The envelopes in Case D are similar for the different models up to about 70 bar, but above 70 bar, the decrease in dew point is different dependent on the model and dependent on the model parameters, especially the k_{ij} for water and CO_2. As for the case with a higher water concentration, the difference between the models above 70 bar is significant, so that the uncertainty above 70 bar must be regarded as large. The deviation is more than 5 ºC for the calculation of the cricondenterm and more than 30 bar for the calculation of the pressure at the cricondenterm.

When using an equation of state, it is reasonable that the non-ideality and uncertainty increases when the pressure increases, and also when the mixture is close to condensation and close to the critical point which is order of magnitude 70 bar. The prediction of vapour/liquid equilibrium becomes more uncertain when water is added to CO_2 and methane because the physical interactions become more complex. The binary parameters which are meant to adjust for non-ideality are normally fitted in the region of vapour/liquid equilibrium which is below order of magnitude 70 bar.

5 Conclusion

The condensation limit for dry and raw biogas under different conditions with varied temperature, pressure and gas composition and using different equilibrium models were calculated.

For dry biogas, all the models Peng-Robinson (PR), Soave-Redlich-Kwong (SRK), PR-Twu, SRK-Twu and Twu-Sim-Tassone (TST) gave similar results. Biogas with 60 mol-% CH_4 and 40 mol-% CO_2 will have a condensation temperature less than -20 ºC. Under normal ambient temperatures (above 0 °C), a mixture with more than 40 % methane will not give any condensation.

A process is simulated where raw biogas is cooled to 10 °C to remove water before compression. The results with biogas saturated with water at low pressure, the different models gave similar results up to about 70 bar, but above this pressure, different models gave different results. The results were dependent on the chosen value of the water/CO_2 binary interaction coefficient. The deviation in dew point temperature was about 6 K.

Both the standard PR and SRK models and the PR and SRK with the Twu α-function and with water/CO_2 binary coefficients included, gave reasonable results for the dew-point and to predict the conditions where it should be safe to avoid condensation.

For the calculation of dew points, it is recommended to use binary interaction coefficients optimized for the gas phase. If accurate calculations of the liquid composition after condensation is needed, a more advanced model like TST or HV with fitted parameters is recommended.

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