mμ, $\lambda_{\text{min}}^{H_2O}$ 238 mμ. *Anal.* Calcd. for $C_{11}H_{16}N_3O_8PBr$: P, 6.37. Found : P. 6.08. Analysis by ion-exchange chromatography gave 86% purity containing 12.3% of nucleoside.

1-Methyl-4-methylthiouracil (X)——Uracil was thiolated with P_2S_5 in pyridine. 4-Thiouracil, thus obtained, conformed to original descriptions.[19] It was methylated by Wheeler's method.[11] 1.0 g. of 4-Thiouracil was dissolved in 10 cc. of dehyd. EtOH, containing 500 mg. of Na, followed by the addition of 2.8 g. of CH_3I. Solidified reaction mixture was dissolved in 20 cc. of dehyd. EtOH and heated. Then 1.0 g. of CH_3I was added to the solution which was heated again for 2 hr. The clear reaction mixture was evaporated to dryness *in vacuo* and the residue was extracted three times with 50 cc. of $CHCl_3$. The evaporation of the combined extracts gave a solid which was dissolved in EtOH, treated with charcoal and recrystallized from benzene. White crystal, m.p. 123～124° (900 mg.). UV : $\lambda_{\text{max}}^{H_2O}$ 302, $\lambda_{\text{shoulder}}^{H_2O}$ 267 mμ. *Anal.* Calcd. for $C_6H_8N_2OS$: C, 46.13; H, 5.16; N, 17.93. Found : C, 45.91; H, 5.15; N, 18.09.

Authors are indebted to Prof. Y. Mizuno for his encouragements in this study. Elementary analysis and ion-exchange analysis were conducted by K. Narita and Y. Kanai of this Faculty to whom the author's gratitude is due. They also appreciate the Grant-in-Aid for Scientific Research from the Ministry of Education.

Summary

Uridine was converted to 2′,3′-O-isopropylidene-5′-O-benzoyluridine and derived to 2′,3′-O-isopropylidene-4-methylthiouridine by successive thiolation and methylation. The latter compound was reacted with either CH_3NH_2 or $(CH_3)_2NH$ to produce 2′,3′-O-isopropylidene-N-methyl- or N,N-dimethylcytidine respectively. N-Methyl- and N,N-dimethylcytidine 5′-phosphate were synthesized by the poly-phosphoric acid method followed by the acidic removal of isopropylidene groups.

(Received March 17, 1961)

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[19] G.B. Elion, W.S. Ide, G.H. Hitchings : J. Am. Chem. Soc., **68**, 2137 (1946).

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123. Yuriko Kato : Formation of a Micelle-like Structure in Aqueous Solution of Glycols.[*2]

(Hospital Pharmacy, University of Tokyo[*1]*)*

Behavior of ionic surfactants in aqueous solution has been reported by McBain[1] and numerous workers, who agreed on the following point : A surfactant in a low concentration dissolves in water by monomolecular dispersion but, in a higher concentration beyond the critical micelle concentration, the surfactant molecules aggregate to form an associated body generally called a micelle. At this concentration, various properties of the solution undergo a drastic change. Only fragmentary reports are available for nonionic surfactants, such as those by Gonik and McBain,[2] and by Goto,

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[*1] Hongo, Tokyo (加藤百合子).

[*2] Paper presented at the Tokyo Local Meeting of the Pharmaceutical Society of Japan, January, 1961.

[1] J.W. McBain : "Colloid Science," 240 (1950). D.C. Heath & Co., Boston.

[2] E. Gonick, J.W. McBain : J. Am. Chem. Soc., **69**, 334 (1947).

et al.[3] Recently, Nakagawa, *et al.*[4] reported that a distinct critical micelle concentration can be observed with a thoroughly purified and unified sample.

The present writer found that glycols also form micelles like nonionic surfactants and that a critical micelle concentration is also present in these solution.

Physical constants, such as the surface tension, possible solubilization of pigments, polarographic behavior, refractive index, viscosity, and dielectric constants were measured of aqueous solution of 14 kinds of glycols, using 1,2- and 1,3-propanediols, 1,2-, 1,3-, 1,4-, and 2,3-butanediols, 1,4-, 1,5-, and 2,4-pentanediols, 1,6- and 2,5-hexanediols, 1,2-octanediol, 1,10-decanediol, and 1,2-dodecanediol.

Experimental and Results

(1) Synthesis

1,2-Butanediol, 1,2-octanediol, 1,2-dodecanediol, 1,4- and 2,4-pentanediol, and 2,5-hexanediol were newly synthesized. The diols thus prepared were identified through elemental analysis and IR spectrum. Other glycols were obtained commercially and purified by repeated distillation or crystallization. The structure and boiling or melting points of these diols are given in Table I.

TABLE I.

Diol	b.p. (°C or °C/mm. Hg)	Diol	b.p. (°C or °C/mm. Hg)
1,2-Propanediol	188.2	1,5-Pentanediol	239.4
1,3-Propanediol	137/85	2,4-Pentanediol	111/23
1,2-Butanediol	193	1,6-Hexanediol	243
1,3-Butanediol	212.3	2,5-Hexanediol	125.5/20
1,4-Butanediol	m.p. 19	1,2-Octanediol	122.5/4
2,3-Butanediol	183	1,10-Decanediol	192/20; m.p. 74
1,4-Pentanediol	221	1,2-Dodecanediol	m.p. 62～63

Synthesis of 1,2-Butanediol

α-Bromobutyric Acid (I)——A mixture of 89 g. (1 mole) of butyric acid and 176 g. (1.1 moles) of Br_2, dried over conc. H_2SO_4, was placed in a 500-cc. flask, 1 cc. of PCl_3 was added, the flask was provided with a reflux condenser connected to an absorption bottle, and heated in an oil bath. The reaction started at 88～90°. evolving HBr, and the total amount of Br_2 reacted after 8 hr. The temperature was raised to 100° towards the end of the reaction and maintained at this temperature for 2 hr. The mixture was distilled in a reduced pressure and 136.55 g. (81.5%) of a fraction of b.p$_{25}$ 125° was obtained.

α-Hydroxybutyric Acid (II)——A mixture of 136.45 g. (0.25 mole) of (I) and a solution of 173.4 g. (0.5 mole) of Na_2CO_3 dissolved in 2,500 cc. of H_2O was boiled for 2 hr., H_2O was evaporated in a reduced pressure, and conc. H_2SO_4 was added to the residue to neutralize Na_2CO_3. This solution was extracted continuously for 5 hr. with AcOEt in an automatic extractor. The solvent was evaporated from the extract solution, in a reduced pressure and a water bath, and the residue was dissolved in benzene. Evaporation of benzene in a reduced pressure left 85.3 g. (theoretical) of crystals.

1,2-Butanediol (III)——Following the method of Rudolff[5] for obtaining hexanediol. A suspension of 10 g. (in slight excess of 2.5 moles) of $LiAlH_4$ in 300 cc. of dehyd. tetrahydrofuran was placed in a three-necked flask of 1 L. capacity, provided with a stirrer and a dropping funnel, and a solution of 10 g. (1 mole) of (Ⅱ) dissolved in 200 cc. of dehyd. tetrahydrofuran was added dropwise, while stirring and ice cooling. The mixture was stirred for 6 hr. after completion of the dropwise addition and then refluxed. After cool, a mixture of 30 cc. of H_2O and 150 cc. of tetrahydrofuran was added dropwise and the mixture was refluxed for ca. 40 min. The cooled reaction mixture was filtered, the filtrate was dried over Na_2SO_4, and tetrahydrofuran was distilled off. Dehyd. benzene was added to the residue, benzene was evaporated, and the residue was distilled at ordinary temperature to collect 6 g. (69.4%) of a colorless viscous liquid, b.p. 193°. IR $\nu_{\max}^{\text{capil.}}$ cm^{-1} : ca. 3400 (broad, OH), 1058(C-O).
Acetate : b.p$_{32}$ 105°. *Anal.* Calcd. for $C_8H_{14}O_4$: C, 55.16; H, 8.10. Found : C, 55.46; H, 8.25.

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3) R. Goto, T. Sugano, N. Koizumi : Nippon Kagaku Zasshi, **75**, 73 (1954).
4) T. Nakagawa, K. Kuriyama, S. Inaba, K. Tori : *Ibid.*, **77**, 1563 (1956).
5) E. Von Rudloff : Can. J. Chem., **36**, 486 (1958).

Synthesis of 1,4-Pentanediol——Obtained by the reduction of methyl levulinate with $LiAlH_4$. Colorless viscous liquid, b.p. 221°. IR $\nu_{\max}^{\text{capil.}}$ cm^{-1}: ca. 3400 (broad, OH), 1060 (C–O).

2,4-Pentanediol——Colorless viscous liquid, b.p$_{23}$111°, obtained by a known method[6] from acetylacetone. IR $\nu_{\max}^{CHCl_3}$ cm^{-1}: ca. 3480 (broad, OH), 1121 (C–O).

2,5-Hexanediol——Colorless viscous liquid, b.p$_{20}$ 125.5°, obtained by a known method[7] from acetonylacetone. IR $\nu_{\max}^{\text{capil.}}$ cm^{-1}: ca. 3400 (broad, OH), 1125 (C–O).

Synthesis of 1,2-Octanediol

α-Bromocaprylic Acid (IV)——Prepared from caprylic acid by the same manner as for α-bromobutyric acid. Liquid, b.p$_{21}$ 156∼164°. Yield, 81.5%.

α-Hydroxycaprylic Acid (V)——Prepared from (IV) by the same manner as for α-hydroxybutyric acid. White scales, m.p. 70°. Yield, 63.9%.

1,2-Octanediol (VI)——Prepared from (V) by the same manner as for 1,2-butanediol. Colorless viscous liquid, b.p$_4$ 122.5°. Yield, 89%. IR $\nu_{\max}^{\text{capil.}}$ cm^{-1}: ca. 3400 (broad, OH), 1069, 1038 (C–O). Acetate: b.p$_{25}$ 152°. *Anal.* Calcd. for $C_{12}H_{22}O_4$: C, 62.58; H, 9.63. Found: C, 63.00; H, 9.39.

Synthesis of 1,2-Dodecanediol

α-Bromolauric Acid (VII)——Prepared from lauric acid by the same manner as for α-bromobutyric acid, b.p$_3$ 165∼177°. Yield, 83.2%.

α-Hydroxylauric Acid (VIII)——Prepared from (VII) by the same manner as for α-hydroxybutyric acid. White microcrystals, m.p. 77∼78°. Yield, 46.2%. *Anal.* Calcd. for $C_{12}H_{24}O_2$: C, 66.63; H, 11.18. Found: C, 66.76; H, 11.52.

1,2-Dodecanediol (IX)——Prepared from (VIII) by the same manner as for 1,2-butanediol. White waxy crystals, m.p. 62∼63°. Yield, 90.9%. *Anal.* Calcd. for $C_{12}H_{26}O_2$: C, 71.23; H, 12.95. Found: C, 71.53: H, 12.91. IR $\nu_{\max}^{\text{Nujol}}$ cm^{-1}: 3328, 3258 (OH), 1104, 1077 (C–O).

(2) 1,2-Propanediol-H_2O Mixture

a) Polarographic Measurement

A previous paper reported the air and O_2 content in the 1,2-propanediol-H_2O mixture measured by the CO_2 induction method.[8] In the present series of experiments, 1,2-propanediol-H_2O mixtures of 0∼9 (v/v)% were saturated with air and dissolved O_2 in this mixture was measured by polarography.

In this case, 0.1 mole of NH_4Cl was added as the supporting electrolyte, without the addition of a maximum suppressor. The measurement was made with the Yanagimoto Polarograph Model AP-I with Yanagimoto Galvarecorder, with sensitivity of 0.02 μA/mm., Damping 2, and dropping mercury of $m=0.644$ mg./sec. and $t=4.36$ sec./drop. The measurement was made at 20° and repeated five times to obtain the mean value.

The polarogram of 0% mixture, i.e. of H_2O, showed the maximum wave of O_2 but the maximum wave was inhibited at 10% of 1,2-propanediol. Therefore, mixtures of 1,2-propanediol and H_2O of varying concentration between 0 and 9% by volume were prepared, each was saturated with air, and submitted to polarography. As shown in Fig. 1, maximum wave of O_2 appeared in mixtures of 0∼7% but the wave was suppressed from 8% mixture, i.e. at a concentration of 1.09*M* of 1,2-propanediol.

Colichman,[9] Meites,[10] and Hubbard[11] stated that the minimum concentration of the surfactant necessary to suppress the maximum wave is approximately equal to the critical micelle concentration of the surfactant, but Nakagawa[4] and Tamamushi[12] disagree with this theory.

From the result of polarographic measurement described above, it seemed possible that 1,2-propanediol forms a micelle-like structure at a concentration of 1.09*M* and following experiments were carried out.

b) Measurement of Viscosity

Hess, Philippoff, and Kiessig,[13] Vetter,[14] and Sata and Tyuzyo[15] reported that the relative vis-

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6) H. Yonemoto: "Yuki Kagobutsu Gōsei-ho" (Syntheses of Organic Compounds), Vol. **13**, 93 (1961). Gihodo, Tokyo.
7) S.W. Chaikin, W.G. Brown: J. Am. Chem. Soc., **71**, 122 (1949).
8) H. Nogami, Y. Kato: Yakugaku Zasshi, **79**, 958 (1959).
9) E.L. Colichman: J. Am. Chem. Soc., **72**, 4036 (1950).
10) L. Meites, T. Meites: *Ibid.*, **73**, 177 (1951).
11) H.M. Hubbard, C.A. Reynolds: *Ibid.*, **76**, 4300 (1954).
12) R. Tamamushi, T. Yamanaka: Bull. Chem. Soc. Japan, **28**, 673 (1955).
13) K. Hess, W. Philippoff, H. Kiessig: Kolloid Z., **88**, 40 (1939).
14) R.J. Vetter: J. Phys. & Colloid Chem., **51**, 262 (1947).
15) N. Sata, K. Tyuzyo: Bull. Chem. Soc. Japan, **26**, 177 (1953).

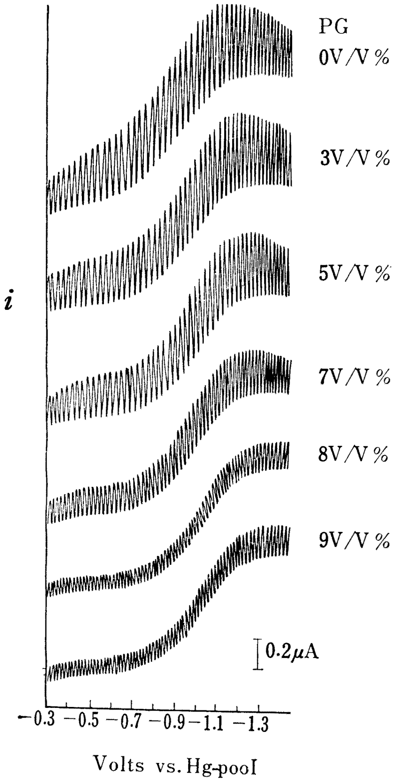

Fig. 1. Polarograms of Oxygen Wave dissolved in PG-Water Mixture

cosity (η_{γ}) of a solution increased with increasing concentration (C) of sodium dodecylsulfate and that a break point appears at the critical micelle concentration, and stated that the minimum point in the relationship between specific viscosity/concentration (η_{SP}/C) and C (*M*) is the critical micelle concentration. In the present experiment, viscosity of 1,2-propanediol-H_2O mixture was measured with an Ubbelohde Viscosimeter, which is not affected by surface tension. As shown in Fig. 2, relative viscosity increased with increasing concentration of 1,2-propanediol and a break appeared at 8% concentration, i.e. 1.09*M*. In the specific viscosity-concentration curve (Fig. 3), a minimum point appeared at 1.09*M*.

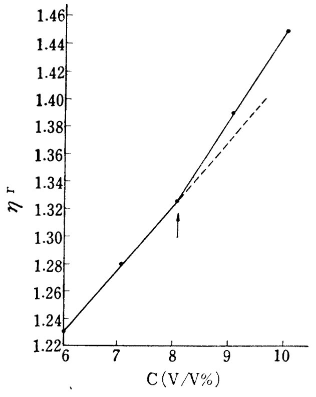

Fig. 2. Dependence of Relative Viscosity on Concentration of PG-Water Mixture at 20°

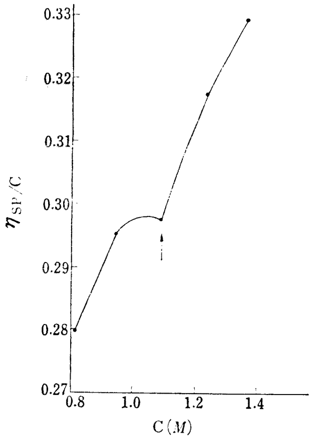

Fig. 3. Relation between η_{SP}/C and C of PG-Water Mixture

c) Measurement of Surface Tension

The effect of surface adsorption of solute molecule may be considered as a factor affecting surface tension of a solution. Periodical change of surface tension due to surface adsorption has been observed in detail by Rayleigh,[16] Harkins,[17] Dreger,[18] and Doss,[19] and Nakagawa, *et al.*[4] reported that of nonionic surfactants. In the present series of work, periodical change of surface tension was measured with a mixture of 1,2-propanediol and H_2O (Fig. 4).

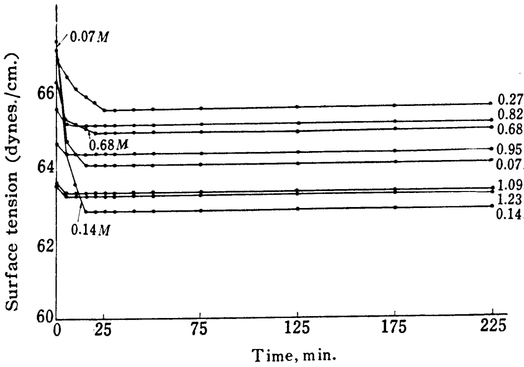

Fig. 4. PG-Water Mixture at 23°; Surface Tension *versus* Time Curve for Various Concentrations

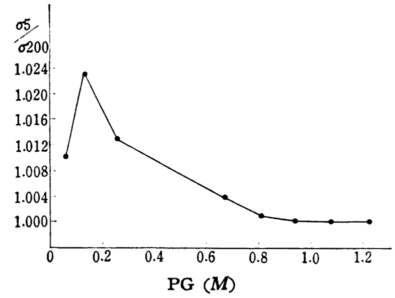

Fig. 5. PG-Water Mixture at 23°; The Ratio of Surface Tension at a Surface Age of 5 min. to Surface Tention at 200 min. for Various Concentrations

A fairly long period is required until a constant equilibrium value is obtained at 0.07, 0.14, 0.27, and 0.68*M* and this is considered to be the period necessary for the 1,2-propanediol molecule to diffuse and adsorb on the surface. On the other hand, such periodical change is hardly observed at 0.82, 0.95, 1.09, and 1.23*M*. This is clearly represented in Fig. 5, in which the ratio of surface tension after 5 min. and that after 200 min., σ_5/σ_{200}, rises once, then falls and finally reaches a constant value. This concentration of 1.09*M* is the critical micelle concentration.

The relationship between surface tension and concentration is shown in Fig. 6 which indicates

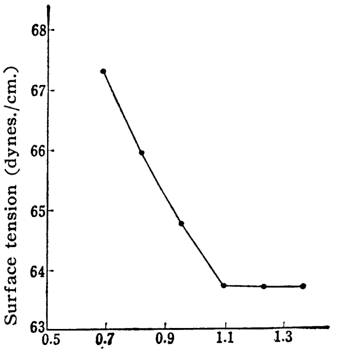

Fig. 6. Surface Tension of PG-Water Mixture at 24°

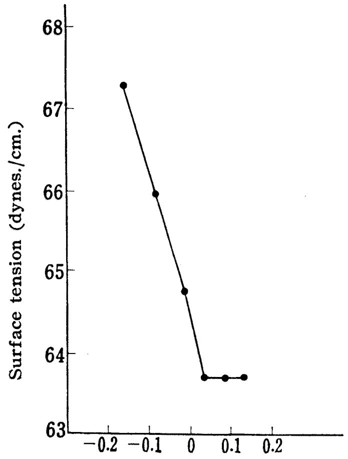

Fig. 7. Surface Tension at 24°, against log C (*M*) PG

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16) L. Rayleigh : Nature, **41**, 566 (1890).
17) G.C. Nutting, F.A. Long, W.D. Harkins : J. Am. Chem. Soc., **62**, 1496 (1940).
18) E.E. Dreger, *et al.* : Ind. Eng. Chem., **36**, 610 (1944).
19) K.S. Gururaja Doss : Kolloid Z., **86**, 205 (1939).

that the surface tension decreases with increasing concentration up to 1.08*M* but remains unchanged with futher increase in the concentration. Relationship between surface tension and logarithm of concentration (Fig. 7) also showed a clear break at 1.08*M*. The surface tension was measured with the du Noüy apparatus and the platinum ring was washed and heated before use.

d) Measurement by Solubilization of Pigments

Measurement of the critical micelle concentration of an aqueous solution of ionic surfactant by solubilization of H_2O-insoluble pigments is widely in use.[1,20] Goto[3] and Nakagawa[4] used this method to measure the critical micelle concentration of an aqueous solution of nonionic surfactant.

In the present series of experiments, 10 cc. of each concentration of 1,2-propanediol-H_2O mixture and ca. 30 mg. of Sudan Ⅲ were sealed in an ampule and shaken in a thermostat of 50° for 48 hr. Excess of the dye was removed in the thermostat and absorbance of its filtrate was measured at 505 mμ, using Hitachi Model EPU-2 Spectrophotometer. Absorbance, E, was plotted against the concentration, C, as shown in Fig. 8, and the amount of the dye solubilized increased markedly from 1.09*M*.

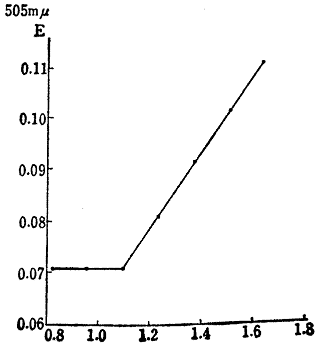

Fig. 8. Solubilization of Sudan Ⅲ by PG-Water Mixture

e) Measurement of Refractive Index

Klevens[21] reported the refractive index of sodium alkylsulfates. In Fig. 9, the difference between the refractive index of 1,2-propanediol-H_2O mixture and that of H_2O is plotted against the concentration and the crossing of the two lines, 1.10*M*, is the critical micelle concentration.

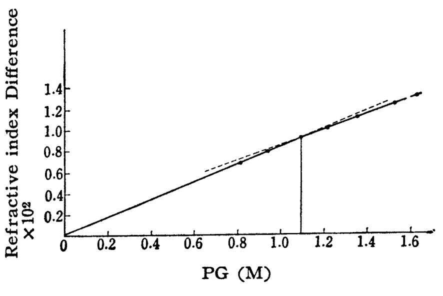

Fig. 9. Refractive Index Increment of PG-Water Mixture plotted as a Function of Concentration

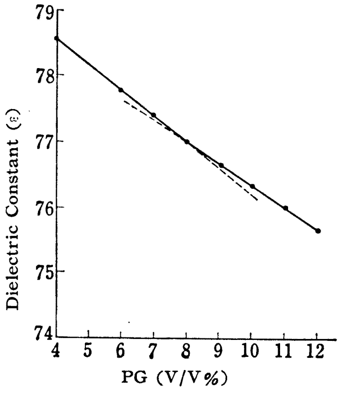

Fig. 10. Dielectric Constant of PG-Water Mixture at 15°

f) Measurement of Dielectric Constant

If 1,2-propanediol solution has a critical micelle concentration, the dielectric constant of this solution should also show a break at the same concentration. Therefore, dielectric constant of 1,2-

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20) M.E.L. McBain, E. Hutchinson : "Solubilization and Related Phenomena," (1955). Academic Press Inc., New York.

21) H.B. Klevens : J. Phys. & Colloid Chem., **52**, 130 (1948).

propanediol-H_2O mixture was measured at various concentrations. The distilled H_2O used in this measurement was freed of CO_2. The measurement of dielectric constant followed the phase compensation method[22] and corrected by the calibration curve. As shown in Fig. 10, a break point was obtained at a concentration of 8(v/v)%.

(3) Results of the Other Glycol-water Mixtures

The foregoing experimental results have shown that a comparatively sudden change occurs in a mixture of 1,2-propanediol and H_2O at the concentration of 1.08~1.10*M* and this fact indicates that a phenomenon similar to a critical micelle concentration is present in a 1,2-propanediol-H_2O mixture. If this were so, there should be a critical micelle concentration in glycols of different length in carbon chain and the following experiments were carried out.

Physical constants measured in aqueous solutions of 1,3-propanediol are listed in Figs. 11~14.

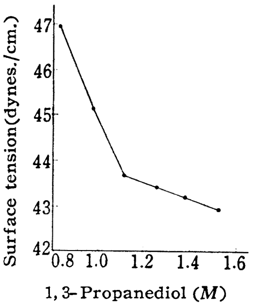

Fig. 11. Surface Tension of 1,3-Propanediol Solution at 21.5°

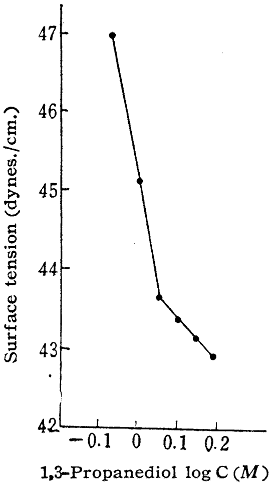

Fig. 12. Surface Tension at 21.5°, against log C (*M*) 1,3-Propanediol

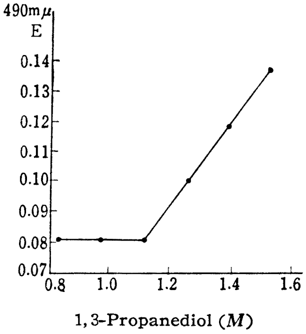

Fig. 13. Solubilization of Sudan III by 1,3-Propanediol Solution

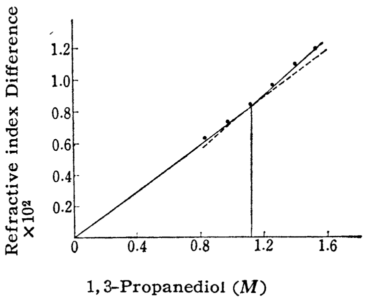

Fig. 14. Refractive Index Increment of 1,3-Propanediol Solution plotted as Function of Concentration

The break point was observed at 1.14*M* in surface tension, at 1.11*M* in pigment solubilization, and at 1.12*M* in refractive index. The critical micelle concentration of 1,3-propanediol, therefore, is thought to be at 1.11~1.14*M*.

Periodical change of surface tension in aqueous solution of 1,2-butanediol is shown in Figs. 15 and 16. At 0.03, 0.06, 0.11, and 0.22*M*, fairly long period is required until a constant equilibrium is reached but periodical change is hardly observed at 0.34 and 0.45*M*, or further at 0.56, 0.67, and 0.78*M*. A constant value of σ_5/σ_{200} is reached at 0.56*M* concentration. Physcal constant of 1,2-butanediol measured are presented in Figs. 17~20.

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22) M. Ishidate, Y. Kamura, K. Nagano : Yakugaku Zasshi, **77**, 407 (1957).

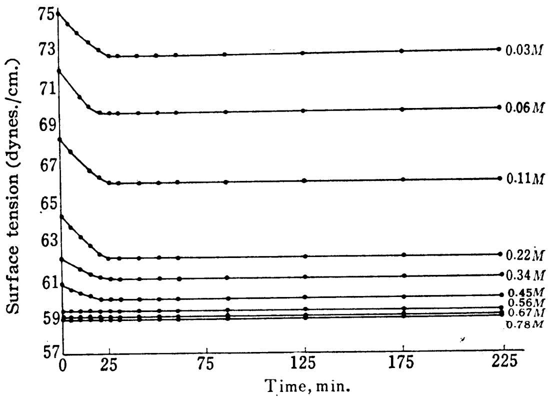


Fig. 15. 1,2-Butanediol Solution at 22°; Surface Tension versus Time Curve for Various Concentrations

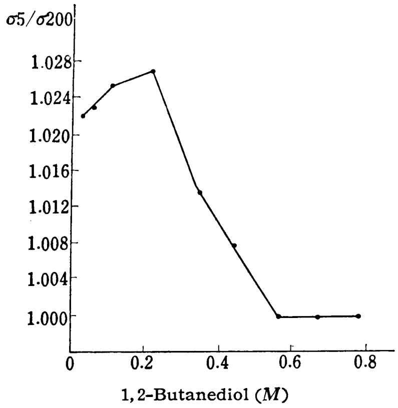


Fig. 16. 1,2-Butanediol Solution at 22°; the Ratio of Surface Tension at a Surface Age of 5 min. to Surface Tension at 200 min. for Various Concentration

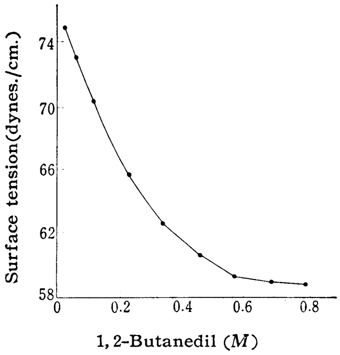
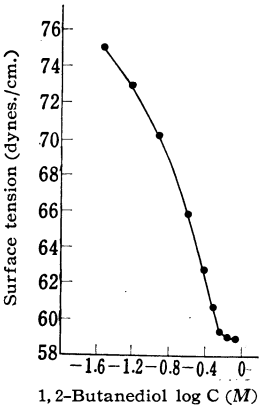


Fig. 17. Surface Tension of 1,2-Butanediol Solution at 22°



Fig, 18. Surface Tension at 22°, against log C (M) 1,2-Butanediol

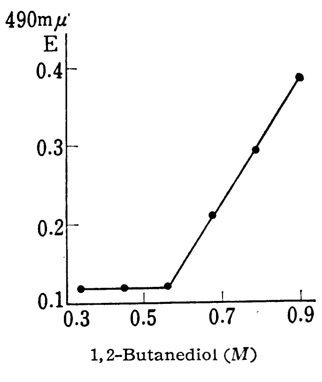


Fig. 19. Solubilization of Sudan III by 1,2-Butanediol Solution

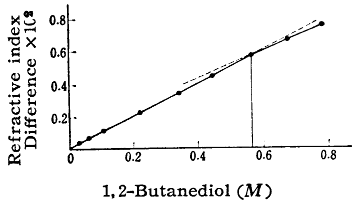


Fig. 20. Refractive Index Increment of 1,2-Butanediol Solution plotted as Function of Concentration

The break point was observed at 0.54*M* in surface tension, at 0.56*M* in pigment solubilization, and at 0.56*M* in refractive index. Therefore, the concentration of 0.54～0.56*M* seems to be the critical micelle concentration of 1,2-butanediol.

Periodical change of surface tension in aqueous solution of 1,3-butanediol is shown in Figs. 21 and 22. A constant value was reached at 0.56*M*. Physical constants of 1,3-butanediol are shown in Figs. 23～25.

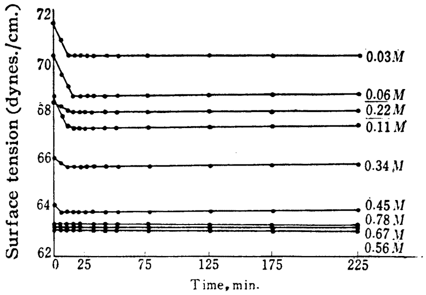


Fig. 21. 1,3-Butanediol Solution at 23°; Surface Tension versus Time Curve for Various Concentrations

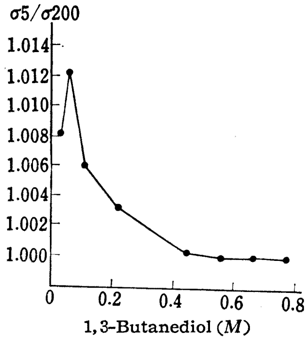


Fig. 22. 1,3-Butanediol Solution at 23°; the Ratio of Surface Tension at Surface Age of 5 min. to Surface Tension at 200 min. for Various Concentrations

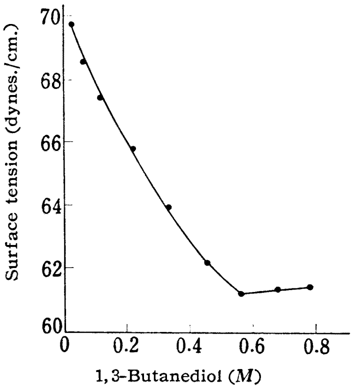


Fig. 23. Surface Tension of 1,3-Butanediol Solution at 21.5°

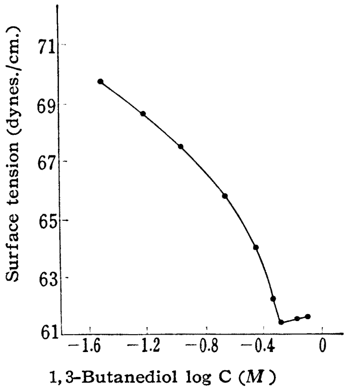


Fig. 24. Surface Tension at 21.5°, against log C (*M*) 1,3-Butanediol

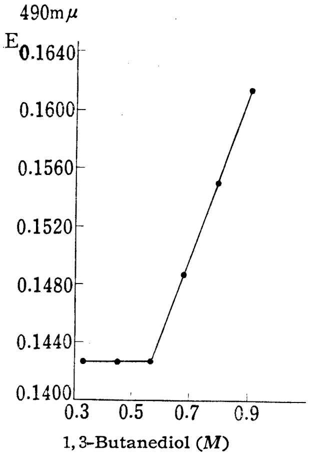


Fig. 25. Solubilization of Sudan Ⅲ by 1,3-Butanediol Solution

The break point was observed at 0.51*M* in surface tension and at 0.56*M* in pigment solubilization, and 0.51～0.56*M* seems to be the critical micelle concentration of 1,3-butanediol.

Physical constants of the aqueous solution of 1,4-butanediol are shown in Figs. 26～28. The break point is present at 0.59*M* in surface tension and at 0.57*M* in pigment solubilization, and 0.57～0.59*M* seems to be the critical micelle concentration of 1,4-butanediol.

Physical constants of the aqueous solution of 2,3-butanediol are shown in Figs. 29～32. Break point was not observed in any of the measurements and it is considered that 2,3-butanediol does not form a micelle.

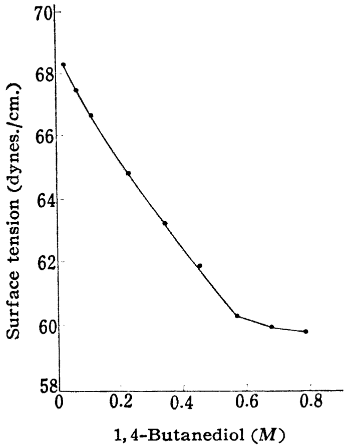


Fig. 26. Surface Tension of 1,4-Butanediol Solution at 22°

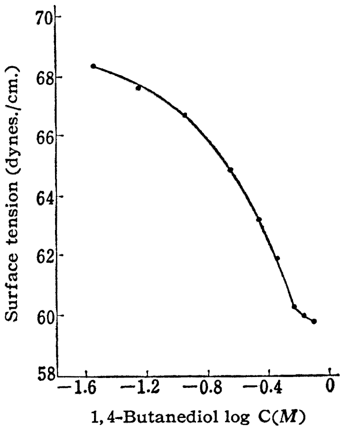


Fig. 27. Surface Tension at 22°, against log C (*M*) 1,4-Butanediol

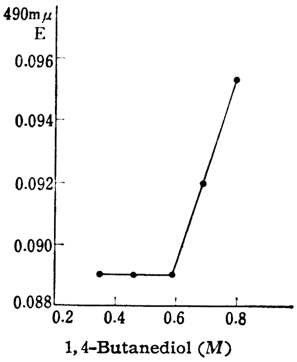


Fig. 28. Solubilization of Sudan III by 1,4-Butanediol Solution

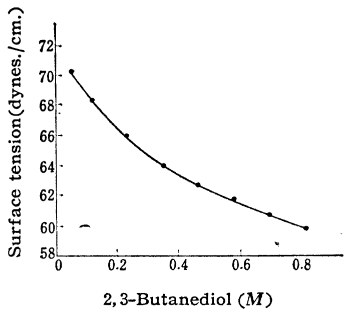


Fig. 29. Surface Tension of 2,3-Butanediol Solution at 22°

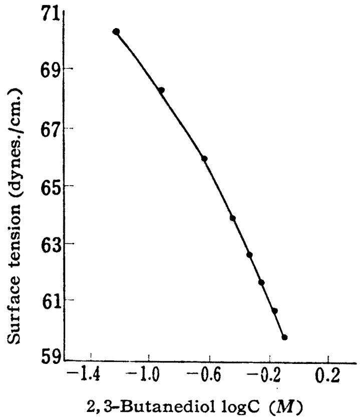


Fig. 30. Surface Tension at 22°, against log C (*M*) 2,3-Butanediol

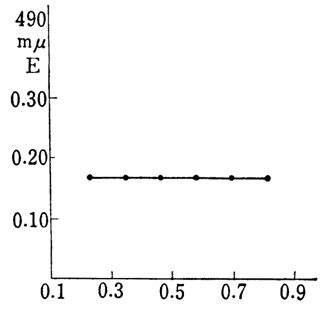


Fig. 31. Solubilization of Sudan III by 2,3-Butanediol Solution

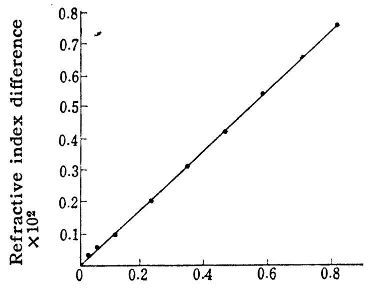


Fig. 32. Refractive Index Increment of 2,3-Butanediol Solution plotted as Function of Concentration

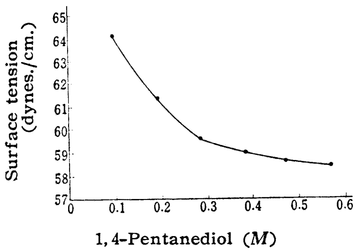


Fig. 33. Surface Tension of 1,4-Pentanediol Solution at 24°

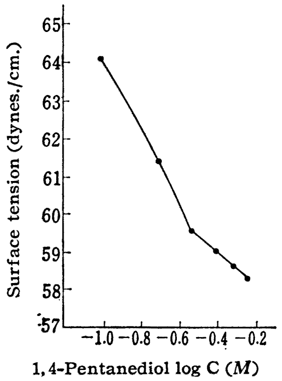


Fig. 34. Surface Tension at 24°, against log C (*M*) 1,4-Pentanediol

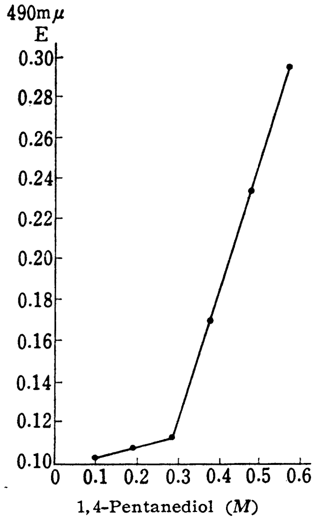


Fig. 35. Solubilization of Sudan III by 1,4-Pentanediol Solution

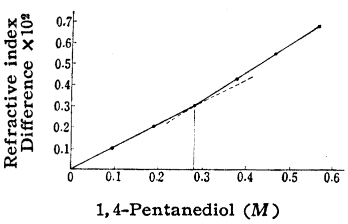


Fig. 36. Refractive Index Increment of 1,4-Pentanediol Solution plotted as Function of Concentration

Physical constants of 1,4-pentanediol are shown in Figs. 33∼36. Break point is observed at 0.30*M* in surface tension, at 0.29*M* in pigment solubilization, and at 0.28*M* in refractive index, and 0.28∼0.30*M* seems to be the critical micelle concentration of 1,4-pentanediol.

Physical constants of the aqueous solution of 1,5-pentanediol are shown in Figs. 37∼40. The break point is observed at 0.29*M* in surface tension, at 0.30*M* in pigment solubilization, and at 0.27*M* in refractive index, and 0.27∼0.30*M* seems to be the critical micelle concentration of 1,5-pentanediol.

Physical constants of the aqueous solution of 2,4-pentanediol are shown in Figs. 41∼44. There is no break point in measurements by any of the methods and 2,4-pentanediol is considered not to form a micelle.

Physical constants of the aqueous solution of 1,6-hexanediol are shown in Figs. 45∼48. The break point is observed at 0.15*M* in both the surface tension and pigment solubilization and at 0.16*M* in refractive index. Therefore, 0.15∼0.16*M* seems to bethe critical micelle concentration of 1,6-hexanediol.

Physical constants of the aqueous solution of 2,5-hexanediol are shown in Figs. 49∼50. There is no break point by any of the measurements and 2,5-hexanediol seems not to form a micelle.

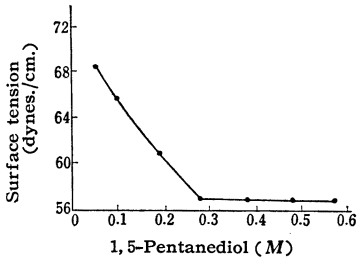


Fig. 37. Surface Tension of 1,5-Pentanediol Solution at 21°

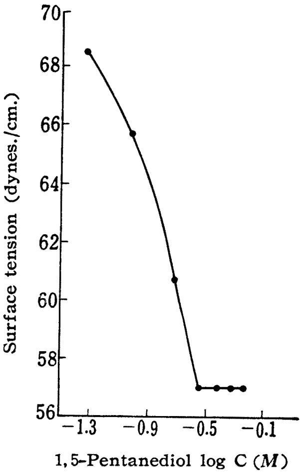


Fig. 38. Surface Tension at 21°, against log C (*M*) 1,5-Pentanediol

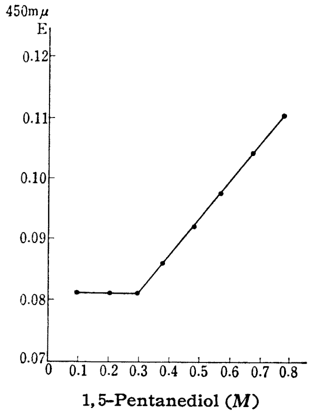


Fig. 39. Solubilization of Sudan III by 1,5-Pentanediol Solution

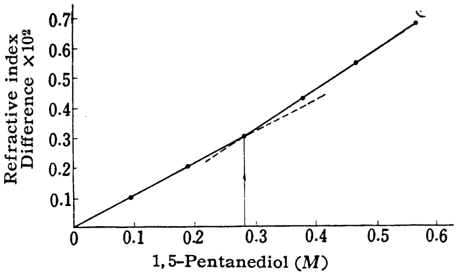


Fig. 40, Refractive Index Increment of 1,5-Pentanediol Solution plotted as Function of Concentration

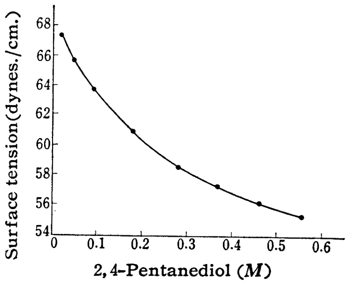


Fig. 41. Surface Tension of 2,4-Pentanediol Solution at 22°

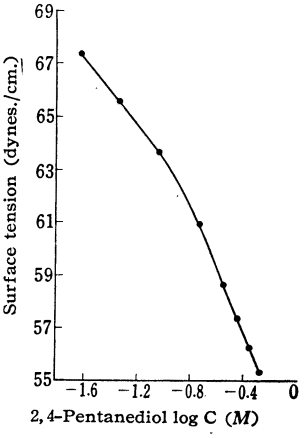


Fig. 42. Surface Tension at 22°, against log C (*M*) 2,4-Pentanediol

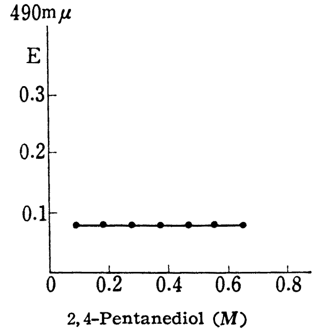


Fig. 43. Solubilization of Sudan III by 2,4-Pentanediol Solution

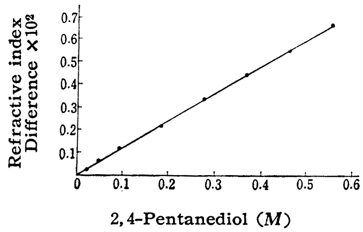


Fig. 44. Refractive Index Increment of 2,4-Pentanediol Solution plotted as Function of Concentration

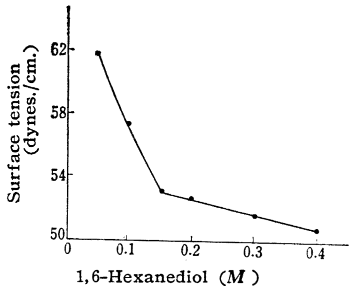


Fig. 45. Surface Tension of 1,6-Hexanediol Solution at 21°

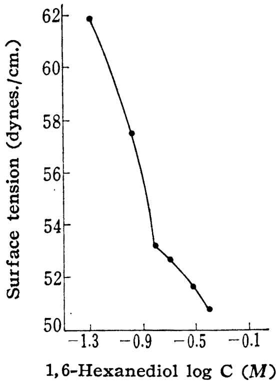


Fig. 46. Surface Tension at 21°, against log C (M) 1,6-Hexanediol

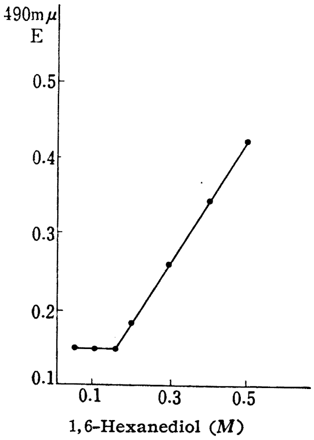


Fig. 47. Solubilization of Sudan III by 1,6-Hexanediol Solution

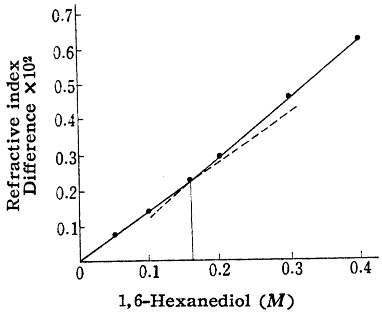


Fig. 48. Refractive Index Increment of 1,6-Hexanediol Solution plotted as Function of Concentration

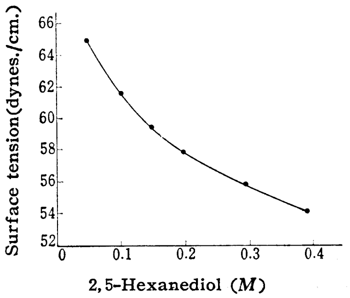


Fig. 49. Surface Tension of 2,5-Hexanediol solution at 24°

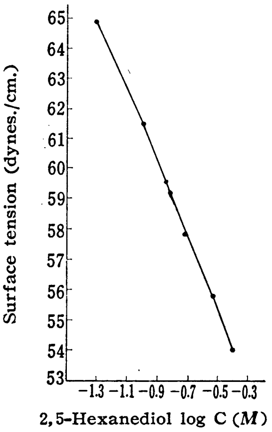


Fig. 50. Surface Tension at 24°, against log C (*M*) 2,5-Hexanediol

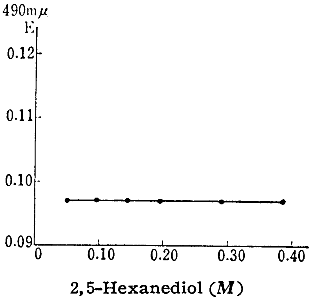


Fig. 51. Solubilization of Sudan III by 2,5-Hexanediol Solution

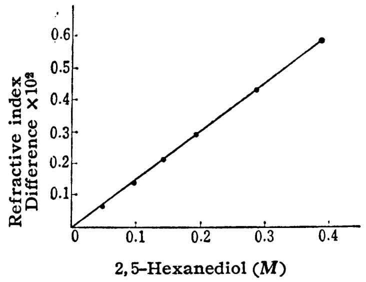


Fig. 52. Refractive Index Increment of 2,5-Hexanediol Solution plotted as Function of Concentration

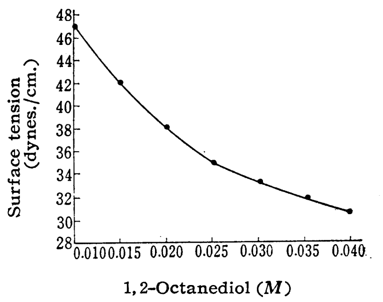


Fig. 53. Surface Tension of 1,2-Octanediol Solution at 20°

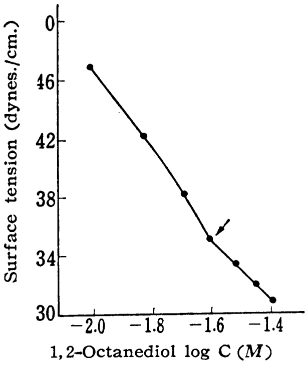


Fig. 54. Surface Tension at 20°, against log C (*M*) 1,2-Octanediol

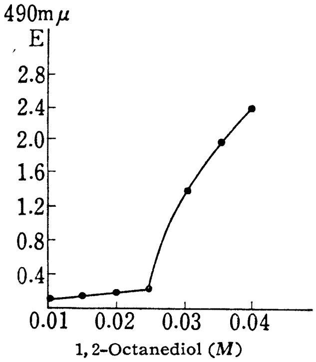


Fig. 55. Solubilization of Sudan III by 1,2-Octanediol Solution

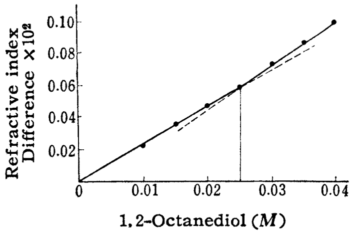


Fig. 56. Refractive Index Increment of 1,2-Octanediol Solution plotted as a Function of Concentration

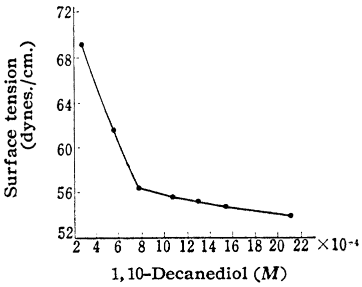


Fig. 57. Surface Tension of 1,10-Decanediol Solution at 22°

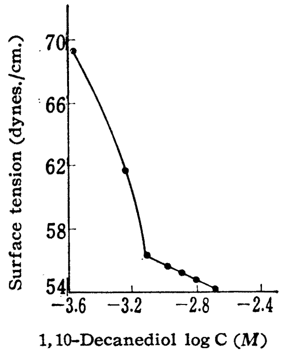


Fig. 58. Surface Tension at 22°, against log C (*M*) 1,10-Decanediol

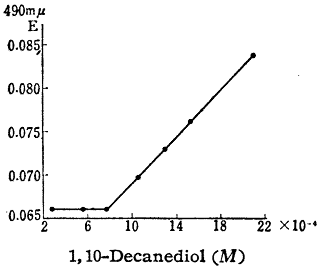


Fig. 59. Solubilization of Sudan III by 1,10-Decanediol Solution

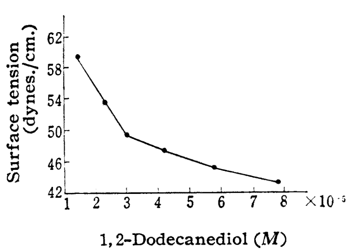


Fig. 60. Surface Tension of 1,2-Dodecanediol Solution at 24°

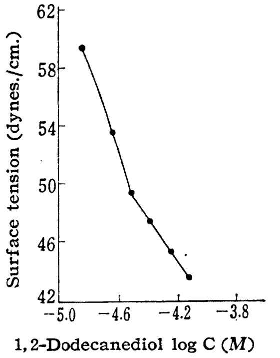


Fig. 61. Surface Tension at 24°, against log C (*M*) 1,2-Dodecanediol

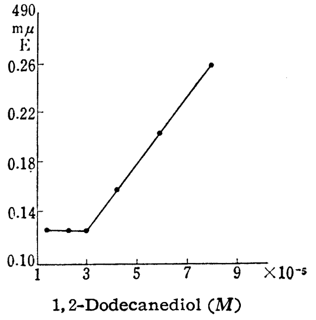


Fig. 62. Solubilization of Sudan III by 1,2-Dodecanediol Solution

Physical constants of 1,2-octanediol solution are shown in Figs. 53∼56. The break point is present at a concentration of $2.50\times10^{-2}M$ in both surface tension and refractive index, and at $2.52\times10^{-2}M$ in pigment solubilization, and $2.50\sim2.52\times10^{-2}M$ seems to be the critical micelle concentration of 1,2-octanediol.

Physical constants of the aqueous solution of 1,10-decanediol are shown in Figs. 57∼59. The break point is present at a concentration of $8.0\times10^{-4}M$ in surface tension and at $7.7\times10^{-4}M$ in pigment solubilization, and $7.7\sim8.0\times10^{-4}M$ seems to be the critical micelle concentration of 1,10-decanediol.

Physical constants of the aqueous solution of 1,2-dodecanediol are shown in Figs. 60∼62. The break point is present at a concentration of $3.25\times10^{-5}M$ in surface tension and at $3.00\times10^{-5}M$ in pigment solubilization, and $3.00\sim3.25\times10^{-5}M$ seems to be the critical micelle concentration of 1,2-dodecanediol.

Discussions

The foregoing experimental data are summarized in Table II. The table gives the number of carbon atoms, kinds of glycols used, and the method for measurement of the critical micelle concentration. 2,3-Butanediol, 2,4-pentanediol, and 2,5-hexanediol do not form a micelle but other glycols do.

Table II. Critical Micelle Concentration of the Glycols

No. of C atoms	Glycols	Determination method			Refractive index	Surface tension	Solubilization	Critical micelle conc. (M)
		Polarography	Viscosity	Diel. const.				
3	1,2-Propanediol	+[a]	+	+	+	+	+	1.08∼1.10
	1,3-Propanediol				+	+	+	1.11∼1.14
4	1,2-Butanediol				+	+	+	0.54∼0.56
	1,3-Butanediol					+	+	0.51∼0.56
	1,4-Butanediol					+	+	0.57∼0.59
	2,3-Butanediol				−	−	−	……
5	1,4-Pentanediol				+	+	+	0.28∼0.30
	1,5-Pentanediol				+	+	+	0.27∼0.30
	2,4-Pentanediol				−	−	−	……
6	1,6-Hexanediol				+	+	+	0.15∼0.16
	2,5-Hexanediol				−	−	−	……
8	1,2-Octanediol				+	+	+	$2.50\sim2.52\times10^{-2}$
10	1,10-Decanediol					+	+	$7.70\sim8.00\times10^{-4}$
12	1,2-Dodecanediol					+	+	$3.00\sim3.25\times10^{-5}$

[a] The Plus (+) sign denotes formation of a micelle and minus (−) indicates that a micelle is not formed.

These experimental results show that glycols with hydroxyls in 1- and 2-positions form a micelle and so do those with hydroxyls at both ends, such as 1,2-propanediol, 1,2-butanediol, 1,2-octanediol, 1,2-dodecanediol, 1,3-propanediol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, and 1,10-decanediol. Glycols with one hydroxyl at terminal end and the other in an intermediate place, such as 1,3-butanediol and 1,4-pentanediol, also form micelle. When the hydroxyls are in intermediate places and none at either terminal ends, such as 2,3-butanediol, 2,4-pentanediol, and 2,5-hexanediol, there is no micelle formation.

The concentration at which micelle is formed decreases with increasing number of carbon atoms and at dodecanediol with 12 carbon atoms, the concentration becomes approximately equal to the critical micelle concentration of nonionic surfactant.

Herzfeld[23] reported that the relationship between the carbon number, N, in the alkyl chain and the logarithm of critical micelle concentration is linear in potassium salt of fatty acids and obtained the following empirical formula :

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[23] S.H. Herzfeld : J. Phys. Chem., **56**, 953 (1952).

$$\log(\text{critical micelle concentration}) = 1.70 - 0.301N$$

It was assumed that a similar relationship might be established for glycols and the relationship between the number of carbon atoms in these diols and the logarithm of critical micelle concentration was plotted (Fig. 63).

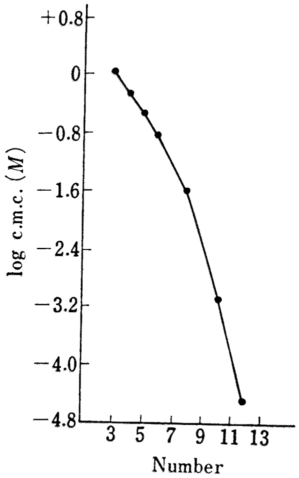

Fig. 63. Variation of Critical Micell Concectration of Glycol with Number of Carbon Atoms

In this case, there was no linear relationship but a continuous line was obtained from 3 to 12 carbon atoms. Conseguently, an empirical formula

$$\log(\text{critical micelle concentration}) = 0.899 - 0.287N$$

is obtained for glycols between C_3 and C_6, while the equation

$$\log(\text{critical micelle concentration}) = 4.245 - 0.731N$$

is obtained for those of C_8 to C_{12}.

It may be concluded from above experimental evidences that a critical micelle concentration is also present in the glycols. However, light scattering and vapor pressure methods were not taken up as the method of measurement and there has been no example of the use of the word "micelle" for compounds with small number of carbon atoms, such as propanediol, and it seemed a little doubtful to use the work "critical micelle concentration." Therefore, the phenomenon was termed the "micelle-like structure," but the term micelle could probably used in those of concentrations approximately equal to the critical micelle concentration of nonionic surfactants.

The author expresses her deep gratitude to Prof. H. Nogami of the University of Tokyo for his kind and unfailing guidance throughout the course of the present work, to Prof. S. Yamada and Assist. Prof. S. Akaboshi for advices in the syntheses of the samples used in the present work, to Dr. Y. Mashiko of the Central Institute for Balneological Research for instructions in the polarographic measurements, and to Dr. Y. Kamura for instructions in the measurement of dielectric constant.

Summary

Physical constants, such as surface tension, solubilization of pigments, polaography, refractive index, and viscosity, were measured of aqueous solution of 14 kinds of glycols of different number of carbon atoms, from propanediol to dodecanediol.

Glycols with hydroxyls on either terminal ends or in 1,2-positions showed a break point in the foregoing physical constants and were considered to form a micelle-like structure.

Glycols with one hydroxyl at a terminal end and the other in a median position also forms a micelle-like structure but those having both hydroxyls in median positions and none at the terminal position do not form such a structure.

The concentration of glycols at which they form a micelle-like structure decreases with increasing number of carbon atoms and the concentration of dodecanediol becomes approximately equal to the critical micelle concentration of nonionic surfactant.

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124. **Tohru Ueda** : Studies on Coenzyme Analogs. XII.[*1] Synthesis of 5-Dimethylaminouridine- and 3-Methyluridine 5′-Phosphate.

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In order to elucidate the hitherto unclarified substrate specificity of snake venom 5′-nucleotidase1) in the level of submolecular structure, the syntheses of several nucleoside 5′-monophosphates were required. Among these compounds, 5-bromo-, 5-hydroxy-, and 5-morpholino-uridine 5′-phosphate, in which the pyrimidine moiety was modified at C_5, were already prepared by the present author.2) In the present paper the synthesis of 5′-phosphate of 3-methyluridine and 5-dimethylaminouridine is described.

As to the biological activity of modified pyrimidine nucleosides, such as 5-bromo-, 5-chloro-, 5-amino-, 5-hydroxy-, 3-methyl-, and 3-methyl-5-bromo-derivatives of uridine and cytidine,3) some works have been done and inhibitory effect of these nucleosides was observed against the incorporation of natural pyrimidine (base or nucleotides) into ribonucleic acid of pyrimidine requiring *Neurospora strain-1298* or *E. coli K-12.*4) Accordingly, from the stand point of pharmaceutical interests for cancerostatic agents, it is worthwhile to synthesize these nucleotides stated above.

Various 5-substituted aminouracils were already synthesized by Philips5) from 5-bromouracil by the reaction with amines at elevated temperature. However, reports dealing with this kind of replacement reaction in the nucleoside level were scanty and the synthesis of 5-aminouridine was reported solely by Visser, *et al.*3a) and Fox, *et al.*

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[*2] Kita 12-jo, Nishi 5-chome, Sapporo, Hokkaido (上田 亨).

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