A New Microwave Resonator to Measure Phase Behaviour of Binary Mixtures

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Phasing out high global warming potential (GWP) refrigerants under the Kigali Amendment to the Montreal Protocol has motivated a search for new environmentally friendly refrigerants. While this search has focussed on identifying species with a reduced GWP, they must also be tested rigorously for their applicability to refrigeration systems. Measurements of phase behaviour are essential part of the characterisation process, where they inform the thermodynamic models used industrially in developing such systems.

Traditional measurement techniques are relatively slow and represent a bottleneck in scale due to the large number of new low GWP refrigerants and binary mixtures to be tested. In this work, we present a new microwave resonator capable of producing rapid phase behaviour measurements for pure and multi-component fluids. The resonator has three distinct modes sensitive to changes in dielectric permittivity at the top, base and whole of the cavity. The top mode (f_{vac} = 2.35 GHz) is sensitive to density or composition changes in the vapour space, the base mode (1.62 GHz) is sensitive to density or composition changes in the liquid space, and the cavity mode (6.57 GHz) is sensitive to interface location or liquid volume fraction (LVF). With this combination, the dielectric constant, dew point, bubble point, density, LVF and composition are all able to be measured. A pure fluid characterisation was achieved with saturated ethane at 303 K. Further, a binary carbon dioxide - propane mixture at temperatures of 273 - 323 K and pressures up to 5 MPa was used to demonstrate the new resonator's ability to rapidly measure phase behaviour. This technique promises significant improvements in measurement throughput which will ultimately contribute to the global effort of introducing more environmentally friendly refrigerants.