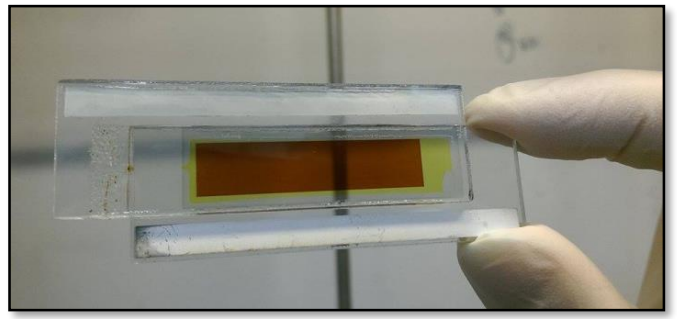
Simple fabrication: NO $TiCl_4$ treatment, NO scattering layer, I^-/I_3^- redox couple;

- Transparent TiO_2 films: thickness **3.0 µm** / Surface area: **3.6 cm²**
- Commercial high stability electrolyte (Dyesol HPE)









«Strip» DSSC

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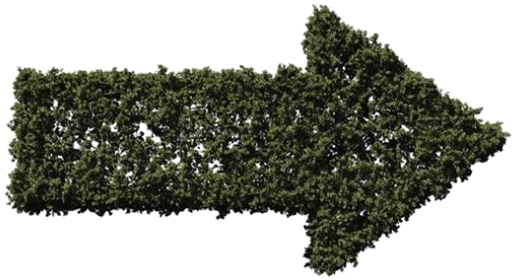
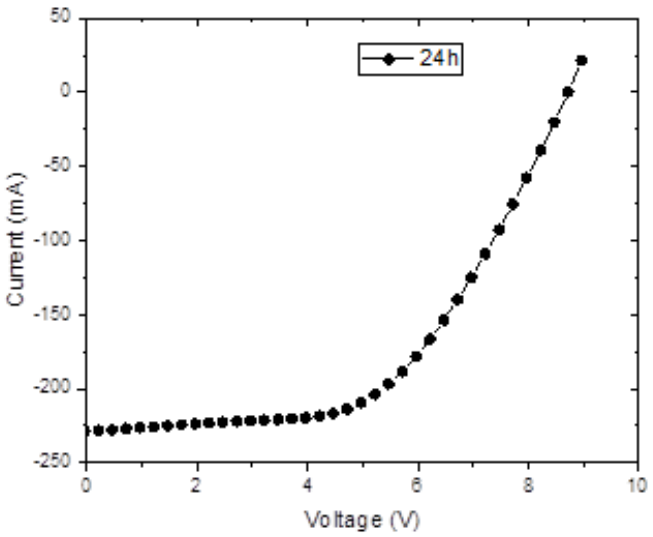
Dye-Sensitized Solar Cells (DSSCs) – Transparent thin-film devices





	Active area (cm^2)	J_{sc} (mA cm^{-2})	V_{oc} (V)	*ff* (%)	η (%)
TTZ5 module	226	12.4	8.72	54.0	4.86
D35cpdt module*	226	10.2	9.06	58.2	4.46

* Dyenamo Red; https://dyenamo.se/dyenamo_dyes.php

Tuscany Region
(FAR-FAS 2007-2013)
www.progettoselfie.it

SELFIE

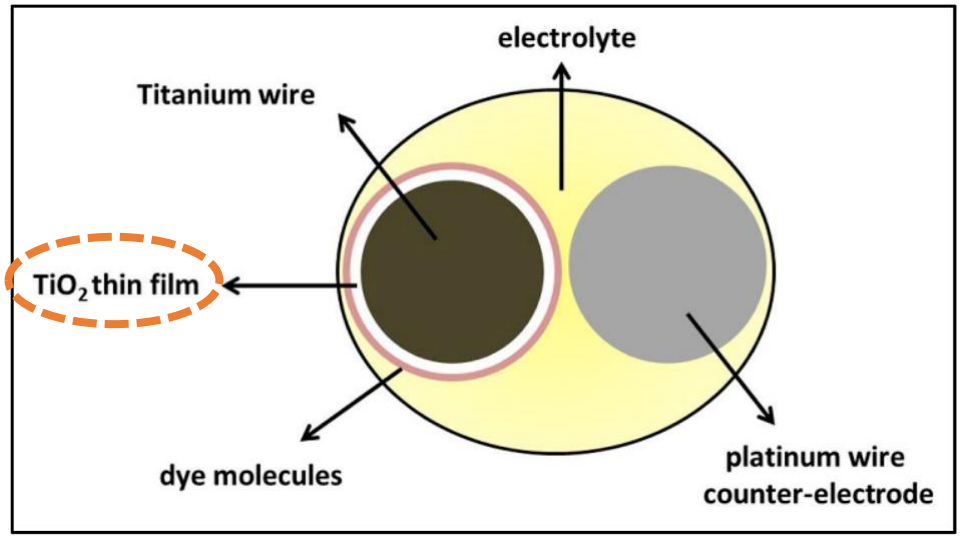
POR CreO Programma Operativo Regionale Crescita e Occupazione 2014 2020

Regione Toscana

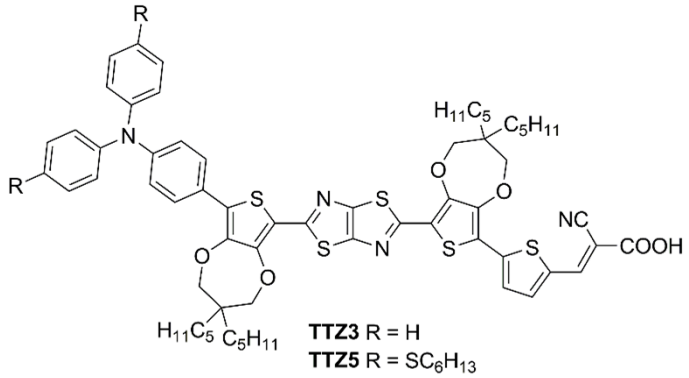
Tuscany Region
(RSI - POR FESR 2014-2020)
ENCOLOR DESIGN

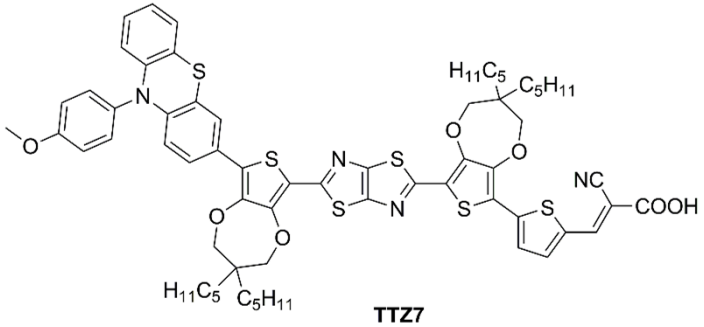
Prof. Aldo Di Carlo and Dr. Luigi Vesce, Center for Hybrid and Organic Solar Energy (C.H.O.S.E.)

Dye-Sensitized Solar Cells (DSSCs) – Fiber-Shaped Solar Cells



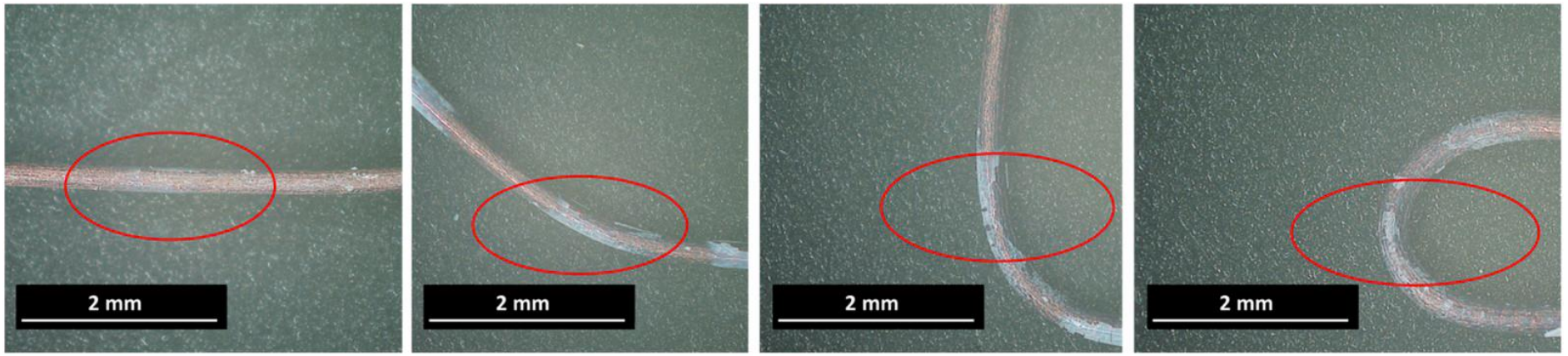
Fiber-Shaped Solar Cell in "2 wires configuration".

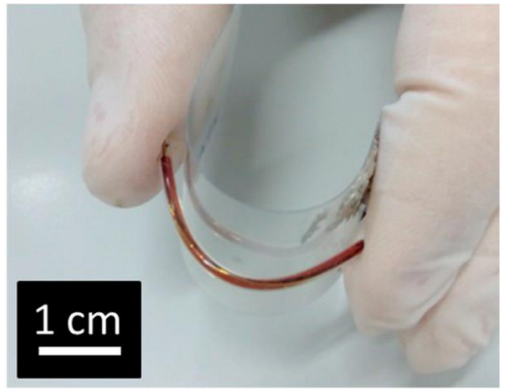




High mechanical stability.
Suitable for wearable application.

Microscope images of TiO_2 coating under mechanical stress at different angle.

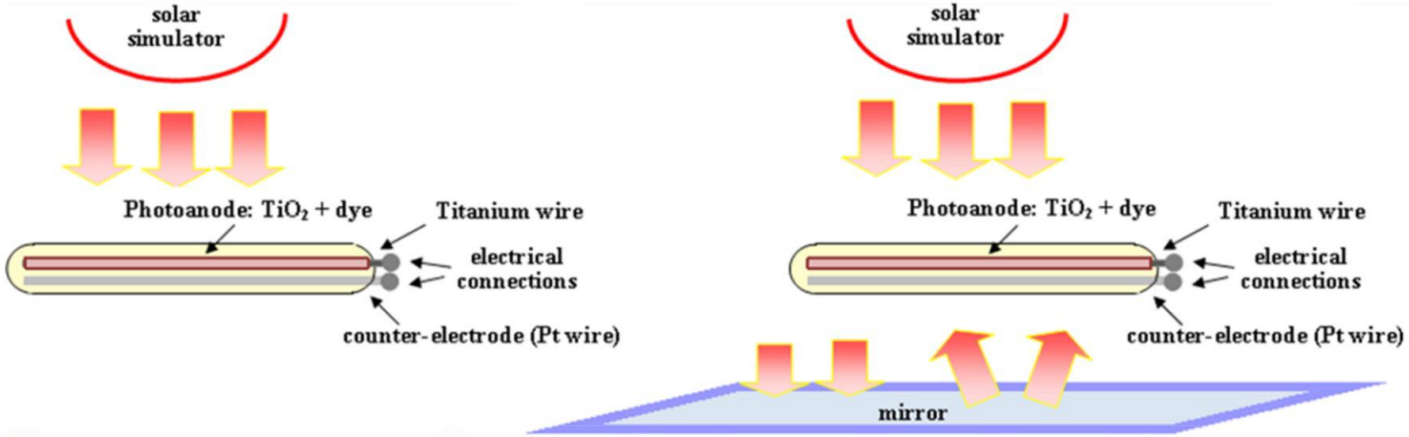


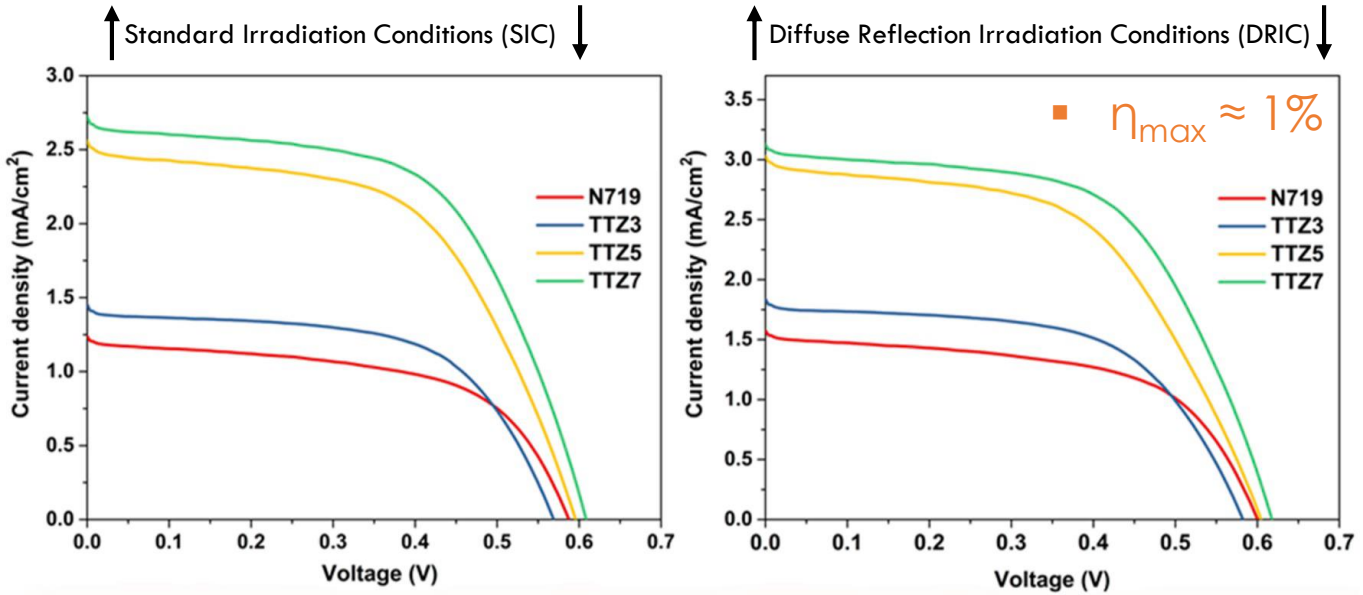


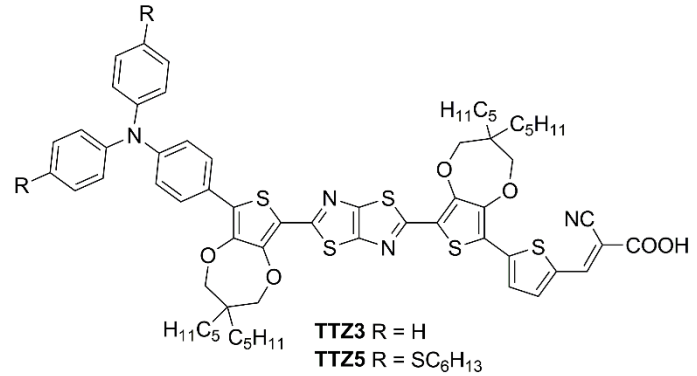
Solar Energy Materials and Solar Cells, **2020**, *204*, 110209

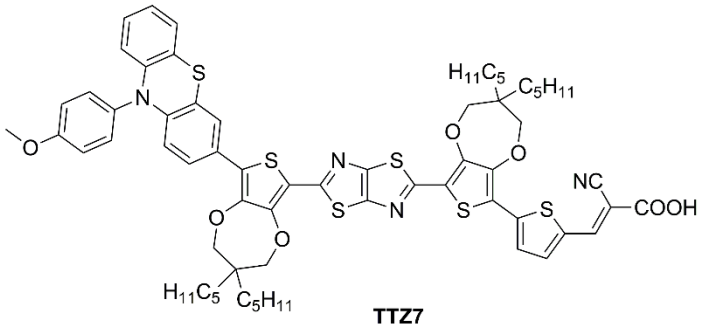
Dr. Alessandra Sanson and Dr. Nicola Sangiorgi, CNR-ISTEC

Dye-Sensitized Solar Cells (DSSCs) – Fiber-Shaped Solar Cells









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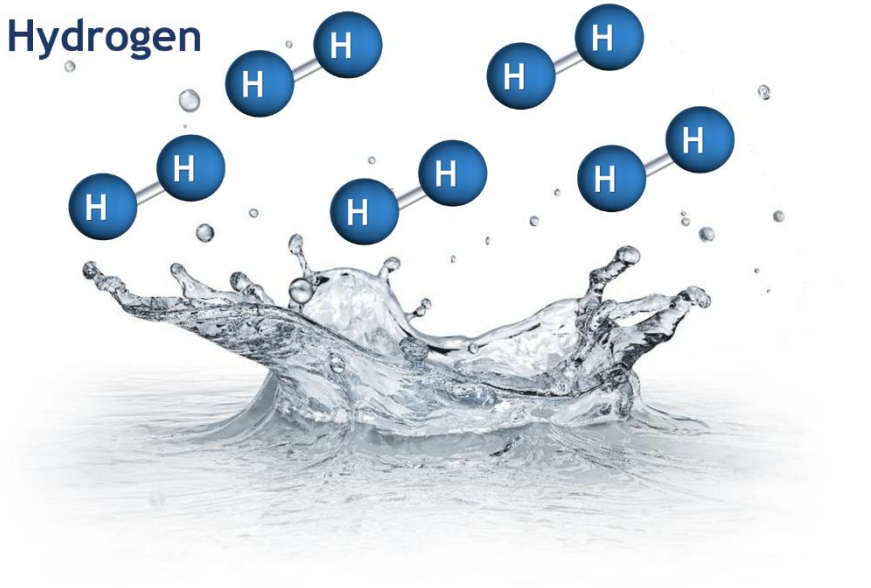
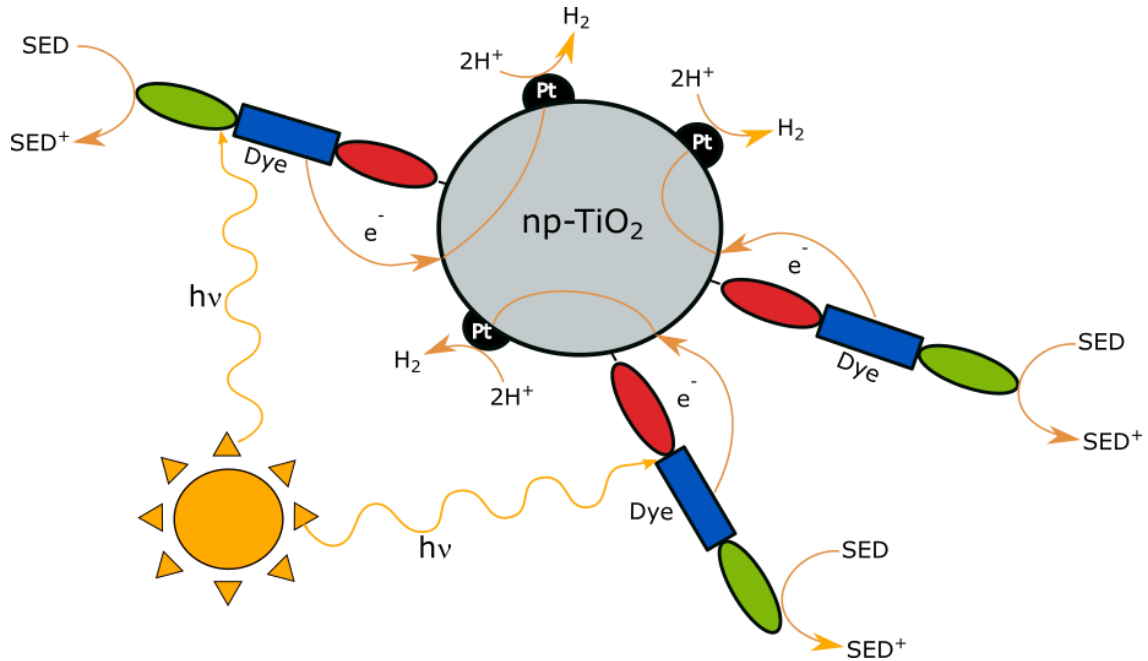
Photocatalytic H_2 Production

An **organic semiconductor** with a smaller band-gap than TiO_2

- ✓ To collect visible light
- ✓ To have an easier charge separation

A **sacrificial electron donor (SED)**, ideally derived from renewable feedstock, to reduce the dye





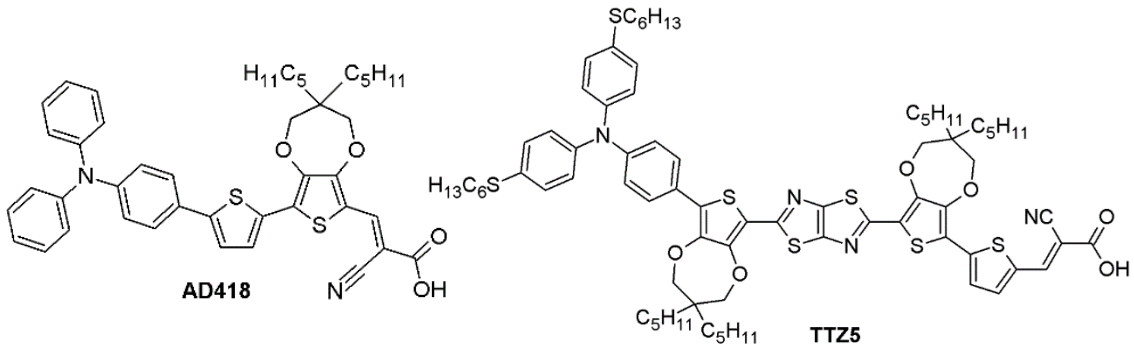
Photocatalytic H_2 Production

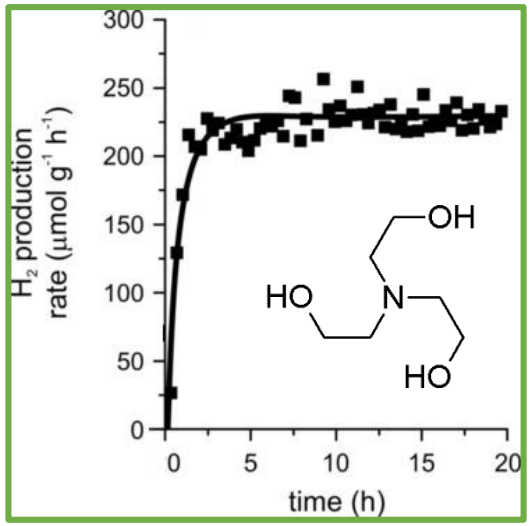
Photocatalytic experiment

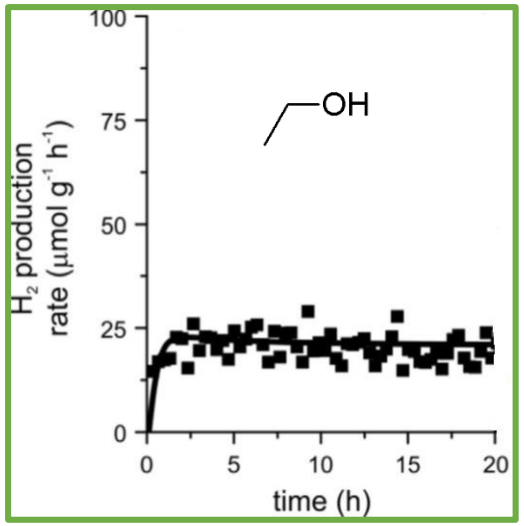
$$\text{TON} = \frac{2 \times H_2\ total\ amount}{dye\ loading}$$

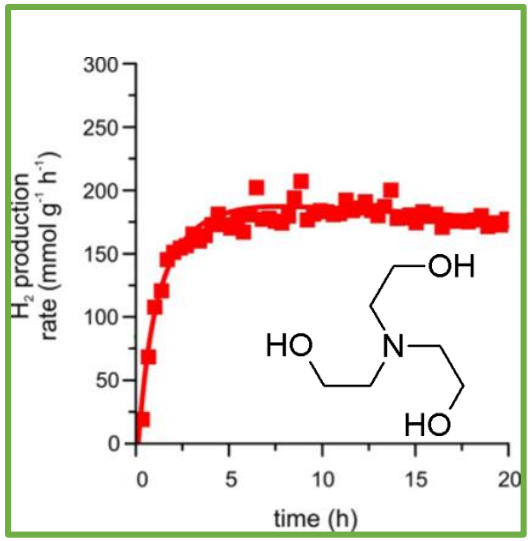
- Dye loading: 10 µmol g^{-1}
- 150 W Xe lamp with a cut-off filter at 420 nm
- Time: 20 hours

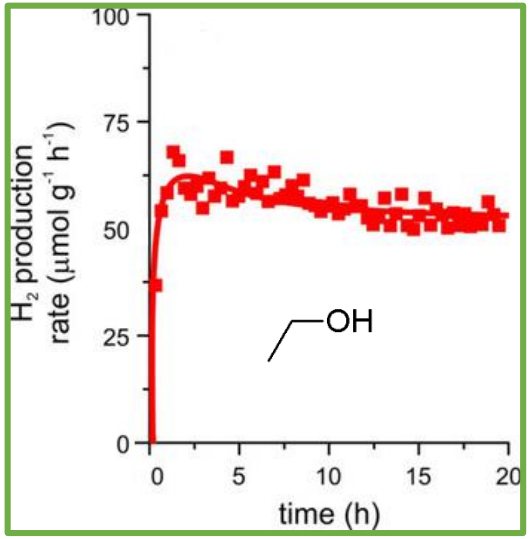
	SED: TEOA		SED: EtOH	
	H_2 amount [µmol g^{-1}]	TON	H_2 amount [µmol g^{-1}]	TON
AD418	4359	872	403	81
TTZ5	3432	686	1105	221











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ChemSusChem, **2018**, *11*, 793

Acknowledgments

LEaF Lab @CNR-ICCOM

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Dr. Matteo Bessi
Dr. Daniele Franchi

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