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SOME PHYSICAL PROPERTIES
OF BUTADIENE AND STYRENE

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With the expansion of the production of synthetic rubber in the United States, the National Bureau of Standards has received a number of requests for data concerning the physical properties of the raw materials used for making synthetic rubber. The variety to be produced in largest amounts is Buna S, and consequently data are very often required for butadiene and styrene, the materials which are co-polymerized to make Buna S.

A search of the literature has been made, and certain properties have been measured at this Bureau in the course of investigations, the results of which in many cases have not yet been published. The values which are regarded as the most reliable at the present time (December 1942) have been collected and put into tabular form. They are presented at this time in order to meet an immediate demand for such data. It should be recognized that in most cases they have not been checked by independent observations. Revisions will be made as further information becomes available.

Especial thanks are due to the Phillips Petroleum Co. for making available their unpublished measurements of the density of liquid butadiene at different temperatures.

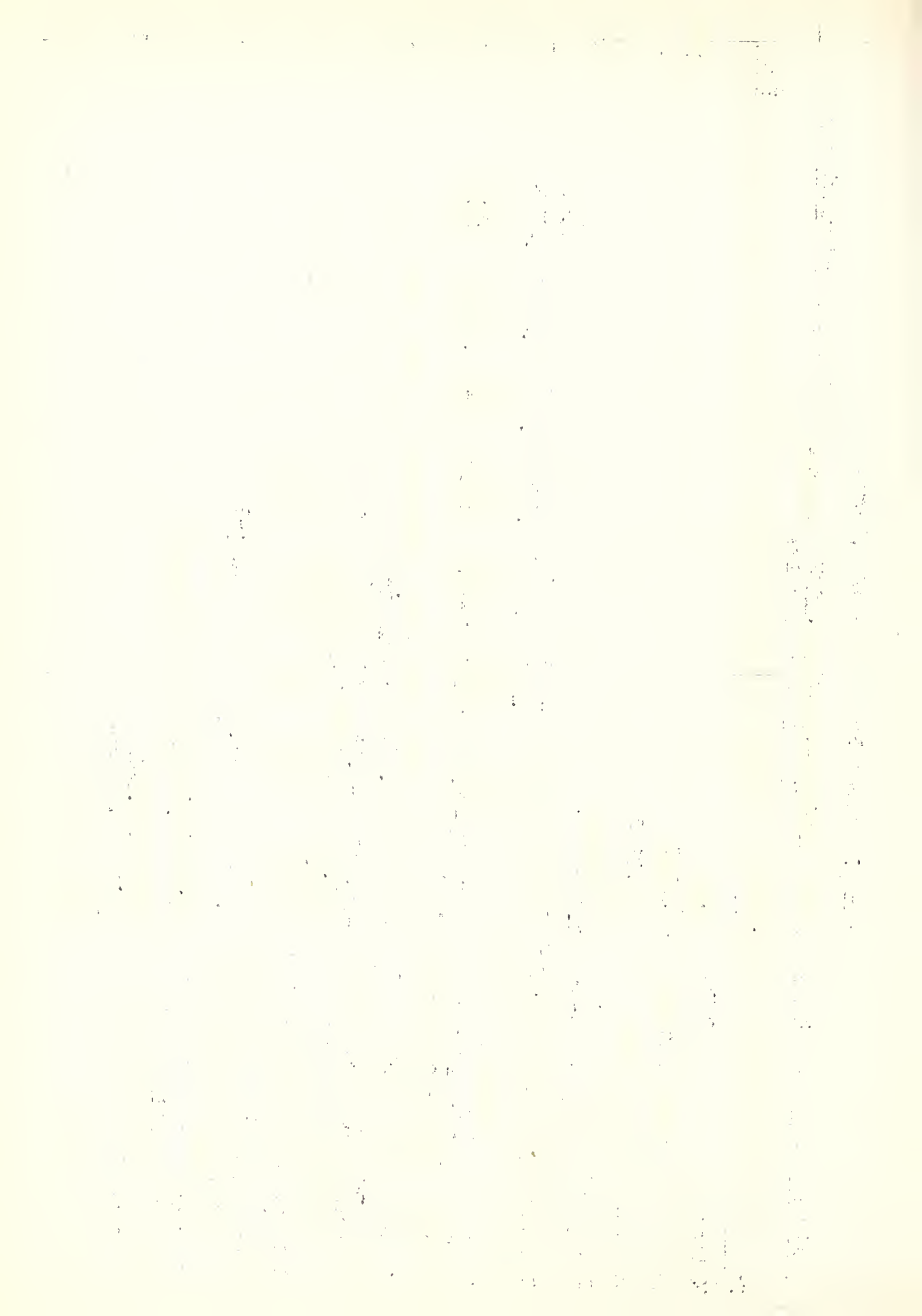
For the convenience of engineers accustomed to using the British engineering system, certain values are also given in the units of this system. They were obtained by conversion from the metric values given in the first part of each table.

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Some Physical Properties of 1,3-Butadiene

Alternative names: biethylene, divinyl, divinyl, erythrene, pyrrolylene, and vinylethylene
(Metric system units)

<u>Property</u>	<u>Value</u>	<u>Source</u>
Molecular weight of C ₄ H ₆	54.088	1
Normal boiling point	-4.6° C	1
Freezing point	-108.9° C	4
Density of vapor at 0° C and 760 mm of mercury	0.00248 g·ml ⁻¹	3
Density of liquid in g·ml ⁻¹	Temp $\frac{-20^\circ}{0.6690}$ $\frac{0^\circ}{.6455}$ $\frac{20^\circ}{.6210}$ $\frac{25^\circ}{.6146}$ $\frac{40^\circ}{.5958}$ $\frac{60^\circ \text{ C}}{.5582}$	
Thermal expansion (liquid) from -20° to +60° C t in degrees C	$V = V_0 (1 + 1.8528 \times 10^{-3} t + 5.148 \times 10^{-6} t^2 + 29.2 \times 10^{-9} t^3)$	3, (2)
Vapor pressure from -80° to +40° C	$\log_{10} p = 6.96128 - \frac{973.6}{t + 243.2}$	1
t in degrees C	-78.51° 0° 25° 40° C	
p in mm of mercury	11.2 760 908 2144 5338	
Rate of change of boiling point with pressure at the normal boiling point	0.0334 (deg C)·(mm of mercury) ⁻¹	1
Heat of vaporization at normal boiling point	99.80 cal·g ⁻¹ 5398 cal·mole ⁻¹	1
Heat of fusion	35.28 cal·g ⁻¹ 1908 cal·mole ⁻¹	1

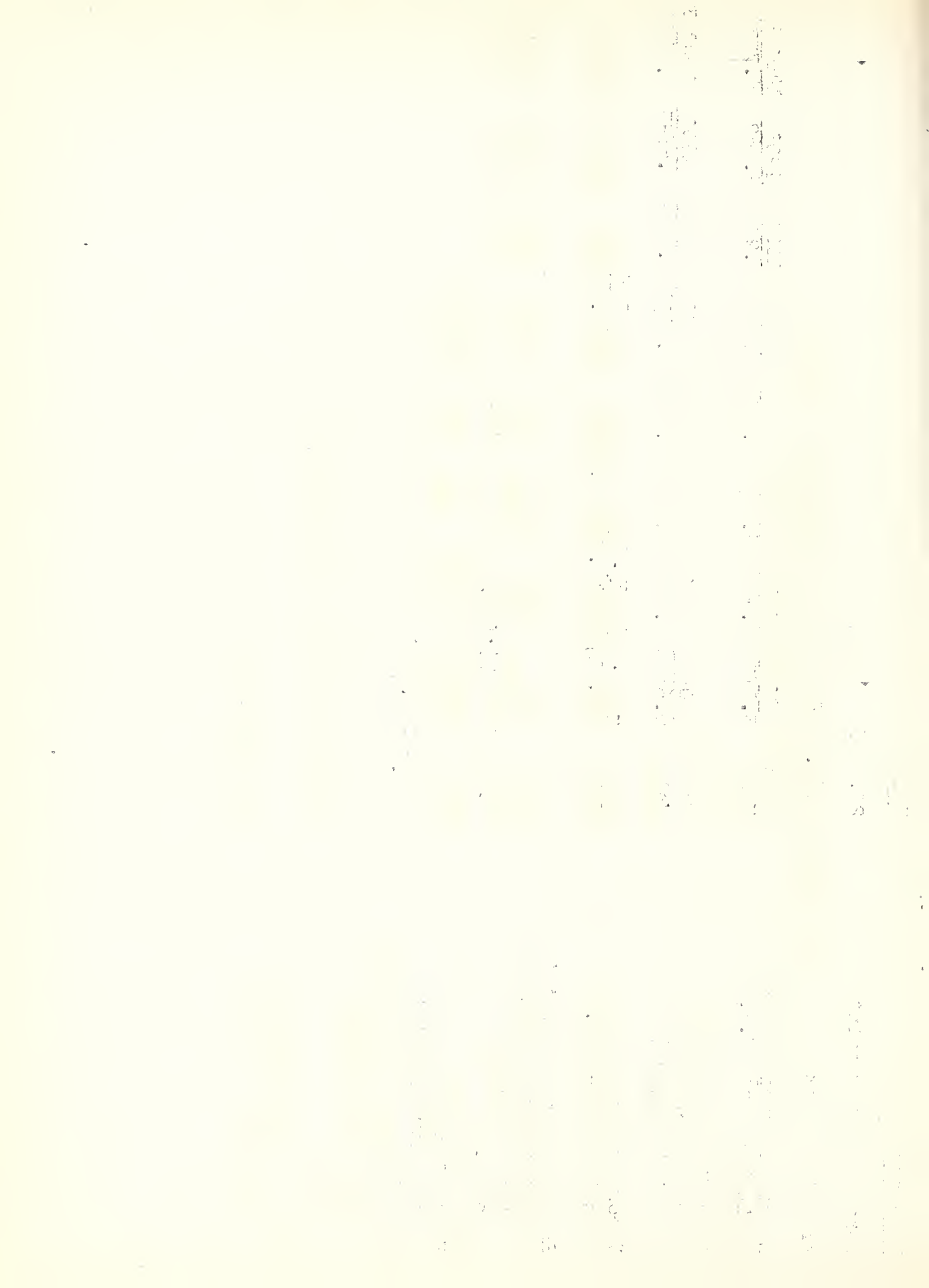


Some Physical Properties of 1,3-Butadiene (Cont)
(Metric system units)

<u>Property</u>	<u>Value</u>	<u>Source</u>
Heat of formation of vapor at 25° C	26,865 cal·mole ⁻¹	5
Heat of combustion of vapor at 25° C at constant pressure (1 atmosphere)	11,055 cal·g ⁻¹ 607,940 cal·mole ⁻¹	5,(2)
Specific heat of liquid at 25° C	0.517 cal·g ⁻¹ ·(deg C) ⁻¹	1
Refractive index for D-line at -25° C	1.4293	6
Unit cell of crystalline material	a = 13.20 Angstrom units c = 8.46 Angstrom units	7
Limits of flame propagation in mixtures with air	2 to 11.5% (by volume) of butadiene	8

Some Physical Properties of 1,3-Butadiene (Cont)
(British engineering units)

<u>Property</u>	<u>Value</u>					
Normal boiling point	23.7° F					
Freezing point	-164.0° F					
Apparent density in air in lb·gal ⁻¹ (U.S.)	Temp 0° Value 5.550	20° 5.445	40° 5.333	60° 5.221	80° 5.101	100° 4.988
Specific gravity with reference to water at 60° F (vacuum)	Temp 0° Value 0.6668	20° .6542	40° .6408	60° .6273	80° .6131	100° .5994
Vapor pressure p in lb/in ² abs.	Temp -109.32° Value 0.217	23.7° 14.7	32° 17.6	70° 36.6	105° F 65.6	
Rate of change of boiling point with pressure at the normal boiling point	1.528 (deg F)·(in. of mercury) ⁻¹					
Heat of vaporization at the normal boiling point	179.6 Btu·lb ⁻¹					



Some Physical Properties of Styrene

Alternative names: cinnamene, phenylethylene, styrol, and vinylbenzene
(Metric system units)

<u>Property</u>	<u>Value</u>	<u>Source</u>
Molecular weight of C ₈ H ₈	104.144	
Normal boiling point	145.2° C	9
Freezing point	-30.60° C	1
Density in g·ml ⁻¹	Temp 0° 20° 25° 40° 60° 80° 100° 120° 145° C Value 0.9240 .9056 .9010 .8873 .8689 .8506 .8322 .8138 .7909	10
Rate of change of density with temperature between 0° and 145° C	$-918 \times 10^{-6} \text{ g}\cdot\text{ml}^{-1}\cdot(\text{deg C})^{-1}$	10
Vapor pressure between -8° and +145° C	$\log_{10} p = 7.2788 - \frac{1649.6}{t + 230}$	10
t in degrees C	0° 25° 100° 145.2° C	
p in mm of mercury	1.28 6.45 166.0 762.4	
Rate of change of boiling point with pressure at the normal boiling point	0.0487 (deg C)·(mm of mercury) ⁻¹	10
Heat of vaporization at normal boiling point	86.9 cal·g ⁻¹ 9040 cal·mole ⁻¹	2
Heat of fusion	25.4 cal·g ⁻¹ 2645 cal·mole ⁻¹	1
Specific heat at 25° C	0.413 cal·g ⁻¹ ·(deg C) ⁻¹ 43.0 cal·mole ⁻¹ ·(deg C) ⁻¹	11

Some Physical Properties of Styrene (Cont)
(Metric system units)

<u>Property</u>	<u>Value</u>	<u>Source</u>
Refractive index for D-line at 25° C	1.5443	10
Rate of change of refractive index with temperature between 17° and 26° C	$-560 \times 10^{-6} \text{ (deg C)}^{-1}$	10
Surface tension at 19° C	32.14 dynes·cm ⁻¹	12
Limits of flame propagation in mixtures with air	1.1 to 6.1% (by volume) of styrene	13

Some Physical Properties of Styrene (Cont)
(British engineering units)

<u>Property</u>	<u>Value</u>
Normal boiling point	293.4° F
Freezing point	-23.08° F
Apparent density in air in lb·gal ⁻¹ (U.S.)	Temp $\frac{32^\circ}{7.702}$ Value $\frac{60^\circ}{7.582}$ $\frac{70^\circ}{7.540}$ $\frac{105^\circ}{7.392}$ $\frac{130^\circ}{7.285}$ 293.4° F 6.590
Specific gravity with refer- ence to water at 60° F (vacuum)	Temp $\frac{32^\circ}{0.9249}$ Value $\frac{60^\circ}{.9105}$ $\frac{70^\circ}{.9055}$ $\frac{105^\circ}{.8877}$ $\frac{130^\circ}{.8749}$ 293.4° F .7915
Vapor pressure p in lb/in ² abs.	Temp $\frac{32^\circ}{0.0247}$ Value $\frac{60^\circ}{.0704}$ $\frac{70^\circ}{.0787}$ $\frac{105^\circ}{.294}$ $\frac{130^\circ}{.583}$ 293.4° F 14.74

Rate of change of boiling
point with pressure at
the normal boiling
point

$$2.22 \text{ (deg F)} \cdot (\text{in. of mercury})^{-1}$$

Heat of vaporization at
the normal boiling
point

$$116 \text{ Btu} \cdot \text{lb}^{-1}$$

SOURCES

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