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#4 Solar Sel Organik - DSSC (Dye-Sensitized Solar Cell)

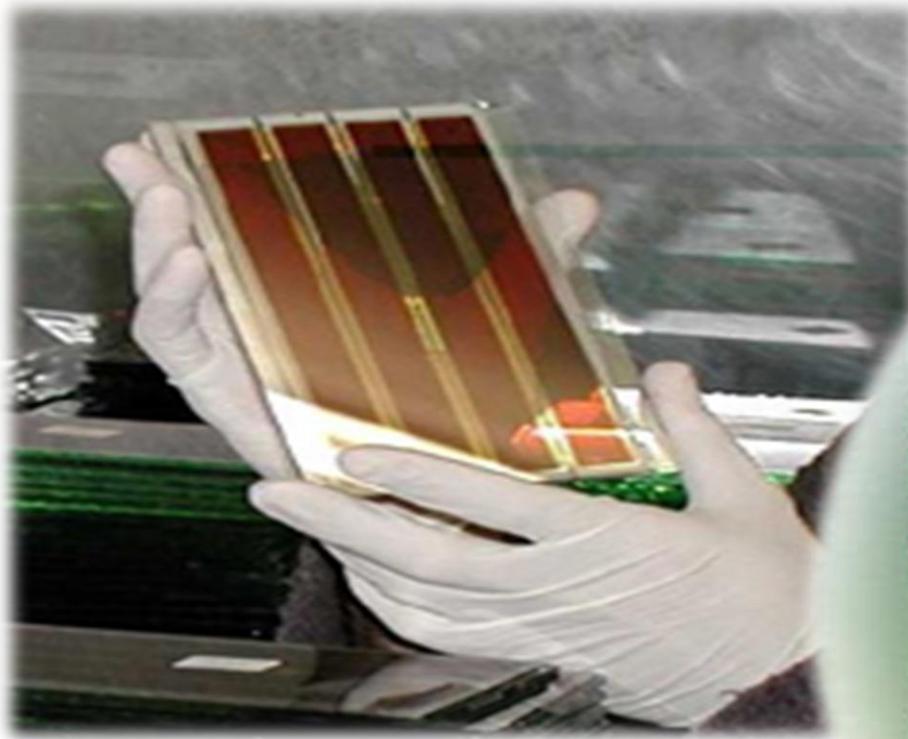
# Elektronika Organik

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Universitas Brawijaya

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# DSSC



# Efisiensi Konversi

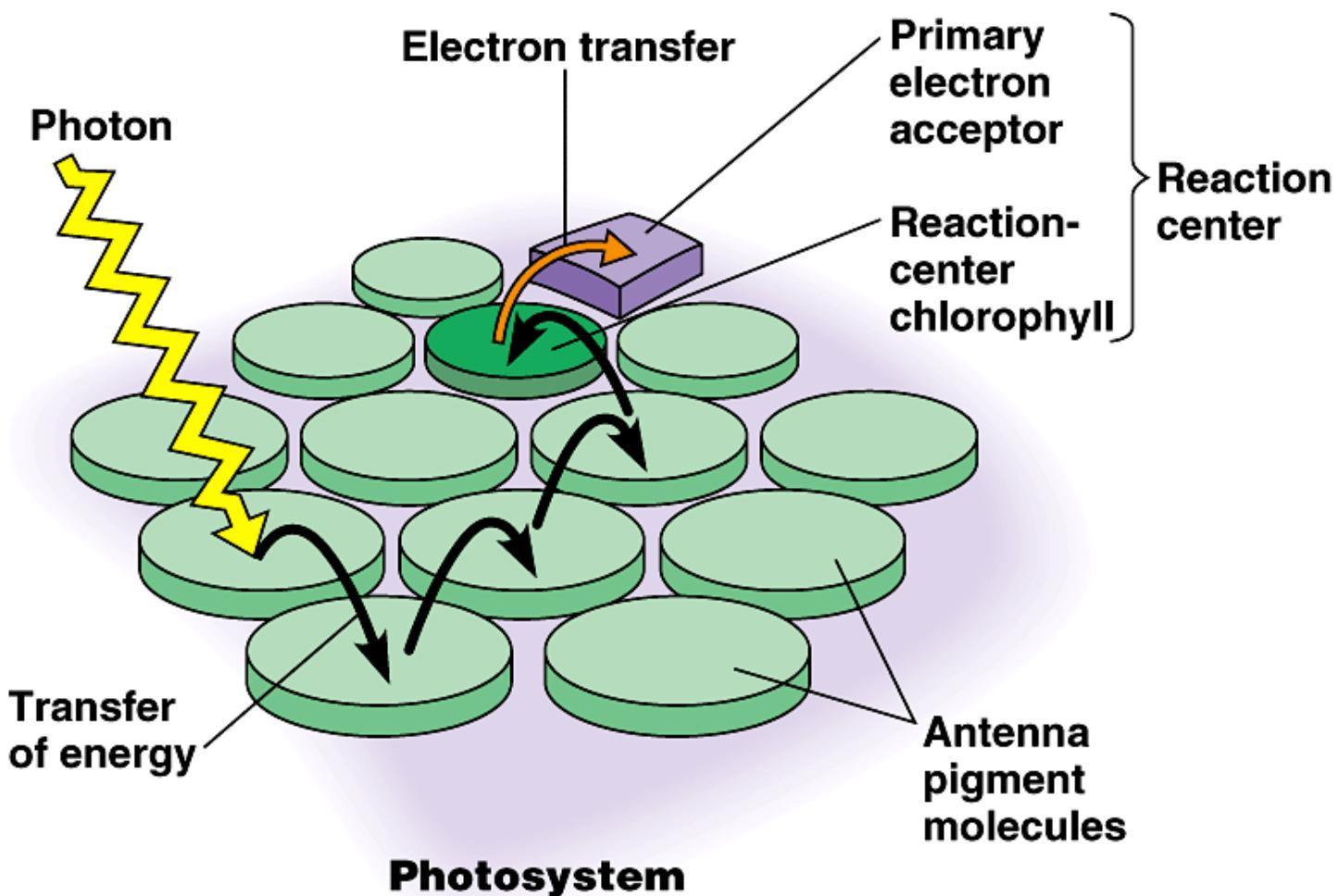
	Laboratory best*	Thermodynamic limit
Single junction		31%
Silicon (crystalline)	25%	
Silicon (nanocrystalline)	10%	
Gallium arsenide	25%	
Dye sensitized	10%	
Organic	3%	
Multijunction	32%	66%
Concentrated sunlight (single junction)	28%	41%
Carrier multiplication		42%

\*As verified by the National Renewable Energy Laboratory.  
Organic cell efficiencies of up to 5% have been reported in  
the literature.  
*(Crabtree & Lewis, 2007)*

# Efisiensi Tipical current photovoltaic

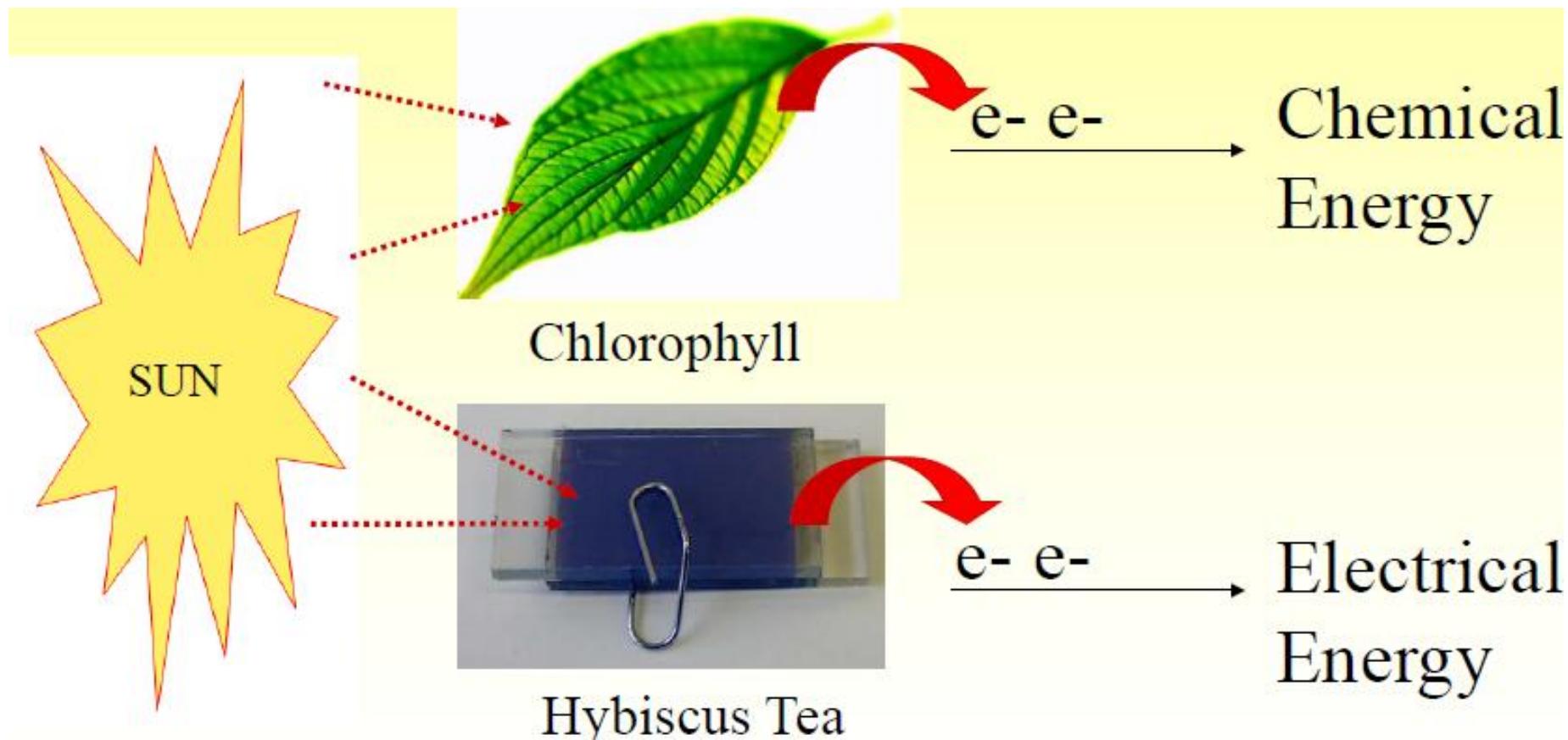
Type	Efficiency
Single crystal Si	$\geq 20\%$
Thin film Si	$\sim 10\%$
Amorphous Si	$\leq 10\%$
CdTe	16%
GaAs Multilayers	$\sim 25\%$ or more
Polymer PV	$\sim 2-8\%$
Gratzel Liquid Electrolyte	$\sim 10\%$
Gratzel Polymer Glass	$\sim 5\%$

# Analogi Fotosintesis

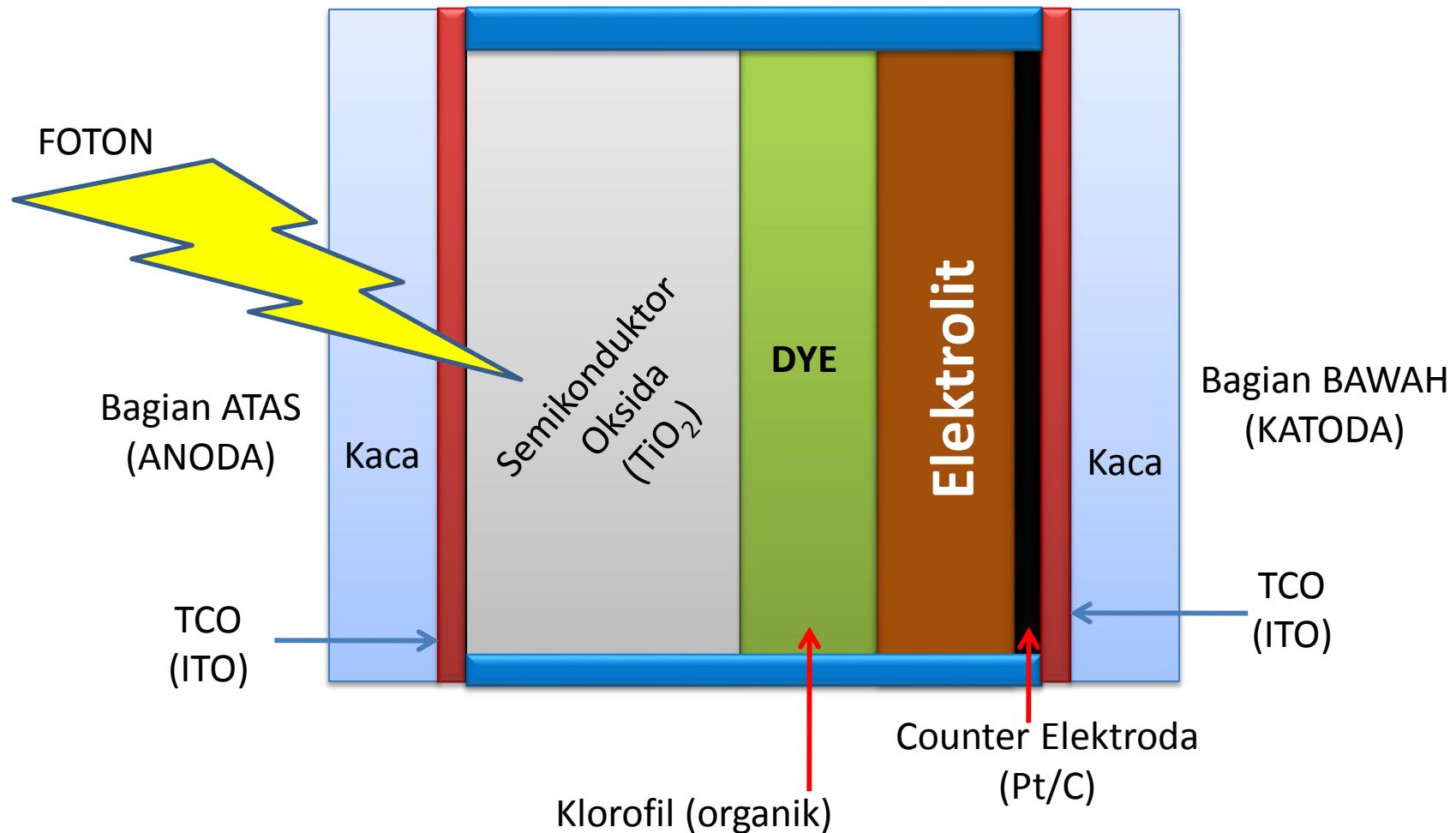


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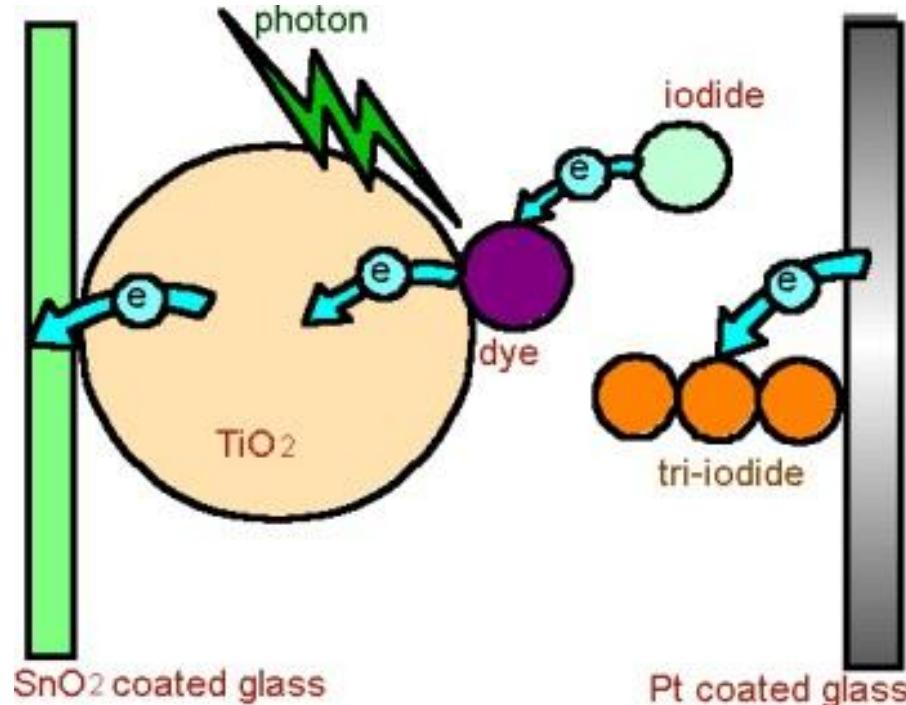
# Fotosintesis vs Solar Sel



# Struktur DSSC (Dye-Sensitized Solar Cell)

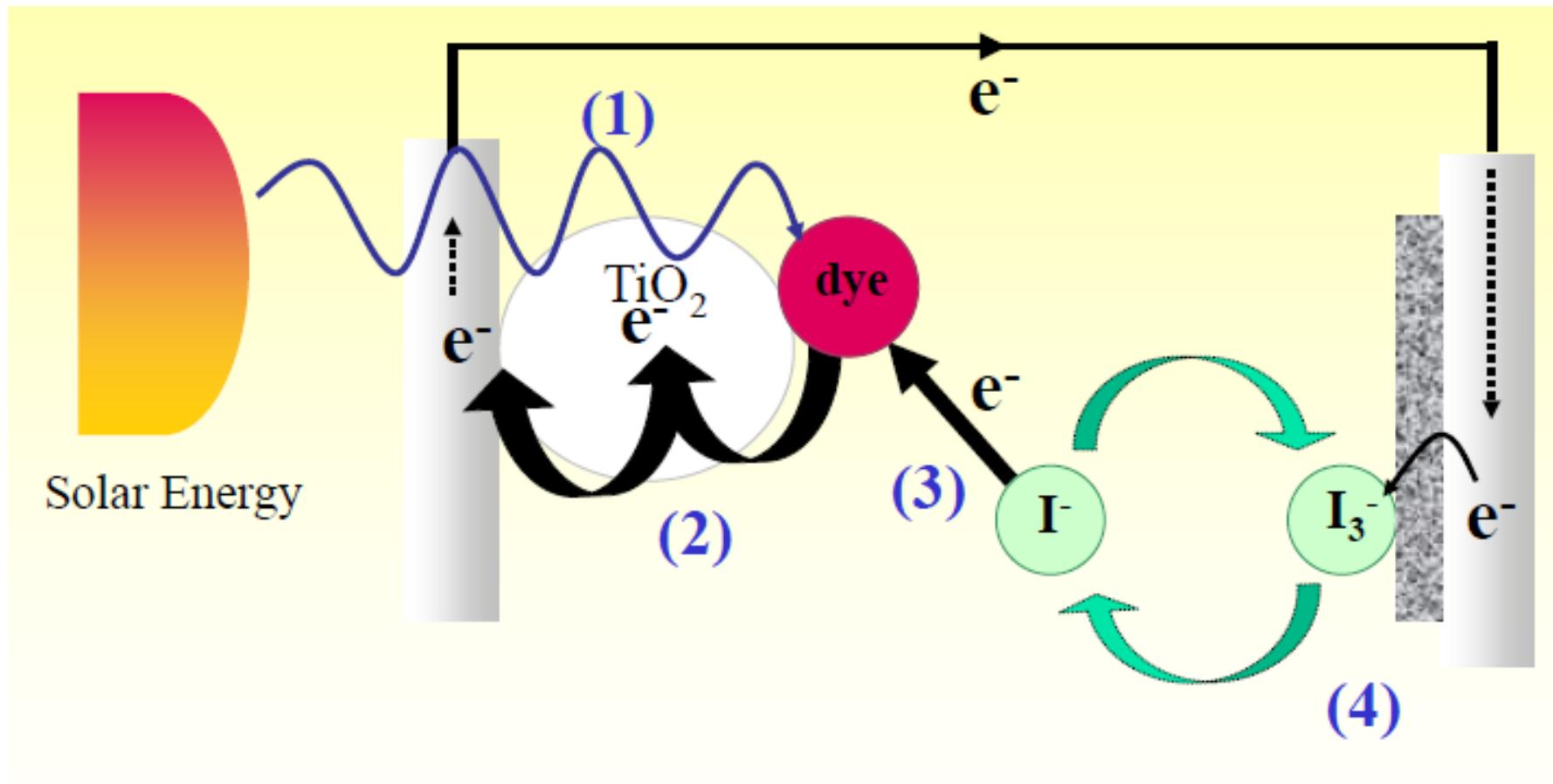


# Gratzel Cell: mimic fotosintesis

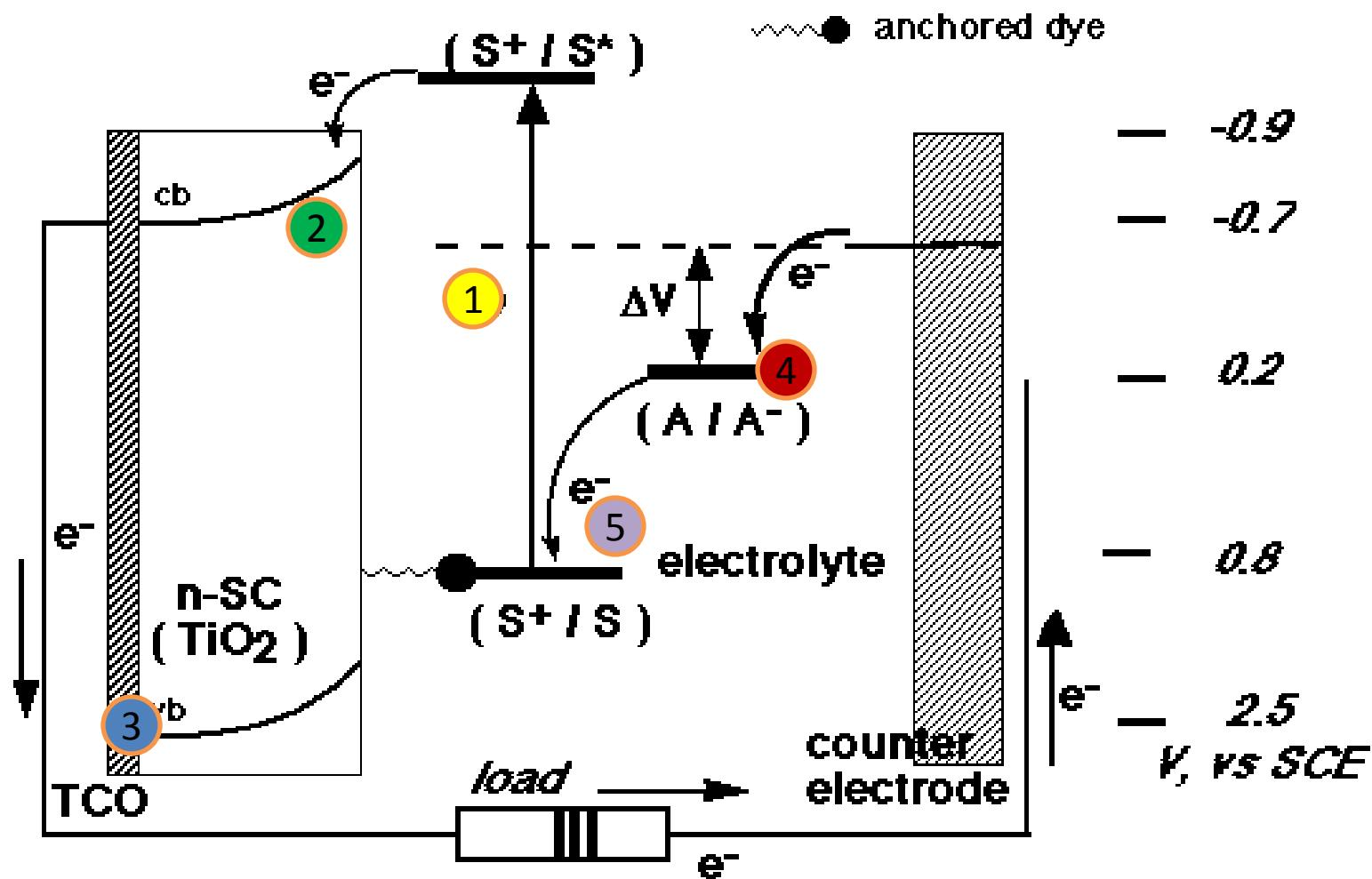


Performansi awal 10% (*efisiensi cahaya menjadi listrik*),  
dan estimasi biaya 1/4 dari PV konvensional.

# Cara Kerja



# Mekanisme: Prinsip operasi DSSC



# Parameter Optimasi

## Material Semikonduktor

Band Gap  
Defects  
Surface Area

## Dye

Absorption Band  
Blocking Efficiency

## Elektrolit

Diffusion Rate  
Redox Potential  
Additives  
Degree of Oxidation

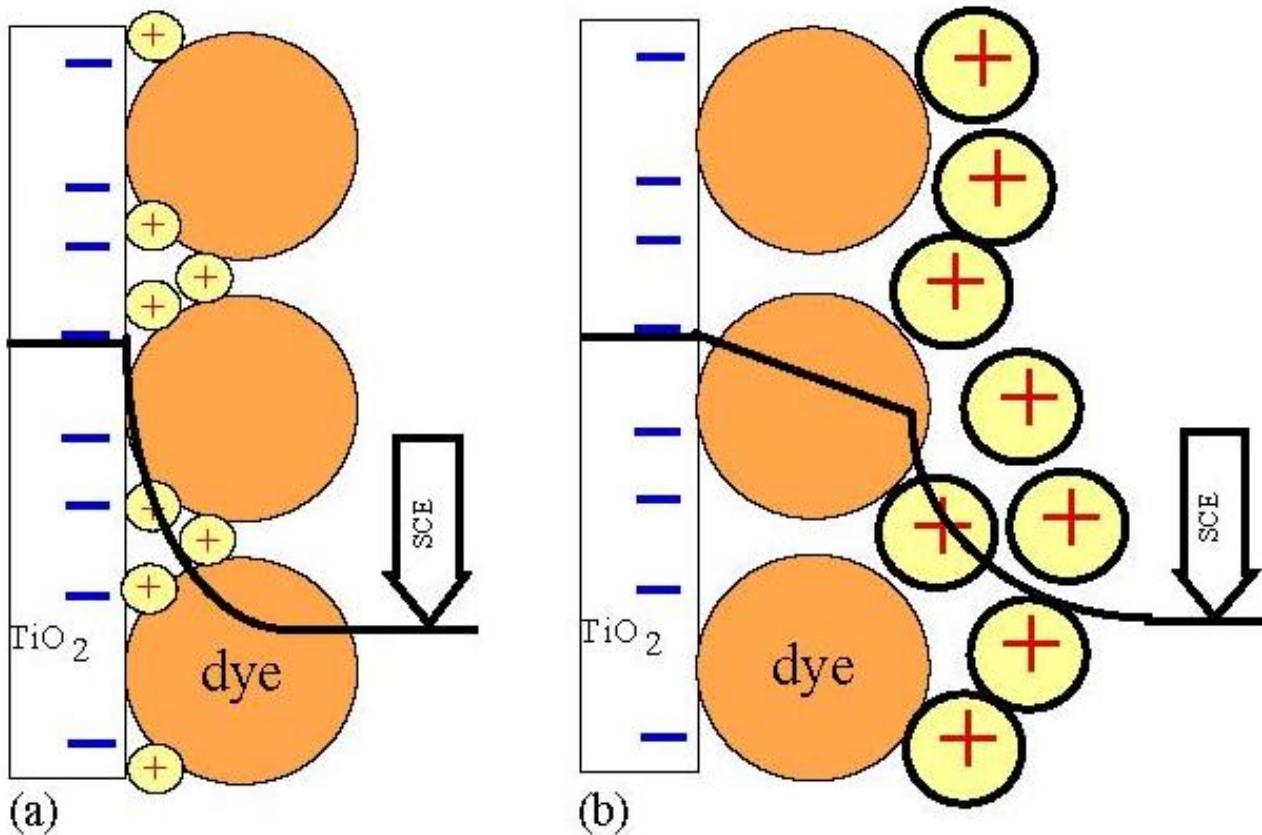
## Rangkaian

Blocking Layers  
Electrocatalytic Deposits

# Reaksi DSSC

Persamaan Reaksi	Deskripsi
$E_{h\nu} + S \rightarrow S^*$	Dye excitation
$S^* \rightarrow E_{h\nu} + S$	Dye relaxation
$S^+ + A^- \rightarrow S + A$	Dye regeneration
$S^* + TiO_2 \rightarrow e_{TiO_2}^* + S^+$	Electron injection
$S^+ + e_{TiO_2}^* \rightarrow TiO_2 + S^*$	Dye recombination
$e_{TiO_2}^* + A \rightarrow A^-$	Electrolyte recombination
$e_{TiO_2}^* + FTO \rightarrow e_I$	Current collection
$e_I + A \rightarrow A^-$	Electrolyte reduction

# Antarmuka



[http://community.nsee.us/concepts\\_apps/dssc/DSSC.html](http://community.nsee.us/concepts_apps/dssc/DSSC.html)

# Analisis DSSC

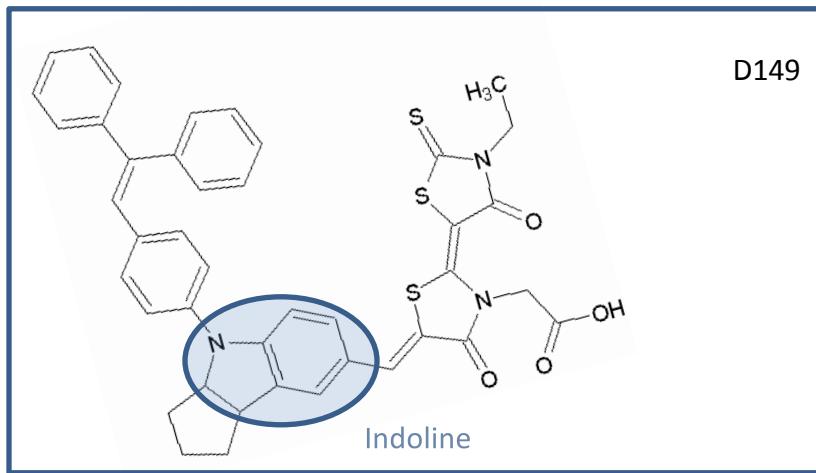
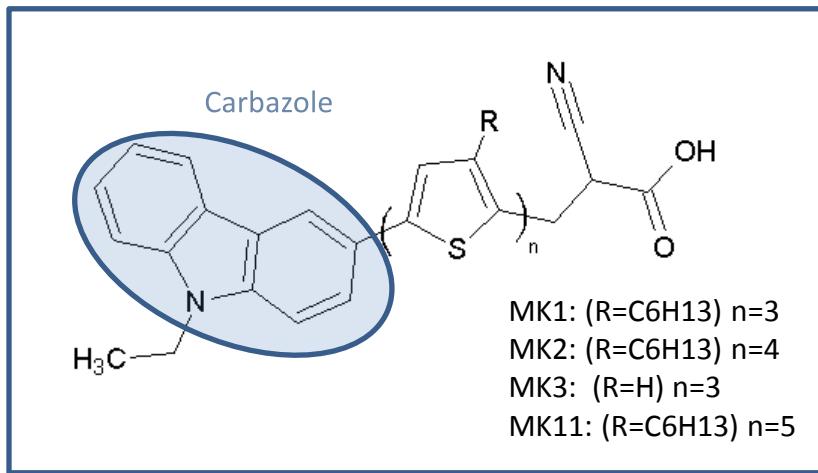
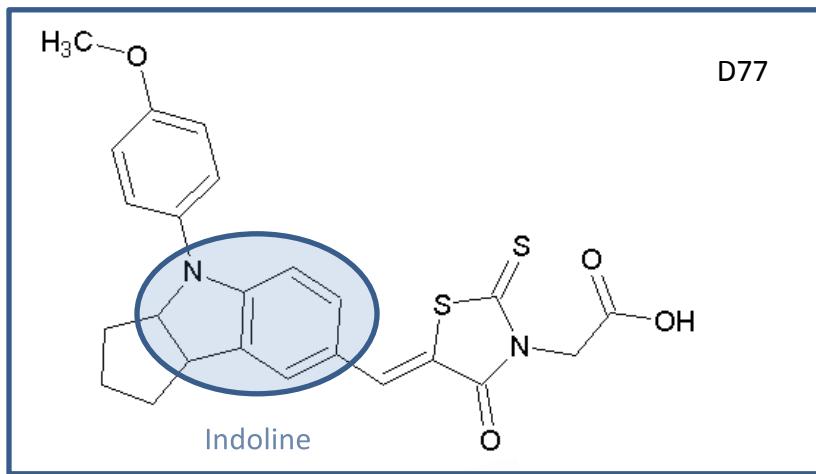
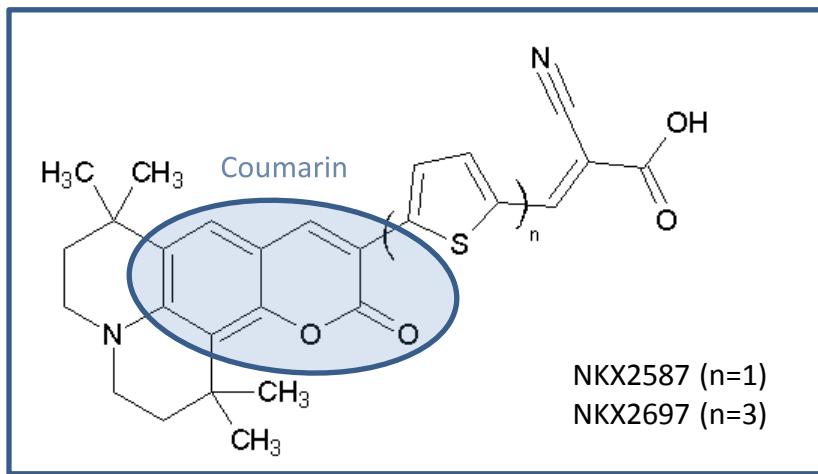
## *Physical and Chemical Properties*

Property	Method(s)
Absorption Band	Absorption Spectra
Redox Potential	Stationary Amperometry
Diffusion Coefficient (electrolyte)	Fixed potential 2-electrode cell
Structure	NMR X-ray diffraction Elemental Analysis

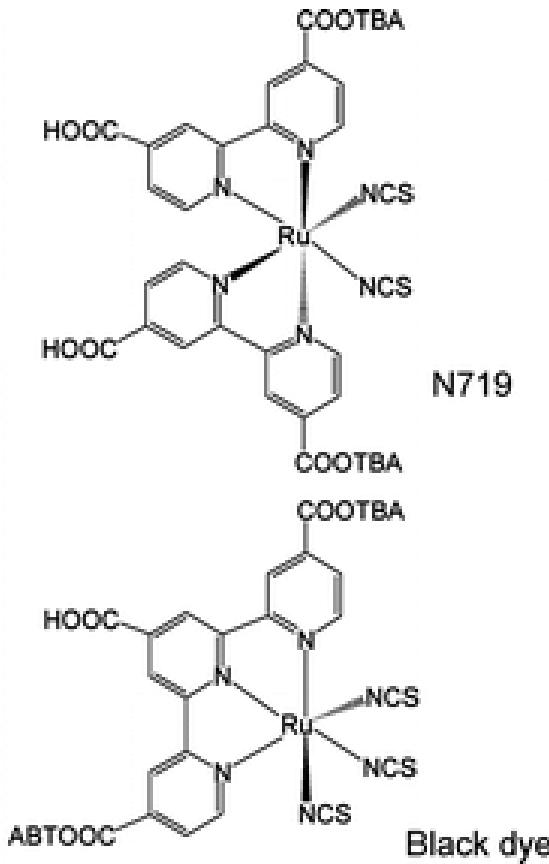
## *Cell Performance*

Properties	Method(s)
Electron Lifetimes	Light-induced photocurrent/voltage transients
Diffusion Coefficients	
Open circuit electron density	Charge extraction
Cell capacitance	Laser pulse over illumination

# Tested Organic Dyes



# Ruthenium Dyes



# Organik vs. Ruthenium

## Ruthenium complexes:

- Have a large absorption band
- Produce the best solar cell efficiency (currently)

## Organic Dyes:

- Have better extinction coefficients
- Allow more variations in structure and color
- Cost much less

# ODSC Results

All showed lower  $V_{OC}$ , and higher  $J_{SC}$ , slightly higher D and lower  $\tau$

## *Size Matters (?)*

$\tau$  is proportional to molecular size (Coumarine/Indoline dyes)

Carbazole dyes showed longer  $\tau$  with increased alkyl chains

Smaller dye molecules need higher  $[I^-]$  (slower reduction kinetics)

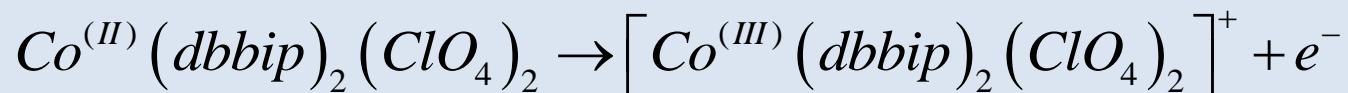
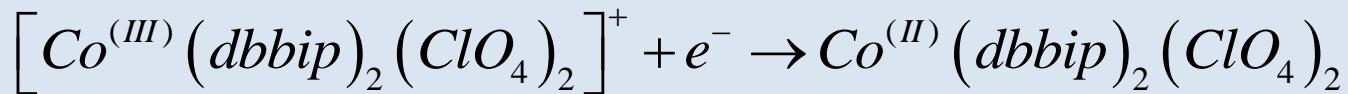
## Charge More

Do not block as well and may create positive  $TiO_2$  surface charge

Organic dyes may complex with triiodide to impede redox current

Organics show aggregation on the  $TiO_2$  surface

# Elektrolit



*(dbbip) = 2,6-bis(1'-butylbenzimidazol-2'-yl)pyridine*

# Iodine vs. Cobalt

## Iodide/Triiodide:

- Absorbs in visible region of spectrum
- Aggressively attacks silver current collectors
- Low redox potential limits open circuit voltage

## Co(II)/Co(III) complexes:

- Minimal absorption in desired region of spectrum
- Outer shell electron transfer (minimal reorganization)
- Single electron transfer

# Cell Optimization Results

## *Sensitizer*

Less negative charges increases performance

Smaller dye allows electrolyte to form ion pairs or steal conduction electron

## *Photoanode ( $TiO_2$ )*

Photocurrent decreases with increasing thickness of layers

Electrolyte is reduced at TCO without good blocking layer

Counterelectrode is not efficient without electrocatalytic platinum deposit

## *Redox Efficiency*

Current density decreases when degree of oxidation exceeds 11%

Counterelectrode illumination is better when mass transport is limiting

## *Additives*

$LiClO_4$  creates positive charge on  $TiO_2$  (photocurrent  $\uparrow$  2x at  $100\text{ W/m}^2$ )

TPB passivates recombination centers (photovoltage  $\uparrow$  by 100mV at  $100\text{W/m}^2$ )

# Review

- Tentukan topik kajian/ review/ ide tentang pengembangan solar cell organik dan DSSC (dapat berupa hasil resume jurnal)

# Review

Baca Paper tentang DSSC berikut dan pelajari tentang: metode, karakteristik, dan performansinya

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- **The effect of photoelectrode TiO<sub>2</sub> layer thickness to the output power of chlorophyll-based Dye-Sensitized Solar Cell (DSSC).** Pramono, S.H.; Maulana, E.; Sembiring, M., in Intelligent Technology and Its Applications (ISITIA), 2015 International Seminar on, vol., no., pp.107-112, 20-21 May 2015. [IEEE Link](#)
- **Effect of Chlorophyll Concentration Variations from Extract of Papaya Leaves on Dye-Sensitized Solar Cell'**, Maulana, E. ; Pramono, S. ; Fanditya, D. ; Julius, M. (2015), World Academy of Science, Engineering and Technology, International Science Index 97, International Journal of Electrical, Computer, Electronics and Communication Engineering, vol. 9, no. 1, 49 – 52. [link jurnal](#)
- **Characterization of Dye-Sensitized Solar Cell (DSSC) Based on Chlorophyll Dye.** SH Pramono, Eka Maulana, AF Prayogo and Rosalina Djatmika. International Journal of Applied Engineering Research. Volume 10, Number 1 (2015) pp. 193-205. [link jurnal](#)
- **Organic Solar Cell based on extraction of Papaya (*Carica papaya*) and Jatropha (*Ricinus communis*) leaves in DSSC (Dye Sensitized Solar Cell)**  
[Sholeh Hadi Pramono, Eka Maulana, M. Julius St., and Teguh Utomo], 2013 [abstract](#)

<http://maulana.lecture.ub.ac.id/research/penelitian-publikasi/>

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