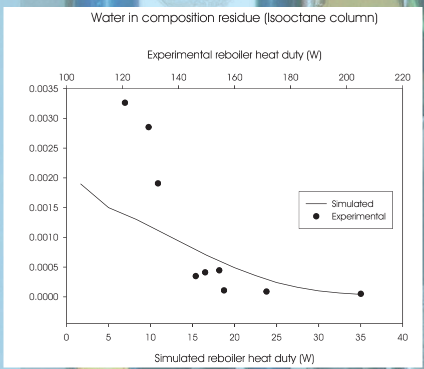
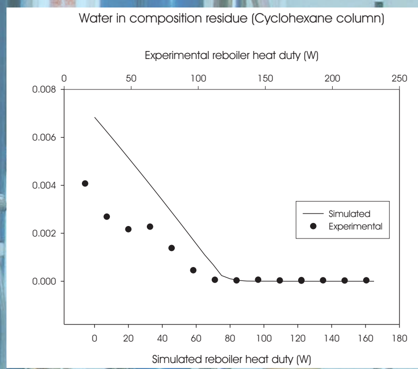
Technical-economic viability of ethanol dehydration by azeotropic distillation with gasoline to obtain an ethanol + gasoline mixture

V. Gomis, M.D. Saquete, A. Font, R. Pedraza
Tel: +(34) 965 90 34 00, Fax: 965 90 38 26, e-mail: vgomis@ua.es
Chemical Engineering Department, P.O. Box 99, E-03080 Alicante (Spain)

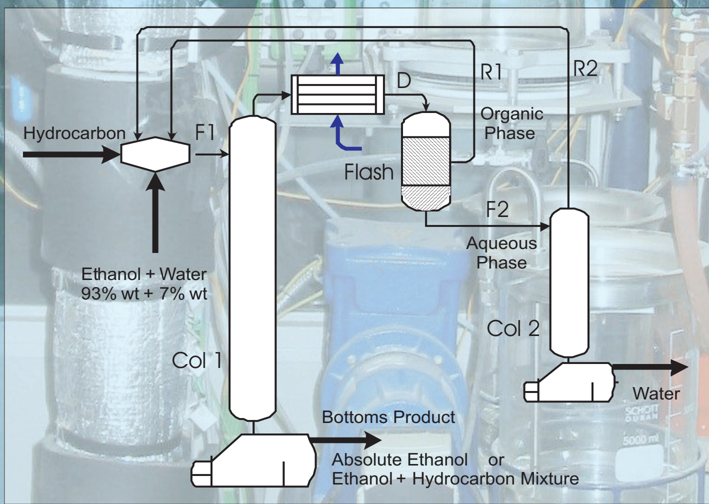
Over the past few decades, developed countries have focused their attention on the curbing of greenhouse gas (GHG) emissions. Transport is responsible for a high percentage of GHG emissions, and for this reason, it is necessary to use alternative fuels that would not contribute in increasing these emissions. Biofuels such as bioethanol have therefore been suggested as a potential alternative to achieve these reductions. Although this can readily be obtained by fermentation of sugar beet, wheat and corn, the disadvantage is that with distillation, it is not possible to completely remove the water content in the stream coming from the fermentation process. The aim of all commercial ethanol dehydration processes is to obtain pure ethanol. However, a likely alternative could be based on the production of a "dry" mixture of ethanol + hydrocarbon by azeotropic distillation using the hydrocarbon as entrainer. In this way, the resulting mixture could be directly employed as gasoline.

The present work discusses the technical and the economic viability of this process. First of all, experimental simulations were carried out in an azeotropic distillation column with two hydrocarbons representatives from gasoline: isooctane and cyclohexane. The operating conditions were adjusted in order to obtain a mixture with a maximum of 5% of ethanol, the limit established by European regulations. Experimental results demonstrate the technical feasibility of the process. The azeotropic distillation allows mixtures of hydrocarbon + ethanol with water concentrations lower than 50 ppm to be obtained.



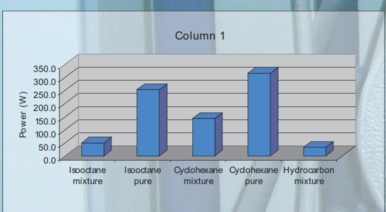


In order to analyze whether the process reduces the energy consumptions of the conventional process for pure ethanol production a simulation using CHEMCAD of both processes has been carried out. The following figure shows the flowsheet of the processes used in the simulation.



First of all, the study was carried out with the two hydrocarbons used in the experimental simulation and finally with a synthetic gasoline constituted by 10.8% hexane, 5.5% heptane, 32.6% isooctane, 13% cyclohexane and 38.1% toluene.

The operating conditions for the production of pure ethanol were chosen to obtain 99.75% wt ethanol in the bottom product of the azeotropic column. In the other process, besides the 5% of ethanol in the bottom product, the proportion of water /ethanol in this stream must be the same as in the previous process studied.



The results obtained have permitted us to conclude that the energy consumptions using certain hydrocarbons or a synthetic gasoline are similar for each process. Nevertheless, the energy consumptions for the processes based on obtaining the ethanol + hydrocarbon mixture are much lower than the case of the conventional absolute ethanol process. This fact highlights the economic advantages of the process. This is due to different flows entering columns and also very different reflux ratios in order to obtain pure components.

References:
Gomis, V., R. Pedraza, O. Frances, A. Font, J.C Asensi. "Dehydration of Ethanol Using Azeotropic Distillation with Isooctane", Ind. Eng. Chem. Res. 46, 4572-4576, 2007
CHEMCAD V, Process Flow sheet Simulator, Chemstations Inc., Houston, 2002