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近赤外増感剤と有機色素を共吸着させた色素増感太陽電池

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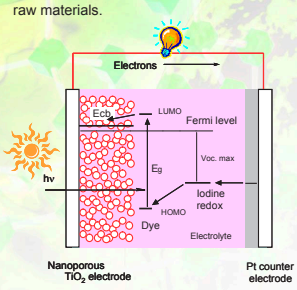
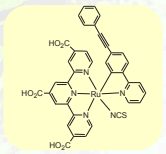
Introduction

Dye-sensitized solar cells (DSCs) are expected to be next generation solar cells because of high efficiency, low cost fabrication and less resource constrains on raw materials.

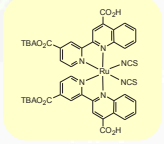


Previous work

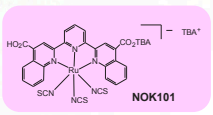
Near-IR sensitizers developed by our group



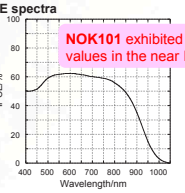
Inorg. Chem. Commun., **2009**, *12*, 842



Inorg. Chem. **2003**, *43*,7921



IPCE spectra

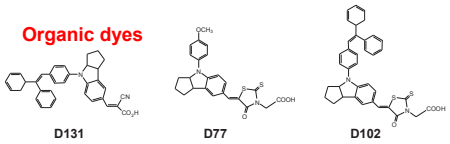


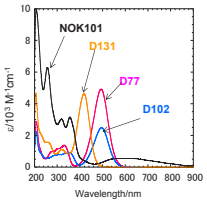
NOK101 exhibited high IPCE values in the near IR region.

N.Onozawa-Komatsuzaki, et.al, Inorg. Chem. Commun., **2009**, *12*, 1212.

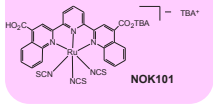
UV-vis spectra of sensitizers

Organic dyes





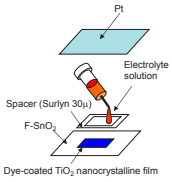
Near-IR sensitizer



Fabrication of DSSCs

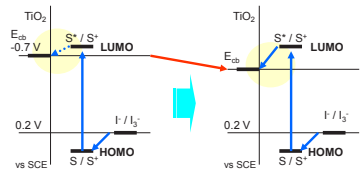
TiO_2 nanocrystalline film electrodes for solar cells
nanoparticle radius ~25 nm + large particle ~300 nm, surface area;
0.25 cm², thickness; 16 μm
Counter electrode
A thin Pt layer sputtered on F-SnO_2 glass
Electrolyte solution
The electrolyte solution is composed of 0.05 M I_2, 2 M LiI, in acetonitrile.

Sensitization of TiO_2 film electrodes
After annealing for 1 hour at 500℃ and dipping in 0.1 M HCl at 80 ℃,
TiO_2 films were immersed in 0.2 mM methanol solution containing of 20 mM deoxycholic acid for 20 hours.



Effect of the electrolyte solutions

The dependence of cell performance on the electrolyte solution was examined.



E_{cb} can be shifted to positive side by the use of LiI-rich electrolyte

Higher quantum efficiency can be expected in the longer wavelength region

Ref; C. A. Bignozzi et.al, *J. Am. Chem. Soc.*, **2005**, *127*, 15342-15343.

Photovoltaic performance

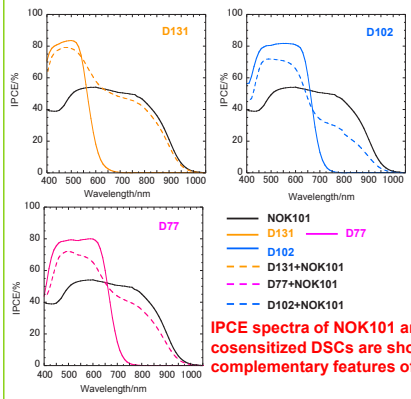
Table 1. Photovoltaic performance of DSC sensitized with **NOK101** and **organic dyes.** Electrolyte composed of 0.05M I_2 and 2M LiI in CH_3CN. A co-adsorbate 20 mM deoxycholic acid was used.

entry	Dye	J_{sc} (mA cm^{-2})	V_{oc} (V)	*FF*	η (%)	Γ_{comp} (x10^{-7} mol cm^{-2})[a]	Γ_{org} (x10^{-7} mol cm^{-2})[b]
1	**NOK101**	17.3	0.43	0.55	4.0	1.5	
2	**D131**	12.4	0.49	0.66	4.0		1.9
3	**NOK101+D131**	19.8	0.44	0.53	4.6	1.4	1.4
4	**D77**	14.3	0.54	0.67	5.1		
5	**NOK101+D77**	18.1	0.42	0.54	4.1	1.5	
6	**D102**	15.5	0.50	0.67	5.1		
7	**NOK101+D102**	17.0	0.44	0.58	4.4		

a) The amount of adsorbed **NOK101**.
b) The amount of adsorbed **D131.** Those of **D77** and **D102** could not be measured because of their decomposition under alkali condition.

D131 was found to be effective as a cosensitizer for DSSC based on NOK101.

IPCE spectra



IPCE spectra of NOK101 and cosensitized DSCs are shown as complementary features of each dye.

Dependence on the immersing condition

Table 2. Effect of DCA (deoxycholic acid)

entry	Dye	Conc. of DCA (mM)	J_{sc} (mA cm^{-2})	V_{oc} (V)	*FF*	η (%)	Γ_{comp} (x10^{-7} mol cm^{-2})[a]	Γ_{org} (x10^{-7} mol cm^{-2})[b]
1	**NOK101**	20	17.3	0.43	0.55	4.0	1.5	
2	**D131**	20	12.4	0.49	0.66	4.0		1.9
3	**NOK101+D131**	20	19.8	0.44	0.53	4.6	1.4	1.4
5	**NOK101**	0	16.6	0.34	0.53	2.9	2.7	
6	**D131**	0	11.7	0.51	0.65	3.8		4.0
7	**NOK101+D131**	0	12.1	0.43	0.65	3.8	1.7	2.0

a) The amount of adsorbed **NOK101**.
b) The amount of adsorbed **D131**.

The conversion efficiency of NOK101-based DSC (4.0%) was improved to 4.6% by cosensitization. The total amount of adsorbed dye is increased by coadsorption.
DCA is necessary for prevent from dye aggregation at the TiO_2 surface.

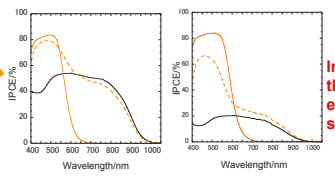
Table 3. Photovoltaic performance of DSC sensitized with **NOK101** and **D131.** Electrolyte composed of 0.05M I_2 and 2M LiI in CH_3CN. A co-adsorbate 20 mM deoxycholic acid was used.

	Dye	Conc. of **NOK101** (mM)	Conc. of **D131** dye (mM)	Immersion time (h)	J_{sc} (mA cm^{-2})	V_{oc} (V)	*FF*	η (%)	Γ_{comp} (x10^{-7} mol cm^{-2})[d]	Γ_{org} (x10^{-7} mol cm^{-2})[e]
1	**NOK101**	0.1		22	13.0	0.43	0.63	3.5	0.9	
2	**D131**		0.1	22	10.9	0.57	0.69	4.3		1.8
3	**NOK101 +D131**[a]	0.1	0.1	22	16.3	0.45	0.62	4.5	0.8	0.7
4	**NOK101**	0.05		44	11.2	0.44	0.66	3.2	1.0	
5	**D131**		0.05	44	9.5	0.54	0.68	3.5		0.8
6	**NOK101 +D131**[b]	0.05	0.05	44	13.5	0.44	0.65	3.9	1.0	0.8
7	**D131+N OK101**[c]	0.05	0.05	44	12.7	0.44	0.65	3.6	0.8	0.3

a) The TiO_2 photoelectrodes were immersed into mixed dye solution.
b) The TiO_2 photoelectrodes were immersed into **NOK101** solution for 22h, then they were immersed into **D131** solution for same time.
c) The TiO_2 photoelectrodes were immersed into **D131** solution for 22h, then they were immersed into **NOK101** solution for same time.
d) The amount of adsorbed **NOK101**.
e) The amount of adsorbed **D131**.

Dependence on the electrolyte

entry	Dye	Electrolyte[a] LiI (M)	DMPmI (M)	J_{sc} (mA cm^{-2})	V_{oc} (V)	*FF*	η (%)
1	**NOK101**	2	0	17.3	0.43	0.55	4.0
2	**D131**	2	0	12.4	0.49	0.66	4.0
3	**NOK101+D131**	2	0	19.8	0.44	0.53	4.6
4	**NOK101**	0.1	0.6	9.5	0.45	0.69	2.9
5	**D131**	0.1	0.6	11.3	0.71	0.71	5.0
6	**NOK101+D131**	0.1	0.6	17.8	0.46	0.62	5.0



In the near-IR region, the effect of electrolyte is significant.

Summary

The conversion efficiency of the dye-sensitized solar cell (DSC) with a new ruthenium(II)–polypyridyl complex having a 2,6-bis(4-carboxyquinolin-2-yl)pyridine ligand (**NOK101**) was improved by cosensitization with an organic dye (**D131**). The IPCE spectra of the DSC with **NOK101** and **D131** were shown as complementary features of each dye. The improvement of solar cell performance of **NOK101**sensitized DSC by cosensitization with **D131** may be mainly due to the increase of the total amount of adsorbed dye.

Acknowledgement

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