(1)

AD D009568

Serial No. 370,236

Filing Date 21 April 1982

Inventor Charles T. Lynch et al

NOTICE

The Government-owned invention described herein is available for licensing. Inquiries and requests for licensing information should be addressed to:

DEPARTMENT OF THE AIR FORCE
AF/JACP

1900 HALF STREET, S.W.
WASHINGTON, D. C. 20324

82 07 15 081

Form NTIS-303
(8-76)

U.S. Department of Commerce
NATIONAL TECHNICAL INFORMATION SERVICE

INVENTION EVALUATION QUESTIONNAIRE

TO:

An evaluation of the invention identified below is requested as part of a Department of Commerce program aimed at promoting the use of Government inventions. Please complete the questionnaire and return it to:

Patent Program
National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161

This questionnaire might also be sent by NTIS to others associated with the development of this invention. Please submit an independently prepared response; do not consult with others receiving a copy of this questionnaire.

Thank you for your cooperation.

INVENTION IDENTIFICATION

Title of invention
HIGH PERFORMANCE MULTIFUNCTIONAL CORROSION INHIBITORS

Inventor(s) Charles T. Lynch and Fred W. Vahldiek	Agency Sponsor USAF
Application Serial No. 370,236	Application Filing Date 21 Apr 1982
Agency Case No. AF INV 14985	Patent No. (if any)

RESPONDENT IDENTIFICATION

Name Charles E. Bricker	Address
Title Patent Adviser	AF/JACPD
Organization AF/JACPD	Wright-Patterson AFB, Ohio 45433
Telephone 513-255-5517	

NTIS use only:

Date completed questionnaire received by NTIS _____

Source code: GP____

Evaluator _____

A D G
B E H
C F I

USCOMM-DC 8901-P78

Please circle numbers and fill in blanks when appropriate.

KNOWLEDGE OF THE INVENTION AND INDUSTRY

A. WHAT IS YOUR RELATIONSHIP TO THE INVENTION ?

1. Inventor/Co-inventor
2. Inventor's Technical Supervisor
3. Patent attorney who prepared/ prosecuted the invention
4. Other patent attorney
5. NTIS Invention Evaluator
6. Other (please specify) _____

B. HOW FAMILIAR WERE YOU WITH THE INVENTION PRIOR TO RECEIVING THIS QUESTIONNAIRE ?

1. Intimately familiar
2. Moderately familiar
3. Was aware of it
4. No previous knowledge

C. HOW FAMILIAR ARE YOU WITH THE INDUSTRY (manufacturing, marketing, and general structure) TO WHICH THE INVENTION RELATES ?

1. Intimately familiar
2. Moderately familiar
3. Not familiar

STATUS OF INVENTION DEVELOPMENT

D. WHAT IS THE CURRENT STATUS OF THE INVENTION ?

1. Not in use and not being developed, last use or development on _____
2. Still being developed
3. Currently in use
4. Unknown

E. HOW FAR HAS THE DEVELOPMENT OF THE INVENTION BEEN CARRIED ?

1. No development beyond preparation of patent application
2. Experimentation models, bread boards, prototypes
3. Limited production
4. Full scale production
5. Unknown

F. WHAT IS THE EXTENT OF CURRENT COMMERCIAL USE OF THE INVENTION ?

1. Being considered for commercial development (specify company) _____
2. Under commercial development (specify company) _____
3. Currently in commercial use (specify company) _____
4. No known commercial interest

SIGNIFICANCE OF INVENTION IN ITS FIELD

G. WHAT IS THE RELATIVE SIGNIFICANCE OF THE INVENTION IN ITS FIELD OF TECHNOLOGY ?

1. Known in existing technology
2. Slight modification
3. Modest advance
(4.) Significant advance
5. Major improvement
6. Pioneer discovery

H. WHAT ARE THE PRINCIPAL ADVANTAGES OF THE INVENTION OVER THE PRIOR ART ?

Multifunctionality of the inhibitor composition.

RELATED DISCLOSURES

I. ARE THERE OTHER PATENTS/PATENT APPLICATIONS THAT DIRECTLY RELATE TO THIS INVENTION ?

1. No
2. Divisional ser. nos. _____
3. Continuation-in-part ser. nos. _____
(4.) Other (please specify) Appl. Ser. No. 265,734 filed May 1981
5. Unknown

J. PLEASE CITE ANY PUBLISHED TECHNICAL REPORTS OR JOURNAL ARTICLES THAT DESCRIBE THE INVENTION AND INDICATE PUBLICATION DATES.

"Materials and Process Applications for Land, Sea, Air, Space" Vol 26, pp 52-64 (1981)

COMMERCIAL POTENTIAL OF INVENTION

K. WHAT IS THE LIKELIHOOD OF ULTIMATE COMMERCIAL USE OF THE INVENTION ?

1. None
2. Poor
3. Fair
4. Good
5. Excellent
(6.) Unknown

L. WHAT IS YOUR ESTIMATE OF CAPITAL INVESTMENT REQUIRED TO COMMERCIALIZE THE INVENTION ?

1. Not applicable
2. Less than $10,000
3. $10,000 to $100,000
4. $100,000 to $500,000
5. $500,000 to $1,000,000
6. Over $1,000,000
7. Unknown

M. WHAT IS YOUR ESTIMATE OF THE COMMERCIAL POTENTIAL OF THE INVENTION AS MEASURED BY GROSS SALES OVER THE LIFE OF THE INVENTION ?

1. None
2. Less than $100,000
3. $100,000 to $500,000
4. $500,000 to $1,000,000
5. $1,000,000 to $5,000,000
6. $5,000,000 to $10,000,000
7. Over $10,000,000
8. Unknown

RECOMMENDATIONS FOR INVENTION EXPLOITATION

N. SHOULD THE U.S. GOVERNMENT PROMOTE THE COMMERCIALIZATION OF THIS INVENTION ?

1. Yes
2. No
3. Unknown

Please comment.

O. SHOULD THE U.S. GOVERNMENT SEEK FOREIGN PATENT PROTECTION ON THIS INVENTION ?

1. Yes
2. No
3. Unknown

If Yes, circle letter next to country where protection should be sought and comment on the market potential.

a. Australia _____
b. Belgium _____
c. Canada _____
d. France _____
e. Great Britain _____
f. Italy _____
g. Japan _____
h. Netherlands _____
i. Sweden _____
j. Switzerland _____
k. West Germany _____
l. Other Countries _____

P. PROVIDE, IF YOU CAN, A LIST OF NAMES AND ADDRESSES OF EXPERTS IN THE FIELD OF THE INVENTION WHO COULD PROVIDE ADDITIONAL EVALUATIONS OF THE COMMERCIAL POTENTIAL OF THE INVENTION.

Q. PROVIDE, IF YOU CAN, A LIST OF SPECIFIC COMPANIES THAT YOU REGARD AS GOOD LICENSING PROSPECTS FOR THE INVENTION (not required if invention appears to have no commercial potential).

R. OTHER COMMENTS:

AF INV 14985
Charles T. Lynch et al

HIGH PERFORMANCE MULTIFUNCTIONAL CORROSION INHIBITORS

RIGHTS OF THE GOVERNMENT

BACKGROUND OF THE INVENTION

This invention relates to corrosion inhibiting compositions and to a process for inhibiting the corrosion of metals. In particular, this invention relates to a multifunctional inhibitor that provides both anodic and cathodic corrosion inhibition for a broad spectrum of metallic materials and structures in aggressive media such as brine, bilge solution and high-chloride contaminated water.

The financial loss due to the degradative effects resulting from corrosion reactions amounts to billions of dollars annually. In an attempt to combat the problem of corrosion and minimize its economic disadvantages, a U.S. Air Force research effort was initiated to develop improved inhibiting compositions. As a part of this research effort a survey and screening of conventional inhibitor compositions such as the polyphosphates, silicates, orthophosphates, chromates, nitrites, and combinations thereof was undertaken to determine their effectiveness in inhibiting corrosion of aircraft structures. Film-forming inhibitors, such as emulsified or soluble oils, long chain amines, alcohols and carboxylic acids were also studied.

Unfortunately, anodic inhibitors, such as the chromates, may cause accelerated corrosion when in contact with a metal in too low a concentration, such as where the concentration decreases during use. The result may be a metal surface protected in most areas, but giving rise to accelerated corrosion in small, highly anodic areas of the metal surface. On the other hand, a significant advantage of chromate inhibiting formulations is their broad protective ability against general corrosion of many metals and alloys.

For nonchromate systems, a rather complex mixture is required to achieve such broad-based protection. The simple borax-nitrite system is, for example, effective for many steels, but must be complemented by other inhibitors to provide adequate protection for high strength aluminum alloys, particularly in the presence of corrosive contaminants such as sodium chloride.

Other inhibitor systems are applicable only to a limited number of alloys or lack the degree of protection for satisfactory and adequate protection for aerospace and other high performance (high strength, high strength:weight ratio, high fatigue resistance) structural alloys. Still other inhibitor systems have not been found satisfactory for use with high performance alloys in the presence of sodium chloride. Commercial formulations which have been tested on aerospace alloys, such as 7075-T6Al, 2024-T3Al, and 4340 steel, in the presence of sodium chloride in aqueous solutions have

ranged from totally ineffective to partially effective in immersion tests.

Toxicity has become an increasingly important consideration in recent years, both with respect to handling of the compounds prior to use, and to the effects of disposal on humans, animals and plants. Consequently, it is necessary to develop substitutes for such popular inhibitors as chromate based formulations and high phosphate based formulations.

A previous study on corrosion prevention of carrier-based aircraft revealed that a considerable savings could be realized in terms of corrosion maintenance by merely rinsing the aircraft with water to remove detrimental particles, such as salt and ash. How, ever, in rinsing aircraft, a very good possibility exists that the water will be trapped in crevices or so-called dry-bay areas. The trapped water, often chemically hard, can cause serious corrosion problems, hence completely jeopardizing the advantage of water rinsing as a corrosion-control method. Therefore, the incorporation of a low concentration of a nontoxic, water-soluble inhibitor into the rinse water becomes a desirable means for improving corrosion resistance.

The value of borax-nitrite as a corrosion inhibitor has long been recognized. Earlier work has shown this combination to be very effective in controlling general corrosion as well as crevice

corrosion of high strength steels. However, the borax-nitrite combination was not found to be effective against the corrosion of other ferrous and nonferrous metals and alloys. For example, nitrite inhibitors are more effective at higher pH ranges (e.g., 8-9) than at more acidic levels. Very high pH levels, however, can be deleterious to some aluminum alloys since aluminum is amphoteric, subject to attack by strong basic solutions.

In our copending application Serial No. 265,734, filed May, 1981, we disclose corrosion inhibiting compositions which are biodegradable, contain no chromates, and offer important and unique advantages over chromate-based inhibitor combinations. The compositions are multifunctional, providing both anodic and cathodic protection. The compositions are nontoxic, low in cost, soluble in aqueous solution and provide protection for a broad spectrum of metallic structures. Concentration of the inhibitor composition in aqueous rinsing solution is nominally 0.3 to 0.5 percent, by weight, of the rinse solution. The inhibiting compositions include sodium borate, sodium nitrite, sodium hexametaphosphate, sodium metasilicate, sodium nitrate and mercaptobenzothiazole in a predetermined range of concentrations.

We have found that the effectiveness of the compositions disclosed by us in the aforesaid application Serial No. 265,734 can be improved by the addition thereto of selected surfactant compounds.

These improved corrosion inhibiting formulations are particularly useful in very aggressive environments containing chloride ion in excess of 1000 ppm (0.1 weight percent). Such high levels may be found in coastal areas and in urine, which contains approximately one weight percent sodium chloride, or about 6000 ppm of chloride ion.

Accordingly, it is an object of the present invention to provide an improved multifunctional corrosion inhibiting composition.

Other objects and advantages of the present invention will be readily apparent to those skilled in the art from a consideration of the following disclosure.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided an improved corrosion inhibiting composition consisting essentially of a mixture of an alkali metal borate, an alkali metal nitrite, an alkali metal nitrate, an alkali metal metasilicate, an alkali metal phosphate, mercaptobenzothiazole (MBT), at least one selected surfactant. In some formulations, zinc sulfate and benzotriazole (BT) are also required. The alkali metal can be either sodium or potassium.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Figure 1 illustrates the anodic-polarization behavior of type 7075-T6 aluminum in local top water, distilled water, 0.1 M NaCl and the basic inhibitor solution;

Figure 2 illustrates the effect of increasing chloride concentration upon the breakdown of passivity of type 7075-T6 aluminum;

Figure 3 illustrates the effect of increasing chloride concentration upon the breakdown of passivity of type 4340 steel;

Figure 4 illustrates the effect of adding a surfactant to an inhibitor solution in preserving passivity of type 7075-T6 aluminum;

Figure 5 illustrates the effect of adding a surfactant to an inhibitor solution in preserving passivity of type 4340 steel;

Figure 6 illustrates the anodic polarization of type 7075-T6 aluminum in natural and in synthetic urine; and

Figure 7 illustrates the effects of adding the inhibitor composition of this invention for preserving the passivity of various metals in synthetic urine solution.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The amounts of each component of the inhibiting composition of this invention are given in Table I, below.

TABLE I

Component	Concentration in aqueous solution (weight percent) Broad	Preferred	Concentration of Dry Ingredients (percent)
Borate	.20 -2.00	0.25 -1.40	68.0 -70.0
Nitrite	.04 - .25	.05 - .20	8.5 -14.0
Nitrate	.04 - .50	.05 - .40	13.5 -17.5
Silicate	.0015- .05	.005 - .04	0.5 - 1.75
Phosphate	.0025- .025	.005 - .02	0.8 -- 0.9
MBT	.0008- .015	.003 - .012	0.25 - 0.5
BT	.0008- .015	.003 - .012	0.25 - 0.5
$ZnSO_4$	.003 - .06	.005 - .05	1.0 - 2.0
Surfactant	.006 - .03	.0050- .025	1.0 - 2.0

The surfactant is a selected avionic or nonionic surface active material. The selected surfactants employed in the corrosion inhibitor of the present invention are, in general, proprietary materials. Table II, below, lists the surfactants employed according to the present invention by (1) an arbitrary designation, (2) a brief description of the composition of the surfactant, (3) the commercial name of the surfactant, and (4) the source for such surfactant.

TABLE II

Proprietary Surface Active Agents

Designation[1]	Description[2]	Commercial Name[3]	Source[4]
SAR	Sodium Dodecylbenzene Sulfonate	Richonate	The Richardson Company Des Plaines, Illinois
SAD	Sodium salt of Phosphonic acid	Dequest	Monsanto Company St. Louis, Missouri
SAB	Corrosion inhibitor (commercial formulation) with complex sulfonate compound	Boeshield T-9	Oxy Metal Industries Corp. Madison Heights, MI
SAM	Dialkyl alkyl phosphonate		Mobil Chemical Company Phosphorous Division Richmond, Virginia
SAP	High molecular weight phosphate		Monsanto Company St. Louis, Missouri
SAT	Octylphenoxy polyethoxy ethanol	Triton X-114	Rhohm and Haas Co. Industrial Chemicals - NA Philadelphia, Pennsylvania
SAO	High molecular weight calcium sulfonate	100 Oil	The Southland Corp. Arthur C. Trask Chemical Division Summit, Illinois
SAE	High molecular weight Barium sulfonate	Estersulf	The Southland Corp. Arthur C. Trask Chemical Division Summitt, Illinois
SAG	Sodium salt of a complex Phosphate ester		GAF Corporation New York, New York

Referring now to the drawings, Figure 1 shows the anodic polarization behavior of type 7075-T6 aluminum in distilled water, local tap water, a 0.1 molar solution of sodium chloride and local tap water containing the corrosion inhibitor disclosed in the aforementioned application Serial No. 265,734. This figure illustrates a very high corrosion current and breakdown in passivity in tap water and in 0.1 M NaCl, as well as illustrating the protection afforded by the aforesaid corrosion inhibitor. Figure 2 illustrates the effect of increasing chloride concentration upon the breakdown of passivity of type 7075-T6 aluminum. Figure 3 illustrates a similar type of behavior with type 4340 steel.

Figures 4 and 5 illustrate the effect of adding 125 ppm of sodium dodecylbenzene sulfonate (SAR) to solutions of increasing chloride concentration, each containing the basic inhibitor mentioned above. A comparison of Figure 4 with Figure 2, although not strictly comparable, clearly indicates the increased protection afforded by the addition of sodium dodecylbenzene sulfonate to the basic inhibitor formulation. A more direct correlation is seen by reference to Figures 5 and 3.

Figures 6 and 7 illustrate the anodic polarization behavior of various metals in a synthetic urine solution. The composition of the synthetic urine is given in Table III below.

TABLE III

Ingredients of Synthetic Urine
(Wt in gm/liter)

urea	20.60
5-hydroxyindoleacetic acid	0.0045
uric acid	0.052
glucuronic acid	0.431
oxalic acid	0.031
citric acid	0.462
glycolic acid	0.042
creatine	0.0721
guanidinoacetic acid	0.027
formic acid	0.013
glucose	0.072
ammonium sulfate	4.00
potassium phosphate	0.175
potassium chloride	0.0100
potassium bromide	0.008
sodium chloride	10.00
p-cresol	0.087
creatinine	1.500
acetone	0.0001
hydroxyquinoline-2 carboxylic acid	0.0028
potassium sulfate	0.134

Figure 6 illustrates that the corrosive behavior of synthetic urine closely approximates that of natural urine. Figure 7 illustrates the anodic polarization behavior of type 7075-T6 aluminum, type 4340 steel, copper and brass in synthetic urine and in synthetic urine inhibited by the multifunctional inhibitor formulation containing 125 ppm of sodium dodecylbenzene sulfonate.

More specific inhibitor formulations are given in Tables IV and V below. All amounts are given in weight percent (in aqueous solution).

TABLE IV

Component	Formulation 1	2	3	4
Borate	0.35	0.35	0.35	0.35
Nitrite	.20	.20	.20	.20
Nitrate	.20	.20	.20	.20
Silicate	.01	.01	.01	.01
Phosphate	.0125	.005	.005	.005
MBT	.0065	.005	.005	.005
BT	.005	.005	.005	.005
SAR, SAE	.0125	------	.0075	------
SAD	.0165	------	------	------
SAT	------	.01	------	------
SAB	------	------	------	.025
$ZnSO_4$	.004	.02-.04	.01	------

TABLE V

Component	Formulations 5	6	7
Borate	0.25	0.35	1.40
Nitrite	.05	.05	.20
Nitrate	.05	.10	.40
Silicate	.002	.01	.04
Phosphate	.003	.005	.02
MBT	.001	.003	.012
BT	------	.003	------
SAR	.0075	.0075	.0075

Formulation 1 is preferred for use where the concentration of chloride is very high, e.g., brine. Formulations 2 and 3 are recommended for use in aggressive solutions such as are found in the bilge areas of aircraft. Formulation 4 will provide protection in high chloride contaminated water, i.e., up to about 1 weight percent NaCl.

Formulation 6 is a preferred formulation for general purpose use. It is effective where little or no dilution is expected during use and low concentrations of chloride and other aggressive reactants are present, i.e., up to about 100 ppm chloride ion. Formulation 5 is effective in situations where no dilution is expected and the concentration of chloride ion or other aggressive reactant is very low. Formulation 7 is for contact inhibitors to form a protective surface layer during immersion.

The concentrations of the various components can be varied by about 20% for conditions where dilution in use is expected.

In Table VI, below, the representative results of tests with several experimental formulations are summarized. These immersion tests were carried out on type 7075-T6 aluminum and type 4340 steel in 1M NaCl solutions.

TABLE VI

Immersion Test Results

No	Inhibitor wt% in 1M NaCl	pH Initial	pH Final	Specimen	Time of Exposure (weeks)	Surface Appearance (Visual Observation)	Remarks
1	0.35 Borate + 0.2 Nitrate + 0.2 Nitrite + 0.01 Silicate + 50 ppm Phosphate + 30 ppm MBT + 100 ppm SAO	7.90	7.90	Al	2	Several pits	Better Inhibitor required
				Steel	2	Clean & shiny; few pits	
2	0.35 Borate + 0.6 Nitrate + 0.6 Nitrite + 0.01 Silicate + 50 ppm Phosphate + 30 ppm MBT	8.30	8.20	Al	1	Clean	Better Inhibitor required
					6	Few pits	
				Steel	1	Clean, Few fine pits	
					6	Many pits at edge	
3	0.35 Borate + 0.2 Nitrate + 0.05 Nitrite + 0.01 Silicate + 50 ppm Phosphate + 50 ppm MBT + 100 ppm SAE	8.20	8.15	Al	4	Clean & shiny	Improvement required
					16	Clean & shiny	
				Steel	4	Clean, pits	
					16	Clean, several pits	

4	0.35 Borate + 0.2 Nitrate + 0.05 Nitrite + 0.01 Silicate + 50 ppm Phosphate + 50 ppm SAM	8.20	8.25	Al	2	Dull, patches of Corrosion	Better Inhibitor required
				Steel	2	Several pits	
5	0.35 Borate + 0.1 Nitrate + 0.05 Nitrite + 0.01 Silicate + 50 ppm Phosphate + 50 ppm MBT + 50 ppm SAP + 100 ppm SAE	8.80	8.70	Al	2	Clean	Fair
					10	Clean, few corrosion streaks	
				Steel	2	Clean	
					10	Clean, pits	
6	0.35 Borate + 0.2 Nitrate + 0.2 Nitrite + 0.01 Silicate + 125 ppm Phosphate + 60 ppm MBT + 100 ppm SAR + 210 ppm SAD + 40 ppm $ZnSO_4$	8.15	8.10	Al	2	Clean & shiny	Excellent inhibition
					12	Clean & shiny	
				Steel	2	Clean & shiny	
					12	Clean & shiny, two fine pits	
7	0.35 Borate + 0.2 Nitrate + 0.2 Nitrite + 0.01 Silicate + 50 ppm Phosphate + 75 ppm SAT + 500 ppm $ZnSO_4$	8.15	8.20	Al	2	Clean & shiny	Excellent Inhibitor
					8	Clean & shiny	
				Steel	2	Clean & shiny	
					8	Clean & shiny	

8	0.35 Borate + 0.2 Nitrate + 0.2 Nitrite + 0.01 Silicate + 50 ppm Phosphate + 100 ppm MBT + 75 ppm SAR + 100 ppm $ZnSo_4$	9.35	9.20	Al	2 8	Clean & shiny Clean & shiny	Excellent Inhibitor
				Steel	2 8	Clean & shiny Clean & shiny, one fine pit	
9	1% SAB	6.25	6.25	Al	4 24	Clean & shiny Badly corroded	Better Inhibitor required
				Steel	4 24	Clean & shiny Badly corroded	
10	0.35 Borate + 0.2 Nitrate + 0.2 Nitrite + 0.01 Silicate + 50 ppm Phosphate + 100 ppm MBT + 250 ppm SAB	8.15	8.20	Al	2 8	Clean & shiny Clean & shiny	Excellent Inhibitor
				Steel	2 8	Clean, one pit Clean & shiny	

In Table VI above and in Table VII, below, the term borate refers to sodium borate tetrahydrate, nitrate to sodium nitrate, nitrite to sodium nitrite, silicate to sodium metasilicate pentahydrate, and phosphate to sodium hexametaphosphate.

In Table VII below, the representative results of tests with several experimental formulations are summarized. These tests were carried out on type 7075-T6 aluminum, type 4340 steel, and brass in synthetic urine solution, and in a mixture of synthetic urine and coffee.

TABLE VII

No	Inhibitor wt% in synthetic urine*	pH Initial	pH Final	Specimen	Time of Exposure (weeks)	Surface Appearance (Visual Observation)	Remarks
11	0.35 borate + 0.2 nitrite + 0.2 nitrate + 0.01 silicate + 100 ppm $ZnSO_4$ + 50 ppm phosphate + 75 ppm SAR	9.35	9.25	Al	2	Clean & shiny	Excellent
					8	Clean & shiny	
				Steel	2	Clean & shiny	
					8	Clean & shiny, one fine pit	
12	0.35 borate + 0.2 nitrite + 0.2 nitrate + 0.01 silicate + 0.01 phosphate + 0.01 MBT + 125 ppm SAR	8.50	8.50	Al	4	Clean & shiny	Excellent
				Steel	4	Clean & shiny	
				Brass	4	Clean & shiny	
13	0.35 borate + 0.2 nitrite + 0.2 nitrate + 0.01 silicate + 125 ppm phosphate + 60 ppm MBT + 40 ppm $ZnSO_4$ + 100 ppm SAR + 200 ppm SAD	8.15	8.15	Al	2	Clean & shiny	Excellent
					12	" " "	
				Brass	2	" " "	
					12	" " "	
				Steel	2	" " "	
					12	" " " , three fine pits	

14	0.35 borate + 0.2 nitrite + 0.2 nitrate + 0.01 silicate + 50 ppm phosphate + 100 ppm MBT + 250 ppm SAB	8.15	8.15	Al	2	Clean & shiny	Excellent
					8	" " "	
				Brass	2	" " "	
					8	" " "	
				Steel	2	Clean, one pit appearing on one surface	
					8	Clean & shiny	
15	0.35 borate + 0.2 nitrite + 0.2 nitrate + 0.01 silicate + 50 ppm MBT + 500 ppm $ZnSO_4$ + 75 ppm SAT	8.15	8.00	Al	4	Clean & shiny	Excellent
					32	" " "	
				Brass	4	" " "	
					32	" " "	
				Steel	4	" " "	
					32	" " "	

* Except Run 15 which was 50% synthetic urine and 50% coffee.

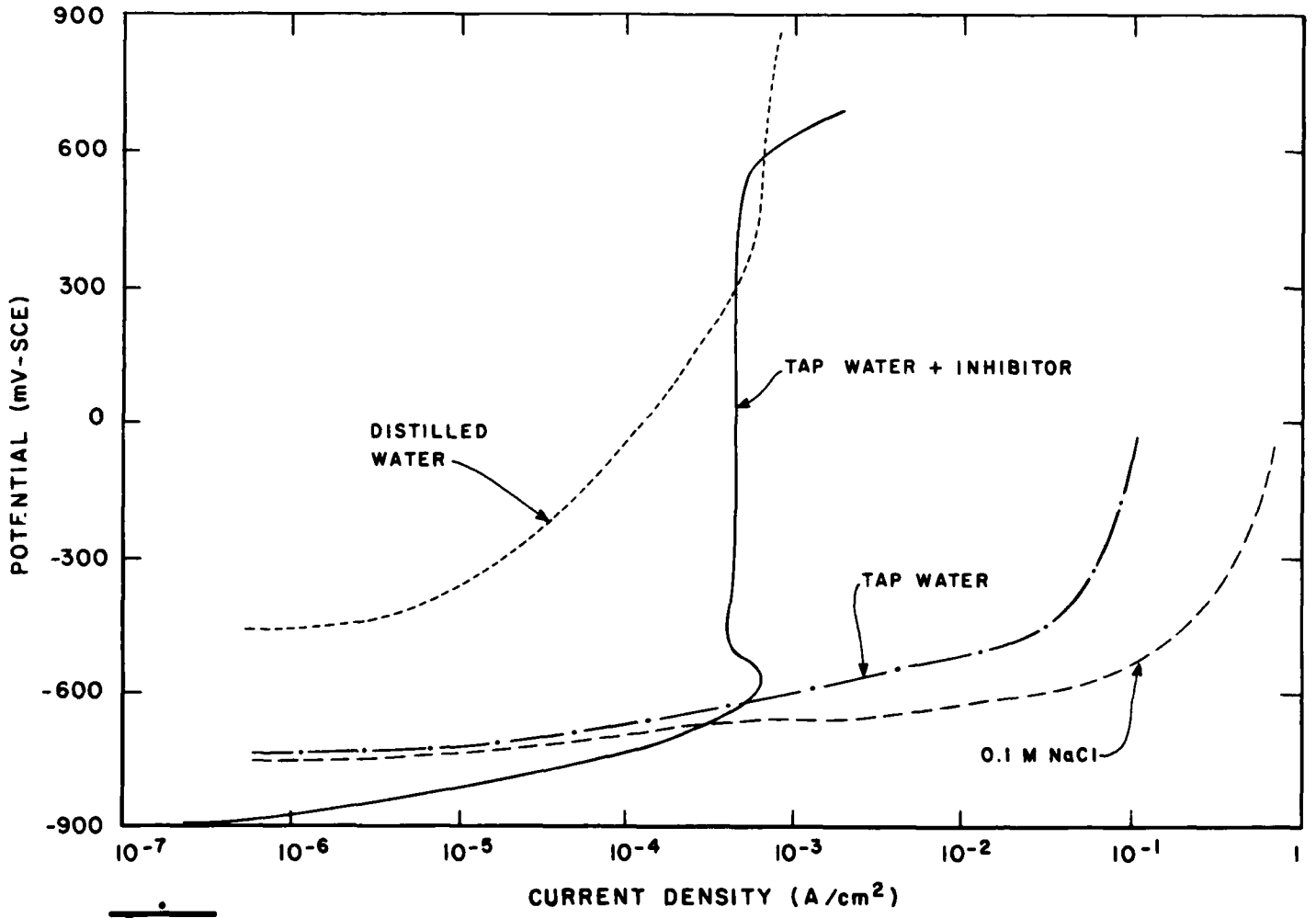
The corrosion inhibiting formulations of this invention may be used in aqueous solution as rinse-type inhibitors and as immersion-type inhibitors. The corrosion inhibitor may be compounded dry, and stored in bulk for later solution in water. In the dry form, the corrosion inhibitor may be incorporated from 20 to 50 weight percent, preferably about 30 weight percent, into a commercial soap formulation, e.g., a handsoap, for use in the lavatory of an aircraft or ship.

The corrosion inhibitor may be incorporated into a coating composition, such as a paint primer by encapsulating the inhibitor formulation with a cellulosic or nylon or other suitable encapsulating material using conventional encapsulating techniques, and incorporating 20 to 50 weight percent, preferably about 30 weight percent, of the encapsulated inhibitor into a conventional coating composition. The corrosion inhibiting components may be released if the coated surface is scratched or otherwise physically damaged.

Various modifications can be made to the above described invention.

ABSTRACT OF THE DISCLOSURE

A multifunctional corrosion inhibitor consisting essentially of an alkali metal borate, an alkali metal nitrate, an alkali metal nitrite, an alkali metal metasilicate, an alkali metal phosphate, mercaptobenzothiazole and at least one selected surfactant.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600
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-300
-600
-900
POTENTIAL (mV-SCE)
10-7
10-6
10-5
10-4
10-3
10-2
10-1
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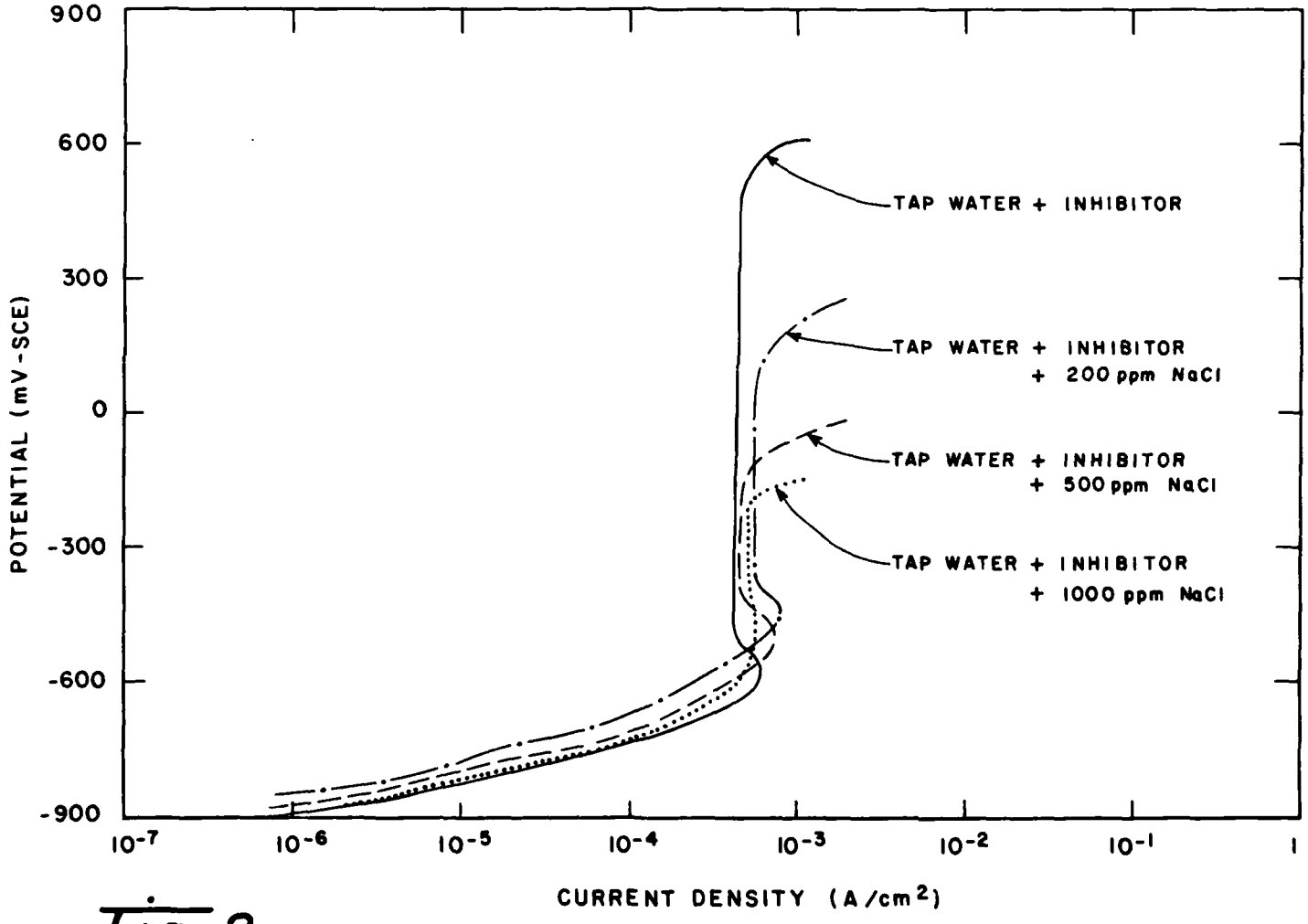
CURRENT DENSITY (A/cm2)
DISTILLED WATER
TAP WATER + INHIBITOR
TAP WATER
0.1 M NaCl

Fig. 1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0
-300
-600
-900
POTENTIAL (mV-SCE)
10-7
10-6
10-5
10-4
10-3
10-2
10-1
1
CURRENT DENSITY (A/cm2)
TAP WATER + INHIBITOR
TAP WATER + INHIBITOR + 200 ppm NaCl
TAP WATER + INHIBITOR + 500 ppm NaCl
TAP WATER + INHIBITOR + 1000 ppm NaCl

Fig. 2

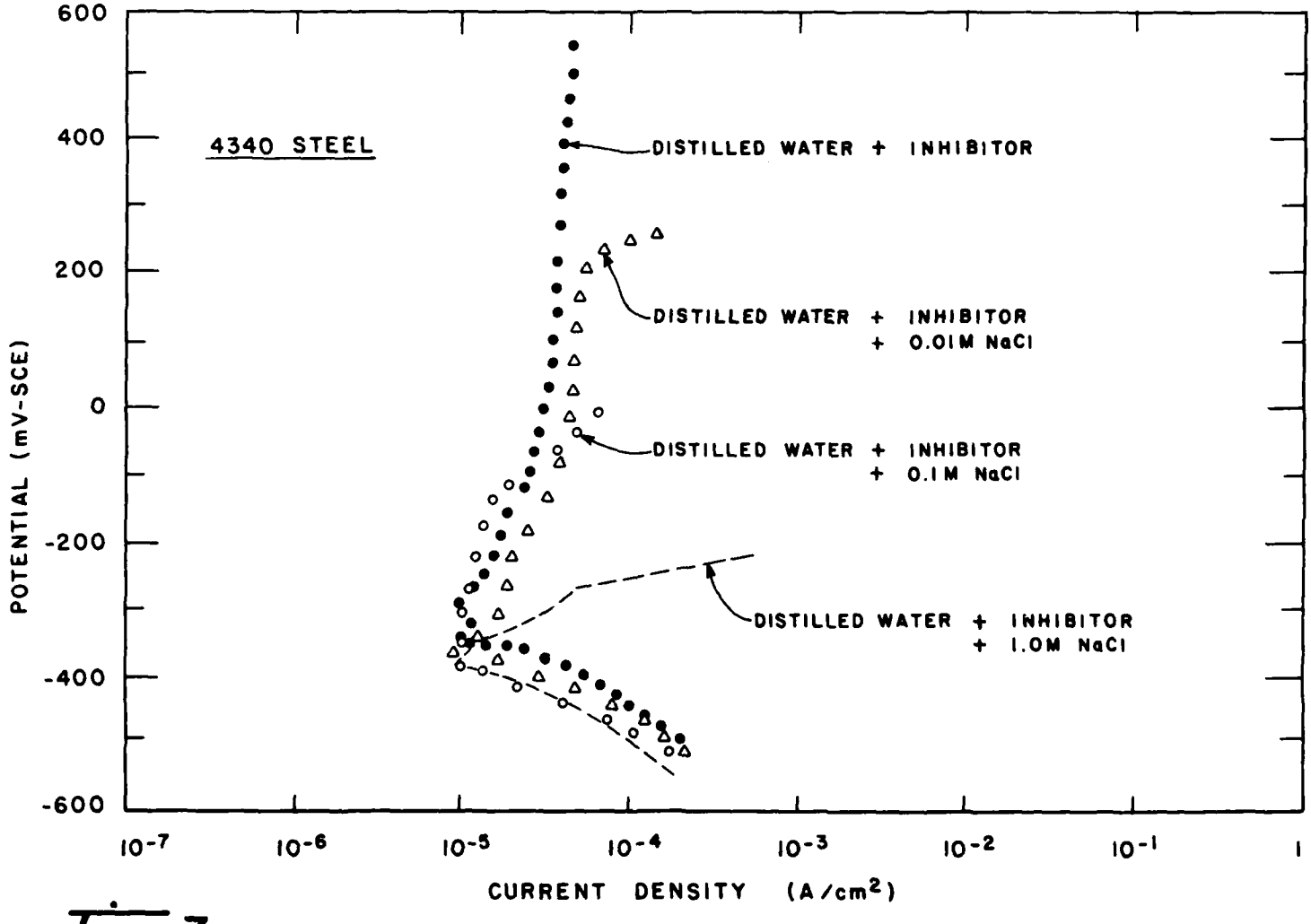
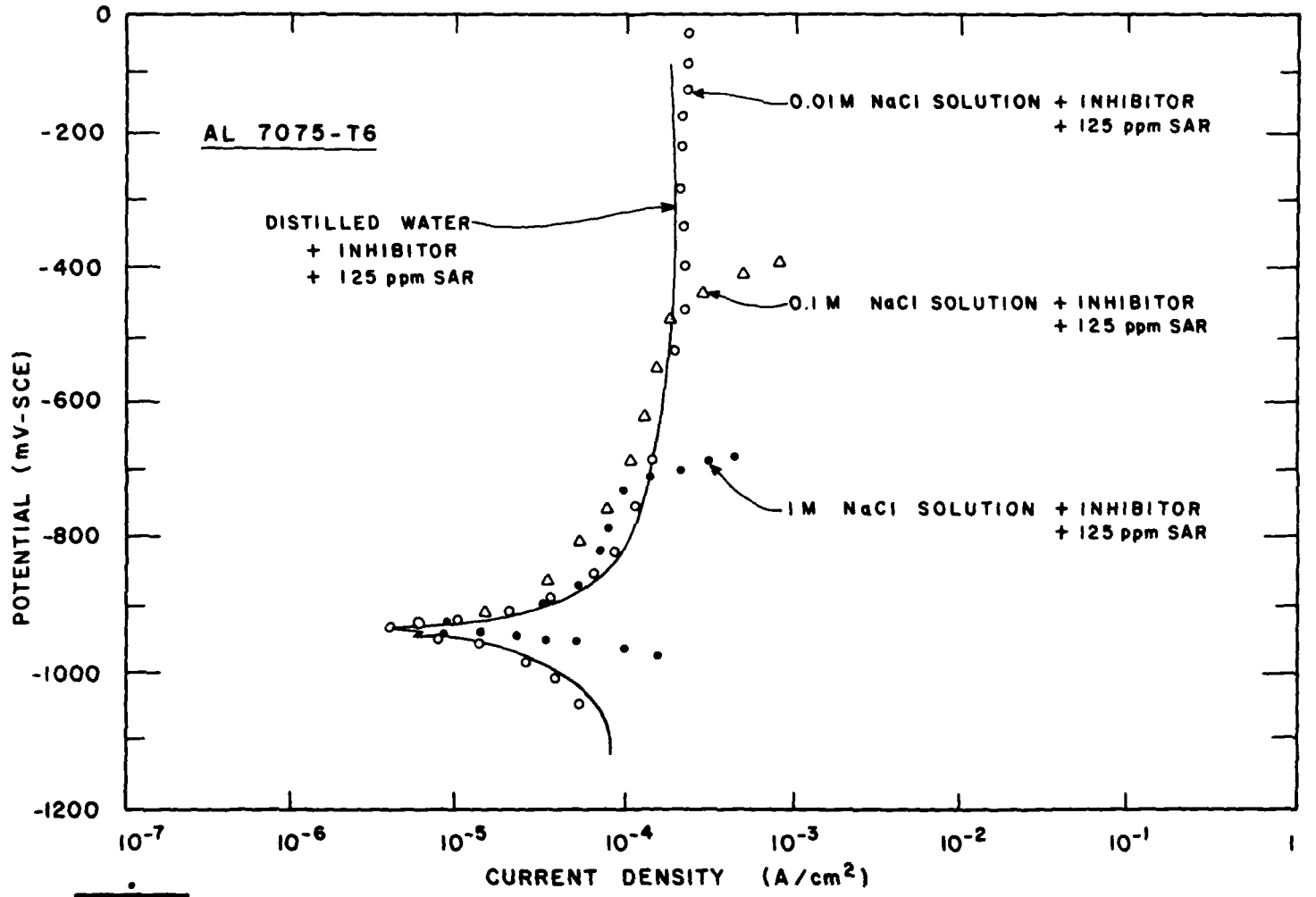

600
400
200
0
-200
-400
-600
POTENTIAL (mV-SCE)
4340 STEEL
DISTILLED WATER + INHIBITOR
DISTILLED WATER + INHIBITOR + 0.01M NaCl
DISTILLED WATER + INHIBITOR + 0.1M NaCl
DISTILLED WATER + INHIBITOR + 1.0M NaCl
10-7
10-6
10-5
10-4
10-3
10-2
10-1
1
CURRENT DENSITY (A/cm2)

Fig. 3


0
-200
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-600
-800
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POTENTIAL (mV-SCE)
AL 7075-T6
DISTILLED WATER
+ INHIBITOR
+ 125 ppm SAR
0.01M NaCl SOLUTION + INHIBITOR
+ 125 ppm SAR
0.1 M NaCl SOLUTION + INHIBITOR
+ 125 ppm SAR
1 M NaCl SOLUTION + INHIBITOR
+ 125 ppm SAR
10^{-7}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
CURRENT DENSITY (A/cm^2)

Fig. 4

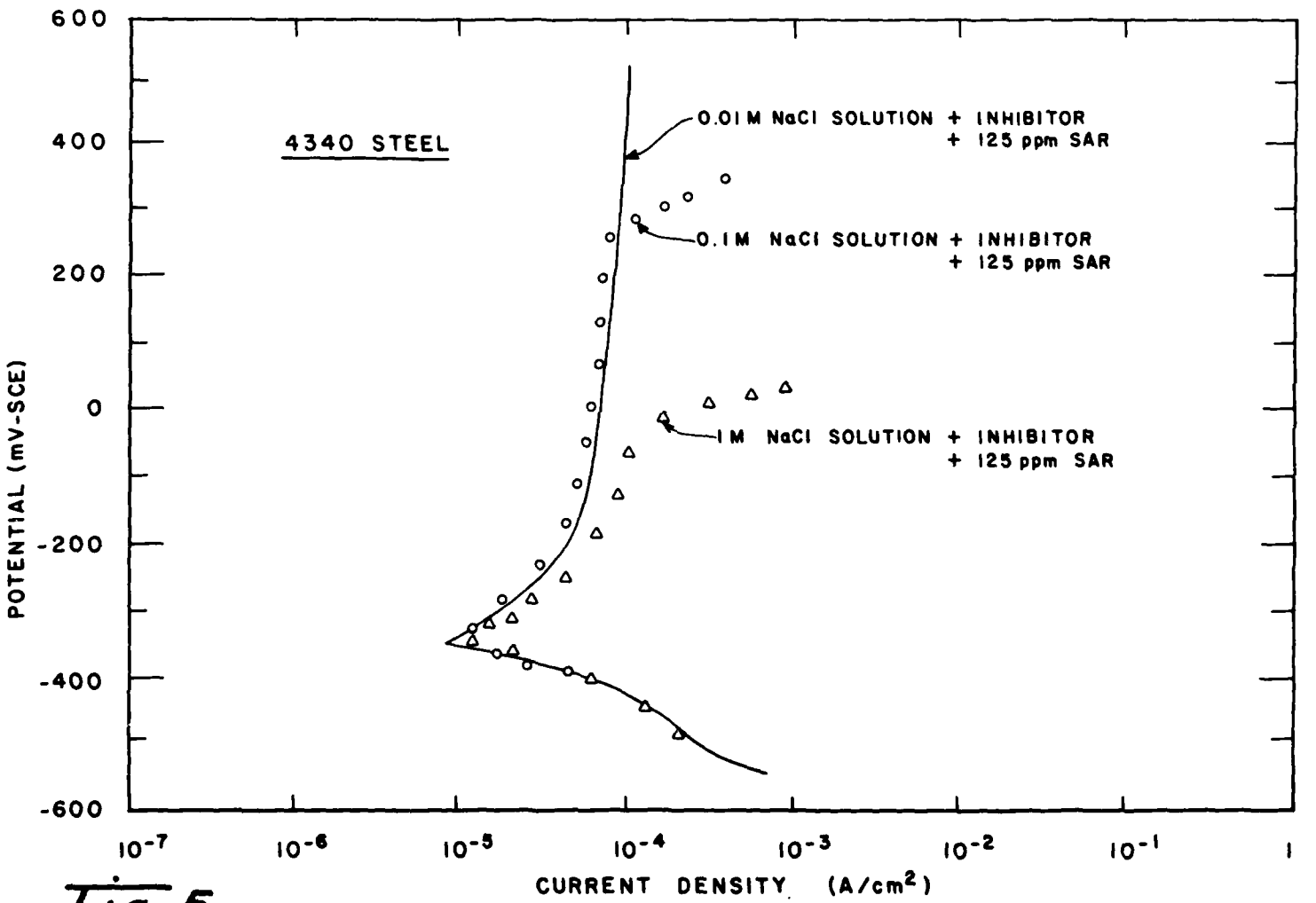
600
400
200
0
-200
-400
-600
POTENTIAL (mV-SCE)
4340 STEEL
0.01 M NaCl SOLUTION + INHIBITOR + 125 ppm SAR
0.1 M NaCl SOLUTION + INHIBITOR + 125 ppm SAR
1 M NaCl SOLUTION + INHIBITOR + 125 ppm SAR
10^{-7}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
CURRENT DENSITY (A/cm^2)

Fig. 5

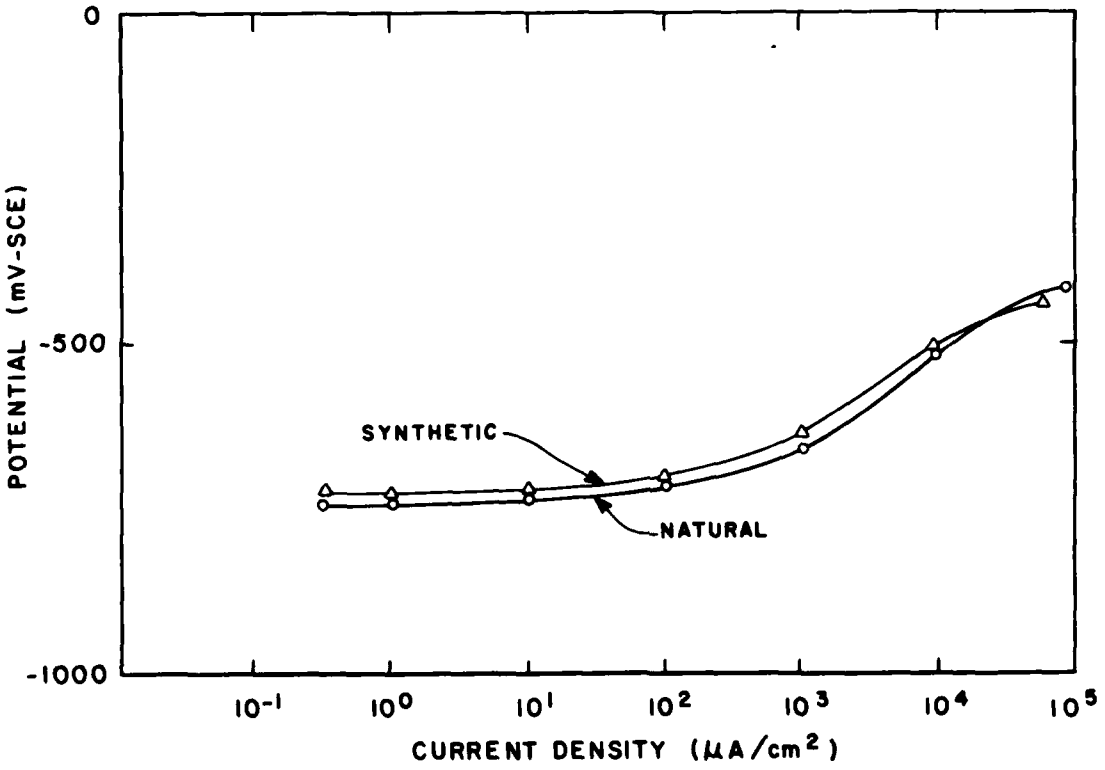
0
-500
-1000
POTENTIAL (mV-SCE)
SYNTHETIC
NATURAL
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
CURRENT DENSITY ($\mu A/cm^2$)

Fig. 6

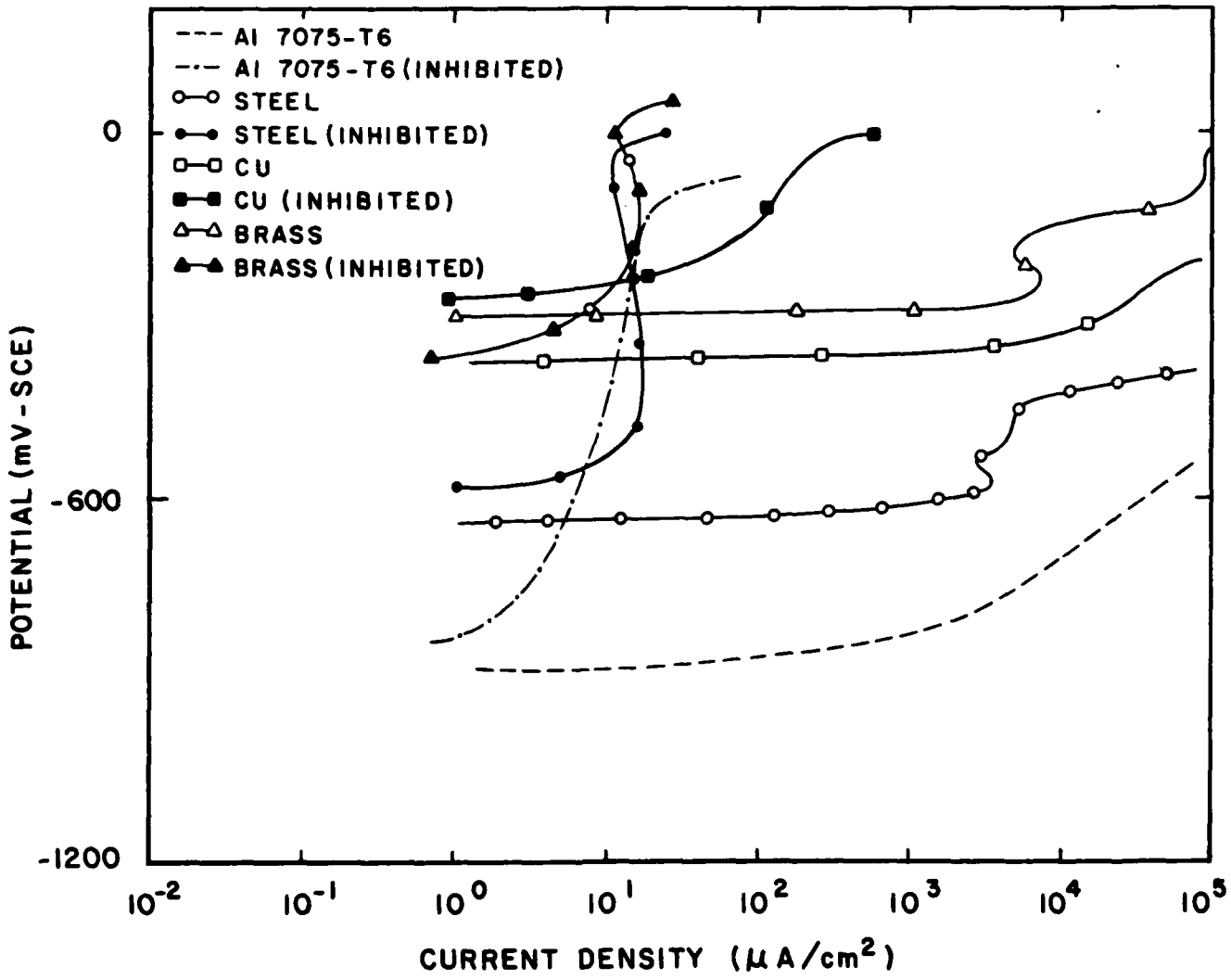
Al 7075-T6
Al 7075-T6 (INHIBITED)
STEEL
STEEL (INHIBITED)
CU
CU (INHIBITED)
BRASS
BRASS (INHIBITED)
0
-600
-1200
POTENTIAL (mV-SCE)
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{5}
CURRENT DENSITY ($\mu A/cm^2$)

Fig. 7