Notes

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UDC 615.771.7-011

Experimental Anticancer Studies. XXXIV.[1] Some Compounds relating to 4-*n*-Hexyl-6-(2-Hydroxyphenyliminomethyl)resorcinol and Their Anticancer Activity

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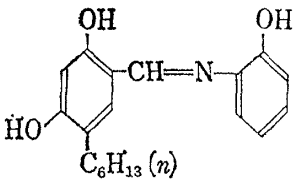
In the preceding paper,[3] data concerned with the inhibitory effect of 4-*n*-hexyl-6-(2-hydroxyphenyliminomethyl)resorcinol (I) against Ehrlich carcinoma (ascites and solid types), Sarcoma 180 and Yoshida sarcoma were reported.

Present paper deals with the preparation of compounds, in which the bridge linkage, azomethine -CH=N-, of (I) or its related compound was replaced with either azo -N=N-, or aminomethyl $-CH_2NH-$, or vinylene -CH=CH-, and with some biological tests.

4-*n*-Hexyl-6-(2-hydroxyphenylazo)resorcinol was obtained by coupling 4-*n*-hexylresorcinol with diazotized *o*-aminophenol in usual manner. By the reduction with $NaBH_4$ of (I) in dioxane failed to give its aminomethyl compound. However, in case of experiment on 2-(2-hydroxyphenyliminomethyl)-4-*n*-hexylphenol the same reduction procedure produced its aminomethyl compound in good yield.



I

Concerning the -CH=CH- linkaged compounds, it was firstly determined that *trans*-2,2'-dihydroxystilbene (V) could be obtained by a series of synthetic procedure presented in Chart 1.

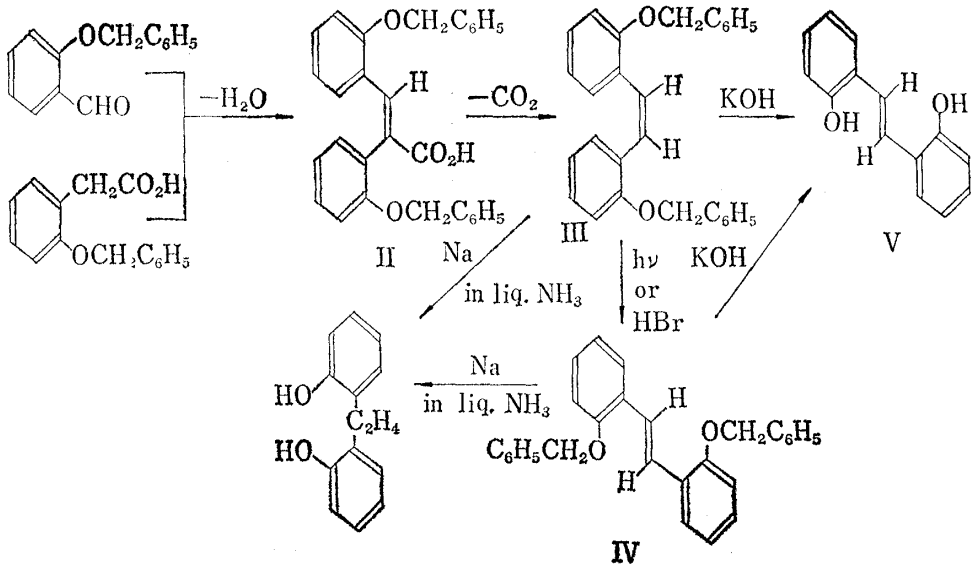


Chart 1. Preparation of *trans*-2,2'-Dihydroxystilbene

1) Part XXXIII: *Ann. Rep. Cancer Inst. Kanazawa* (Japanese text), **1**, 1967 (in press).
2) Location: *Takara-machi, 13-1, Kanazawa.*
3) T. Ujiie, *Ann. Rep. Cancer Inst. Kanazawa* (Japanese text), **1**, 1967 (in press).

According to the Perkin reaction, *trans*-α-(2-benzyloxyphenyl)-2-benzyloxycinnamic acid (II), as a main product, and a trace amount of both 3-(2-benzyloxyphenyl)coumarin and *trans*-2,2′-dibenzyloxystilbene (IV) were obtained from the reaction mixture of O-benzylsalicylaldehyde and O-benzylhomosalicylic acid in the presence of triethylamine and acetic anhydride. Refluxing of (II) in quinoline in the presence of copper-chromium-oxide afforded decarboxylation to produce *cis*-2,2′-dibenzyloxystilbene (III), which was shown to be easily converted by ultraviolet light irradiation to *trans*-2,2′-dibenzyloxystilbene (IV). Debenzylation was effected by heating either of these *cis* and *tarns* forms with potassium hydroxide in ethylene glycol at 240° for about 20 hours, giving *trans*-2,2′-dihydroxystilbene (V)[4] as a sole product.

It should here be noted that following two procedures could not be used for obtaining 2,2′-dihydroxystilbene from 2,2′-dibenzyloxystilbene: 1) Treatment of *cis*-2,2′-dibenzyloxystilbene with hydrobromic acid in acetic anhydride. In this case, there occurred a

Table I. Two Forms of 2,2′-Dibenzyloxystilbene

Property	(III)	(IV)
mp (°C)	96	181
	transfer by irradiation of UV light to (IV)	
UV λ_{max}^{EtOH} mμ (ε)	277 (9, 280) 300 (9, 190)	233 (shoulder) (17, 600) 287 (12, 370) 328 (15, 950)
	cis-form	*trans*-form

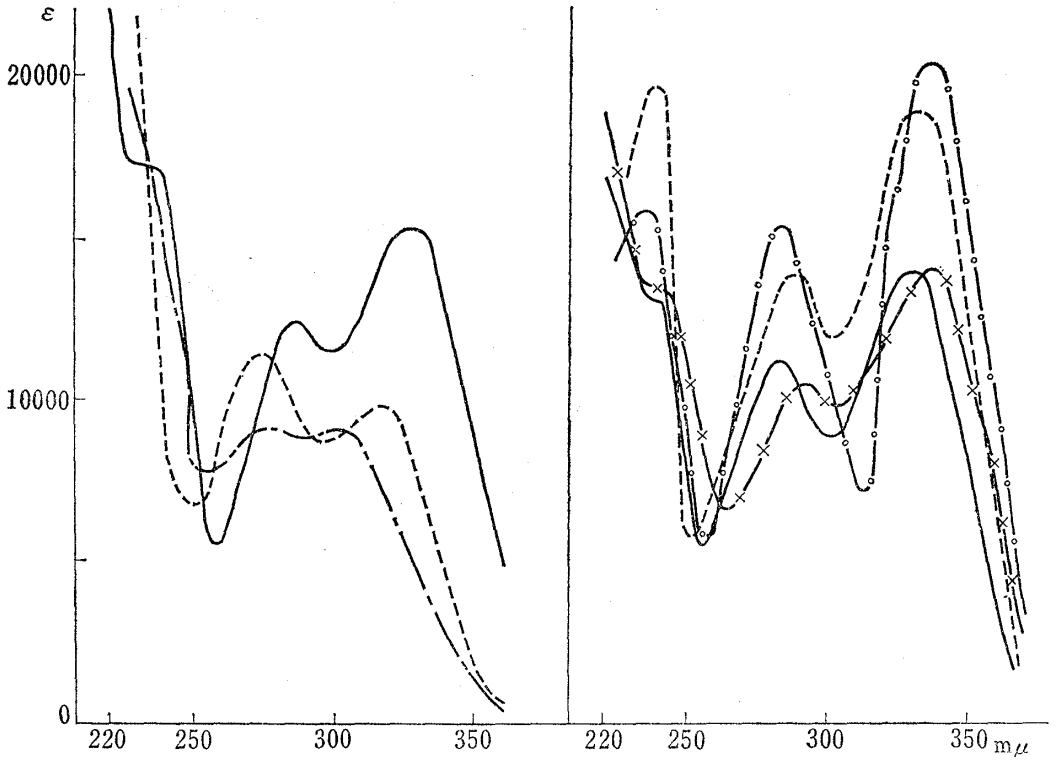


Fig. 1. Ultraviolet Absorption Spectra (in EtOH)

——— *trans*-2,2′-Dibenzyloxystilbene
— - — *cis*-2,2′-Dibenzyloxystilbene
——— *trans*-α-(2-Benzyloxyphenyl)-2-benzyloxycinnamic acid
——— *trans*-2,2′-Dihydroxystilbene
——— *trans*-2,2′-Dihydroxy-5-*n*-hexylstilbene
—○— *trans*-2,2′-Dibenzyloxy-5-*n*-hexylstilbene
—×— *trans*-2,2′,4-Tribenzyloxy-5-*n*-hexylstilbene

4) Two compounds, mp 95° and 197°, for 2,2′-dihydroxystilbene were reported, but their structural assignment has not been done hitherto; K. Kopp, *Ann.*, **277**, 339 (1893).

formation of *trans*–2,2′–dibenzyloxystilbene as a primary product, and a formation of aklaline soluble amorphous powder as the end product. 2) The fission reaction with metallic sodium in liquid ammonia. In this case, there occurred a production of 2,2′–dihydroxydibenzyl from both the *cis* and *trans* forms.

Here, the assignment of *cis* and *trans* forms was based on the differences in the physico–chemical properites between the *cis* and *trans* stilbene derivatives.

The liquid condensation mixture from 2,4–dibenzyloxy–5–*n*–hexylbenzaldehyde and O–benzylhomosalicylic acid was used for decarboxylation by copper–chromite method. The liquid product thus obtained was irradiated by ultraviolet light with the production of *trans*–2,2′,4–tribenzyloxy–5–*n*–hexylstilbene. Debenzylation of this *trans* compound gave, however, negative result.

5–*n*–hexylsalicylaldehyde was prepared from *p*–*n*–hexylphenol by the Reimer–Tiemann reaction. The condensation product of 5–*n*–hexylsalicylaldehyde and O–benzylhomosaliculic acid, after being decarboxylation, was irradiated by ultraviolet light to obtain *trans*–2,2′–dibenzyloxy–5–*n*–hexylstilbene. Debenzylation by heating with potassium hydoxide of *trans*–2,2′–dibenzyloxy–5–*n*–hexylstilbene was performed in triethylene glycol with good yield of *trans*–2,2′–dihydroxy–5–*n*–hexylstilbene.

The ultraviolet absorption spectra of stilbene derivatives above described are shown in Fig. 1.

Anticancer experiments performed with nine compounds have indicated that 4–*n*–hexyl–6–(2–hydroxyphenyliminomethyl)resorcinol (I) and 2–(2–hydroxyphenyliminomethyl)–4–*n*–hexylphenol were effective in inhibiting the growth of tumour cells in mice. By surveying the

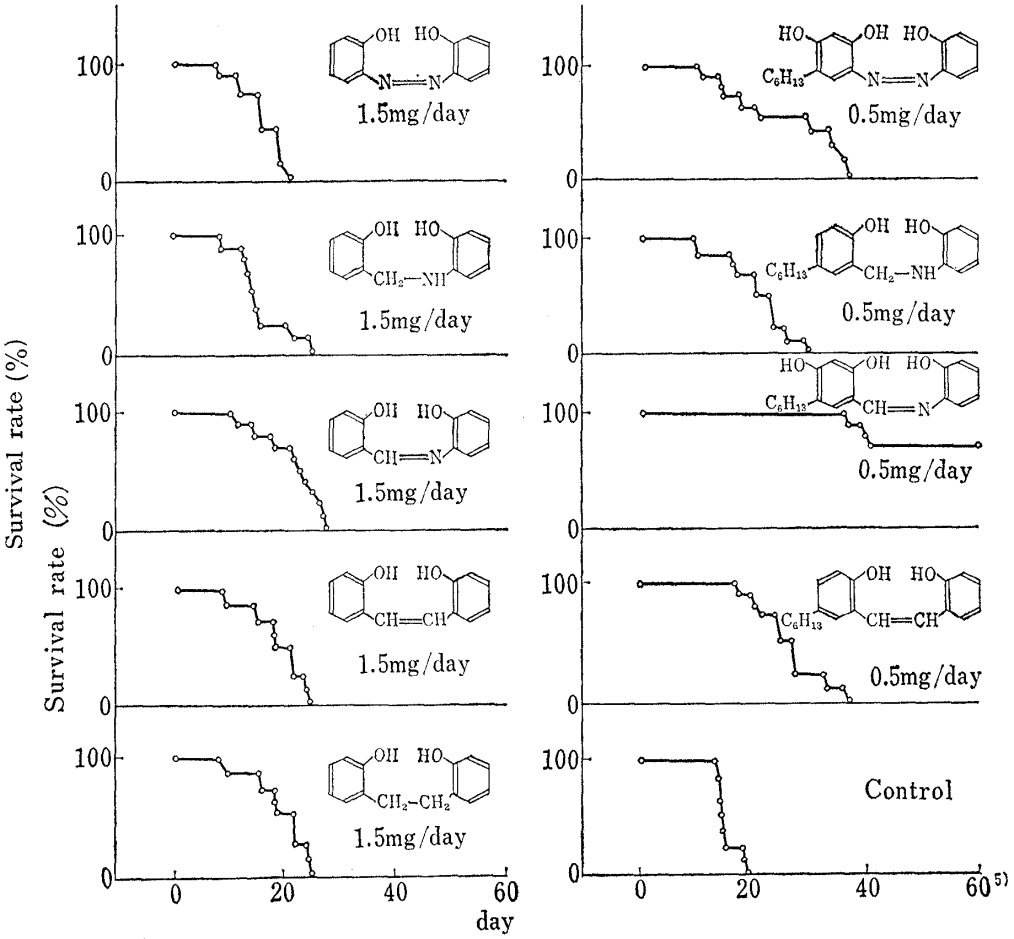
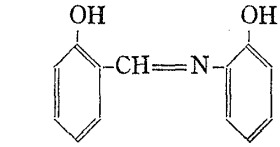
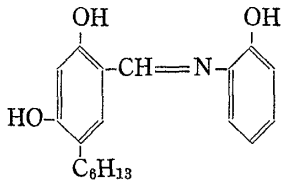
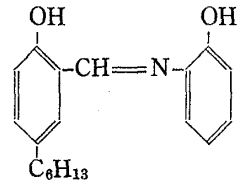
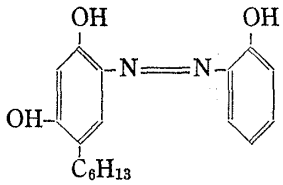
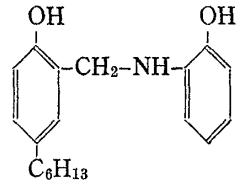
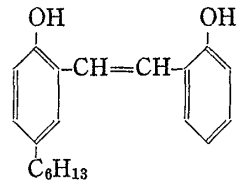


Fig. 2. Action on Ehrlich Ascites Carcinoma in Mice

a) The animals were autopsied with no tumour finding.

results presented in Fig. 2 and Table II, it may be said that both radicals, hexyl and azomethine –CH=N–, are contributive to the activity of (I).

Table II. Action on Ehrlich Ascites Carcinoma in Mice

Compound	LD_{50} in mice[a] (*i.p.*, mg/kg)	Dose (*i.p.*, mg/kg)	Anticancer effect (Survivors after days)[b] 10	20	30	40	50	60
	>2,000	2,000	3	1	0			
	>2,000	125	3	3	1	0		
		250	3	3	3	3	3	3
		500	3	3	3	3	3	3
	>2,000	125	3	3	2	1	1	1
		250	3	3	3	3	3	3
		500	3	3	3	3	3	3
	>1,000	1,000	3	3	1	0		
	150	25	3	0				
		50	3	3	3	1	1	1
		100	2	2	2	1	1	1
	150	12.5	3	1	0			
		25	3	2	1	1	1	1
		50	3	3	2	2	2	2
		100	2	2	2	2	2	2
Control (CMC)	•	•	3	0				

a) LD_{50} was determined after 10 days from numbers of survivors per test animal group following Behrens & Kärber's method.
b) 3 animals for each group.

Experimental

Preparation of Chemicals[5]

4-*n*-Hexyl-6-(2-hydroxyphenylazo)resorcinol——2.85 g of 4-*n*-hexylresorcinol was dissolved in 200 ml of 0.5 N NaOH and chilled well. To this solution was added, with stirring, diazotized *o*-aminophenol solution prepared from 1.6 g of *o*-aminophenol in 44 ml of N HCl and 10 ml of 10% $NaNO_2$. The reddish colored solution resulted was acidified with HCl. The precipitate was collected, washed with water, dried, and

5) All melting points and boiling points were uncorrected.

recrystallized from benzene to give orange needles, mp 187—188°. Yield, 2.5 g. *Anal.* Calcd. for $C_{18}H_{22}O_3N_2$: C, 68.79; H, 7.01; N, 8.91. Found: C, 69.11; H, 7.57; N, 8.50.

2-(2-Hydroxyphenylaminomethyl)phenol——To 2.13 g of 2-(2-hydroxyphenyliminomethyl)phenol in 30 ml of dioxane was added, with stirring, 378 mg of $NaBH_4$ in 30 ml of methanol under cooling. The pale yellow solution resulted was condensed under reduced pressure, and the residue was dissolved in water. Neutralization with dil. HCl of this solution caused precipitate, which was washed with water and dried. Introduction of HCl gas into ether solution of this dried substance caused a separation of white powder, which was crystallized from a mixture of ethanol and ether to give 2-(2-hydroxyphenylaminomethyl)phenol as white needles, mp 200—202° in semiquantitative yield. *Anal.* Calcd. for $C_{13}H_{13}O_2N \cdot HCl$: C, 62.03; H, 5.56; N, 6.00. Found: C, 62.14; H, 5.92; N, 5.86.

5-*n*-Hexylsalicylaldehyde——To a solution of 49 g of *p*-*n*-hexylphenol in 420 ml of 50% NaOH, keeping at 60—70°, under stirring, 210 ml of $CHCl_3$ was added over the period of about 1 hr and the reaction mixture, after additional 2 hr stirring at 80°, was poured into ice water. Acidification, extraction with ether and distillation under reduced pressure gave 5-*n*-hexylsalicylaldehyde as an oil (42 g), bp 131—133° (3 mm Hg).

2-(2-Hydroxyphenyliminomethyl)-4-*n*-hexylphenol——A reddish colored solution obtained by refluxing a mixture of 2.06 g of 5-*n*-hexylsalicylaldehyde and 1.06 g of *o*-aminophenol in 20 ml of ethanol for 1 hr was reduced *in vacuo*, residue was recrystallized from aq. ethanol to give orange red plates of 2-(2-hydroxyphenyliminomethyl)-4-*n*-hexylphenol (2.3 g), mp 112—113°. UV λ_{max}^{EtOH} mμ (ε): 239 (shoulder), (18,600), 273 (11,150), 355 (12,720). *Anal.* Calcd. for $C_{19}H_{23}O_2N$: C, 76.73; H, 7.80; N, 4.71. Found: C, 76.68; H, 7.72; N, 4.76.

2-(2-Hydroxyphenylaminomethyl)-4-*n*-hexylphenol——2-(2-Hydroxyphenyliminomethyl)-4-*n*-hexylphenol was treated with $NaBH_4$ in the same way as described in the case of 2-(2-hydroxyphenyliminomethyl)-phenol. The reaction product was recrystallized from petroleum ether to give white fine crystals, mp 82°. Yield, semiquantitative. *Anal.* Calcd. for $C_{19}H_{25}O_2N$: C, 76.22; H, 8.42; N, 4.68. Found: C, 76.22; H, 8.27; N, 4.57.

***trans*-*a*-(2-Benzyloxyphenyl)-2-benzyloxycinnamic acid (II)**——A mixture of 5.3 g of 2-O-benzylsalicylaldehyde and 6.0 g of 2-O-benzylhomosalicylic acid, 5.0 g of triethylamine and 10 ml of acetic anhydride was refluxed at 200—250° for 6 hr, and to the reaction mixture, after cooling, was added 10 ml of conc. HCl. Swirling of this mixture afforded yellowish paste, which was then dried on a cray plate and washed with ether. The ether insoluble material was recrystallized from a mixture of benzene and petroleum ether to yield the carboxylic acid (II) as colorless needles, mp 196°. Yield, 9.0 g. UV λ_{max}^{EtOH} mμ (ε): 274 (11,700), 313 (9,830). IR ν_{max}^{Nujol} cm^{-1}: 2500—2800 (carboxylic OH), 1680 (conjugated C=O). *Anal.* Calcd. for $C_{29}H_{24}O_4$: C, 79.82; H, 5.51. Found: C, 80.02; H, 5.76. From ether washings, two compounds were isolated by hot ethanol treatment: The one, mp 181—182° and sparingly soluble in hot ethanol, was identified as *trans*-2,2′-dibenzyloxystilbene (IV) by mixed mp and IR comparison. Yield, 0.2 g. The other was mp 170—171.5° (from benzene, pet. ether), white needles, and easily soluble in hot ethanol. Yield, 0.3 g. UV λ_{max}^{EtOH} mμ (ε) 269 (11,020), 287 (10,740), 320 (11,630). IR ν_{max}^{Nujol} cm^{-1}: 1723 (α-pyrone ring). *Anal.* Found: C, 80.19; H, 4.98. This compound was confirmed to be identical with 3-(2-benzyloxyphenyl)coumarin obtained by the method described below. 3-(2-Benzyloxyphenyl)coumarin: A mixture of 1.3 g of salicylaldehyde, 1.5 g of O-benzylhomosalicylic acid, 2.5 ml of acetic anhydride and 2.0 ml of triethylamine was refluxed for 3 hr. After cooling, addition of conc. HCl, swirling, benzene extraction, washings with water, conc. $NaHSO_3$, 2% NaOH, and water, and evaporation of solvent in that order yielded colorless needles (2.1 g), mp 171°(from benzene, pet. ether). UV λ_{max}^{EtOH} mμ (ε): 269 (11,020), 287 (10,740), 320 (11,630). IR ν_{max}^{Nujol} cm^{-1}: 1723 (α-pyrone ring). *Anal.* Calcd. for $C_{22}H_{16}O_3$: C, 80.49; H, 4.88. Found: C, 80.35; H, 4.75.

***cis*-2,2′-Dibenzyloxystilbene (III)**——A mixture of 7.0 g of the compound (II), 1.4 g of copper-chromite catalyst[6] and 20 ml of anhydrated quinoline was heated at 230—240° for 1 hr, after cooling to the reaction mixture was added 50 ml of ether, and followed by filtration. After treatment with 5% HCl of the filtrate, ether was evaporated, residue was crystallized from a mixture of benzene and pet. ether to give *cis*-2,2′-dibenzyloxystilbene (III) as colorless prisms (5.0 g), mp 96°.[7] UV λ_{max}^{EtOH} mμ (ε): 277 (9,280), 300 (9,190). *Anal.* Calcd. for $C_{28}H_{24}O_2$: C, 85.68; H, 6.16. Found: C, 85.73; H, 6.51.

Conversion of *cis*-2,2′-Dibenzyloxystilbene (III) to *trans*-2,2′-Dibenzyloxystilbene (IV) by Irradiation of Ultraviolet Light——0.6 g of *cis*-form dissolved in 50 ml of dioxane was irradiated with ultraviolet light for 70 hr, and resulted solution was reduced *in vacuo*, and recrystallization of the residue was made with the use of benzene and Norit to give *trans*-2,2′-dibenzyloxystilbene (IV) as violet luminescent colorless needles, mp 182°. Yield, 0.5 g. UV λ_{max}^{EtOH} mμ (ε): 233 (17,600), 287 (12,370), 328 (15,950). *Anal.* Calcd. for $C_{28}H_{24}O_2$: C, 85.68; H, 6.16. Found: C, 85.79; H, 6.57.

6) *Org. Syntheses, Coll. Vol.*, **1**, 844 (1932).
7) 2,2′-Dibenzyloxystilbene of mp 117.6° was reported by P. Pascal, L. Normand, *Bull. soc. chim. France*, (4) **9**, 1067 (1911).

Effect of HBr on *cis*-2,2′-Dibenzyloxystilbene (III) in Acetic Anhydride——A mixture of 2.0 g of *cis*-2,2′-dibenzyloxystilbene, 2.0 g of acetic anhydride and 6.0 ml of conc. HBr was gradually heated to 120—130°, when separation of solid material occurred, the reaction mixture was immediately poured into ice water, and solid material was collected, washed with water, then with ether, and crystallized from benzene to give 1.8 g of colorless needles, mp 179—181°. The compound was shown to be identical with *trans*-2,2′-dibenzyloxystilbene above-described. It is to be noted that continued heating of the mixture should be avoided, since there occurred a production of alkaline soluble amorphous powder.

Na-liq. NH_3 Fission Reaction of *cis*-2,2′-Dibenzyloxystilbene (III)——2.0 g of *cis*-2,2′-dibenzyloxystilbene dissolved in 60 ml of benzene and ether (1:1 vol./vol.) was added with stirring into 300 ml of well cooled liq. ammonia, to the mixture metallic sodium (0.7 g) in small pieces was added at −60° under stirring during 2 hr. After evaporation of ammonia, residue was extracted with water and benzene. Acidified water layer was extracted with ether. The ethereal solution was washed with water and evaporated to give an oil which was chromatographed over alumina. Elution with a mixture of chloroform and acetone (4:1 vol./vol.) and crystallization from petroleum ether gave 2,2′-dihydroxydibenzyl as colorless needles (0.5 g), mp 115°(lit,[8] mp 115°). UV λ_{max}^{EtOH} mμ (ε): 278 (4,870). *Anal.* Calcd. for $C_{14}H_{14}O_2$: C, 78.48; H, 6.59. Found: C, 78.53; H, 6.57. From the benzene layer 1.0 g of starting material was recovered.

***trans*-2,2′-Dihydroxystilbene (V)**——A mixture of 2.0g of *cis*-2,2′-dibenzyloxystilbene, 8.0 g of KOH and 40 ml of ethylene glycol in a pressure bottle was heated at 240° for 20 hr. The reaction mixture was, after cooling, poured into 200 ml of ice water and extracted with a mixture of benzene and ether (1:1 vol./vol.). The water layer was acidified with N HCl, separated material was, after extraction with ether, crystallized from benzene to give *trans*-2,2′-dihydroxystilbene as colorless needles, mp 198°.[4] Yield, 0.9 g. UV λ_{max}^{EtOH} mμ (ε): 236 (13,660), 280 (11,100), 329 (14,100). *Anal.* Calcd. for $C_{27}H_{30}O_3$: C, 79.22; H, 5.70. Found: C, 79.21; H, 5.78.

2,4-Dibenzyloxy-5-*n*-hexylbenzaldehyde——O-benzylation of 2,4-dihydroxy-5-*n*-hexylbenzaldehyde was effected by acting 14 g of benzylchloride, 1.0 g of KI and 14 g of K_2CO_3 on 11.3 g of the compound in 60 ml of ethanol. Refluxing of the reaction mixture for 5 hr, dilution with water, washing of precipitates with water, recrystallization from ethanol yielded white needles of 2,4-dibenzyloxy-5-*n*-hexylbenzaldehyde, mp 96—97°. Yield, 18.5 g. *Anal.* Calcd. for $C_{27}H_{30}O_3$: C, 80.60; H, 7.46. Found: C, 80.90; H, 7.70.

***trans*-2,2′,4-Tribenzyloxy-5-*n*-hexylstilbene**——By refluxing a mixture of 15 g of 2,4-dibenzyloxy-5-*n*-hexylbenzaldehyde, 9.0 g of O-benzylhomosalicylic acid, 15 ml of triethylamine and 30 ml of acetic anhydride at 150—170° for 12 hr, by treating the paste thus produced with conc. HCl, and by decarboxylation of oily product by copper chromite catalyst-quinoline method, viscous oily substance was obtained. The crude material in dioxane was irradiated with ultraviolet light. Crystallization from a large amount of ethanol gave colorless fine needles, mp 137°. UV λ_{max}^{EtOH} mμ (ε): 242 (14,900), 290 (11,500), 334 (16,000). *Anal.* Calcd. for $C_{41}H_{42}O_3$: C, 84.53; H, 7.22. Found: C, 84.47; H, 7.51.

O-Benzyl-5-*n*-hexylsalicylaldehyde——From 42 g of 5-*n*-hexylsalicylaldehyde, 38 g of O-benzyl-5-*n*-hexylsalicylaldehyde was obtained. bp 216—221° (3 mm Hg). *p*-Nitrophenylhydrazone, mp 168—170° (from ethanol). Orange needles. *Anal.* Calcd. for $C_{26}H_{29}O_3N_3$: C, 72.36; H, 6.77; N, 9.74. Found: C, 72.36; H, 6.60; N, 9.72.

***trans*-2,2′-Dibenzyloxy-5-*n*-hexylstilbene**——This compound was obtained from reaction mixture of 30 g of O-benzyl-5-*n*-hexylsalicylaldehyde, 30 g of O-benzylhomosalicylic acid, 40 ml of acetic anhydride and 40 ml of triethylamine at 200° for 8 hr, after treatment with conc. HCl, with quinoline-copper chromium oxide, and with ultraviolet light. Crystallization from ethanol gave 14 g of white needles, mp 105°. UV λ_{max}^{EtOH} mμ (ε): 238 (19,750), 285 (13,870), 330 (19,100). *Anal.* Calcd. for $C_{34}H_{36}O_2$: C, 85.67; H, 7.61. Found: C, 85.73; H, 7.49.

***trans*-2,2′-Dihydroxy-5-*n*-hexylstilbene**——A mixture of 2.0 g of 2,2′-dibenzyloxy-5-*n*-hexylstilbene, 14 g of KOH and 60 ml of triethylene glycol in a pressure bottle was heated at 230—240° for 10 hr, the reaction mixture was, after cooling, poured into ice water, and treated with ether. From acidified water layer, white fine plates, mp 139°(from pet. ether), were obtained. Yield, 1.0 g. UV λ_{max}^{EtOH} mμ (ε): 235 (15,600), 283 (15,100), 339 (20,300). *Anal.* Calcd. for $C_{20}H_{24}O_2$: C, 81.04; H, 8.16. Found: C, 80.86; H, 8.27.

Biological Test

Experimental Animal——Male albino mice of ddN-strain weighing 18—20 g purchased from Central Laboratories for Experimental Animals, Tokyo, were used.

Cancer Cell Suspension——Ascites fluid withdrawn from 7-day-old Ehrlich ascites carcinoma bearing mice was centrifuged, and the sedimented cells were washed and diluted with physiological saline to give a carcinoma cell suspension of 2×10^7 cells per ml.

Chemicals——Phenolic compounds were used as solution in saline with the aid of appropriate amount of alkali or as suspension in 1% carboxymethylcellulose.

Anticancer Experiment——Mice were implanted intraperitoneally with 0.2 ml of the cancer cell suspension. Treatment was initiated 24 hr after the implantation. In the experiments, as shown in Fig. 2,

8) J. Thiele and O. Holzinger, *Ann.*, **305**, 99 (1899).

a daily dose of a chemical to be tested was injected intraperitoneally into each mouse of a corresponding groups for 7 successive days. In another experiments, only one administration of 1.0 ml of suspension of a chemical to be tested was done as in the case of Table II.

Acknowledgement The author is grateful to Prof. H. Okamoto of School of Medicine, Kanazawa University, Prof. S. Koshimura and Dr. R. Koshiura of this laboratroy for their encouragements, to Mr. H. Itadani of the Faculty of Pharmacy, Kanazawa University for elemental analyses. This work was supported in part by a Grant-in-Aid of Scientific Research Expenditure of Ministry of Education, Japan.

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Studies on Pharmaceutical Suspensions. (1). On the Structural Viscosity of Oil Suspensions

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(Received March 29, 1967)

It is generally accepted that the physical properties of aqueous suspensions, including pharmaceuticals, are extremely complex requiring a profound knowledge of rheological characteristics in suspension formulation.

Despite many excellent discussions on the theory of flow concerning Newtonian and non-Newtonian materials so far published,[2-4)] little seems to have been clarified about the influence of dispersed phase on the rheological properties of suspensions, particularly at high concentration of dispersed phase. Thick suspenison showing an isothermal reversible sol-gel transformation under any rate of shear offer many problems to a pharmaceutical rheologist regarding manufacturing processes, storage and practical application.

This paper deals with some of the rheological factors which are responsible for the changes in flow properties of oil suspensions. It also refers to the influence of dispersed phase upon the structural viscosity of suspensions which are prepared with oils commonly used for external application.

Experimental

Materials——Three calcium carbonate powders different in particle size distribution were kindly provided by the Nittoh Powder Chemical Industry (Hiroshima).

The oil suspension vehicles used throughout this experiment were as follows: mineral oil-heavy (MO-350)[5)]; mineral oil-light (MO-70)[6)]; isopropyl myristate (IPM)[7)]; lanolinalcohol acetylate (AC)[8)]; olive oil.[9)]

In order to remove free acids, the last three materials were washed thoroughly with 0.1 N Na_2CO_3 solution and with purified water. By this procedure the acid value was lowered from 0.079 to 0.015, 0.077 to 0.047

1) Location: *Dojima-hamadori, Fukushima-ku, Osaka.*
2) C.C. Mill, "Rheology of Disperse Systems," Pergamaon Press, London, 1959.
3) J.J. Hermans, "Flow Properties of Dispersed Systems," North-Holland Publishing Co., Amsterdam, 1953.
4) E.K. Fisher, "Colloidal Dispersions," 3rd ed., John Wiley & Sons, Inc., New York, 1959.
5) Silcol P-350, Matsumura-Sekiyu Co., Nishinomiya, Hyogo.
6) Silcol P-70, Matsumura-Sekiyu Co., Nishinomiya, Hyogo.
7) Containing 99.5% of isopropyl myristate. Abrac, England.
8) Acecol-L, Croda, England.
9) J.P. VII.