Application of Henry's law to a wet air oxidation process as a pretreatment strategy for bioethanol production

【Module Learning Objectives】

- VLE calculation based on Raoult's law and Henry's law

【Associated Sections in Selected Textbooks】

- Introduction to Chemical Engineering Thermodynamics[1] Sec. 10.3

【Associated Web Modules】

【Process Background and Problem】

The complex structure of lignocellulosic biomass (agro residues, forest residues, energy crops, municipal wastes, etc.), made up of cellulose, hemicelluloses (polymer consisting of xylose, arabinose, galactose, mannose, glucose) and lignin, is resistant to degradation and limits biomass utilization for ethanol production[2]. Lignocellulose needs various treatments to release the constituent monomeric sugars that can be fermented to useful products like ethanol. Two main steps are: (1) a pretreatment that enhances cellulose content, removes lignin, and releases pentoses and hexoses from hemicellulose and (2) an enzymatic (or acid) treatment that generates glucose from cellulose. Pretreatment has been considered to be one of the most expensive steps in the process of lignocellulose-to-ethanol conversion and can contribute to as much as 30% of the total cost[3]. Improvement of pretreatment efficiency can significantly lower the cost of lignocellulosic ethanol. One of the pretreatment methods is wet air oxidation (WAO), which involves the sub-critical oxidation of organics or oxidizable inorganic components at elevated temperatures (125–320 ^{o}C) and pressures (0.5–2 MPa) using a gaseous source of oxygen (usually air)[4,5,6]. Though the capital cost for WAO is higher than other pretreatment techniques, the operating costs are almost entirely for power to compress air[5,6]. WAO has been reported to be a potentially effective pretreatment technique for fractionating lignocellulose into a solubilised hemicellulose fraction and a solid cellulose rich fraction with minimum inhibitor formation, thereby facilitating enhanced enzymatic hydrolysis of the pretreated material for subsequent ethanol fermentation with minimum inhibitor formation[7,8].

In one such WAO pretreatment experiment, air was compressed to 1 MPa and was assumed in equilibrium with liquid water at 125^{o}C. If Henry's constant for air dissolved in water under the

given condition is 3500bar, calculate the mole fraction of air in the liquid phase and in the vapor phase.

References:

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(4) Banerjee, S.; Sen, R.; Pandey, R. A.; Chakrabarti, T.; Satpute, D.; Giri, B. S.; Mudliar, S. Evaluation of Wet Air Oxidation as a Pretreatment Strategy for Bioethanol Production from Rice Husk and Process Optimization. *Biomass- Bioenergy* **2009**, *33*, 1680.
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