

Denaturing Ethanol Fuel: Project Gaia Procedures and Protocol

Objective: To mark alcohol fuel for cooking as recognizable and to render the fuel undrinkable.

Protocol: Denaturing ethanol should be done within a drum container of a minimum of 55 gallons. With smaller quantities, it is easy to put too much color or too much Bitrex in the alcohol. Bitrex is the most bitter chemical known to man, and is used as a bittering agent for alcohol fuels.

Once the dye and Bitrex have been added to the ethanol fuel, contained in bottles, and distributed, the alcohol fuel will have been rendered undrinkable for the final users. With proper safety training in the use of the stove and handling of the fuel, the combination has been proven to be extremely safe.

Denaturing with Bitrex: Formula for 55-gallon drum with Bitrex at 10 ppm

1. Based on prior work, it is recommended to denature at not less than 10 ppm but NOT MORE THAN 20 ppm. It is very, very important not to over-denature. The fuel would become obnoxious to use because any spillage on the hand at over 20 ppm would leave a bitter residue that could easily travel to the mouth.

10 ppm = $10/1,000,000 = 1/100,000$, meaning that 1kg of Bitrex is enough for 100,000 kg of ethanol. Since the density of ethanol is about 0.8 this means:

1 kg is enough for $100,000/0.8 = 125,000$ L of ethanol
5 L of ethanol needs $5/125,000 = 0.00004$ kg of Bitrex
 $0.00004 \text{ kg} = 0.04 \text{ g}$
5 L of ethanol needs $5 \times 1000/125,000 = 0.04$ g of Bitrex
10 L: 0.08 g of Bitrex
25 L: 0.20 g of Bitrex
(And 1 L of ethanol needs only 0.008 g of Bitrex to achieve 10-ppm level)

One gallon US = 3.78 liters
A 55 gallon drum = 208.19205 liters
 $208.19205 \text{ liters per drum} \times 0.008 \text{ g of Bitrex} = 1.665 \text{ g of Bitrex for each 55 gallon drum.}$

**As you see, it is not a matter of measuring with a teaspoon but rather what you can put on the tip of a small knife.*

2. The Bitrex should be weighed out on a gram scale, accurate to two decimal places. It should be thoroughly mixed into the ethanol. This is not difficult since the Bitrex is readily soluble.

3. The Bitrex is harmless and inert, but very bitter. Therefore, a breathing mask should be worn (a simple filter mask) and latex gloves should be worn on the hands. Eye protection should also be worn. The Bitrex should be opened carefully on a flat surface in a closed room with no draft or air current. The Bitrex should be weighed on the gram scale and then put directly into the ethanol. The Bitrex container should be immediately resealed and the container placed back in its protective bag. Gloves,

mask, and eye shield can then be taken off, for once the Bitrex is in the ethanol it will not powder in the air. The mixers, regardless of these precautions, will note a bitter taste on their lips. This will pass quickly (30 minutes). Even when great care is taken, some of the Bitrex, in tiny, tiny amounts, will have powdered in the air and will be detected on the lips, through or around the mask. The concentration won't be enough to cause prolonged annoyance. However, if the procedures above are not followed, the mixers will have far greater annoyance.

Blue Dye:

1. Rather than weighing or measuring out computed amounts of the dye, add extremely small amounts of the dye (each color, alternately), stir the ethanol, and observe the color density and quality. When you achieve what is desired, stop there. It will be very easy to get too much color in the ethanol, which is not wanted.
2. Take a narrow diameter straw or a glass pipette, dip it in the [color 1] dye, cover the top, and transfer a drop into the drum of ethanol. Do the same with the [color 2] dye. Mix well. Dip in a beaker and take out some of the ethanol to look at in the light. Repeat with the [color 1&2] dyes until you have sufficient color. NEVER add more than one drop of each color at a time before examining the result. Keep a record of what you are adding. Once you have that formula, stick to it consistently.
3. The ethanol should have just enough color to be recognizable or distinguishable, BUT NO MORE. It should be very clear, colored just enough so that you know it is not water. You should be able to easily see through it. The less color, the better. The intent is simply to achieve a signature appearance.

Bottling:

1. Once properly denatured and dyed, the alcohol fuel is ready to be bottled for distribution. The ethanol can be distributed in labeled 1.2 liter plastic bottles (single-use for fuel canister of the CLEANCOOK stove) or it can be poured into jerry cans of various sizes (5, 10 Liters). It is important that jerry cans have a wide mouth or opening. Beneficiaries should be properly trained in safe storage and use of their alcohol fuel.

Tips:

- 1) The key to successful denaturing is to not add too much Bitrex.
- 2) The Bitrex should be added up to 10 ppm.
- 3) Conserve resources: Bitrex can go a very long way if used in the proper quantity.
- 4) Do not denature at too high a rate or the household consumers will get Bitrex on their hands (and it will give a bitter taste to food).
- 5) Also beware of adding too much color dye. One wants to achieve only a very light [blue] translucent color, just enough to distinguish ethanol fuel from water.
- 6) Once you find the desired color intensity, use the same amount as a guide for the next batch. Care should be taken to color the alcohol exactly the same way each time for a consistent color.