Example Application
Materials in the House
EYH 2012 Cornell University

I. *What is the main goal of your workshop? In 2-3 sentences describe what the participants should know, be able to do, etc., after attending.*

Our workshop is focused on using everyday materials found in the home to show how polymers behave to teach basic materials science concepts. They will learn, on a basic level, how cross-links work (silly putty), why materials are strong (straws / shrinky dinks), how they are made (nylon), and how they break (straws. CDs).

II. *Please provide us with a bulleted summary of your planned activities during the workshop and the learning objectives for each one. We would like to use these to get an idea as to what the exact content of the workshop would be, please be as detailed as possible. Remember, you will have an entire hour.*

1. Safety introduction (10 min)

   Introduce lab. Explain basics of lab safety (googles, lab coats, hair tied back, gloves), what's in a chemistry lab, location of safety equipment (shower, fire extinguisher, fire blanket). After the explanation, the girls and buddies will be 'polymerized' by having them walk randomly about the lab and when they come into contact with another person, they will join hands. At the end, they will have made a poly(EYH participant).

   Learning objectives: lab safety. This is of fundamental importance to everyone working in a lab. A polymer is a repeating (poly-) strand of building blocks (-mer). The properties of these polymer chains are what we spend our time studying, because they have such interesting and important properties that affect our everyday life.

2. *CD breakage (5 min, safety glasses, gloves)*

   To the group, the use of an acetone squirt bottle should be explained (flammable solvent, don't squirt other girls, will remove nail polish) and the amount necessary for bending a CD (and where the girls should squirt) will be explained. The girls will then be put in pairs (preferably with another girl). One girl will bend the CD, while the other squirts a bit of acetone at the bent part. Breakage will ensue! As a comparison, a little bit of acetone will also be squirted onto an unbent CD (use one of the broken halves).

   Learning objectives: solubility; The way polymer chains pack together has a dramatic impact on their properties. In the case of CDs, which are made of semicrystalline polycarbonate, the stress induced by bending combined with the rapid expansion of the polymer network causes the catastrophic failure of the material. This swelling can be observed more peacefully when acetone is dropped on the CD, which then becomes cloudy. In this case the crystallites *are swelling or aggregating to sizes where they can scatter light, which is seen as a transparent to cloudy transition. Polymer solubility can be quantified with a solubility parameter with units of Hidebrands or (cal cm^{-3})$^{-0.5}$, which is directly related to the enthalpy of dissolution. When the solubility parameter of a polymer is close enough to that of a solvent, swelling and eventual dissolution will result. This has real world has real world applications, as recently a cooling system at a CA state prison failed when the engineers used ethylene glycol (14.2) in combination with a polyacrylonitrile (15.4) storage unit.*

3. Styrofoam dissolution (5 min, safety glasses, gloves)

   The pairs will then be given another squirt bottle with DI water and two stryofoam cups. Have the girls place one cup in each beaker/crystallization dish. Water will be squirted into one and acetone in the other. The cup with acetone in it will release the trapped gas and eventually dissolve.

   Learning objective: This again demonstrates the difference in solubility between different solvents. In the case of the acetone, we can additionally see that there is gas trapped within the material. This is important, because it helps makes the cups insulating.

4. Nylon (10 min, gloves, safety glasses)

   The girls (wearing gloves and safety glasses) will mix the two monomers of nylon (hexamethylenediamine and sebacoyl chloride) in a beaker. At the interface of these two liquids, they will be able to pull out a nylon film with a glass rod. This will then be disposed of in the chemical waste. A comparison should be made to regular nylons and mention that polymer processing is key.

   Learning objectives: the combination of two monomers (liquids) can result in a new material with very different properties (Nylon), i.e. what a polymer is, how its made, and why its used so much. Monomers often come in liquid form (but can also be gasses), but at the end of the polymerization we are often left with either sticky goo or eventually solid materials.

5. Silly Putty (10 min, gloves, safety glasses)

   The girls will pour 1-2 glugs of elmers glue, 2-3 drops of food coloring, and a shake of borax into a paper cup. They will then stir the mixture with a popsicle stick until it becomes thick. More borax can be added if it is still too gooey and more elmers can loosen it up if its too thick.

   Learning objectives: Cross linking. Elmers glue is predomimantly poly(vinyl acetate), by adding sodium tetraborate (borax) the acetate chains are noncovalently linked together to form crosslinks. Adding crosslinks to a material dramatically changes its materials properties, for example butadiene rubber is crosslinked with sulfur (vulcanization) to make conventional tires.

6. Straw breakage (5 min, safety glasses)

The girls will be in paired up with a new partner and given four straws. First, each girl will be asked to pull the straw apart from either end (uniaxial tension along the long axis of the straw). This should be very difficult for all of them. Next, have one girl will roll up a straw around both of their fingers from each end (creating an air pocket in the middle) and the other girl will flick it, causing a pop. Now repeat, with the girls' roles switched.

Learning objective: chain alignment. In this case you are applying a force in two different directions, highlighting the importance of chain orientation on polymer properties. When the straws are extruded (think of the Playdoh press, where you push the lever down and the Playdoh squirts out), the chains align parallel to the flow rate. Pulling along these chains is very difficult, because you are pulling against the strength of the entire polymer chain. But applying a force (by flicking, enhanced by the increased pressure from twisting the straw) orthogonal to the chain orientation causes the material to fail.

7. Shrinky dink (10 min, safety glasses)

   Precut rectangles of shrinky-dink paper will be passed out to the girls along with a fine tip clickable sharpie. The girls can then write a message (e.g. "Chemistry Rules!") on the rectangle. The shrinky-dink material can then be put on a preheated hotplate. When the material is done shrinking, it can be taken off with tongs and once cooled, given to the girls to take home.

   Learning objectives: shrinky dinks are processed such that their chains align biaxially with an intrinsic strain. When the polymer is heated above the glass transition temperature, there is enough energy for the chains to move and subsequently relax. The induced strain causes the material to shrink along the length of the chain, resulting in shrinkage that maintains the aspect ratio of the material.

8. Wrap up (5 min)

   We will go through the activities that the girls did on the board and under each one, have the girls name one or two things they learned in each station. Their answers can be read of their sheets that they were given (to take home) as well. This part can be extended if the station runs quickly or shortened to save time.

III. What prior knowledge (if any) do you expect the girls to have to complete your workshop?

The only prior knowledge required is what an atom/molecule is, just that they exist and make up the universe. These activities will do the rest.

IV. What materials do you anticipate needing to obtain to make the workshop as interactive and engaging as possible?

The group (where we all work) can provide some of the basic materials: elmer's glue, borax, glassware, goggles for their use, some of the basic reagents for the Nylon activity, acetone, and any chemical waste disposal.

Ideally, we will be situated in one of the chemistry teaching labs. There we will have access to water, hot plates, and gloves.

We would need financial support to cover hexamethylene diamine (Nylon), sebacoyl chlrode (Nylon), food coloring, shrinky dink sheets, straws, CDs, and Styrofoam cups. All of these materials can be reused again next year.