Technical University of Denmark

DTU

Simulation of a basic catalyzed continuous process for the production of biodiesel

Paz Garcia, Juan Manuel; Rubio, A. García; Merchán, M. C. Rey; Lahoz, C. Gómez; Alonso, C. Vereda

DTU Library
Technical Information Center of Denmark

SIMULATION OF A BASIC CATALYZED CONTINUOUS PROCESS FOR THE PRODUCTION OF BIODIESEL

J. M. Paz García[1], A. García Rubio[2], M. C. Rey Merchán[2], C. Gómez Lahoz[2] and C. Vereda Alonso[2]

[1]Dpt. of Civil Engineering, Technical University of Denmark (DTU), Lyngby, Denmark
[2]Dpto. de Ingeniería Química, Universidad de Málaga. Málaga, Spain.

Introduction

This work presents a preliminary design study of a conventional biodiesel plant using the alkaline homogeneous catalysis. The plant is designed for the treatment of 1 kmol h^{-1} of triolein (more than 7000 tons / year), which is chosen to represent the vegetable oil. The usual methanol to oil molar ratio (6:1) for the alkaline homogeneous catalysis is assumed. The study is performed using the process simulation software HYSYS 2006.5 developed by Aspen Technology, Inc.. The process flowsheet diagram is presented below, in which the more remarkable information for the simulation is showed.

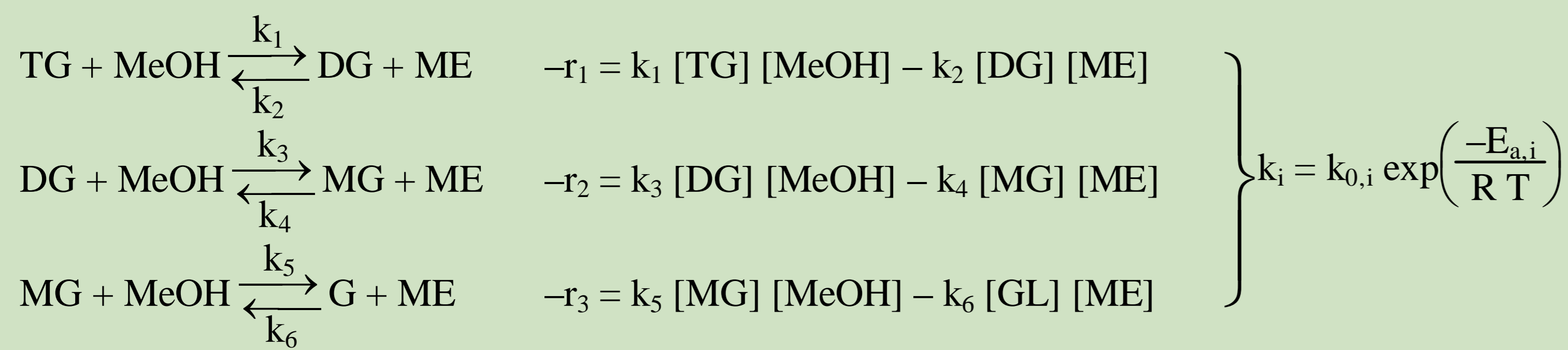### Kinetics of the homogeneous catalyzed transesterification reactions

$$TG + MeOH \underset{k_2}{\overset{k_1}{\rightleftharpoons}} DG + ME \qquad -r_1 = k_1 [TG][MeOH] - k_2 [DG][ME]$$

$$DG + MeOH \underset{k_4}{\overset{k_3}{\rightleftharpoons}} MG + ME \qquad -r_2 = k_3 [DG][MeOH] - k_4 [MG][ME]$$

$$MG + MeOH \underset{k_6}{\overset{k_5}{\rightleftharpoons}} G + ME \qquad -r_3 = k_5 [MG][MeOH] - k_6 [GL][ME]$$

$$k_i = k_{0,i} \exp\left(\frac{-E_{a,i}}{R\,T}\right)$$

Table 1. Arrhenius' parameters for the kinetics from (Vicente et al., 2005)

	k_1	k_2	k_3	k_4	k_5	k_6
$k_{0,i}$ (m^3 kmol^{-1} s^{-1})	7.37 10^9	2.12 10^{+10}	4.55 10^{+14}	2.60 10^{+14}	1.17	N.R.^{a}
$E_{a,i}$ (J/mol)	72891	71413	95690	94653	13713	N.R.^{a}

a. Not reversible.

Influence of the water to biodiesel

Influence of the water to biodiesel mass ratio on the concentration of methanol in the biodiesel product at the water washing column, in which glycerol and methanol are separated from biodiesel. A 40 ‰ water to biodiesel ratio and 5 equilibrium stages allow a methanol content in the biodiesel stream below 0.3%.
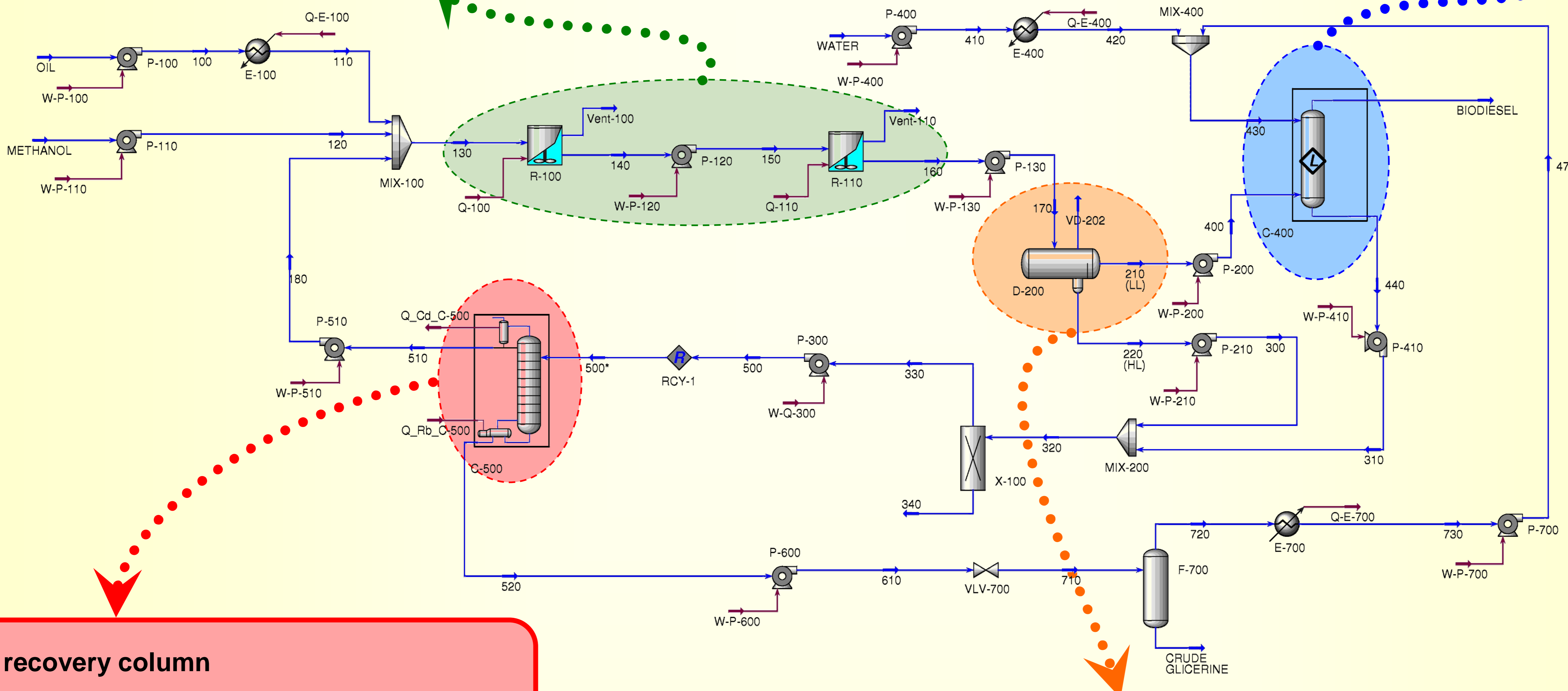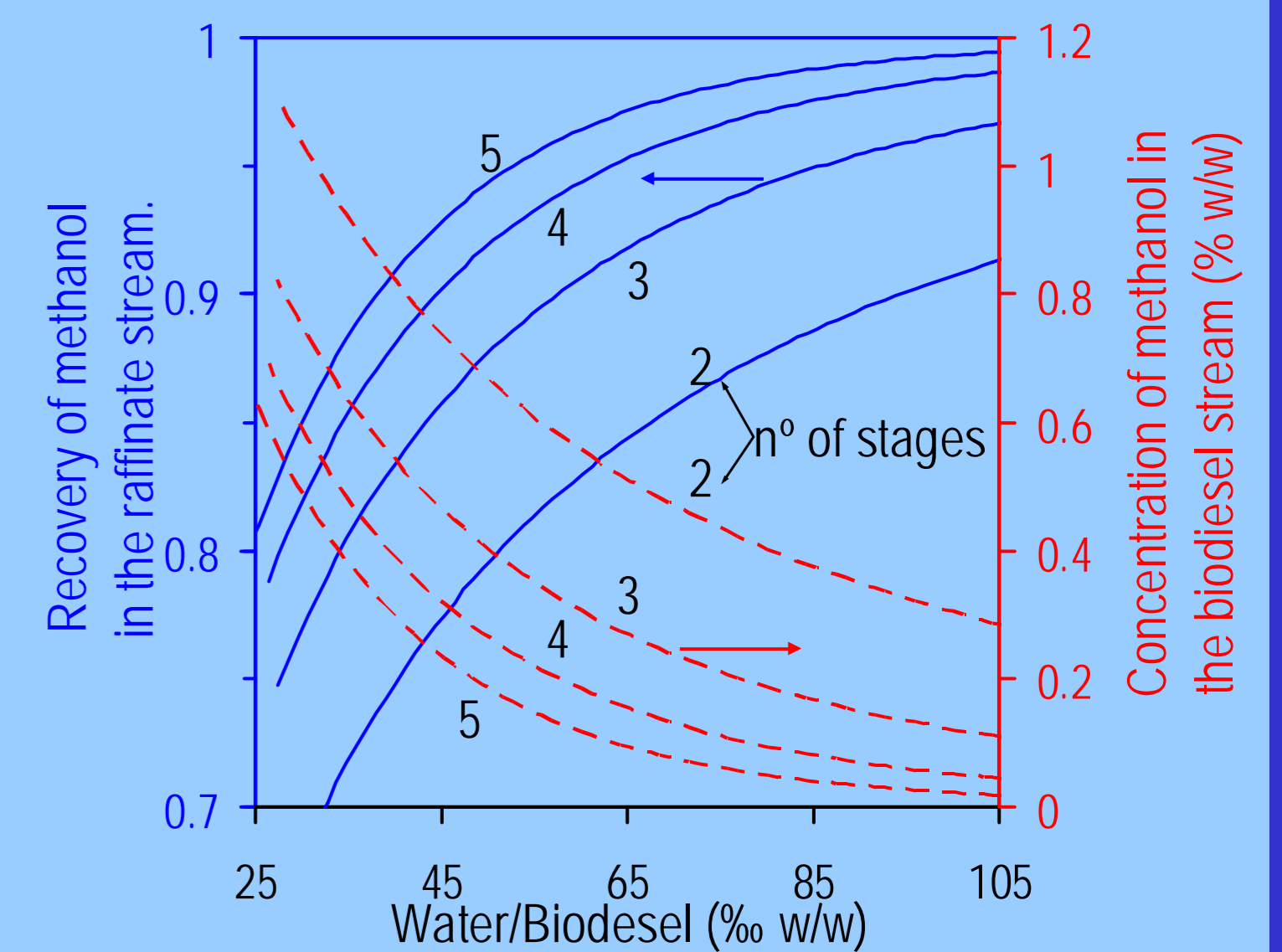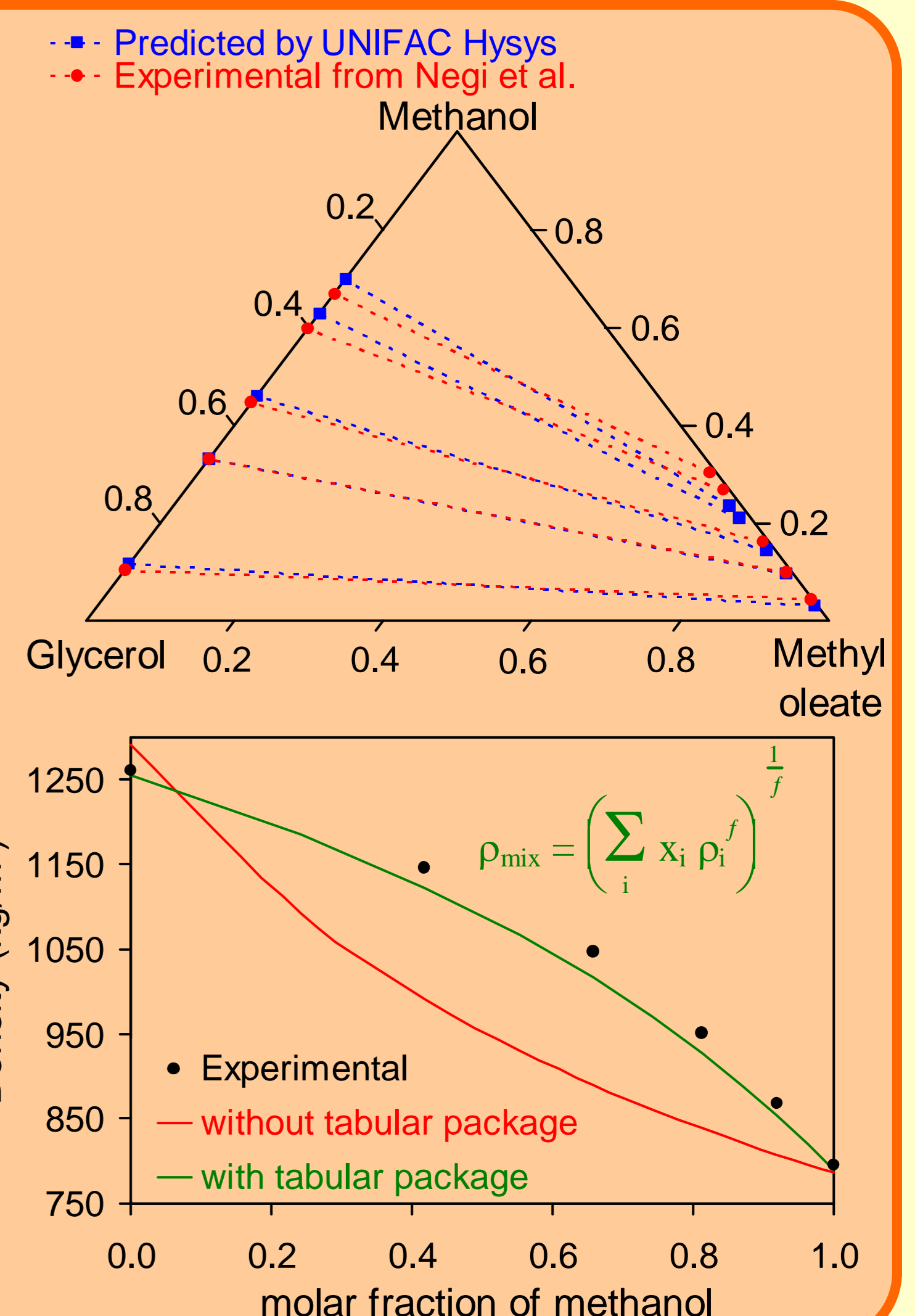

Methanol recovery column

The methanol recovery is performed in a packet distillation column, because the biodiesel capacity production of this plant is not very high. According to the rigorous model of HYSYS, 18 equilibrium stages are needed for a recovery of 99.9% of methanol. If the packing material is 3" Raschig rings, the column size is 0.6 m diameter by 8 m height (HTEP=0.43 m), according to the empirical correlation used by HYSYS, which is based on the flooding velocity.

Acknowledgement

Thermodynamic predictions for the settler

The reliability of the partition of the main components predicted by HYSYS in the settler is assessed by the comparison of the simulation results with the experimental results from Negi et al. (2006) for the liquid-liquid phase equilibrium in the ternary system at 60 ºC.

The density values calculated by the property package of HYSYS are incorrect to such an extent that the density value of the glycerol phase can become lower than that of the methyl ester phase. Therefore the tabular package in conjunction with the property package should be used, in this case density was calculated applying the default mixing rule in mole basis with mixing parameters (f) equal to −1.

- - Predicted by UNIFAC Hysys
- - Experimental from Negi et al.

$$\rho_{mix} = \left(\sum_i x_i\,\rho_i^f\right)^{\frac{1}{f}}$$

- Experimental
- without tabular package
- with tabular package

12th Mediterranean Congress of Chemical Engineering