

Small Scale Ethanol Production

Amanda Runge



Figure 1: Photograph of Working Laboratory Set-up

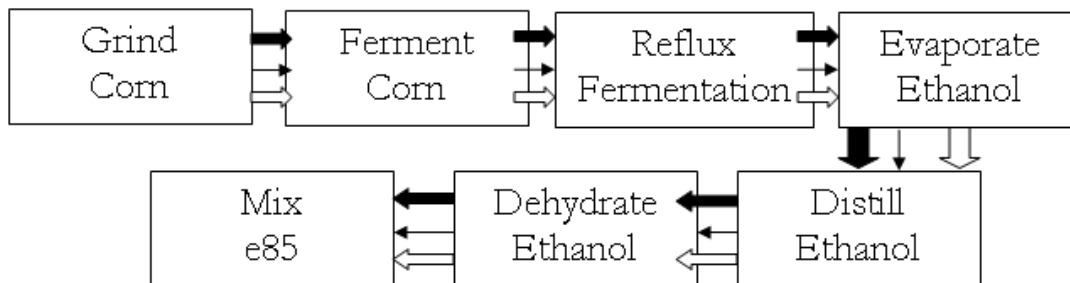


Figure 2: Functional Analysis of Process

Summary:

Alternative energy is currently a topic of considerable interest to the public, with the introduction of hybrid cars and alternatives for fossil fuels. Ethanol is currently a leading alternative to replace to gasoline currently being used for automobiles. Ethanol can be produced from corn and mixed with different amounts of gasoline reducing the amount of greenhouse gas emissions. E85 and E10 are two types of ethanol gasoline comprised of 85% ethanol and 15% gasoline, and 10% ethanol and 90% gasoline respectively.

The field of chemical engineering deals with the demands for producing ethanol on the industrial level, but Hope College's Introduction to Engineering course is tackling the issue on a small scale level in an organic chemistry hood. The development of a small scale ethanol production laboratory will be used to demonstrate principles of chemical engineering in the introductory course. The laboratory set-up as well as the laboratory procedure have many requirements that must be fulfilled before allowing students into the laboratory, it must be: safe, be able to be completed, be explained in a general way for students to understand (Many students have not taken upper level chemistry courses, therefore will not know many of the techniques.), the professor should be able to manage as well as easily prepare the laboratory, waste produced should be disposed of safely, and should be inexpensive.

To develop a procedure, an overall process of producing ethanol from corn was determined and from there was elaborated to produce a process that works and a laboratory procedure that students can follow. The general process followed was: to grind up the kernels of corn, ferment the corn, reflux the fermentation, evaporate the ethanol, distill the ethanol, dehydrate the ethanol, and mix the ethanol with the appropriate amount of gasoline. From this general process, a way to ferment the corn, a determination between using a packed column or empty column for reflux, and a determination between using simple distillation or fractional distillation was needed. It was decided that the best to determine a working procedure was to go into laboratory and experiment with the different conceptual designs.

The first step was to ferment the corn, which can be done using an enzyme, alpha amylase, and yeast. A few problems arose during this step in the process, alpha amylase cannot be purchased by itself inexpensively (The cost is about \$150 for one gram) and yeast needs oxygen to ferment, but if left too long it begins to mold because yeast is a fungus. To eliminate the expense of the amylase, a dietary supplement, which contains the alpha amylase, enzyme, was purchased at a local health food store, Nature's Market, for about twenty dollars. To eliminate the fermentation from becoming mold, it was left to ferment for two days as well as left uncovered in the hood to minimize contamination, while allowing the yeast oxygen.

Through experimentation, it was determined that an empty reflux column and simple distillation would be used to obtain the desired results, while making it somewhat simple for the students. Based on experimentation the final, working procedure would consist of fermenting the corn for two days, the fermentation would be refluxed in an empty column, and simple distillation would be used to recover the ethanol. The procedure was evaluated using Infrared Spectrometry to determine whether or not ethanol was being produced. A known spectrum of ethanol was compared with the spectrum from the produced product. The results matched up well; ethanol was produced.

