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Report

on

The Density of Navol (Hydrogen Peroxide) Solutions as Dependent on Temperature. Including a Nomogram for Rapid Determinations.

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WASHINGTON, D.C.

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ABSTRACT

A new and accurate series of determinations of the density of Navol solutions has been made. The results are presented in tabular form as well as by means of a nomogram. The solutions tested were not pure, but contained the customary stabilizing agents found in all commercial preparations of this chemical. However, in the amounts actually present, these agents have a negligible effect on the density. The object of the work is to make possible the quick and accurate determination of the strength of Navol solutions by means of a hydrometer and thermometer.

Authorization

1. This study is a part of a series of studies on the general properties of Navol solutions undertaken as a part of Bureau of Ordnance Project Order 6476-Ord. of 12 June 1936 S75-1(90)(Q8).

Object

2. To determine accurately the density of Navol solutions, in the range of strength 40 per cent to 55 per cent, corresponding to different temperatures, in order to facilitate strength measurements by hydrometer on shipboard and elsewhere.

Previous Work

3. These densities had previously been roughly determined at the Naval Research Laboratory, but it was felt that this older work was based on an insufficient number of observations.

Procedure

4. The densities of hydrogen peroxide solutions were determined with the aid of dilatometers over a limited range of concentrations and temperatures. The dilatometers had a capacity of 50 cc with a 1 cc calibrated stem. The temperature range was from 1.8°C to 37.2°C, and the concentrations used were 43.3 per cent, 46.9 per cent, 51.5 per cent and 55.45 per cent hydrogen peroxide. The curves drawn from the measurements were extrapolated to obtain values from 0°C to 40°C in temperature and 43 per cent to 56 per cent in concentration. The measurements are given in Table I, and the values taken from the curves plotted from these data are given in Table II.

5. The method used was as follows - The Navol solution obtained from the 250 pound drums was 46.90 per cent hydrogen peroxide; being lower than the concentration desired, it was concentrated at reduced pressure in the presence of sulphuric acid. The concentration rose steadily until 55.45 per cent hydrogen peroxide was obtained. Part of this sample was used directly, part diluted with the original solution to give the 51.5 per cent solution. The original Navol was used for one sample and some original diluted with water for the 43.3 per cent solution. These solutions were contained in glass volumetric flasks and cooled to near 0°C. The dilatometers were also cooled, and with the aid of a capillary tube on a funnel the solutions were transferred to the dilatometers. They were then placed in the bath to come to a constant temperature at 1.8°C. A portion of the samples used to fill the dilatometers were titrated with $KMnO_4$ solution and H_2SO_4 to determine the

concentrations. Measurements were made on the dilatometers at 1.8°C, 13.2°C and 19.4°C, and the dilatometers removed from the bath and weighed. They were replaced in the bath and measured at 27.7°C and 31.2°C. At these temperatures some bubbling took place. They were cooled and a portion removed and titrated. The titrations gave the same values of concentration as before use within the error of determination. After standing at 0°C over night (at this temperature no bubbling took place) they were introduced into the bath at 37.2°C and measurements taken when they came to temperature. Readings taken against time were constant when equilibrium was reached. Bubbling also took place at this temperature, but titrations again gave the same concentration. In two cases, the amount removed for titration gave a suitable volume to be read on the stem at the high temperature, i.e., for 55.45 per cent and 51.5 per cent. At 46.9 per cent a little too much had been removed and was filled with some of the 55.45 per cent sample to take a reading. Titration of this sample gave 48.3 per cent. No reading was made on the 43.3 per cent at 37.2°C. At 37.2°C the concentrations were 48.3 per cent, 51.5 per cent and 55.45 per cent.

6. The volumes on the stems were read with a cathetometer and could be determined to 1 part in 100,000, the same order of variation found due to temperature change. The temperature was constant to ± .02°C. The variation of temperature was determined by a Beckman thermometer, while the bath temperature was read from a -5°C to 200°C Mercury thermometer of 24 inch length, which had been calibrated at National Bureau of Standards. The actual experimental results are listed in Table I below.

TABLE I

Temperature °C	Concentration 43.3%	46.90%	48.30%	51.50%	55.45%
1.8	1.1793	1.1946		1.2167	1.2341
13.20	1.1712	1.1865		1.2078	1.2265
19.40	1.1666	1.1818		1.2030	1.2210
27.7	1.1606	1.1753		1.1967	1.2143
31.2	1.1579	1.1725		1.1936	1.2111
37.2			1.1741	1.1877	1.2051

Densities at temperatures and concentrations shown.

Results

7. A formula which represents the above data with fair accuracy is as follows:

$$P = 21.66 + 228.1\ (D-1.100) + .0984T$$

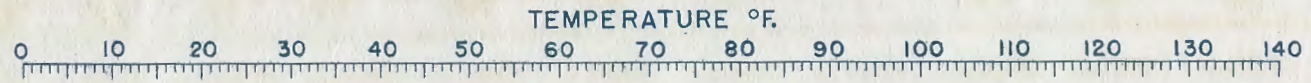
where P = percentage strength or concentration on a weight basis; D = density in grams per milliliter; and T = temperature Fahrenheit. This formula was used in computing the nomogram presented on the following page.

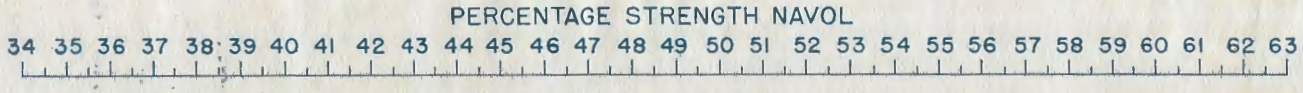
8. Table II presents the data of Table I interpolated to cover the range zero to 40 degrees Centigrade. It is not computed by the formula in paragraph 7, and small discrepancies will be found between the two.

TABLE II

Table of Densities

Temp. °C	Concentration 44%	45%	46%	47%	48%	49%	50%	51%	52%	53%	54%	55%	56%
0	1.1840	1.1886	1.1930	1.1974	1.2020	1.2067	1.2108	1.2156	1.2199	1.2242	1.2288	1.2331	1.2380
2	1.1827	1.1872	1.1916	1.1960	1.2006	1.2053	1.2095	1.2142	1.2185	1.2229	1.2275	1.2319	1.2366
4	1.1812	1.1857	1.1902	1.1946	1.1991	1.2038	1.2081	1.2128	1.2171	1.2216	1.2262	1.2306	1.2353
6	1.1797	1.1842	1.1887	1.1931	1.1977	1.2023	1.2068	1.2140	1.2157	1.2202	1.2248	1.2292	1.2339
8	1.1782	1.1827	1.1872	1.1917	1.1962	1.2008	1.2054	1.2098	1.2143	1.2187	1.2234	1.2278	1.2324
10	1.1767	1.1812	1.1857	1.1902	1.1947	1.1992	1.2040	1.2084	1.2128	1.2172	1.2220	1.2264	1.2310
12	1.1752	1.1797	1.1842	1.1887	1.1932	1.1977	1.2025	1.2068	1.2113	1.2158	1.2205	1.2249	1.2295
14	1.1736	1.1782	1.1827	1.1871	1.1917	1.1962	1.2010	1.2053	1.2098	1.2143	1.2190	1.2234	1.2280
16	1.1721	1.1767	1.1812	1.1856	1.1902	1.1947	1.1995	1.2037	1.2083	1.2127	1.2175	1.2219	1.2264
18	1.1706	1.1752	1.1797	1.1840	1.1886	1.1931	1.1979	1.2022	1.2068	1.2112	1.2160	1.2203	1.2248
20	1.1691	1.1736	1.1781	1.1824	1.1871	1.1915	1.1963	1.2006	1.2052	1.2096	1.2144	1.2187	1.2231
22	1.1675	1.1721	1.1765	1.1809	1.1855	1.1899	1.1946	1.1989	1.2035	1.2080	1.2128	1.2171	1.2214
24	1.1660	1.1705	1.1750	1.1893	1.1840	1.1883	1.1930	1.1972	1.2019	1.2064	1.2111	1.2154	1.2197
26	1.1644	1.1690	1.1733	1.1777	1.1823	1.1867	1.1913	1.1955	1.2001	1.2047	1.2093	1.2136	1.2180
28	1.1629	1.1674	1.1717	1.1761	1.1807	1.1851	1.1895	1.1939	1.1984	1.2030	1.2075	1.2118	1.2163
30	1.1613	1.1658	1.1701	1.1745	1.1790	1.1834	1.1878	1.1921	1.1966	1.2012	1.2055	1.2100	1.2145
32	1.1597	1.1641	1.1684	1.1728	1.1773	1.1817	1.1860	1.1903	1.1948	1.1994	1.2038	1.2082	1.2126
34	1.1581	1.1624	1.1668	1.1712	1.1756	1.1800	1.1843	1.1885	1.1930	1.1975	1.2019	1.2063	1.2106
36	1.1565	1.1608	1.1651	1.1694	1.1738	1.1782	1.1825	1.1867	1.1911	1.1956	1.1999	1.2043	1.2087
38	1.1548	1.1591	1.1634	1.1677	1.1720	1.1765	1.1807	1.1848	1.1893	1.1938	1.1979	1.2024	1.2068
40	1.1532	1.1574	1.1617	1.1660	1.1702	1.1747	1.1788	1.1830	1.1874	1.1919	1.1959	1.2004	1.2048





NOMOGRAM FOR DETERMINING STRENGTH OF NAVOL SOLUTIONS FROM DENSITY AND TEMPERATURE