THE EFFECT OF PRESSURE ON THE VISCOSITY OF ETHYLENE[1]

W. A. FELSING, University of Texas, Austin
and
FORREST BLANKENSHIP, University of Oklahoma, Norman

INTRODUCTION

At pressures near atmospheric gaseous viscosities are known with some certainty; but at higher pressures, and in the critical region, there is great need for reliable data. The petroleum industry, in particular, has expressed a need for data regarding the effect of temperature and pressure on the viscosity of gaseous hydrocarbons.

The object of this research was to develop a high-temperature, high-pressure viscometer and to obtain representative data for ethylene.

The damping of a torsion pendulum provides a measure of the viscosity of the medium in which it is suspended. The coefficient of viscosity, η, is given in terms of the logarithmic decrement, λ, by the following relation developed by Maxwell (1866):

$$\eta = (\lambda - \chi) / C T$$

where χ is the logarithmic decrement due to internal friction in the suspension, C is an instrumental constant, and T is the period of the pendulum.

A study of the methods available and of previous investigations leads to the conclusion that an oscillating-disc viscometer of the type described by Mason and Maass (1940) should be capable of yielding reliable data on gases over a wide range of temperature and pressure.

APPARATUS

The oscillating-disc assembly constructed for this research comprised a silver disc 34 mm in diameter and 0.6 mm thick suspended horizontally in a short silver cylinder. The top and bottom of the flat cylinder served as fixed plates between which the movable disc oscillated with a clearance of 0.3 mm above and below. The suspension filament was made of constantan wire 0.001 in. in diameter and was attached to the movable disc by means of a short rod of No. 28 constantan wire. A small permalloy magnet and a mirror were attached to the rod. The magnet served as an armature for establishing oscillations, and the mirror permitted deflections to be observed by means of a telescope and scale.

The pressure bomb containing the oscillating-disc assembly had a volume of 250 cc and was designed to accommodate pressures up to 10,000 lbs./sq. in. To avoid extraneous damping due to magnetic effects, the bomb was constructed of cold rolled aluminum, and the starting coils attached outside the bomb to activate the permalloy armature were supplied with alternating current. The bomb was provided with two glass windows for observing deflections, checking on the alignment of the suspension, and observing the behavior of the meniscus in the neighborhood of the critical point.

Samples were introduced with the aid of an injection cell and a mercury displacement pump. Pressures were measured to within 0.5 per cent with a Bourdon-tube pressure gauge having a 14-in. dial.

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[1] This paper is taken from the dissertation presented by Forrest Blankenship in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the University of Texas, August 1943.

The bomb was suspended by a rugged framework in such manner that a constant-temperature bath could be raised about it. Thermostating was accomplished by balancing a platinum resistance thermometer on a Mueller bridge. By using a sensitive galvanometer and a long optical lever in connection with a photoelectric relay, the control heater was activated by changes of less than 0.001°C.

The optical system utilized a telescope and scale combination. The 100-cm scale was 225 cm from the mirror on the suspension.

RESULTS

The expression for viscosity in terms of the logarithmic decrement contains two constants. These were evaluated by calibration with dry carbon-dioxide-free air and purified hydrogen. The logarithmic decrement was computed by the method of Mason and Maass (1940).

Water-pumped nitrogen from a commercial cylinder was investigated at 30° C and pressures up to 1200 lbs./sq. in. The data compared well with that of Michels and Gibson (1931), who obtained viscosity isotherms at 25° and 50° C.

Viscosities were determined for ethylene at 30° and 50° C at pressures up to 2100 and 2700 lbs./sq. in., respectively. Under favorable conditions, the data obtained were reproducible to within 0.05 per cent.

VISCOSITY OF ETHYLENE

Pressure lbs./sq. in.	η_{30}° C x 10^7 cgs.	η_{50}° C x 10^7 cgs.
15	1011.7	.....
600	1173.8	.....
900	1538.6	.....
1200	2693.0	.....
1500	3479.1	2451.1
1800	3969.0	3006.4
2100	4331.4	3458.5
2400	.....	3843.0
2700	.....	4104.2

LITERATURE CITED

Mason, S. G., and O. Maass. 1940. Measurement of viscosity in the critical region. Ethylene. Canad. J. Research **18B**: 128-137.

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