The Transport Properties of Pentafluoroethane (R125)

Efficient design of chemical processing equipment for various industrial sectors such as transportation, petroleum refining, energy, and refrigeration requires reliable values for the transport properties - viscosity and thermal conductivity. To meet these data needs, NIST pursues an integrated strategy that combines experiment and theory in the development of advanced models for transport properties, leading to predictions of reliable information even when experimental data may be lacking.

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NIST's primary approach to providing industry with needed property data is the critical assessment of all available experimental data and their representation by correlations, incorporating theory where possible. Previously we have provided representation of the viscosity and thermal conductivity surfaces of industrially important fluids such as dodecane (an alkane), and R134a (a hydrofluorocarbon). Here we have extended the model base to the viscosity and thermal conductivity of the fluorinated ethane, pentafluoroethane, also known as R125. This fluid has been proposed as a component in refrigerant mixtures such as R410A and R407C that are under consideration as replacements for the refrigerant chlorodifluoromethane (R22), that has been scheduled for phase-out due to environmental concerns over ozone depletion. Another application of R125, due to its reduction in global warming emissions over perfluoro compounds, is for use as a dielectric etchant. In addition, the solvent properties of R125 under supercritical conditions are also under investigation. The availability of accurate descriptions of the thermophysical properties of R125 aids the successful development of applications.

Pentafluoroethane, is a proposed component in alternate, more environmentally benign, refrigerant mixtures, has desirable qualities as a dielectric etchant, and its solvent properties under supercritical conditions are being investigated.

The goal of this work is to provide a wide-ranging correlation for the thermal conductivity and the viscosity of R125. It was clear from our review of the available literature that new measurements of the thermal conductivity of R125 were crucial to the development of an improved wide-ranging correlation. We measured new data, covering a temperature range from 190 K to 390 K and a pressure range of 0.1 MPa to 70 MPa, which were used together with available data from the literature to develop a correlation for the thermal conductivity of R125 that covers the temperature range from 190 K to 512 K. The experimental thermal conductivity data have an uncertainty less than 1% for measurements removed from the critical point and for gas at pressures above 1 MPa, which increases to 3% in the critical region and for gas at low pressures (<1 MPa). The quality of the primary data sets is such that the thermal-conductivity correlation for R125 is estimated to have an uncertainty of about 3 % at a 95 % confidence level, with the exception of state points near the critical point and the dilute gas, where the uncertainty of the correlation increases to 5 %.

Developing a new representation of the viscosity surface of R125 was hampered with the difficulty of deviations of more than 100% among the available experimental data. These discrepancies were all the more puzzling, and difficult to rationalize; all measurements used modern experimental apparatus having been carried out since 1990. Experimental contributions from NIST identified the underlying source of these discrepancies.

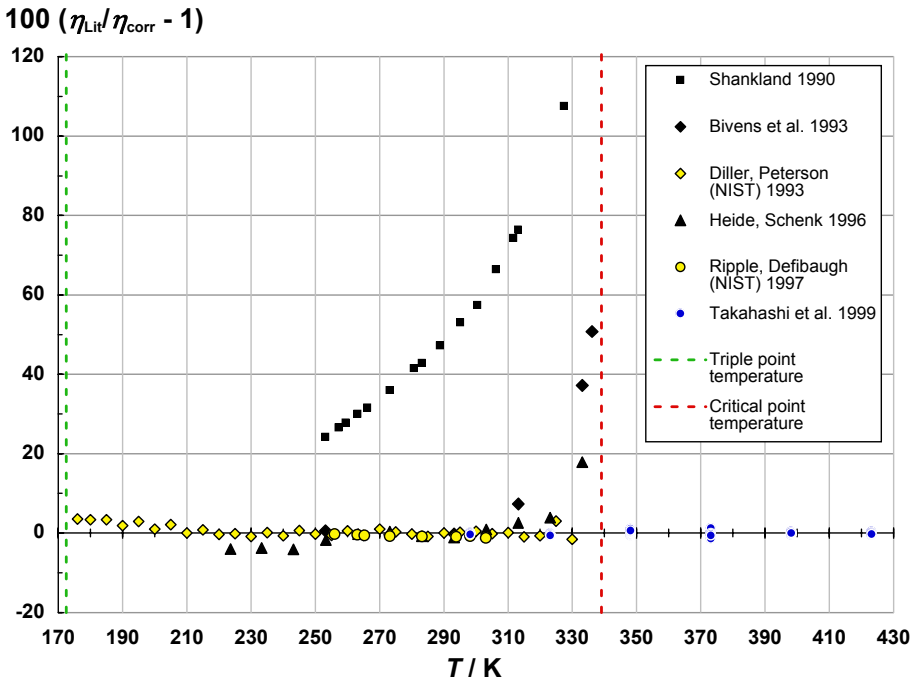
Laesecke, T. O. D. Lüddecke, R. F. Hafer, and D. J. Morris. ***Viscosity Measurements of Ammonia, R32, and R134a. Vapor Buoyancy and Radial Acceleration in Capillary Viscometers.*** Int. J. Thermophys., 20(1999)2.

R. F. Hafer and A. Laesecke***. Extension of the Torsional Crystal Viscometer to Measurements in the Time Domain.*** Meas. Sci. Technol., 14(2003)5.

Sealed capillary viscometers had been employed without accounting for the vapor buoyancy on the liquid flow. Coiled capillaries had been used without considering the radial acceleration of the liquid in such tubes. And viscosity measurements with torsionally vibrating piezoelectric quartz crystals had been carried out without regard of either the applied drive voltage or the transient crystal relaxation upon frequency changes. These insights made it possible to identify the most reliable data for the new correlation of the viscosity of R125 (see Figure). It is valid over a wide range of fluid states including the supercritical region, spanning a temperature range from the triple point at 172.52 K to 500 K with pressures up to 60 MPa. The formulation is theory-based to the extent possible. It includes a zero-density contribution, the initial density dependence according to the Rainwater-Friend theory (developed at NIST), and a residual contribution with free-volume terms and polynomials in terms of reciprocal temperature and density. The viscosity correlation has an estimated uncertainty of 3.0 % along the saturation boundary in the liquid phase, and of 0.8 % in the vapor.

Dissmenation: These correlations are important to both our infrastructural work, and the information will be disseminated through such standard reference databases as NIST REFPROP.

Future Plans: The ongoing program of integrated modeling and experimental work will continue to focus on both immediate and specific demands for transport property information and on longer-term efforts to improve our predictive capabilities of important industrial fluids.



Publications

R.A. Perkins, M.L. Huber, ***Measurement and Correlation of the Thermal Conductivity of Pentafluoroethane (R125) from 190 K to 512 K at Pressures to 70 MPa,*** J. Chem. Eng. Data, 51 (2006)3, 898-904.

M.L. Huber, A. Laesecke, ***Correlation for the Viscosity of Pentafluoroethane (R125) from the Triple Point to 500 K at Pressures up to 60 MPa,*** Ind. Eng. Chem. Research, ASAP web release May 6, 2006. http://pubs3.acs.org/acs/journals/doilookup?in_doi=10.1021/ie051367l