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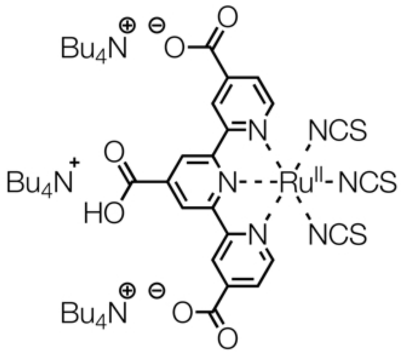
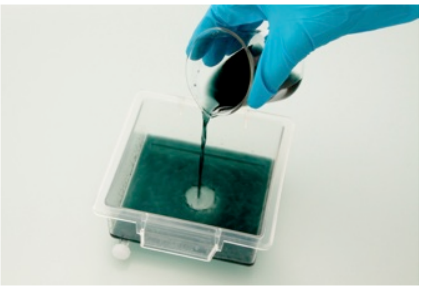
Ruthenizer 620-1H3TBA

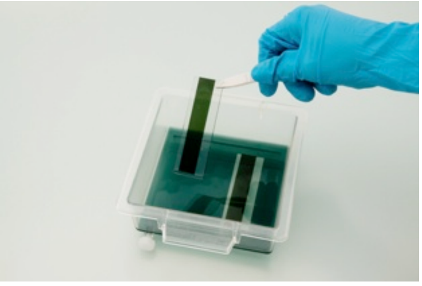
Panchromatic Photo-Sensitizer for Dye Solar Cell Application



Ruthenizer 620-1H3TBA is a panchromatic ruthenium dye that absorbs light in a broad range of the visible spectrum. Sometimes referred as Black Dye in the literature, it is so far one of the best sensitizers in Dye Solar Cell applications. Ruthenizer 620-1H3TBA gives dark-green colored electrodes and excellent photovoltaic performances.

Similar to our other ruthenium sensitizers, Ruthenizer 620-1H3TBA is ready-to-use, and available in quantities suitable for both research and industrial purposes.





Characteristics

Aspect	dark green powder
Synonyms	N749; Black Dye
Chemical Name	triisothiocyanato-(2,2':6',6"-terpyridyl-4,4',4"-tricarboxylato) ruthenium(II) tris(tetra-butylammonium)
Molecular Formula	$C_{69}H_{117}O_6N_9S_3Ru$
Formula Weight	1364.7 g/mol
CAS Number	359415-47-7
HS Code	7110.4900
Absorption λ(max)	610 nm; 536 nm; 411 nm; 339 nm; 328 nm
Emission λ(max)	854 nm (EtOH, RT)
HOMO Level	0.66 V/(Ag/AgCl)
LUMO Level	-0.83 V/(Ag/AgCl)
Solubility	DMC, AcCN, EtOH, MeOH, tBuOH, H_2O

Retail Quantities

100 mg	ref.	21812
200 mg	ref.	21822
500 mg	ref.	21852
1 g	ref.	21813
2 g	ref.	21823
5 g	ref.	21853
10 g	ref.	21814
20 g	ref.	21824

Pricing on product page:
solx.ch/ru620tba

How to Order

Please visit our webshop at shop.solaronix.com, or send us an e-mail or fax indicating your desired products.

Bulk Supply

In addition to the retail quantities listed above, Ruthenizer 620-1H3TBA is also available in bulk for industrial purpose. Inquiries are welcome.

USAGE

Ruthenizer 620-1HTBA is known to very efficiently photosensitize titanium dioxide (titania) over a very broad range of the visible spectrum, up to ~920 nm. For this reason, it earned the common name of Black Dye in the Dye Solar Cell community, even though its color is dark green. It is so far one of the best pigments for this photovoltaic application, along with Ruthenizer 535-bisTBA.

Ruthenizer 620-1H3TBA is used to prepare staining solutions in which metal-oxide semi-conductor electrodes will be immersed. The dye naturally adsorbs on the semiconductor surface, resulting in a colored electrode bearing a sensitizing layer of dye molecules.

The chemical structure of Ruthenizer 620-1H3TBA makes it particularly prone to aggregate. This phenomenon is detrimental to photovoltaic performance, as excited dyes molecules tend to deactivate each others when stacked. To prevent dye aggregation during staining, consider adding a co-adsorbent like chenodeoxycholic acid to the dye solution. Chenodeoxycholic acid is also available from Solaronix.

Staining Procedure For Titania Electrodes

Weigh the amount of dry powder necessary to make a 0.5 mM ethanol solution of the required volume. Make sure the volume is sufficient to completely immerse your electrode(s).

> *The addition of chenodeoxycholic acid (10 folds) in the staining solution yields a significant performance.*

Place the dye powder in a sealable container and add the required volume of ethanol. Absolute ethanol is good, but not strictly necessary. Alternatively, methanol or ethanol/*tert*-butanol (1:1) can be used with this dye.

Stir the mixture in a sealed vessel at room temperature (e.g. a glass bottle with stir bar). The solution rapidly turns dark green although most of the solid is yet to be dissolved. Coarse grains can take a while to dissolve, so prolong stirring until no traces of solid are visible.

> *If necessary, briefly sonicate briefly the solution to help dissolution. Beware that excessive sonication is potentially harmful to the dye molecules.*

Position the titania electrodes in a flat-bottomed, sealable container, side by side, with titania layers facing up. This is important in order to prevent scratching the fragile titania surface.

Pour a freshly prepared dye solution into the container so as to fully immerse the electrodes in the solution. Too little liquid won't allow the titania surface to adsorb enough dye and the electrodes may appear unevenly colored.

> *For best results fire the titania electrodes just before staining so they don't pick up ambient moisture. It is best to put them in the staining bath while still warm, 50-60°C. Such mesoporous titania electrodes are easily polluted by volatile substances.*

Seal the container with a lid and wait for the titania surface to get entirely stained. This takes several hours and can be conveniently left overnight. Make sure to avoid excessive light exposure during the staining process. Dye molecules are very light sensitive in solution, and even more so when adsorbed on titania and dry.

Remove the stained electrodes with plastic tweezers (to avoid metal traces pollution). Rinse thoroughly with ethanol to remove any excess dye which could otherwise cause a detrimental build up of dye molecules. Discard the rinsing waste.

> *Staining solutions can be reused several times, provided the concentration is sufficient. However, dye solutions are not suitable for long term storage. Dye oxidation and precipitation may occur over time. It is preferable to store the dried dye powder in its original container and prepare solutions when needed.*

Completely dry the electrodes with an inert gas flow or with a brief blow of a hair-drier from a reasonable distance. Make sure to assemble the solar cells immediately. Stained electrodes are fragile, keep them in a sealed environment away from light until you are ready for assembly.

A properly stained titania electrode should look quite dark (especially if opaque) and green (in any case), otherwise it will result in poor cell performance.

Common Pitfalls

A white or faded coloration indicates poor staining, the entire surface of the electrode visibly didn't get colored. Try to increase the dye concentration or lengthen staining time. If the problem persists, use recommended staining conditions for troubleshooting, change solvent, or check for moisture in the solution.

It could also indicate the structure of the titania electrode is not porous enough. Investigate possible titania issues such as firing process, poor porosity, or bigger particle size.

A brownish stained electrode indicates the dye has been oxidized, it's no longer purple. Discard the staining solution for a fresh one if it has changed color as well. Also, avoid exposing freshly stained electrodes to ambient atmosphere or moisture for too long, dye molecules adsorbed on the titania can be easily oxidized, especially when exposed to light.

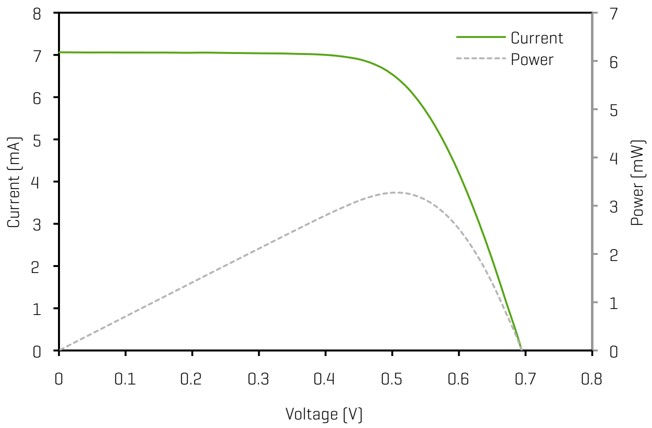
Staining the electrodes for too long can also lead to reduced solar cell performance because of dye molecule aggregation. Consider using a lower concentration, or shorten the staining time if possible.

EXAMPLE

A Dye Solar Cell Sensitized with Ruthenizer 620-1H3TBA

A 36 mm^2 titania photo-anode was prepared with 2 prints of Ti–Nanoxide T/SP and 1 print of Ti–Nanoxide R/SP on a piece of TCO22–7 glass substrate. The electrode was treated with $TiCl_4$, and stained in a solution of Ruthenizer 620–1H3TBA using the procedure described above with chenodeoxycholic acid (1:10) as a co-adsorbent. A platinum coated cathode was prepared on another TCO22-7 substrate with a layer of Platisol T. The two electrodes were laminated together using Meltonix 1170-60, and the solar cell was filled with Iodolyte HI-30 through a hole in the cathode. The filling hole was then sealed with Meltonix 1170-60 and a thin glass circle of 6 mm diameter.

The resulting solar cell was placed under 1 sun illumination using a Solaronix Solixon Class-A solar simulator and equipped with an adequate mask to avoid over-illumination, yielding the following current-voltage curve and tabulated results.



V_{oc}	694 mV	**FF**	0.67
J_{sc}	19.62 mA/cm^2	**Eff.**	9.1 %

STORAGE AND SAFETY

Storage

Store the product in its original container, upright and tightly sealed. Keep in a dry place at room temperature, away from light exposure.

The product is not known to suffer from degradation when stored properly. Consider filling the container with inert gas for very long term storage.

While in use, avoid leaving the container open unnecessarily.

Safety

Ruthenizer 620-1H3TBA is for research and development use only and is intended to be manipulated by knowledgeable personnel. Ensure good ventilation of the workplace, and wear suitable protective equipment.

Signal word: Warning

For a complete description of safety measures, please refer to the Material Safety Datasheet (MSDS) of Ruthenizer 620–1HTBA.

solaronix.com/msds/

RELATED PRODUCTS

Cited in This Document

- Chenodeoxycholic Acid, staining additive.
- TCO22–7, FTO coated glass substrates.
- Ti–Nanoxide T/SP, screen-printable titania nanoparticle paste.
- Ti–Nanoxide R/SP, screen-printable reflective titania paste.
- Platisol T, platinum precursor paint.
- Iodolyte HI–30, very high performance electrolyte.
- Meltonix 1170-60, hot-melt sealing films.
- Solixon, continuous illumination solar simulators.

Consider Also

- Ruthenizer 535–bisTBA, high performance sensitizer.
- Ruthenizer 520–DN, amphiphilic ruthenium dye.
- Labware: Staining Boxes, Plastic Tweezers.

REFERENCES

Articles About N749

For further reading, have a look at the following articles:

- Chem. Commun. 1997, 1705-1706 [doi:10.1039/a703277c]
- Coord. Chem. Rev. 1998, 177(1), 347-414 [doi:10.1016/S0010-8545(98)00189-1]
- Journal of Electroanalytical Chemistry 2000, 490, 7-16 [doi:10.1016/S0022-0728(00)00181-9]
- J. Am. Chem. Soc. 2001, 123, 1613-1624 [doi:10.1021/ja003299u]
- Journal of Molecular Structure 2003, 658, 25–32 [doi:10.1016/S0022-2860(03)00408-3]
- J. Phys. Chem. B 2003, 107, 1157-1162 [doi:10.1021/jp026522d]
- J. Photochem. Photobiol. A.. Chemistry 2004, 164, 3–14 [doi:10.1016/j.jphotochem.2004.02.023]
- J. Am. Chem. Soc. 2005, 127, 15342-15343 [doi:10.1021/ja053438d]
- Chem. Eur. J. 2005, 11, 4024-4034 [doi:10.1002/chem.200500119]
- J. Phys. Chem. C 2009, 113, 15417–15421 [doi:10.1021/jp905366t]

People Using Ruthenizer 620–1H3TBA

A random selection of publications using Ruthenizer 620–1H3TBA:

- J. Sol. Energy Eng. 2013, 135(3), 031011 [doi:10.1115/1.4023517]
- Nano Lett. 2012, 12(5), 2520–2523 [doi:10.1021/nl3007159]
- RSC Advances 2012, 2, 4463–4471 [doi:10.1039/c2ra01248k]

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