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STUDIES ON THE OILINESS CHARACTERISTICS OF STEARIC ACID, BENZENE AND THEIR DERIVATIVES BASED ON STATIC FRICTION DETERMINATIONS FOR STEEL ON STEEL

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Research Period: 1942-1944

Prepared for and Reviewed with Authors
by U. S. Naval Technical Mission to Japan

December 1945

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LIST OF TABLES AND ILLUSTRATIONS

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SUMMARY

The oiliness characteristics of stearic acid, benzene and their derivatives were measured, and the effects of the polar group on oiliness were compared with each other. The results were as follows:

1. The $-NH_2$ and $-COOH$ groups were the most effective in regard to oiliness, the $-OH$ group was the next, and the $-COCH_3$, $-OCH_3$, $-CN$ were comparatively less effective.

2. The derivatives of stearic acid were better oiliness carriers than the corresponding derivatives of benzene.

I. INTRODUCTION

A great number of substances which are said to be effective as "Oiliness carriers" are known,* but the quantitative relationship between the oiliness and the chemical nature of the substances are only partly known. Accordingly, it may be important to clear up the relationship between the oiliness and the chemical structures of various compounds. With this object, studies were made of the oiliness of stearic acid, benzene and their derivatives during the period from March, 1942 to October, 1944.

II. DETAILED DESCRIPTION

A. Samples Used

1. The method of preparation and the physical and chemical properties of stearic acid, benzene and their derivatives are summarized in Table I(B)28.

2. The white oil used in making blends was prepared by treating a commercial liquid paraffin with concentrated sulphuric acid, and its properties are as follows:

Reaction	Neutral
Density(d_4^{20})	0.8856
Viscosity (Redwood No. 1 sec)	
at 100°C	775
at 300°C	262
Pour Point (°C)	-16
Acid Value	0.03
Saponification Value	0.34
Corrosion	None

B. Test Procedure

The test procedure comprised a static friction determination for steel on steel using a modified Deeley machine as in the case of the Research Project No. 57.

*Byers J.H. Nat. Pet. News July 14 (1937)
ibid Dec. 16 (1936)
Halston A.W. ibid Dec. 9 (1936)

C. Results

The results are summarized in Table II(B)28 and Table III(B)28 and graphically represented in Figures 1(B)28 and 2(B)28.

1. Oiliness of Stearic Acid and its Derivatives. The oiliness of octadecane, octadecyl alcohol, stearic acid, methyl stearate, methyl octadecyl ether, methyl heptadecyl ketone, stearonitrile, stearoamide were measured, and were found to fall in the following order in regard to their effectiveness:

a. In the case of the straight compounds (not is solution): Stearoamide, stearic acid, octadecyl alcohol, staronitrile, octadecane, methyl heptadecyl ketone, methyl stearate.

b. In the case of 1% solution in the white oil, stearoamide, stearic acid, octadecane, stearonitrile, octadecyl alcohol, methyl stearate, methyl octadecyl ether, methyl heptadecyl ketone: Generally speaking, $-CONH_2$ and $-COOH$ groups were most effective to oiliness, $-CH_3$, $-OH$, $-CN$ the next, and $-COOCH_3$, $-COCH_3$, $-OCH_3$ were least effective.

2. Oiliness of Benzene and its Derivatives. The oiliness of benzene, phenol, benzoic acid, methyl benzoate, anisol, acetophenone, benzonitrile aniline were measured, and were found to be in the following order:

a. In the case of the straight compounds (100%): Benzoic acid, anisol, phenol, aniline, methyl benzoate, acetophenone, benzene.

b. In the case of 1% solution of the compounds in the white oil: Phenol, methyl benzoate, benzonitrile, benzoic acid, acetophenone, aniline, benzene, anisol.

Generally speaking, $-OH$, $-COOH$, $-COOCH_3$ groups were comparatively effective.

III. CONCLUSION

The authors made a survey on the oiliness of ordinary polar groups and found that $-OH$, $-COOH$ groups were the best and $-OH$, $-COOCH_3$ were next.

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Table I(B)28
PROPERTIES AND METHODS OF PREPARATION OF COMPOUNDS

Name	Chemical Structure	M.P. (°C)	B.P. (°C)	Other Characteristics		Method of Preparation
Octadecane	$CH_3(CH_2)_{16}CH_3$	28	163-164/3.5mm			Prepared by means of hydrogenation of ethyl stearate.
Octadecyl Alcohol	$CH_3(CH_2)_{17}OH$	58.5	133-135/3.5mm			A marketed sample was fractionated and recrystallised with alcohol.
Stearic Acid	$CH_3(CH_2)_{16}COOH$	69-70	218-220/9mm	AV 197		A marketed sample was fractionated in vacuum and recrystallised with 95% alcohol.
Methyl Stearate	$CH_3(CH_2)_{16}COOCH_3$	38-39	164-166/7.3mm			Purified stearic acid was esterified with methanol by an ordinary method. The raw ester was washed with 2% sodium hydroxide solution and water and then recrystallised with 60% alcohol.
Methyl Octadecyl Ether	$CH_3(CH_2)_{17}OCH_3$					Octadecyl iodide was prepared from the above mentioned octadecyl alcohol and iodine, using red phosphorous as catalyst, and then it was reacted with sodium ethylate in the medium of ether.
Methyl Heptadecyl Ketone	$CH_3(CH_2)_{16}COCH_3$	55-56	170-182/4mm			Barium stearate (353gm) and barium acetate (128gm) were mixed and brought to dry distillation. The fraction distilled from 300°C to 390°C was taken. (449gm) The raw product was washed with hot solution of 2% sodium hydroxide and fractionated in vacuum. The fraction boiling from 170°C to 182°C in vacuum of 4mm Hg was taken (50gm) and recrystallised with alcohol.
Stearonitrile	$CH_3(CH_2)_{16}CN$	41	165-170/3mm			Stearamide (128gm) and phosphorous pentoxide (60gm) were mixed and maintained at 200°C in vacuum of 1mm Hg. The distillate (103gm) was fractionated in vacuum and recrystallised with methanol.
Stearamide	$CH_3(CH_2)_{16}CONH_2$	104	250-251/12mm.			Stearyl chloride prepared from stearic acid and phosphorous trichloride was brought to reaction with 30% ammonia cooling with ice water. The raw product was recrystallised with alcohol. The yield was 57% of stearyl chloride.
				d_4^{20}	n_D^{20}	
Benzene	C_6H_6	5.5	80-80.5	0.8799	1.5015	A marketed benzene was treated with concentrated sulphuric acid and recrystallized.
Phenol	C_6H_5OH		178-179			A marketed phenol was fractionated.
Benzoic Acid	C_6H_5COOH	121-122				A marketed pure sample was used.
Methyl Benzoate	$C_6H_5COOCH_3$		198-200			
Anisol	$C_6H_5OCH_3$		150-160	0.9950	1.5170	A marketed sample was washed with 2% solution of sodium hydroxide and fractionated.
Acetophenone	$C_6H_5COCH_3$		199-203	1.0295	1.5337	A marketed sample was fractionated.
Benzonitrile	C_6H_5CN		188-190	1.0030	1.5285	A marketed pure sample was used.
Aniline	$C_6H_5NH_2$		183-185			A marketed sample was fractionated.

Table II(B)28
STATIC COEFFICIENTS OF FRICTION OF STEARIC ACID AND ITS DERIVATIVES

Names of Samples	Chemical Formula	Straight Compounds		1% Solution Compounds in the White Oil	
		Static Coef. of Friction	Temp.* (°C)	Static Coef. of Friction	Temp (°C)
White Oil		0.121	25		
Octadecane	$CH_3(CH_2)_{16}CH_3$	0.109	35	0.108	25
Octadecyl Alcohol	$CH_3(CH_2)_{17}OH$	0.102	63	0.113	25
Stearic Acid	$CH_3(CH_2)_{16}COOH$	0.074	75	0.105	25
Methyl Stearate	$CH_3(CH_2)_{16}COOCH_3$	0.120	45	0.115	25
Methyl Octadecyl Ether	$CH_3(CH_2)_{17}OCH_3$			0.115	25
Methyl Heptadecyl Ketone	$CH_3(CH_2)_{16}COCH_3$	0.111	60	0.119	25
Stearonitrile	$CH_3(CH_2)_{16}CN$	0.105	45	0.111	25
Stearoamide	$CH_3(CH_2)_{16}CONH_2$	0.067	114	0.100	25

*The temperature was raised by means of a heater, up to about 5°C above the M.P. of the compounds.

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Table III(B)28
STATIC COEFFICIENTS OF FRICTION OF BENZENE AND ITS DERIVATIVES

Names of Samples	Chemical Formula	Straight Compounds		1% Solution Compounds in the White Oil	
		Static Coef. of Friction	Temp.* (°C)	Static Coef. of Friction	Temp. (°C)
White Oil		0.121	25		
Benzene	C_6H_6	0.170	13	0.118	25
Phenol	C_6H_5OH	0.145	50	0.110	25
Benzoic Acid	C_6H_5COOH	0.141	126-128	0.114	25
Methyl Benzoate	$C_6H_5COOCH_3$	0.146	21.5	0.113	25
Anisol	$C_6H_5OCH_3$	0.143	25.8	0.119	25
Acetophenone	$C_6H_5COCH_3$	0.153	25.8	0.116	25
Benzonitrile	C_6H_5CN	0.162	23	0.113	25
Aniline	$C_6H_5NH_2$	0.145	22.5	0.117	25

*The temperature was raised by means of a heater, up to about 5°C above the M.P. of the compounds.

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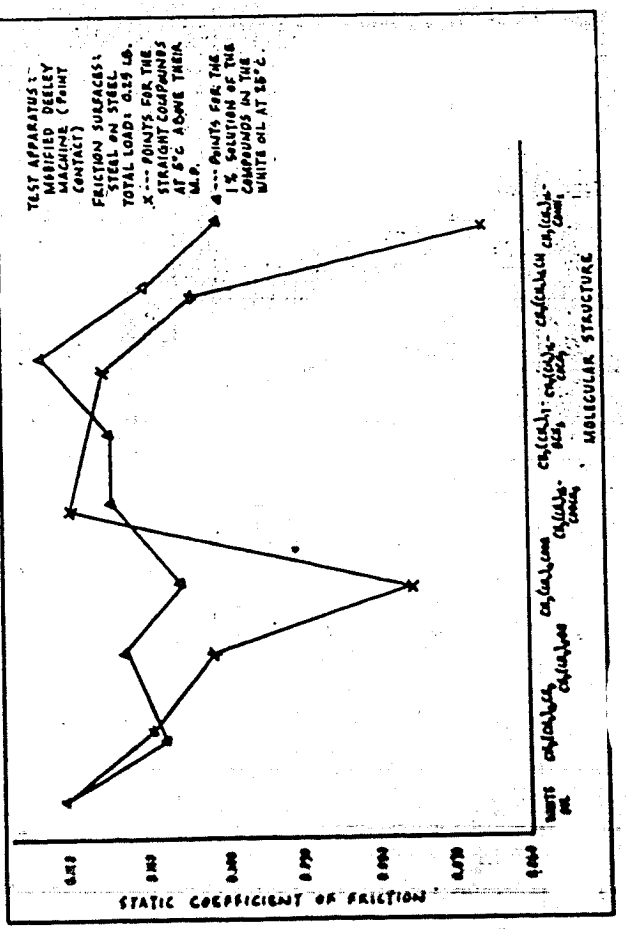

Figure 1(B)28

STATIC COEFFICIENTS OF FRICTION OF STEARIC ACID AND ITS DERIVATIVES

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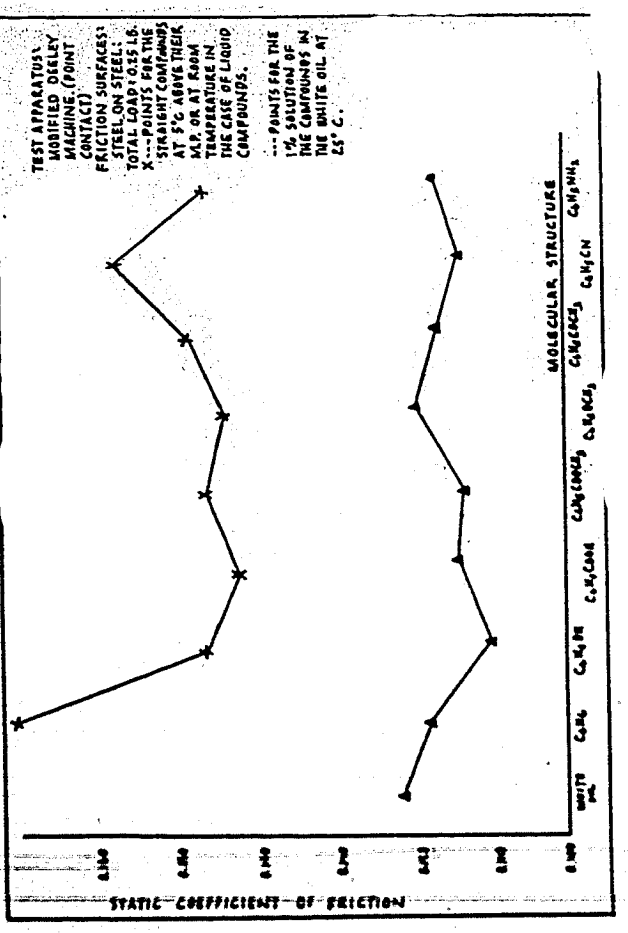

Figure 2(B)28

STATIC COEFFICIENTS OF FRICTION OF BENZENE AND ITS DERIVATIVES