



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. The list is divided into those materials that are *included* in the Solar Cell kit, those that are *needed but not included*, and those that are *optional*.

Materials marked with a star ★ are available for separate purchase from ICE; go to: <https://icestore.chem.wisc.edu/products/replacement-parts>. Listed below is information about other suppliers of depletable materials that may be difficult to obtain (but remember, part numbers may change).

Equipment and Supplies: Required and Included

- ★ **Conductive (tin dioxide coated) transparent glass slides, in protective glassine envelopes (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 several suppliers including: Hartford Glass Co., P.O. Box 613, Hartford City, IN 47348; 765/348-1282; fax: 765/348-5435; e-mail: hartglas@netusal.net; or Pilkington North America Inc., P.O. Box 799, Toledo, OH 43697-0799; 419/247-3731; fax: 419/247-3821; <http://www.pilkington.com>. [[sets of 10 additional slides may be purchased from ICE](#)]
- ★ **Colloidal titanium dioxide powder, AEROXIDE® TiO₂ P 25 (20 g included)**
Six grams are used per batch of TiO₂ suspension. A supplier in the U.S. of Evonik Corporation's Aeroxide P-25 titanium dioxide is: The Cary Company, 1195 West Fullerton Avenue, Addison, IL 60101; 630/629-6600; www.thecarycompany.com. [[20-g jars of TiO₂ may be purchased from ICE](#)]
- ★ **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 Div., 6801 River Place Blvd., Austin, TX 78726-9000; 800/245-3573 or 512/984-1800; or Digi-Key, stock #3M1181A-ND, 701 Brooks Ave. South, Thief River Falls, MN, 56701; 800/344-4539; fax: 218/681-3380. [[pieces of copper foil tape may be purchased from ICE](#)]

Materials Included

These materials are included with the ICE Nanocrystalline Solar Cell Kit.

Additional components and replacement parts marked with an ★ are available from ICE at: <https://icestore.chem.wisc.edu/products/replacement-parts>

materials included

**Materials Included
(continued)**

These materials are included with the ICE Nanocrystalline Solar Cell Kit.

Additional components and replacement parts marked with an * are available from ICE at: <https://icestore.chem.wisc.edu/products/replacement-parts>

these materials included

- * **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).

Additional 15 mL bottles of electrolyte solution may be purchased from ICE as [replacement parts](#). If you choose to prepare the solution yourself, you can do so as described below:

- **Calculations** for making the electrolyte solution:

Potassium Iodide, KI:

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

Iodine, I₂:

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

- **Procedure** for making the electrolyte solution

Put the correct amount (10 mL) of ethylene glycol in a container. Weigh 0.127 g of I₂ 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.

- Soft graphite pencil (HB woodless graphite pencil) (1 included)**
Graphite pencils may be purchased from any art supply store. Alternatively, an artist's charcoal pencil, a cleaned carbon rod taken from an alkaline battery, or soot from a candle flame can be used.
- 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.
- * **1000-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. [[potentiometers are available from ICE](#)]
- Protective Glassine envelope to store the glass slides (included)**
More envelopes can be purchased from a stamp collecting supplier.
- Dropper bottle (1 included)**
Used for storing and dispensing the TiO₂ suspension.

Equipment and Supplies: Required, NOT Included

- ❑ **Surfactant (such as Triton[®] X 100 or clear dish detergent)**
Triton[®] X 100 can be obtained from Avantor Performance Materials (previously Mallinckrodt Baker), 222 Red School Lane, Phillipsburg, NJ 08865; 908/859-2151; <http://www.mallbaker.com/>. Triton[®] X 100 is also readily available from Sigma-Aldrich, an international chemical supplier. Find a local distributor at <http://www.sigmaaldrich.com/>.
- ❑ **Light source**
 - **Option 1 (Recommended)**
Sunlight produces the highest readings of voltage and current. Ideally students will be able to test their solar cells outdoors in direct sunlight.
 - **Option 2**
A halogen lamp with (integral) parabolic reflector. For example: PAR-38 type halogen flood light bulbs or smaller JDR type halogen flood light bulbs by Sylvania, GE, Philips, or other major brands are readily available at hardware stores or from online retailers. 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 the 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 CuSO₄ solution. This blue solution will absorb most of the IR light, but will allow most of the visible light to pass through. The CuSO₄ filter or the TEC glass is placed between the light source and solar cell using clamps and a ring stand.
 - **Option 3**
An overhead projector with (integral) parabolic reflector. If using an overhead projector, the assembled solar cell must be held with a ring stand and clamps midway between the projector's glass surface and projection lens to achieve illumination levels comparable to sunlight.
- ❑ **Heat Source (see p 36, Figure N)**
 - **Option 1**
Low-air flow hot air gun, or paint stripper gun. Available from most home improvement, hardware, and painting supply companies. A 25 cm × 4 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**
Ceramic top hotplate (must be able to reach ~450 °C)
 - **Option 3**
An alcohol lamp, ring stand, and ceramic triangle.
- ❑ **Nitric or acetic acid solution (10 mL, pH 3–4 in deionized water) or 0.2 mL acetylacetone (used per TiO₂ suspension batch)**

Materials NOT Included

These required materials are NOT included with the ICE Nanocrystalline Solar Cell Kit.

materials NOT included

Materials NOT Included (continued)

These required materials are NOT included with the ICE Nanocrystalline Solar Cell Kit.



- 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**
- Organic dye**
Prepared from blackberries, raspberries, pomegranate seeds, Bing cherries, or green citrus leaves, fresh or frozen
- Multimeter, capable of measuring volts and ohms.**
A digital multimeter is best. Two multimeters per group work best, but see Appendix One (page 60) for alternate instructions if only one meter is available per group.
- Alligator clips (large)**
The clips should exert a large pressure when closed.
- Zip-lock™ or other sealable plastic storage bags**
- Hookup wire (black and red)**
- 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
- Glass stirring rod**
- Absorbent tissue paper**
- Cotton swabs**
- Filter paper, glassware for filtration**
- Safety goggles**
- Protective gloves, tight fitting**

Optional Materials

These materials are NOT included with the ICE Nanocrystalline Solar Cell Kit and are NOT required.



Equipment and Supplies: Optional

- 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; <http://www.maxonmotorusa.com/contact.html> 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. If unavailable, use a motor that will run on 4 mA and 0.4V
- Capacitor: 10,000 micro-Farad, single polarity**
Available from electronic supply companies. ICE recommends soldering wires to the capacitor leads so that connections are easier to make.