



Materials and Supplies

What follows is a comprehensive list of materials and supplies necessary to complete all portions of the Nanocrystalline Dye Sensitized Solar Cell kit. In the event that the provided supplies become depleted, suppliers are listed for the materials that are difficult to obtain.

Equipment and Supplies:

- Conductive (tin dioxide coated) transparent glass (10 pieces included)**
Two (2) pieces of glass are used per solar cell. Pre-cut commercial (2.5 cm × 2.5 cm) TEC 8 or TEC 10 glass can be purchased from one of several suppliers. Hartford Glass Co. Inc., P.O. Box 613, Hartford City, IN 47348; 765/348-1282; 765/348-5435 (fax); e-mail: hartglas@netusal.net; or Pilkington North America Inc., P. O. Box 799, Toledo, OH 43697-0799; 419/247-3731; 419/247-3821 (fax).
- Colloidal titanium dioxide powder, AEROXIDE® TiO₂ P 25 (20 g included)**
Six grams are used per batch of TiO₂ suspension. Evonik Degussa Corporation, 379 Interpace Parkway, Parsippany, NJ 07054; 973/541-8106; or Evonik Degussa GmbH, Rellinghauser Straße 1-11, D-45128, Essen, Germany; +49-201-177-01.
- Surfactant (such as Triton X 100 or clear dish detergent)**
Triton X 100 can be obtain from Mallinckrodt Baker, Inc., 222 Red School Lane, Phillipsburg, NJ 08865; 908/859-2151.
- Light source**
 - **Option 1. (Recommended)**
An overhead projector with (integral) parabolic reflector. If an overhead projector is used, the assembled solar cell must be held with a ring stand and clamps midway between the projector's glass plate and projection lens to achieve illumination levels comparable to sunlight.
 - **Option 2.**
A halogen lamp with (integral) parabolic reflector. For example: Sylvania PAR 38 Halogen, GE12, or MB-JDR-75 can be obtained

at many hardware stores. When using a halogen lamp, it is important to use a 10×10 cm piece of conductive glass (e.g. TEC 10 or 15) or other suitable heat (IR) filter to protect the solar cell from excessive heating. Hold setup together with clamps and a ring stand.

A suitable IR filter can be made by using a petri dish filled with 0.1 M CuSO_4 solution. This blue solution will absorb most of the IR light, but will allow most of the visible light to pass through. The CuSO_4 filter or the TEC glass is placed between the light source and solar cell using clamps and a ring stand.

☐ **Heat Source (see p 38, Figure N)**

• **Option 1.**

Low air flow hot air gun, or paint stripper gun. Leister Model Hotwind S from Assembly Supplies Co., 2245 Enterprise Street, Escondido, CA 92029; 760/504-0333; or Steinel Typ. 3449 from Insulation Supply Co., 1901 Harpers Way, Torrance, CA 90501; 800/457-7715.

A $25 \text{ cm} \times 4 \text{ cm}$ (inner diameter) glass tube, Pyrex or quartz is best. Use clamps and a ring stand to hold the setup together. One clamp holds the heat gun. Another clamp holds the tube. To prevent burning, all clamps that are exposed to elevated temperatures should have their rubberized coatings removed.

• **Option 2.**

An alcohol lamp, ring stand, and ceramic triangle.

☐ **Iodide electrolyte solution in dropper bottle (15 mL included)**

0.5 M Potassium iodide mixed with 0.05 M iodine in water-free ethylene glycol (not very stable in sunlight without a UV filter).

The calculations for making the electrolyte solution are as follows.

Potassium Iodide, KI:

$$(0.5 \text{ mol/L}) \times (0.01 \text{ L}) \times (166.01 \text{ g/mol}) = 0.83 \text{ g in } 10 \text{ mL of solvent}$$

Iodine, I_2 :

$$(0.05 \text{ mol/L}) \times (0.01 \text{ L}) \times (253.81 \text{ g/mol}) = 0.127 \text{ g in } 10 \text{ mL of solvent}$$

Here is the procedure to make the electrolyte solution:

Put the correct amount (10 mL) of Ethylene Glycol in a container. Weigh 0.127 g of I_2 and add it to 10 mL of Ethylene Glycol. Weigh 0.83 g KI and add to the same 10 mL of Ethylene Glycol. Mix together with a clean glass rod or mixing instrument. Do not get any water in the electrolyte solution. Keep in mind that the chemicals are hygroscopic and will pick up moisture from the air. Keep all bottles and containers tightly capped when not in use.

If you want to mix up a 100 mL (0.1 L) batch multiply all the gram values (above) by 10.

- Nitric or acetic acid solution (10 mL, pH 3–4 in deionized water) or 0.2 mL acetyl acetone (used per TiO₂ suspension batch)**
- Polycarbonate (Lexan) plastic plate (2.5 cm × 2.5 cm)**
Note: the lenses on most safety glasses are polycarbonate—a lens from a discarded pair of safety glasses will work.
- Ethanol and deionized water in wash bottles**
- Soft graphite pencil (no. 2) (1 pencil included).**
Alternatively, an artist's charcoal pencil or cleaned carbon rod taken from an alkaline battery can be used.
- Copper foil tape (3M No. 1181 with pressure sensitive conductive adhesive) (included).**
Two 1-cm long pieces are used per solar cell. 3M Electrical Specialties Division, 6801 River Place Blvd., Austin, Texas 78726-9000; 800/245-3573 or 512/984-1800; or Digi-Key, stock #3M1181A-ND, 701 Brooks Avenue South, Thief River Falls, MN, 56701; 800/344-4539; 218/681-3380 (fax).
- Organic dye**
Prepared from blackberries, raspberries, pomegranate seeds, Bing cherries, or green citrus leaves, fresh or frozen
- Binder Clips (small) (10 clips included).**
The binder clips should be bent so that the pressure they exert is not too great. The jaws should be partially opened. Two clamps are used per solar cell.
- Multimeter, capable of measuring volts and ohms.**
A digital multimeter is best. Two multimeters per group work best, but see Appendix One (see p 62) for alternate instructions if only one meter is available per group.
- 500-Ohm potentiometer (1 potentiometer included), variable load.**
It is recommended that three wires be soldered to the potentiometer leads so that connections are easier to make during the data collection portion of the experiment.
- Hookup wire (black and red)**
- Alligator clips (large)**
The clips should exert a large pressure when closed.
- Zip-lock™ or other sealable plastic storage bags**
- Glassine envelopes (5 included) to store the glass plates.**
More envelopes can be purchased from a stamp collecting supplier.
- Dropper bottle (1 included)**
Used for storing and dispensing the TiO₂ suspension.
- Pipettes (or auto pipette)**

- Mortar and pestle**
- Ring stand and clamps**
Used to fix the solar cell a certain distance from light source
- Tweezers or forceps**
- Tongs**
- Petri dish or beaker**
- Transparent tape**
Scotch™ brand by 3M works well
- Candle**
White or colorless to match Transparent tape (Scotch™ brand by 3M works well)
- Glass stirring rod**
- Absorbent tissue paper**
- Cotton swabs**
- Filter paper, glassware for filtration**
- Safety goggles**
- Protective gloves, tight fitting**

Optional equipment and supplies:

- Sephadex LH 20 (Pharmacia) column**
- Motor (Maxon A-max 103707, or 2522.938-12.112.000)**
Maxon Precision Motors, Inc., 101 Waldron Road, Fall River, MA 02720, USA; 508/677 0520; or Maxon Motor AG, P.O. Box 263, CH-6072 Sachseln, Switzerland; Fax: + 41 41 666 1616; <http://www.maxonmotor.com>. Approximately \$40 per motor.
- Capacitor: 10,000 micro-Farad, single polarity**
Available from electronic supply companies. It is recommended that wires be soldered to the capacitor leads so that connections are easier to make.