Partial Properties in Biodiesel Production and Separation

【Module Learning Objectives】

- Partial properties and property relations for mixtures

【Associated Sections in Selected Textbooks】

- Introduction to Chemical Engineering Thermodynamics [1] Sec. 11.1 – 11.3

【Associated Web Modules】

- Biodiesel reactor:

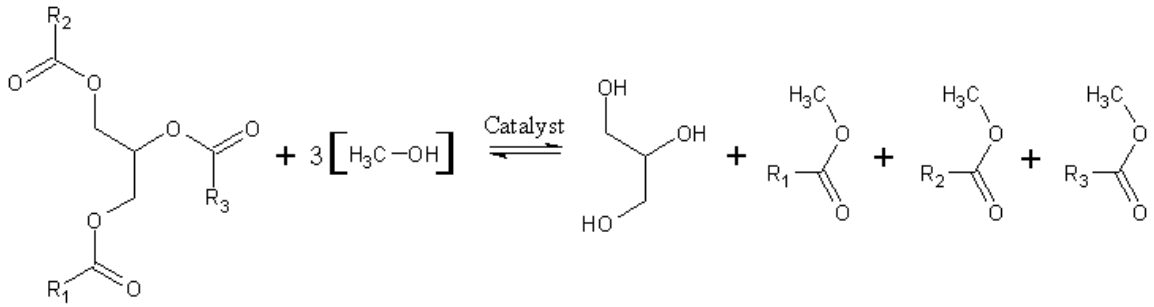
http://biofuelsacademy.org/web-modules/equipment/reactor/biodiesel-reactor-tank/

- Glycerol settling tank:

http://biofuelsacademy.org/web-modules/equipment/tank/glycerol-settling-tank/

【Process Background and Problem】

Fatty acid methyl esters (FAMEs), the primary molecules that make up biodiesel, are produced from the transesterification of triglycerides with methanol as shown below.



Assuming that a system composed of triglycerides and methanol reacts and proceeds mostly to completion, the product mixture will be made of FAMEs, excess methanol, water and glycerol, the byproduct of the reaction. The glycerol is much denser than the biodiesel, and separates by gravity in a settler [2]. After removing the FAMEs using flash distillation, a system of methanol and water will be left. For this binary liquid system, the molar volume ($cm^3\,mol^{-1}$) at T and P is modeled by [3]:

$$V = 40.41x_1 + 18.02x_2 - (4.13x_1 + 3.52x_2)\, x_1 x_2$$

where methanol is defined as species 1 and water species 2.

(a) Find expressions for the partial molar volumes of both species at *T* and *P*.

(b) Show that when these expressions are combined in accord with Eq. (11.11) [2]the given equation for *V* is recovered.

(c) Show that these expressions satisfy Eq. (11.14), the Gibbs/Duhem equation.

(d) Show that $(d\bar{V}_1/dx_1)_{x_1=1} = (d\bar{V}_2/dx_1)_{x_1=0} = 0$.

(e) Plot values of *V*, $\bar{V}_1$, and $\bar{V}_2$ calculated by the given equation for *V* and by the equations developed in (a) vs. x_1. Label points V_1, V_2, $\bar{V}_1^{\infty}$, and $\bar{V}_2^{\infty}$, and show their values.

Bibliography

[1] S. L. Scott, "UC Santa Barbara Chemical Engineering," [Online]. Available: http://www.chemengr.ucsb.edu/~ceweb/courses/che128/pdf/. [Accessed 28 March 2014].

[2] J. M. Smith, H. C. Van Ness and M. M. Abbott, Introduction to chemical engineering thermodynamics, Boston: McGraw-Hill; 7th ed., 2005.

[3] F. Koohyar, F. Kiani, S. Sharifi, M. Sharifirad and S. Rahmanpour, "Study on the change of refractive index on mixing, excess molar volume and viscosity deviation for aqueous solution of methanol, ethanol, ethylene glycol, 1-propanol and 1, 2, 3-propantriol at T= 292.15 K and atmospheric pressure," *Research Journal of Applied Science, Engineering & Technology,* vol. 4, pp. 3095--3101, 2012.