P_{bub} and P_{dew} calculation based on the DePriester chart for a fast pyrolysis and hydrotreating process [1]

【Module Learning Objectives】

- VLE calculation based on K-value correlations and DePriester chart.

【Associated Sections in Selected Textbooks】

- Introduction to Chemical Engineering Thermodynamics [2] Sec. 10.6

【Process Background and Problem】

Pyrolysis is the thermal decomposition of carbonaceous material in the absence of oxygen to produce solid char, gas, and a liquid product. Residence times for fast pyrolysis are on the order of seconds [3]. After rapidly quenching the pyrolysis vapors and aerosols, three product phases are formed. The yields of each phase depend on the operating conditions, reactor design and feedstock characteristics, including ash content and the relative amounts of cellulose and lignin. The products are:

Fast pyrolysis liquid: (also known as bio-oil and pyrolysis oil) is obtained after vapor condensation. Bio-oil is black or dark brown and free flowing at room temperature and typically contains less than 30% of water and hundreds of oxygenated components [4]. It is mostly immiscible in hydrocarbon liquids and can be upgraded by hydrotreating to lower the oxygen content and decrease hydrophilicity.

Solid char: is primarily composed of carbon. It is separated from the fast pyrolysis vapors and aerosols by cyclone. This solid product can be used as fuel.

Non-condensable gas: is collected during vapor condensation. The gas is recycled internally as fluidizing gas for the fast pyrolysis reactor and/or collected for fuel use.

The non-condensable gas is a mixture of hydrocarbons, including methane, ethane, propane, butane, carbon dioxide, excess hydrogen, etc. After recovering excess hydrogen (e.g., by pressure swing adsorption) and removing CO_2, we assume the mixture contains 20 mol-% methane, 15 mol-% ethane, 25 mol-% proprane and 40 mol-% isobutene. Determine the dewpoint and bubblepoint pressures for the mixture at 50(ºF). De Priester charts (next page) [2] can be used to determine the K-values.
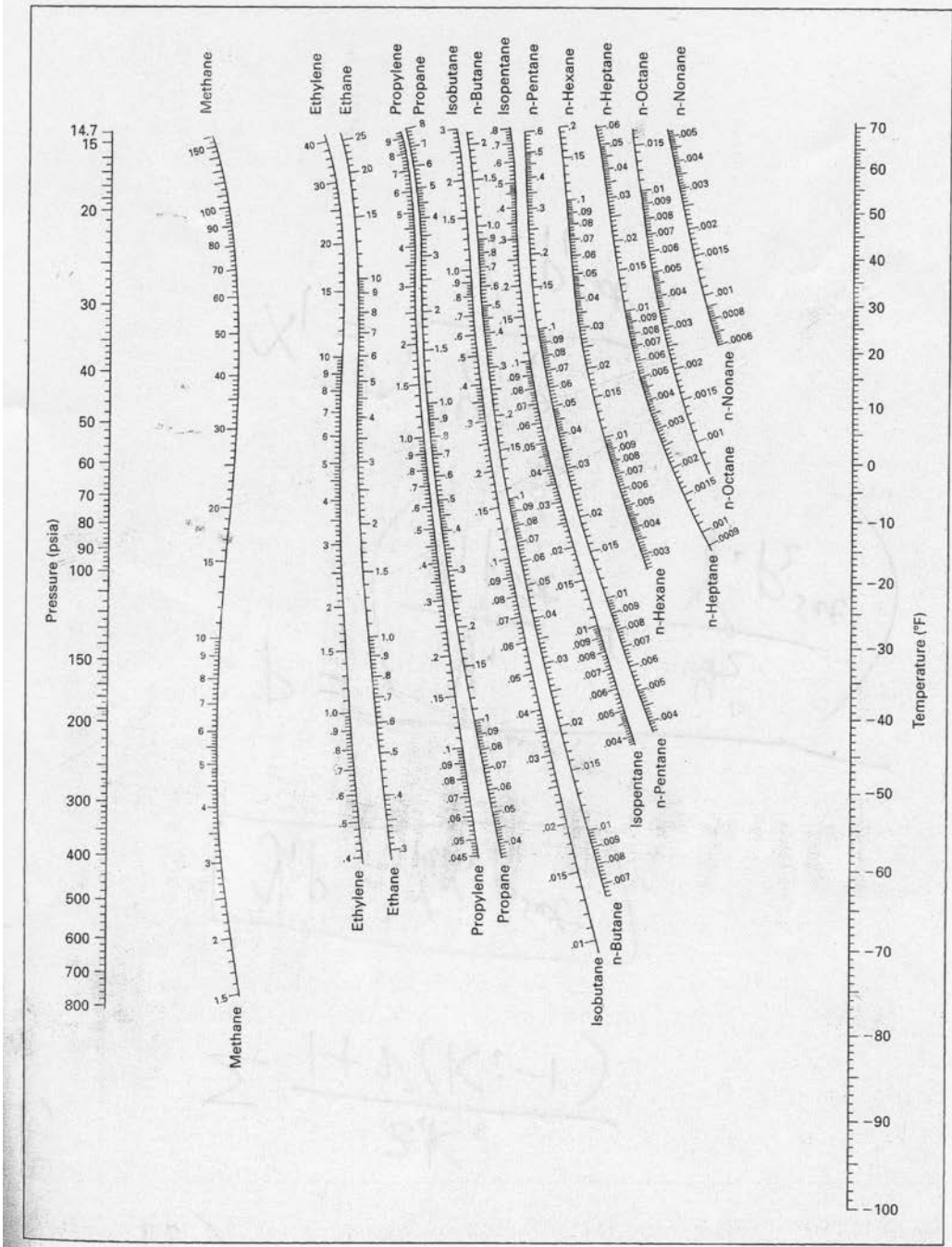
Figure 10.13: *K*-values for systems of light hydrocarbons. Low-temperature range. (Reproduced by permission from C. L. DePriester, *Chem. Eng. Progr. Symp. Ser. No. 7*, vol. 49, p. 41, 1953.)

Bibliography

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[3] P. Basu, Biomass gasification and pyrolysis: practical design and theory, Academic press, 2010.

[4] D. C. Elliott, "Transportation fuels from biomass via fast pyrolysis and hydroprocessing," *Wiley Interdisciplinary Reviews: Energy and Environment,* vol. 2, pp. 525--533, 2013.