Greenspan Acoustic Viscometer: Progress Towards a Standard for Gases

K.A. Gillis, J.B. Mehl, and M.R. Moldover
Physical and Chemical Properties Division
National Institute of Standards and Technology
Gaithersburg, MD 20899 USA

The Greenspan viscometer is a compact acoustic resonator in which the test gas oscillates at frequency f between two cavities through a duct of radius r_d. In a first approximation, the viscosity η of the gas is related to the Q of the oscillation through $Q^2 = r_d^2 \rho \pi f / \eta$. As developed by us, the Greenspan viscometer is an absolute instrument. That is, the viscosity is deduced from measurements of the dimensions of the instrument and its frequency response. No calibration is used. Typically, the cavities have volumes of approximately 30 cm^3 and the duct has a radius of 1 mm to 3 mm and a length of 1.5 mm to 6 cm. Typical values of f are 100 Hz to 300 Hz. During 1996, we reported [*Rev. Sci. Instrum.* **67**, 1850-1857 (1996)] that our "best" Greenspan viscometer had systematic errors of approximately 1%. Subsequently, the theory of the instrument was improved and four new viscometers were manufactured. New test data for argon, helium, and propane were taken at ambient temperature and spanned 2½ decades in $D_v \equiv \eta / \rho$. Two of the new viscometers have ducts with radii r_d = 1.0556 mm. For argon in these instruments, the relative mean and RMS deviations of the measured viscosity are 0.001 ± 0.006 and −0.002 ± 0.003 from the viscosity obtained from a multi-property correlation based on a realistic interatomic potential. The other two new viscometers have ducts with radii r_d = 2.3141 mm. For these instruments, the relative mean and RMS deviations of the viscosity of argon are 0.002 ± 0.003 and −0.005 ± 0.003. It is remarkable that the instruments with different values of r_d and ducts of different lengths give comparably good results that appear to approach the accuracy of the very best viscosity measurements in gases. When the test gases were helium and propane, the agreement with viscosity data from the literature was almost as good.