

# Physical Properties of Hydrocarbons

## Part 44—Sulfur-Containing Hydrocarbons

This is the final part in a long running, very popular series. The end of the article contains a complete index to all 44 parts—the series having started in July 1965

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CARBON DISULFIDE has been a major chemical for many years. In 1968, about 800 million pounds were consumed. Two-thirds of this was in viscose rayon and cellophane production. Most of the rest was used to produce carbon tetrachloride. Neither of these outlets appear to provide much future growth for carbon disulfide. The major manufacturing route is to react methane and sulfur vapor at 900° C.

Methanethiol is produced from methanol and hydrogen sulfide. It is used in production of methionine, jet fuels and fungicides.

Dimethyl sulfide and ethanethiol are well-known to most engineers as odorants in fuel gases. They are also used as intermediates and solvents.

The physical properties of all four compounds have been extensively studied by various investigators.

**Vapor Pressures and Critical Properties.** The critical properties and vapor pressures of methanethiol,<sup>1,2,5,4</sup> ethanethiol,<sup>1,3,5</sup> dimethyl sulfide<sup>1,3,6,7</sup> and carbon disulfide<sup>1,8,9</sup> have been experimentally determined.

**Heat of Vaporization.** O'Brien and Alford have measured the heat of vaporization of carbon disulfide from 0° C to the critical point.<sup>8</sup> The value at the boiling point is reported for the other three compounds.<sup>4,5,6,7</sup> Kharbanda's nomograph was used to estimate the heat of vaporization at other temperatures.<sup>10</sup> Comparison with five experimental values showed an average error of 2.9 percent.

**Heat Capacity.** The vapor heat capacities are reported in the literature for all four compounds.<sup>5,6,11,12,13</sup>

Liquid heat capacity data are available from the melting point to the boiling point for all four compounds.<sup>4,5,6,14</sup> The data were extended by the equation,

heat capacity times the cube root of the density equals a constant. The heat capacities of these compounds change very slowly with temperature. Consequently, better accuracy was obtained by using the cube root of the density in the equation. The average error for 10 points was 1.3 percent.

**Density.** The densities from 0° C to the critical points have been measured for all four compounds.<sup>1,3,8,15</sup>

**Viscosity.** The vapor viscosities were estimated by the method proposed by Bromley and Wilkes.<sup>16</sup>

Liquid viscosity data are available for ethanethiol at 25° C;<sup>1</sup> for dimethyl sulfide from 0-36° C;<sup>1</sup> and from -13° C to +46° C for carbon disulfide.<sup>1,3</sup> Souder's method was used to estimate the viscosities at other temperatures.<sup>17</sup> The constant in the equation was calculated from an experimental data point for all but methanethiol. The constant had to be estimated from the molecular structure for methanethiol. The probable error is 5-10 percent.

**Surface Tension.** The *International Critical Tables*<sup>1</sup> and Timmermans<sup>3</sup> report viscosity data from 0 to 60° C for the compounds. The data were extended over the -80 to +120° C range by the equation, surface tension equals a constant times the density raised to the fourth power. The error should be about 2 percent.

**Thermal Conductivity.** The thermal conductivities were estimated by the methods used in previous articles.<sup>18,19</sup>

### LITERATURE CITED

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- <sup>19</sup> Robbins, L. A., and C. L. Kingrea, American Petroleum Institute, Division of Refining 42 (III), pp. 52-61 (1962).

**Indexing Terms:** Amines-9, Carbon Disulfide-9, Computations-4, Dimethyl Sulfide-9, Ethanethiol-9, Heat-7, Hydrocarbon-9, Liquid Phase-5, Methanethiol-9, Physical Properties-7, Pressure-6, Properties/Characteristics-7, Sulfides/Inorganic-9, Temperature-6, Vapor Phase-5.

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TABLE 44-1—Physical Properties of Sulfur-Containing Hydrocarbons

	Boiling Point, °C	Melting Point, °C	Molecular Weight	Critical Properties		
				T <sub>c</sub> , °C	P <sub>c</sub> , psia	d <sub>c</sub> , g/ml
Methanethiol . . . . .	5.96	-123.0	48.102	196.8	1050	0.323
Ethanethiol . . . . .	34.4	-147	62.13	225.5	795	0.301
Dimethyl Sulfide . . . . .	37.3	-98.3	62.13	229.9	801	0.306
Carbon Disulfide . . . . .	46.2	-112	76.143	273	1105	0.368

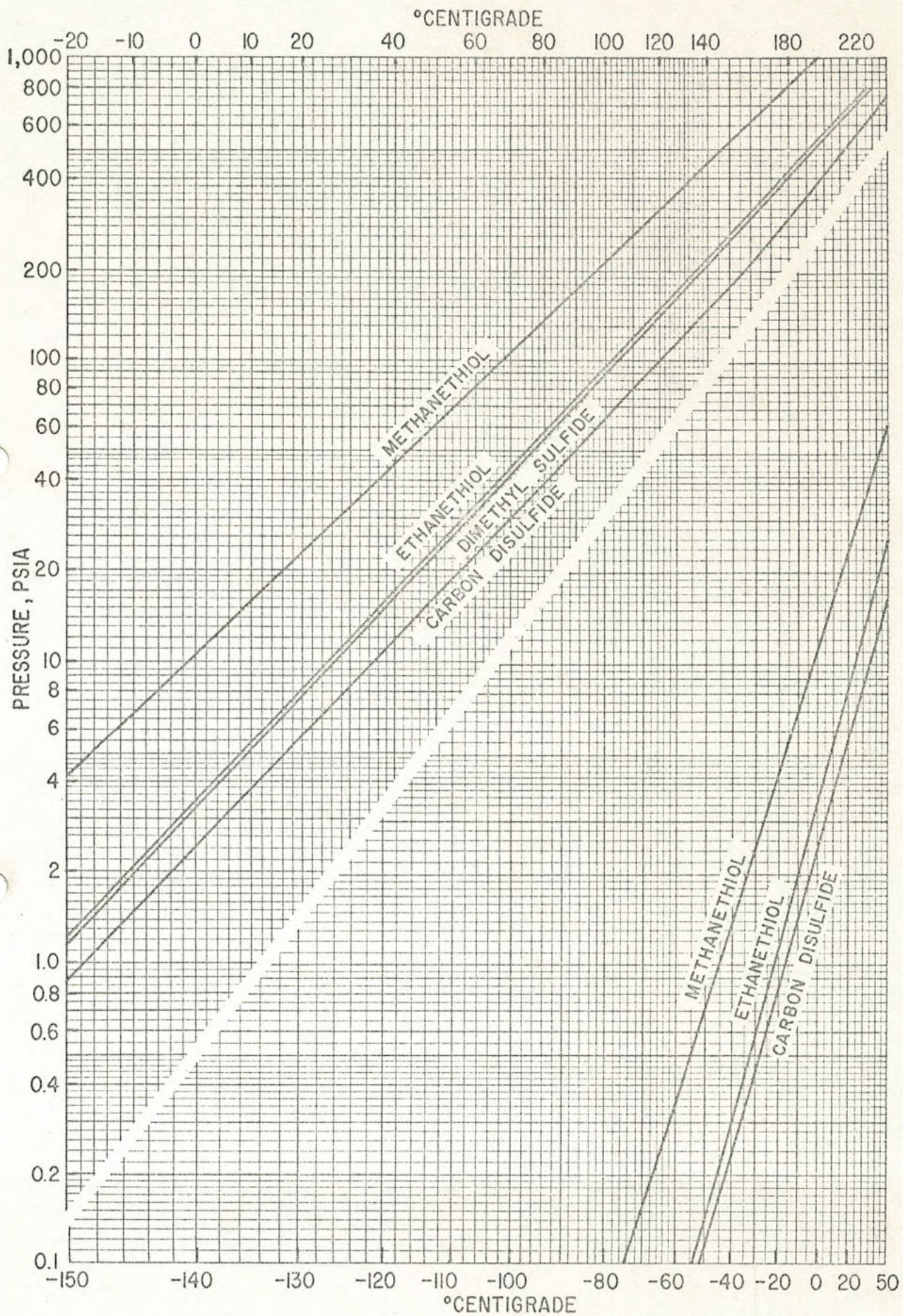


Fig. 44-1—Vapor pressure of sulfur-containing hydrocarbons from -75 to 240°C.

PHYSICAL PROPERTIES OF HYDROCARBONS . . .

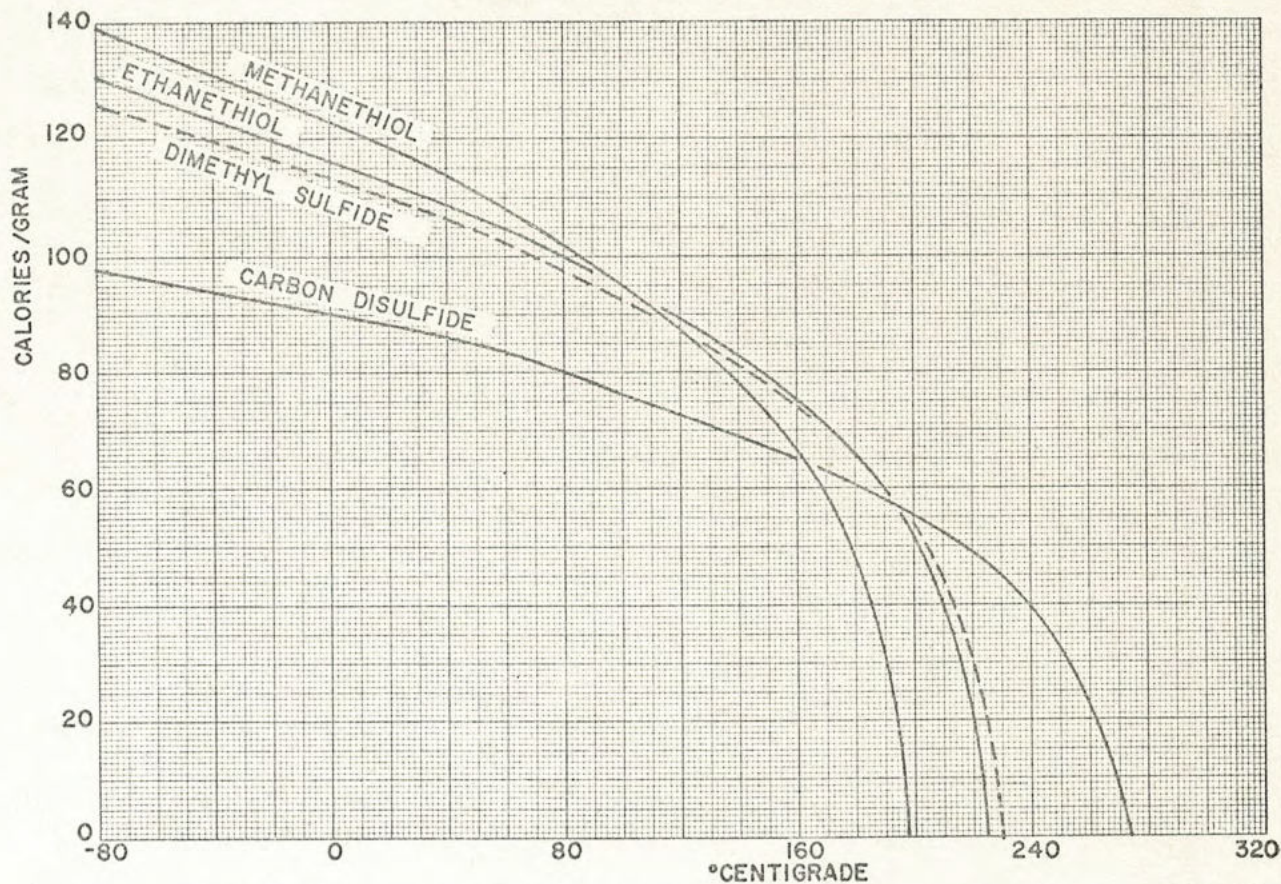


Fig. 44-2—Heat of vaporization of sulfur-containing hydrocarbons from -80 to 275°C.

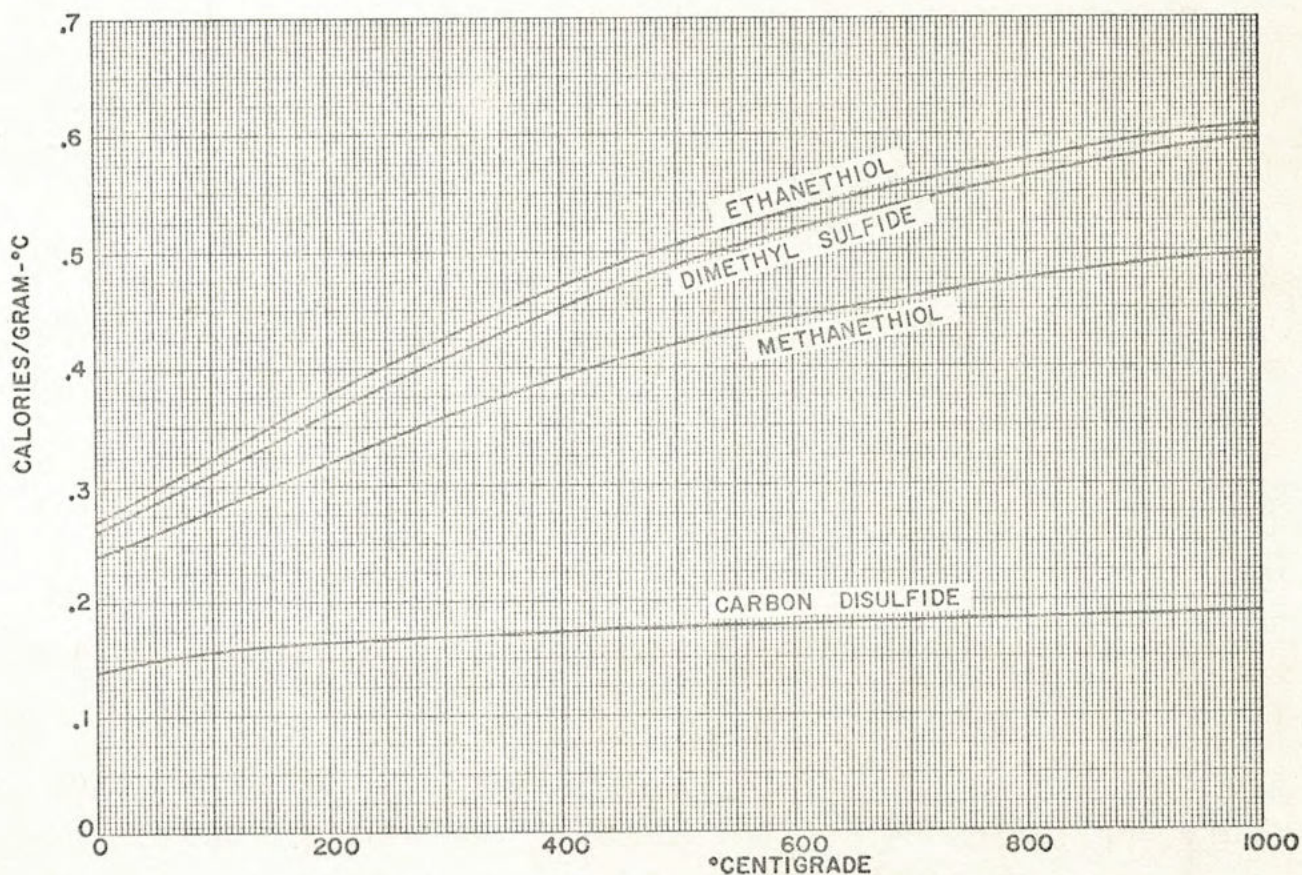


Fig. 44-3—Vapor heat capacity of sulfur-containing hydrocarbons from 0 to 1,000°C.

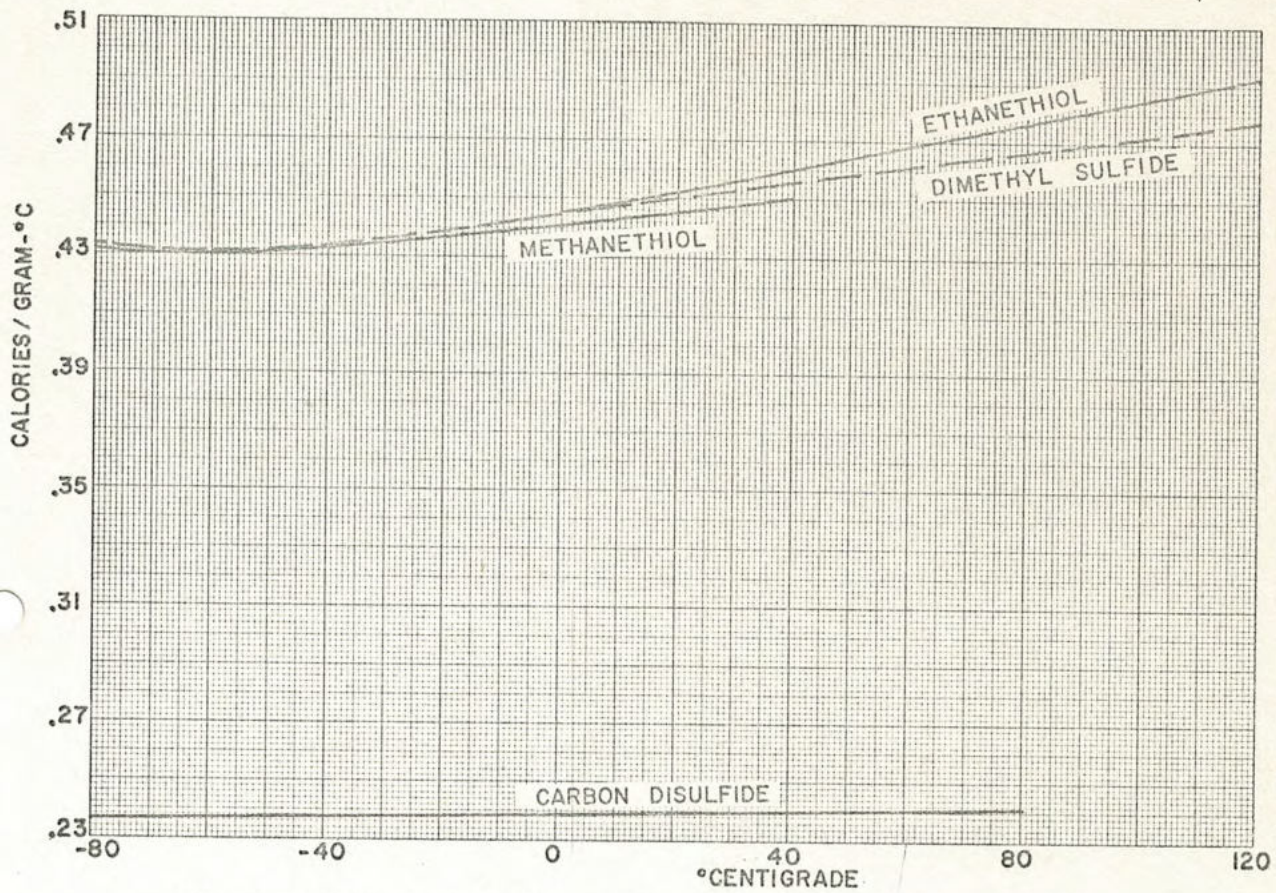


Fig. 44-4—Liquid heat capacity of sulfur-containing hydrocarbons from -80 to 120°C.

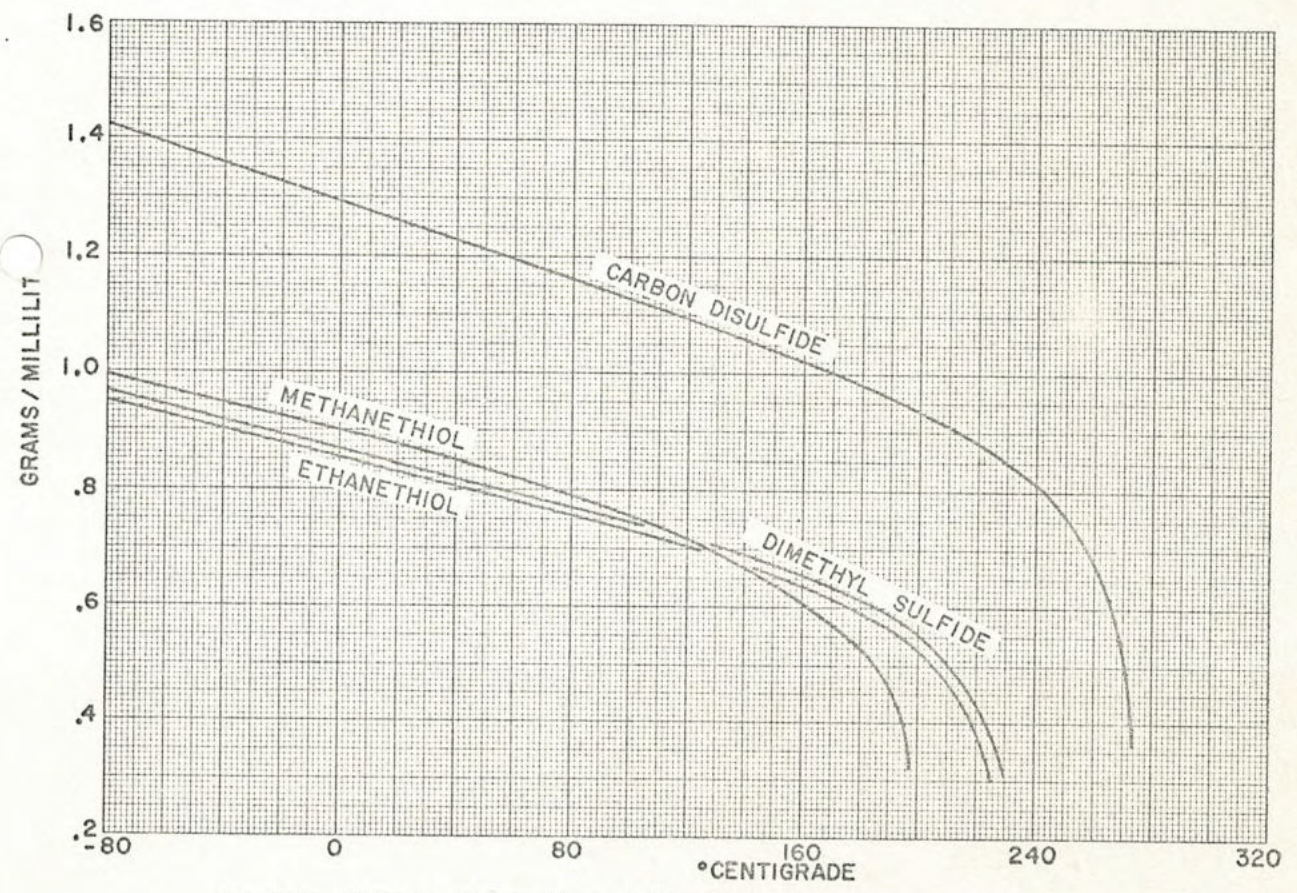


Fig. 44-5—Liquid density of sulfur-containing hydrocarbons from -80 to 275°C.

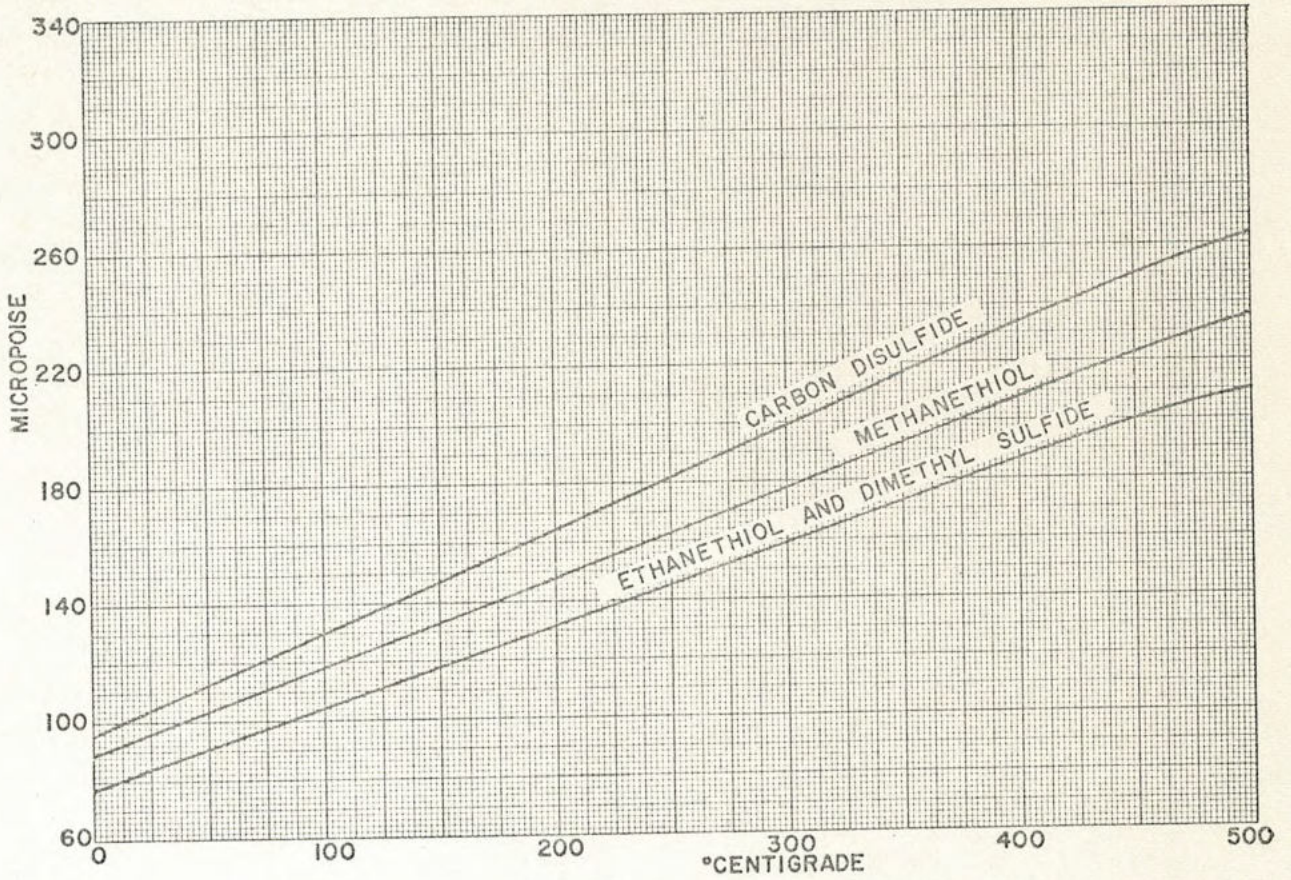


Fig. 44-6—Vapor viscosity of sulfur-containing hydrocarbons from 0 to 500°C.

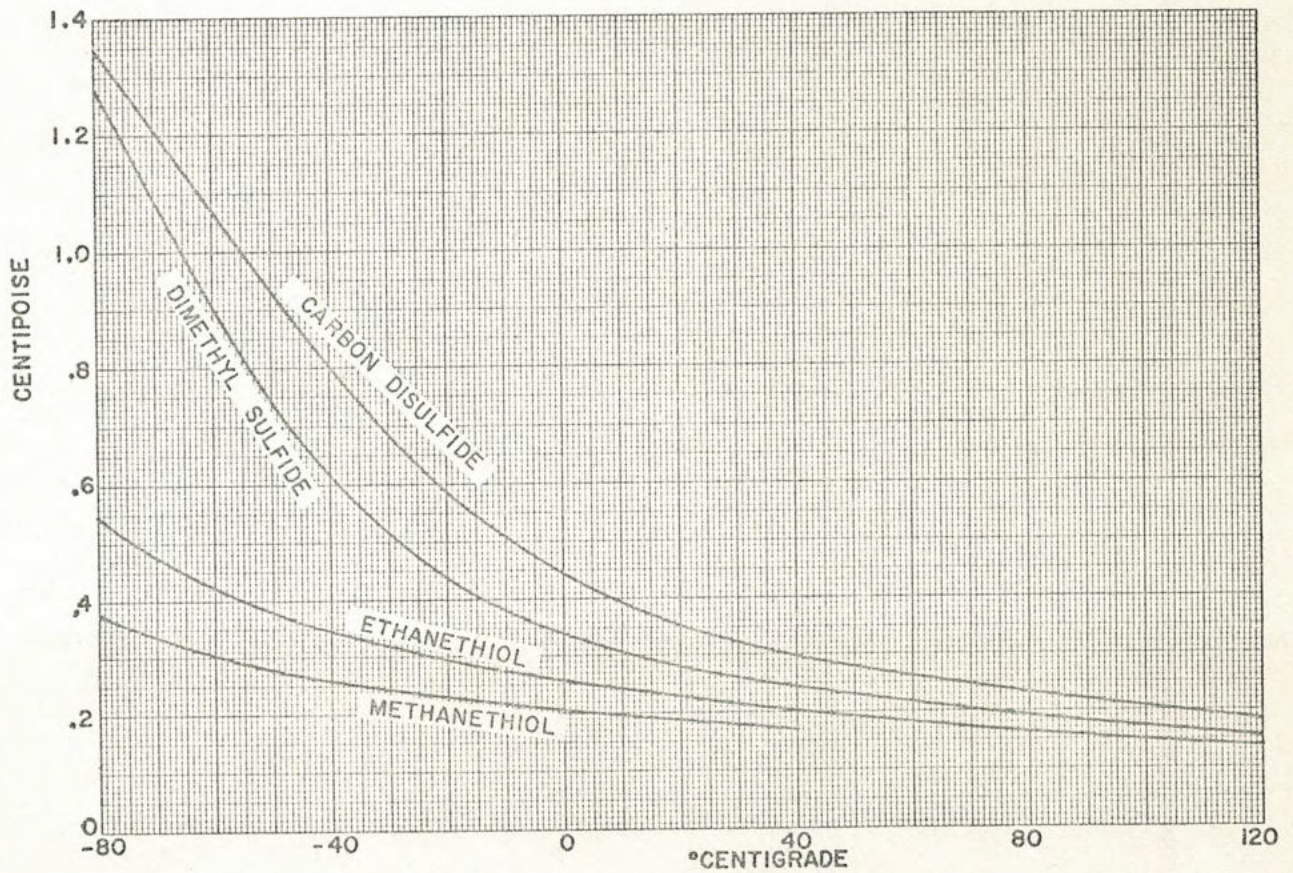


Fig 44-7—Liquid viscosity of sulfur-containing hydrocarbons from -80 to 120°C.

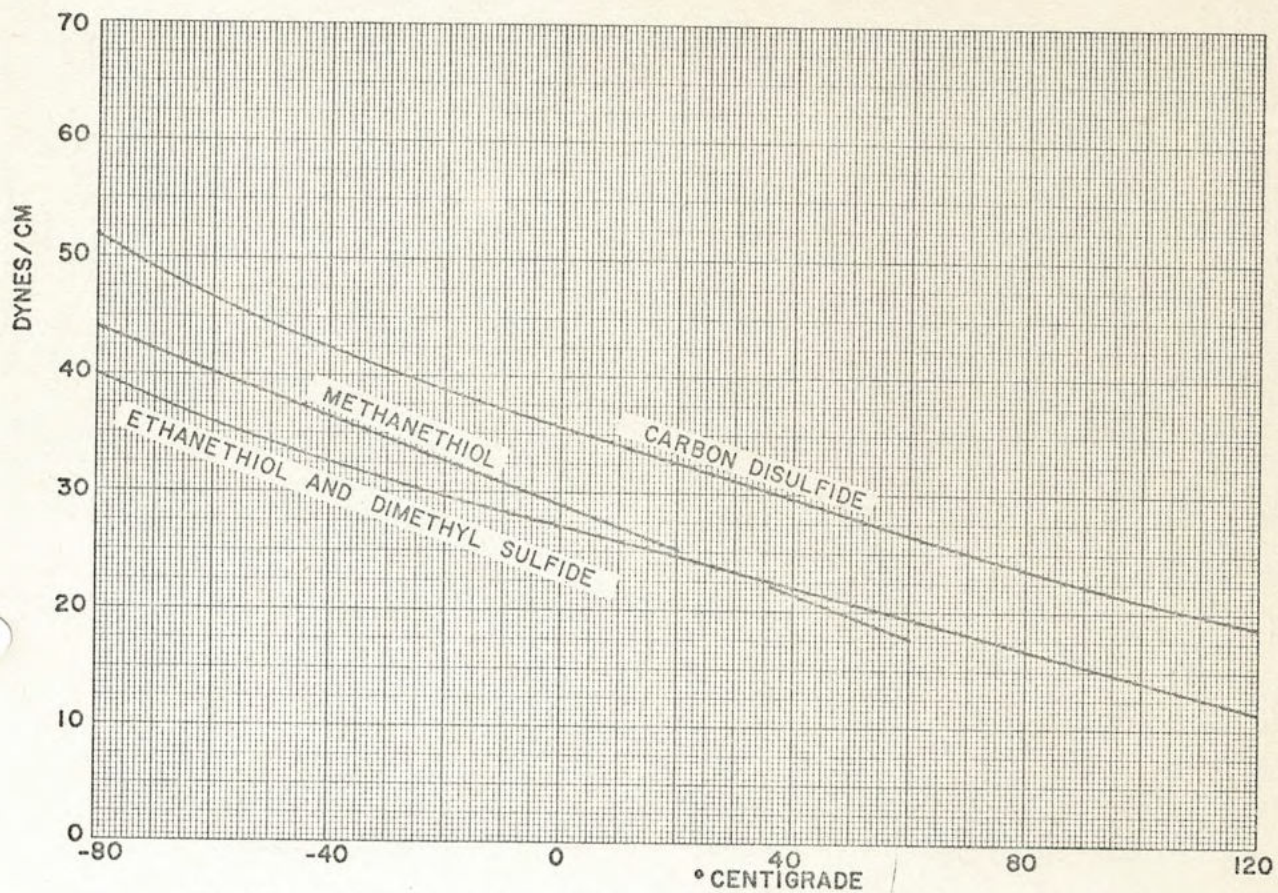


Fig. 44-8—Surface tension of sulfur-containing hydrocarbons from -80 to 120°C.

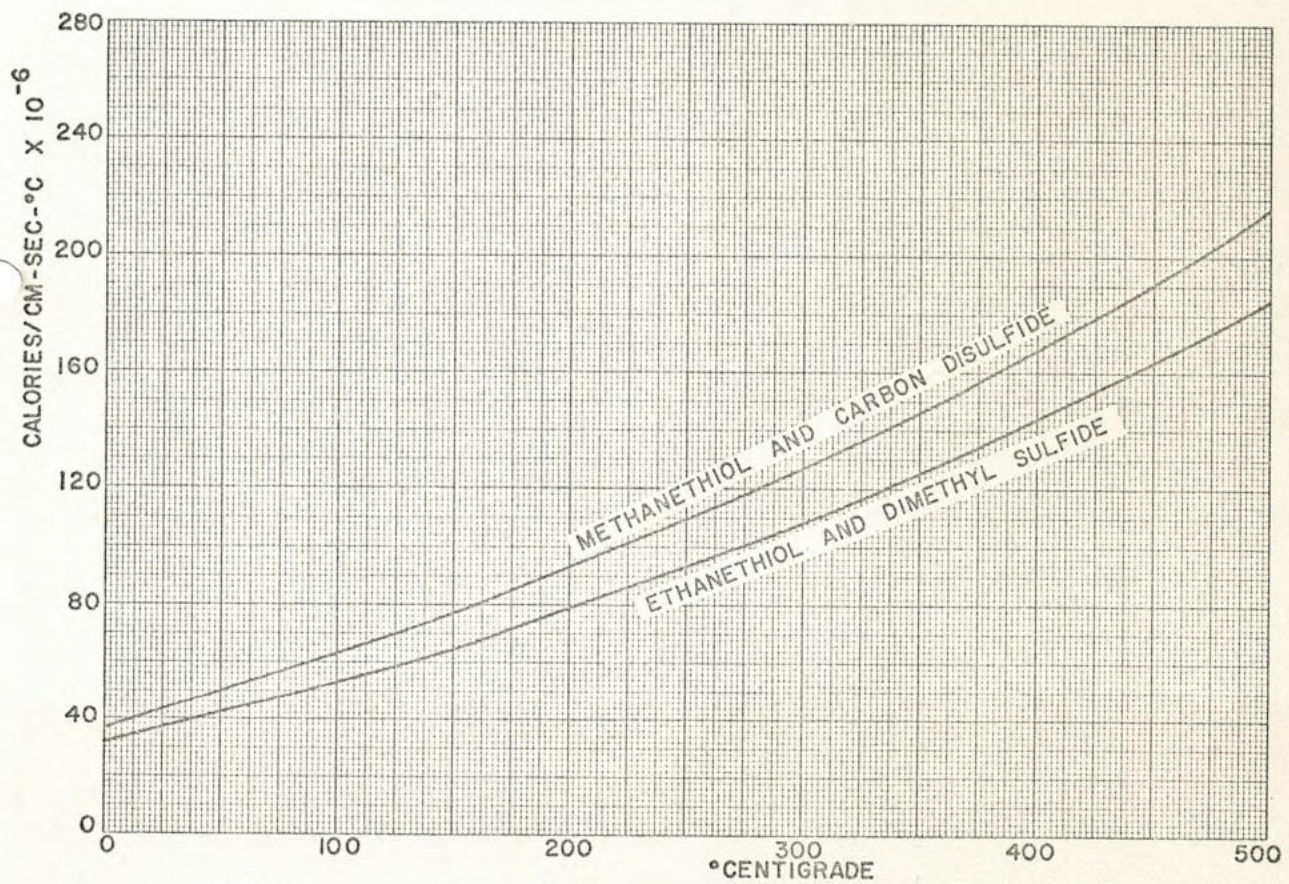


Fig. 44-9—Vapor thermal conductivity of sulfur-containing hydrocarbons from 0 to 500°C.

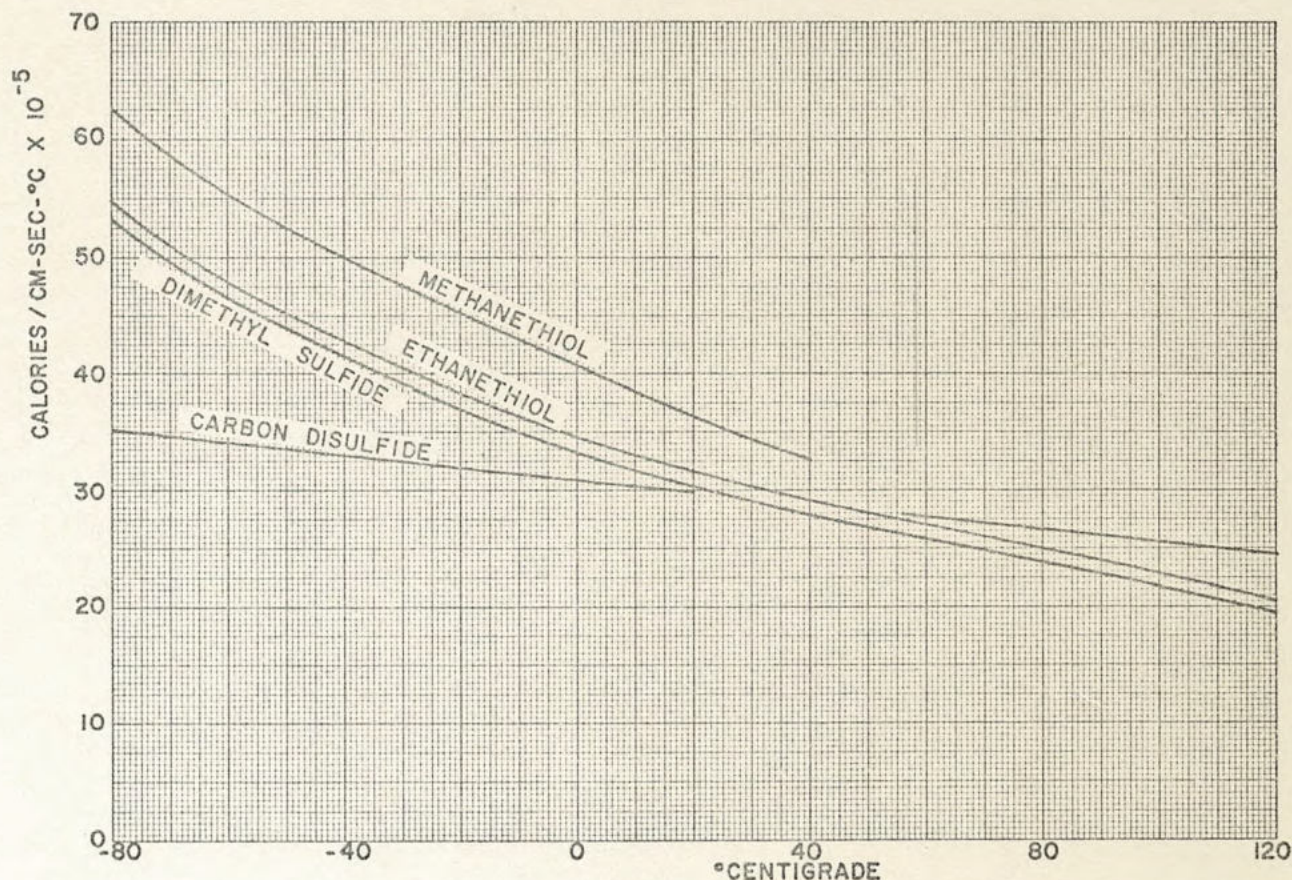


Fig. 44-10—Liquid thermal conductivity of sulfur-containing hydrocarbons from  $-80$  to  $120^{\circ}\text{C}$ .

### About This Series

Since the beginning of this series, Mr. Gallant has reported on roughly 150 compounds. For each of these he has given the latest data pertaining to: vapor pressure, critical properties, heat of vaporization, heat capacity, density, viscosity, surface tension and thermal conductivity. Both the liquid and gas phases have been covered. Where possible, experimental data are reported. When experimental data were not available, correlations were used. In most cases, estimates have been included as to the accuracy of the correlations used. Most parts were prefaced by a short section dealing with pertinent market data concerning the compounds covered.

### Complete Index to "Physical Properties of Hydrocarbons"

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3	C <sub>2</sub> to C <sub>4</sub> Alkynes	Sept. 1965
4	C <sub>2</sub> to C <sub>4</sub> Diolefins	Oct. 1965
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6	Chlorinated Ethylenes	June 1966
7	Chlorinated Aliphatics	July 1966
8	Primary Alcohols	Oct. 1966
9	Thermal Conductivity of C <sub>1</sub> to C <sub>6</sub> Hydrocarbons	Dec. 1966
10	C <sub>3</sub> to C <sub>4</sub> Hydrocarbons	Jan. 1967
11	Miscellaneous Alcohols	Feb. 1967
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16	C <sub>5</sub> to C <sub>8</sub> Alkenes	Aug. 1967
17	C <sub>4</sub> to C <sub>8</sub> Branched Hydrocarbons	Sept. 1967

Part No.	Subject	Month, Year
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44	Sulfur-Containing Hydrocarbons	April 1970

The entire series will soon be available in hardback book form, Volume 1 is already in print and includes Parts 1 through 23. Volume 2 will soon be published to include Parts 24 through 44. Volume 2 will also include a section of physical properties of water. Both volumes are available from Gulf Publishing Co., Book Department, P. O. Box 2608, Houston, Texas 77001.