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Technical

☘Half Esters of Dibasic Acids as Additives in Water-Based Cutting Fluids

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ABSTRACT

Several half esters from long chain dibasic acids were prepared, and corrosion and lubricity tests for these products as water-based cutting fluid additives were made. Triethanolamine salts of half esters of sebacic acid and dodecanedioic acid showed effective rust-inhibiting and anti-wear properties for water-based cutting fluids.

INTRODUCTION

Various cutting fluids are used for machining operations. Recently, the use of water-based cutting fluids has been considered. The relationship between the properties of water-soluble cutting fluids and the chemical structures of many organic compounds used in these fluids has not been reported in detail. We previously reported that α-substituted fatty acids (1) have excellent properties for water-soluble cutting fluids. This paper describes our evaluation of new additives derived from dibasic acids for water-soluble cutting fluids.

EXPERIMENTAL

Preparation of Monoethylester of Sebacic Acid (1,8-octanedicarboxylic acid)

A mixture of sebacic acid and diethyl sebacate was refluxed with concentrated hydrochloric acid and dibutyl ether, and the monoester was isolated by fractional distillation as reported previously (2). Other monoesters listed in Table I were prepared in a similar manner.

Test Methods

Aqueous solutions (0.5%) of triethanolamine salts of the half esters listed in Table I were used. Distilled and deionized water was used for corrosion tests.

Method A Corrosion test with cast iron chips. Two g of cast iron chips (JIS G 5501, FC-20) (in Japanese JIS) which had been washed with benzene were immersed in 0.5% aqueous solution (5 ml) of cutting fluids in a watch glass. The container was covered. After 10 min, the solution was removed by filtration. The rust-preventative effect (the amount of rust on the cast-iron chips) was observed after 24 hr. Ten points show no appearance of rust. Seven points show a little appearance of rust.

Method B Corrosion test with steel panels. Two panels (JIS G 3141, SPCC-B) (in Japanese JIS) which had been polished with emery paper (no. 610) followed by benzene rinse were immersed in a 0.5% aqueous solution of cutting fluids. After 10 min, the panels were removed from the solution and allowed to remain in the air at room temperature. After 74 hr, the amount of rust on the steel panels was observed. Ten points show no rust. Seven points show a small amount of rust. These methods are based on the I.P. Corrosion test 125/63T (aqueous cutting fluids corrosion of cast-iron chips and steel panels, JIS G 3310).

Test methods of welding load (kg/cm^2), the coefficients of friction and the surface tension (dyne/cm) have been described in detail elsewhere (1).

Practical tests were performed as follows. Cutting conditions: machine, band sawing machine; cutting sample, connecting rod S 40C (hardening); cutting velocity, 200 m/min. Cutting fluid A is a mixture of sebacic acid (10 weight %), triethanolamine (20%) and water (70%). Cutting fluid B is a mixture of monooleyl ester of sebacic acid (10 weight %), triethanolamine (20%) and water (70%). These samples were used as a 5% aqueous solution for testing. The same results were obtained in the corrosion, lubricity and practical tests using either distilled water or city water in Japan (Tokyo and Osaka).

RESULTS AND DISCUSSION

It is known that half esters of dibasic acids can be prepared from the reaction of long chain dibasic acids with their diesters (2). The industrial application of these easily acces-

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TABLE I

Cutting Fluid Characteristics of Various Monoesters from Dibasic Acids[a]

Monoester $HOOC(CH_2)_nCOOR$ R=	n=	Welding load ($kg\ cm^{-2}$)	Coefficient of friction	Surface tension ($dyne\ cm^{-1}$)	Corrosion test	
					Method A	Method B
H	4	3.0	0.410	57	3	3
C_2H_5	4	6.0	0.235	53	3	3
n-C_4H_9	4	6.5	0.226	44	5	5
n-C_8H_{17}	4	4.0	0.360	40	5	5
n-$C_{18}H_{35}$ [c]	4	10.0	0.180	33	8	8
C_2H_5	6	9.5	0.182	45	10	10
H	8	5.0	0.321	56	10	10
CH_3	8	9.5	0.236	41	10	10
C_2H_5	8	16.0	0.166	46	10	10
n-C_8H_{17}	8	8.0	0.280	47	10	10
n-$C_{18}H_{35}$ [c]	8	14.0	0.130	37	10	10
H	12	5.0	0.350	58	10	10
n-C_8H_{17}	12	7.0	0.271	41	10	10
$C_6H_5CH_2$	12	13.5	0.233	45	10	10
n-$C_{18}H_{35}$ [c]	12	14.0	0.140	37	10	10
C_2H_5	d	14.0	0.166	38	10	10
C_4H_9	d	15.5	0.141	37	10	10
Sodium nitrite	–	3.0	0.48	72	7	10
Triethanol amine	–	4.5	0.355	70	5	5

[a]Aqueous solutions (0.5%) of triethanolamine salts were used.

[b]Method A is Corrosion test with cast-iron chips. Method B is Corrosion test with steel panel. Values of 10 show no rust; values of 7 show a small amount of rust.

[c]n-$C_{18}H_{35}$ is oleyl group.

[d]Compound c is $HOOC(CH_2)_6C(CH_3)=CH(CH_2)_2CH=C(CH_3)(CH_2)_6COOR$

sible half esters has been a subject of some interest. We prepared various half esters of long chain dibasic acids and examined the properties of water-soluble cutting fluids prepared from them. We found that triethanolamine salts of higher half esters have excellent anti-rust and anti-wear properties. Thus, the monoethyl ester of 1,8-octanedicarboxylic acid (II) was prepared from the acid (I) and its

$$HOOC(CH_2)_8COOH \rightarrow HOOC(CH_2)_8COOC_2H_5$$

(I) (II)

diethyl ester (2). An aqueous solution (0.5%) of the triethanolamine salt of II showed excellent properties in corrosion tests with cast iron chips (method A) and steel panels (method B). The welding load of this aqueous solution was about 16 kg/cm^2 at 200 rpm with a 4-ball type (Soda-type) lubrication oil testing machine. Welding loads should have as high a value as possible, the desirable value being more than 10 kg/cm^2. Similarly, other half esters have excellent properties in anti-water and anti-rust tests, and their characteristics are shown in Table I.

Some practical cutting tests with these water-based fluids provided the following results. Using a cutting fluid containing monooleyl ester of (I) (sample B), the number of abrasive cut-off pieces was about 25,000. However, using a cutting fluid (sample A) containing the dibasic acid and no half ester, the number of abrasive cut-off pieces was only about 10,000.

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