THE DEGRADABILITY OF SURFACTANTS IN TEXTILE

MILL WASTES WITH HYDROGEN PEROXIDE

A THESIS

Presented to

The Faculty of the Graduate Division

By

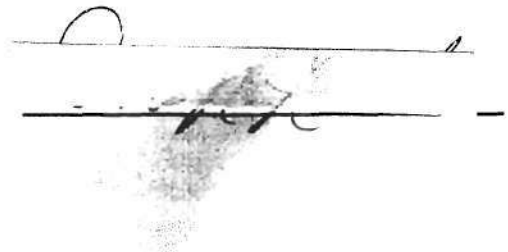Denis N. Nonaka

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in the A. French Textile School

The Georgia Institute of Technology

August, 1968

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Approved:

Chairman

Date approved by Chairman: Aug 20 1968

DEDICATION

I gratefully dedicate this thesis to my wonderful parents. Their sacrifices have made this educational venture possible, and their encouragement and faith have been boundless.

ACKNOWLEDGMENTS

I would like to express my appreciation to my thesis advisor, Professor R.K. Flege. His guidance and assistance were most beneficial.

The author wishes to thank Professor C. E. Kindsvater, who offered much advice and guidance as a member of the thesis reading committee. I would also like to thank Dr. R.S. Ingols for his suggestions and counsel.

Appreciation is also given to Dr. James L. Taylor for providing the opportunity to attend graduate school.

This study was supported by the Water Resources Center of the Georgia Institute of Technology under provisions of P.L. 88-379.

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SUMMARY

Linear Alkyl Benzene Sulfonates (LAS) are water soluble surfac-
tants widely used in textile dyeing operations. The presence of LAS
in effluents in excess of one part per million (ppm) or greater
causes a foam problem for a period of approximately five days under
normal primary treatment conditions before the compound is sufficiently
degraded to a level where foam is eliminated. This study was an attempt
to determine a method to eliminate the problem of foam during these
five days after discharge into a river or stream.

This thesis shows the effects of hydrogen peroxide treatment
for degrading LAS compounds and reducing foaming of solutions of LAS.

Analyses were made to determine the effects of various concentra-
tions of hydrogen peroxide on a standard LAS solution of 28 ppm. in the
presence of boiling only and boiling with 12 hours of ultraviolet light
treatment, and to determine the maximum allowable ratio of hydrogen
peroxide to LAS to eliminate foaming.

Results disclosed that hydrogen peroxide, in the presence of
boiling only, or with a combination of boiling and 12 hours of ultra-
violet light treatment at a maximum ratio of 4,000 parts LAS (28 ppm.)
to one part of 35 percent hydrogen peroxide will eliminate foaming.

CHAPTER I

INTRODUCTION

The textile industry is one of the largest consumers of anionic surfactants; sixty million pounds were used in 1966 (1) in textile wet processing operations. Surfactants are used as wetting agents, penetrating agents, leveling agents, solubilizing agents, and detergents in dyeing operations. Until 1965, principal surfactants used in dyeing were non-linear or branched tetrapropylene alkyl benzene sulfonate anionic compounds (ABS). The use of these compounds resulted in a foaming problem when the dyehouse effluent containing ABS in quantities of one part per million (ppm) or greater was discharged into a river or stream, because these compounds were non-biodegradable and resistant to normal chemical treatment. The surfactants passed through sewage treatment plants to remain in streams and rivers, causing a foam problem when water flow was turbulent. It has been estimated that no more than half of the ABS entering a sewage treatment plant is broken down; and since the ABS does not break down for many weeks, suds may appear in drinking water (2).

Dr. Albert E. Berry, secretary-treasurer of the Canadian Institute on Pollution, had this to say on foam problems caused by detergents (3):

The thing about detergents in water supplies is that they are highly visible. You cannot see viruses in the water. You cannot see poisonous industrial wastes. The amount of life-giving oxygen in water is not apparent to the eye.

But you cannot miss a two-foot high drift of bubbling
suds, and that is what makes people mad.

If people get steamed up about relatively harmless
detergent foam, they may eventually find out what is
really wrong with our water using practices and what
an enormous problem we are going to face in the next
100 years or so in getting clean waters where and when
we want them.

In 1965, many manufacturers of anionic surfactants began pro-
ducing the linear dodecyl alkyl benzene sulfonate type detergent (LAS)
which was readily biodegradable and retained the cleansing properties
and the low costs of the non-linear alkyl benzene sulfonates after
discharge from the textile plant under normal treatment conditions.
However, the compound was not completely degraded for at least five
days and the problem of foaming was still possible during these
five days.

Anionic detergents such as LAS could cause color build-up in
rivers and streams when combined with discharged dyestuffs, cationic
finishing agents, or colorless dye intermediates in waste effluent
from the same or other textile plants. The problem is complicated
by the introduction of newer type dyes and finishing agents needed
for the newer type fibers being produced.

Detergents or dispersing agents are used in dyeing processes
for synthetic fibers to hold the disperse dyes in suspension during
the dyeing process. They are not consumed in the dyeing process.
Instead, they are used to maintain an appropriate environment during
the dyeing process. Detergents or dispersing agents are selected for
their use with reference to their capability of maintaining a stable
colloidal dispersion of the dye. Biodegradability of the detergent is
not a factor affecting its selection.

The complete degradation of the LAS compound could lead to a reduction in color build-up by the formation of less complex and easier to treat "secondary" compounds. Techniques such as the use of storage ponds or "lagoons" or the addition of lime after the addition of a metallic coagulant such as calcium or copperas to the waste effluent could lead to a better removal of color if the secondary compounds are treated separately.

Linear Alkyl Benzene Sulfonates are benzene sulfonate derivatives containing a linear or straight chain containing 12 to 15 carbons attached to a benzene ring which has a sulfo (SO_3) group attached. The effect of bacterial microorganisms in river water on these compounds causes an attack on the end of the linear chain; and by beta oxidation processes, two carbon atoms are removed at a time leaving a terminal carboxyl group as the end product attached to the benzene ring. The formation of the carboxylic acid derivative of this sulfonated benzene ring is said to eliminate the problem of foaming (4).

The new type of LAS is a modification of the old ABS structure. The highly branched alkyl chain derived from tetrapropylene is replaced with a relatively straight chain derived from alpha olefins. The branched structure of ABS is centered around the quaternary carbon atom, i.e., a carbon atom attached to four other carbon atoms which can be at the benzene junction and also further out on the chain. This quaternary carbon atom renders the ABS molecule extremely resistant to biological attack. The removal of the quaternary carbon from the alkyl chain reduces the stability enough to yield a "softer" type surfactant such as LAS (5).

As the LAS type surfactants need approximately five days to be degraded enough to eliminate foaming, the problem of foaming is still possible during these five days (6). If the LAS is put into a system with a high bacterial count, such as the activated sludge used in sewage disposal plants, it is degraded in a few hours (7). However, textile mills do not use this type of sophisticated process and depend largely upon primary treatment processes such as: sedimentation, neutralization, holding ponds, and aeration, which do not break down LAS fast enough.

Foam may be considered as a colloidal system consisting of a gas or gases suspended in a viscous liquid or semi-solid, (8) or as a measurably stable honeycomb structure of air cells whose walls consist of their liquid films. Foams are formed by introducing air or other gases under the surface of a mass of liquid, or by agitating the surface so that it breaks and encloses the air. The mechanism by which foam disappears or is destroyed spontaneously is relatively simple. The liquid drains out from between the two parallel surfaces of the individual film, thereby causing the film to become progressively thinner. At a certain critical thickness, the film collapses and the foam disappears (9).

Foam is a phenomenon that is noticed when either positively or negatively adsorbed materials are found in solution. Surface active agents have a hydrophobic (hydrocarbon) chain linked to a hydrophilic group which may be anionic, cationic, or "zwitterionic". The products which give the greatest amount of foam are those which have a terminal hydrophilic group, i.e., LAS compounds.

Detergents and wetting agents used in dyeing are usually composed of a strong hydrophobic group which gives the molecule attracting properties for grease, oil and one or more strong hydrophilic groups which render the molecule water soluble. The best detergents have a long hydrocarbon chain with a short water soluble group at the end (10).

Because the field of treating LAS compounds with chemicals instead of biological microorganisms is relatively new, the literature available is not abundant. It is known, however, that certain chemicals can attack the LAS compound and cause a change in the chemical structure of the compound. If a chemical treatment method with respect to the LAS compound could be developed to eliminate the foaming problem, the textile mills would no longer have to worry about unsightly foam and possibly color problems along the rivers and streams into which dye wastes are discharged. Disperse dyes, as a result, could more readily precipitate and become easier to remove in treatment plants.

Statement of the Problem

Linear Alkyl Benzene Sulfonates (LAS) are water soluble surfactants used by the textile industry in dyeing operations. However, the discharge of this compound in concentrations of 1.0 ppm. or greater in dye wastes results in a foam problem. Approximately five days are required for biological microorganisms to become environmentally acclimated enough to degrade the compound sufficiently to eliminate the foaming problem.

The purpose of this research is to evaluate the effects of hydrogen peroxide (H_2O_2) on linear alkyl benzene sulfonates, and to determine if the LAS was sufficiently degraded so that the presence of foam was quickly eliminated or greatly reduced.

CHAPTER II

PROCEDURE

The method used to test for detergent degradability was to take 1,000 milliliters (ml.) of 28 ppm. LAS solution (based on 0.1 percent LAS on weight of fabric at a 35 to 1 weight of liquor to weight of fabric basis), and add 10 ml. of oxidizing agent. The pH was kept at five or adjusted to nine with 10 ml. of 0.1 N Sodium Hydroxide (NaOH) and the solution was then boiled for five minutes. The solution was cooled in an ice bath to bring the temperature to 55° F. The solution was then stirred by hand with a glass rod every 10 minutes to check if any foam formed upon stirring. If any foam was formed after 24 hours aging, the concentration of the LAS in the treated solution was still greater than 1.0 ppm., and so the sample was discarded and eliminated from further testing. The samples were checked every 10 minutes for the first two hours and then at 30 minute intervals where possible for 24 hours.

Another type detergent degradability test was run, omitting boiling of the solution. Instead, the treated LAS solution was heated with an ultraviolet (UV) light source (Hanovia Chemical Company Serial Number SC 638, 100 watts) for 12 hours. A third type detergent degradability test was run using the UV light in conjunction with the boiling. The UV light was turned on immediately after boiling of the treated sample took place, and was kept on for 12 hours. The results of the

testing (see Appendix, Table 1) showed that the LAS solution treated with 10 ml. of 35 percent hydrogen peroxide (H_2O_2) at pH nine with boiling only and boiling with 12 hours of UV treatment resulted in no foam. Thus, the results of these investigation procedures form the basis of this thesis. Further tests were run to determine the effects of various concentrations of H_2O_2 on a standard LAS solution and to find the minimum quantity of H_2O_2 needed to eliminate foaming.

One thousand ml. of a standard LAS solution of 28 ppm., whose pH was adjusted to nine with the addition of 10 ml. of 0.1 N NaOH was reacted with three different concentrations of H_2O_2 -10 ml. of 35 percent H_2O_2, 10 ml. of 3.5 percent H_2O_2, and 4 ml. of 3.5 percent H_2O_2 - each under the conditions of five minutes of boiling only or five minutes of boiling and 12 hours of UV treatment. The treated sample solutions which were three inches deep in a 3,000 ml. beaker were then cooled immediately in an ice bath to adjust the temperature of the sample to 55° F. In the case of the UV test, the UV light was turned on immediately after the boiling took place. After the treated sample was kept in the ice bath for one hour, an aliquot was taken for analytical testing to determine the concentration of the LAS remaining in solution.

For accurate determinations of the concentrations of LAS present in treated H_2O_2 samples, a colorimetric spectrophotometric analysis was used called the Methylene Blue Test.

The determination of trace amounts of anionic detergents in sewage, sewage effluents, and river waters has attracted considerable

interest and attention for some time, especially due to the wide-spread introduction of compounds of the alkyl aryl sulfonate class. Such materials of which linear alkyl benzene sulfonates are a leading example are more resistant than soap or alkyl sulfates to normal methods of sewage purification and by virtue of their surface activity, inter-fere with the efficient operation of sewage works.

The colorimetric method (Methylene Blue Test) proposed by Abbot (11), and used as the basis of this study introduces a new principle not found in other analytical procedures to determine alkyl aryl sulfonates, that of pre-extraction of impurities. The optical density of the blank is greatly reduced, and accurate and reproducible results of alkyl aryl sulfonates present in waters down to concentrations of about 0.01 ppm. are obtained.

Reagents - All materials were of reagent grade and all solutions were prepared with de-ionized water.

Alkaline borate solution - Equal volumes of 0.05 M Sodium Tetraborate and 0.1 N Sodium Hydroxide were mixed.

Sulfuric acid - 1.0 N H_2SO_4 was used.

Methylene blue solution - Dissolved 0.25 gram of "vital-stain" grade methylene blue in de-ionized water and diluted to one liter.

Chloroform - Reagent grade was used.

Into a 250 ml. separatory funnel was added 50 ml. of de-ionized water, 10 ml. of alkaline borate buffer solution, and five ml. of the methylene blue solution. Ten ml. of chloroform was added to the funnel, the funnel shaken for 30 seconds, and then allowed to settle. The

chloroform extract was then run out into a waste chloroform beaker.

Into a second 250 ml. separatory funnel was added 100 ml. of de-ionized

water, 10 ml. of alkaline borate buffer solution, and five ml. of

methylene blue solution. Ten ml. of chloroform was added, the separatory

funnel shaken for 30 seconds, and then allowed to settle. The chloroform

layer was then run out into the waste chloroform beaker. Then three ml.

of chloroform was added to both separatory funnels with no shaking.

The chloroform was then run into the waste chloroform beaker. The

entire extraction cycle using 10 ml. of chloroform and three ml. of

chloroform was then repeated once more. Then to the second separatory

funnel was added three ml. of 1.0 N H_2SO_4.

To the first separatory funnel was added 100 ml. of the treated

LAS solution. Fifteen ml. of chloroform was added and the funnel shaken

evenly and gently twice a second for one minute. After allowing the

contents of the funnel to separate for two minutes, the chloroform

extract was run into the second separatory funnel containing the

extracted and acidified methylene blue solution. The contents of this

funnel were shaken evenly and gently twice a second for one minute and

the contents of the funnel were then allowed to settle for two minutes.

The chloroform layer was then run through a small filter funnel plugged

with glass-wool into a 50 ml. volumetric flask. The operations described

above were then repeated twice more starting at "Fifteen ml. of chloroform

was added....." and the extracts were combined in the flask and chloro-

form was then added to dilute the extract to the mark.

A blank determination using de-ionized water was carried out in exactly the same manner described above and the optical densities of the blank and sample extracts were measured at a wavelength of 650 millimicrons using the Beckman DU Model Spectrophotometer with one centimeter silica cells and a 0.04 mm. slit setting. Chloroform was used as reference. The cells were rinsed three times with the solution before reading the optical density.

The difference between the optical densities of the sample reading and the blank reading gave the concentration of LAS present in ppm. when read off a standard calibration curve.

The standard calibration curve was established by extracting as described above known concentrations of LAS in solution and plotting optical densities of these LAS extracts at 650 millimicrons v. the chloroform extracts from the blank (See Appendix, Figure 7).

CHAPTER III

DISCUSSION OF RESULTS

The results of this work are discussed below by figure number. General conclusions that may be drawn from the results are presented in Chapter IV. Raw data obtained during the course of the research are presented in the Appendix.

Figures 1 - 6 show the results of the treatment of a MARS SA 98 97 percent active agent (Seydel-Woolley Company, Atlanta, Georgia) LAS (Linear Dodecyl Benzene Sulfonate) solution (28 ppm) with various concentrations of H_2O_2 under two different conditions - boiling only, and boiling followed by 12 hours of UV treatment.

Figure 1 shows the effects of a 100 volumes LAS solution (28 ppm) to one volume 35 percent H_2O_2 with boiling only. Under these conditions over a period of time approaching two days, a decrease in the LAS concentration from 28 ppm. initially to a final concentration of 0.18 ppm. is shown.

Figure 2 shows the effects of a 100 volumes LAS solution (28 ppm.) to one volume 35 percent H_2O_2 with boiling and 12 hours of UV treatment. As compared to Figure 1, the concentration of LAS remaining in solution is less in Figure 2 with passing time. The LAS decreases in Figure 2 from 28 ppm. initially to a final concentration of 0.17 ppm.

Figure 3 shows the effects of increasing the ratio of LAS to H_2O_2. With a 1,000 volumes LAS solution (28 ppm.) to one volume 35 percent H_2O_2 and boiling only, a decrease in the LAS concentration from 28 ppm. initially to a final concentration of 0.34 ppm. is shown.

Figure 4 shows the effects of a 1,000 volumes LAS solution (28 ppm.) to one volume 35 percent H_2O_2 with boiling and 12 hours of ultra-violet treatment. As is the case with the comparison of Figure 2 to Figure 1, the concentration of LAS remaining in solution after treatment is reduced slightly with a combination of boiling and UV treatment than with boiling only. A decrease in the LAS concentration from 28 ppm. initially to a final concentration of 0.32 ppm. is shown.

Figure 5 shows the effects of a 4,000 volumes LAS solution (28 ppm.) to one volume 35 percent H_2O_2 with boiling only. This ratio of LAS to H_2O_2 is the maximum allowable as the concentration of the LAS in solution was exactly 1.0 ppm. after the first analysis was run immediately after boiling took place. Overall, a decrease in the LAS concentration from 28 ppm. initially to a final concentration of 0.88 ppm. is shown.

Figure 6 shows the effects of a 4,000 volumes LAS solution (28 ppm.) to one volume 35 percent H_2O_2 with boiling and 12 hours of UV treatment. As shown previously, the concentration of LAS present is reduced slightly more in this sample treated with boiling and 12 hours of UV treatment as compared to the sample treated with boiling only. The concentration of LAS decreased from 28 ppm. initially to a final concentration of 0.86 ppm.

With boiling and 12 hours of UV treatment, the concentration of LAS present is slightly less than that found in the boiling tests only. The entire trend of the graphs shows that as the ratio of LAS to 35 percent H_2O_2 increases, the ability to reduce foam decreases. Also, at no time did the concentration of the LAS in the treated solutions exceed 1.0 ppm., which is the maximum allowable in rivers and streams (12).

The effects of H_2O_2 on other chemicals found in dyehouse effluent were not evaluated, as a pure solution containing LAS, NaOH, H_2O_2 and deionized water only was used in this work. However, the peroxide treatment of the dyehouse effluent should be done at the completion of the dyeing cycle, where further contamination of the effluent is eliminated.

The economics of this treatment method is important to determine its feasibility in the textile industry. Based on the most economical method to reduce foam - 4,000 volumes LAS (28 ppm.) to one volume 35 percent H_2O_2 - the cost of treating this solution is .3¢ per pound of fiber processed (See Appendix, Table 9).

CHAPTER IV

CONCLUSIONS

(1) Hydrogen Peroxide is an effective chemical agent for reducing foaming problems caused by linear dodecyl benzene sulfonates.

(2) Treatment of LAS compounds with up to 4,000 volumes LAS (28 ppm.) to one volume 35 percent H_2O_2, followed by boiling only, eliminates foam problems caused by LAS.

(3) The greatest rate of LAS degradation occurs in the first hour of effluent retention after treatment.

(4) The use of supplementary UV treatment with boiling provides an insignificant reduction of LAS compared to boiling only.

(5) Under all test conditions and varying concentrations of LAS to H_2O_2, as the holding time increases, the concentration of LAS remaining in solution decreases.

CHAPTER V

RECOMMENDATIONS

(1) Further research should be done to investigate the effects of a lagoon or holding pond to eliminate foam problems caused by LAS.

(2) An investigation should be carried out on the effects of oxidizing agents other than those mentioned in this work on LAS.

(3) The effects of switching from LAS to other type chemicals which cause no foam should be investigated.

(4) Further tests should be run by varying the conditions mentioned in this research.

(5) The effects of electrolytic oxidation on LAS should be investigated.

(6) The effects of H_2O_2 on other chemicals found in dyehouse effluent should be investigated.

APPENDIX

Table 1. Preliminary Chemical Analysis Data

Solution	pH	Boiling Only	Boiling and 12 Hrs. UV	UV Only
H_2O_2	pH 5	Foam	Foam	Foam
	pH 9	No Foam	No Foam	Foam
NaOCl	pH 5	Foam	Foam	Foam
	pH 9	Foam	Foam	Foam
Na_2O_2	pH 5	Foam	Foam	Foam
	pH 9	Foam	Foam	Foam
$KMnO_4$	pH 5	Foam	Foam	Foam
	pH 9	Foam	Foam	Foam

Table 2. Chemical Analysis Data for Solution 1.*

Boiling Only

Test No.	Slit	Sensitivity	(S) Sample A_{650} mμ	(B) Blank A_{650} mμ	S-B	ppm. LAS
1.	.04 mm	6	.166	.013	.153	.28
2.	.04 mm	6	.164	.013	.151	.28
3.	.04 mm	6	.155	.012	.143	.27
4.	.04 mm	6	.139	.012	.127	.24
5.	.04 mm	6	.121	.012	.109	.20
6.	.04 mm	6	.115	.013	.102	.18

* 100 volumes LAS (28 ppm.) : 1 volume 35 percent H_2O_2

Table 3. Chemical Analysis Data for Solution 2. *

Boiling and 12 Hours UV

Test No.	Slit	Sensitivity	(S) Sample $A_{650 \text{ m}\mu}$	(B) Blank $A_{650 \text{ m}\mu}$	S-B	ppm. LAS
1.	.04 mm	6	.164	.014	.150	.28
2.	.04 mm	6	.162	.013	.149	.28
3.	.04 mm	6	.154	.013	.141	.26
4.	.04 mm	6	.135	.014	.121	.22
5.	.04 mm	6	.129	.014	.115	.21
6.	.04 mm	6	.115	.013	.102	.18
7.	.04 mm	6	.107	.013	.096	.17

* 100 volumes LAS (28 ppm.) : 1 volume 35 percent H_2O_2.

Table 4. Chemical Analysis Data for Solution 3.*

Boiling Only

Test No.	Slit	Sensitivity	(S) Sample A$_{650}$ mμ	(B) Blank A650 mμ	S-B	ppm. LAS
1.	.04 mm	6	.297	.018	.279	.54
2.	.04 mm	6	.287	.012	.275	.54
3.	.04 mm	6	.252	.014	.238	.47
4.	.04 mm	6	.233	.013	.220	.43
5.	.04 mm	6	.220	.014	.206	.40
6.	.04 mm	6	.207	.013	.194	.38
7.	.04 mm	6	.193	.013	.180	.34

* 1,000 volumes LAS (28 ppm.) : 1 volume 35 percent H_2O_2.

Table 5. Chemical Analysis Data for Solution 4.*

Boiling and 12 Hours UV

Test No.	Slit	Sensitivity	(S) Sample A_{650} mμ	(B) Blank A_{650} mμ	S-B	ppm. LAS
1.	.04 mm	6	.295	.014	.281	.54
2.	.04 mm	6	.286	.013	.273	.53
3.	.04 mm	6	.248	.014	.234	.44
4.	.04 mm	6	.228	.014	.214	.41
5.	.04 mm	6	.214	.013	.201	.39
6.	.04 mm	6	.198	.014	.184	.35
7.	.04 mm	6	.183	.013	.170	.32

* 1,000 volumes LAS (28 ppm.) : 1 volume 35 percent H_2O_2.

Table 6. Chemical Analysis Data for Solution 5.*

Boiling Only

Test No.	Slit	Sensitivity	(S) Sample $A_{650\ m\mu}$	(B) Blank $A_{650\ m\mu}$	S-B	ppm. LAS
1.	.04 mm	6	.520	.015	.505	1.00
2.	.04 mm	6	.514	.014	.500	.99
3.	.04 mm	6	.496	.014	.482	.96
4.	.04 mm	6	.478	.014	.464	.92
5.	.04 mm	6	.475	.015	.460	.91
6.	.04 mm	6	.472	.014	.458	.90
7.	.04 mm	6	.464	.014	.450	.89

* 4,000 volumes LAS (28 ppm.) : 1 volume 35 percent H_2O_2.

Table 7. Chemical Analysis Data for Solution 6.*

Boiling and 12 Hours UV

Test No.	Slit	Sensitivity	(S) Sample A650 mμ	(B) Blank A650 mμ	S-B	ppm. LAS
1.	.04 mm	6	.520	.014	.506	1.0
2.	.04 mm	6	.512	.014	.498	.98
3.	.04 mm	6	.487	.015	.472	.93
4.	.04 mm	6	.473	.014	.459	.91
5.	.04 mm	6	.465	.014	.451	.89
6.	.04 mm	6	.457	.015	.442	.88
7.	.04 mm	6	.450	.014	.436	.86

* 4,000 volumes LAS (28 ppm.) : 1 volume 35 percent H_2O_2.

Table 8. Chemical Analysis Data for Standard Curve

ppm. LAS	Slit (mm.)	Sensitivity	(S) Sample A_{650} mμ	(B) Blank A_{650} mμ	S-B
0.2476	.54	6	.130	.012	.118
0.2900	.54	6	.148	.013	.135
0.3248	.54	6	.168	.011	.157
0.4290	.54	6	.262	.017	.245
0.7970	.54	6	.404	.013	.391

Table 9. Economic Feasibility Calculations

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28 ppm. in 4,000 grams solution

= (28/1,000,000) x 4,000

= .112 parts LAS

Therefore, .112 parts (grams) LAS are in 4,000 parts LAS solution (28 ppm.)

1.000 parts H_2O_2 (35 percent) required

1.000/.112 = 8.9 pounds H_2O_2 (35 percent) to destroy

one pound of LAS

For 1,000,000 pounds of fiber at 0.1 percent of LAS

requires 1,000 pounds of LAS and 8,900 pounds H_2O_2

to destroy the LAS

At .35¢ per pound of 35 percent H_2O_2 = $3,115 cost of H_2O_2

$3,115 / 1,000,000 pounds of fabric - $.003 per pound of

fiber processed for cost of H_2O_2.
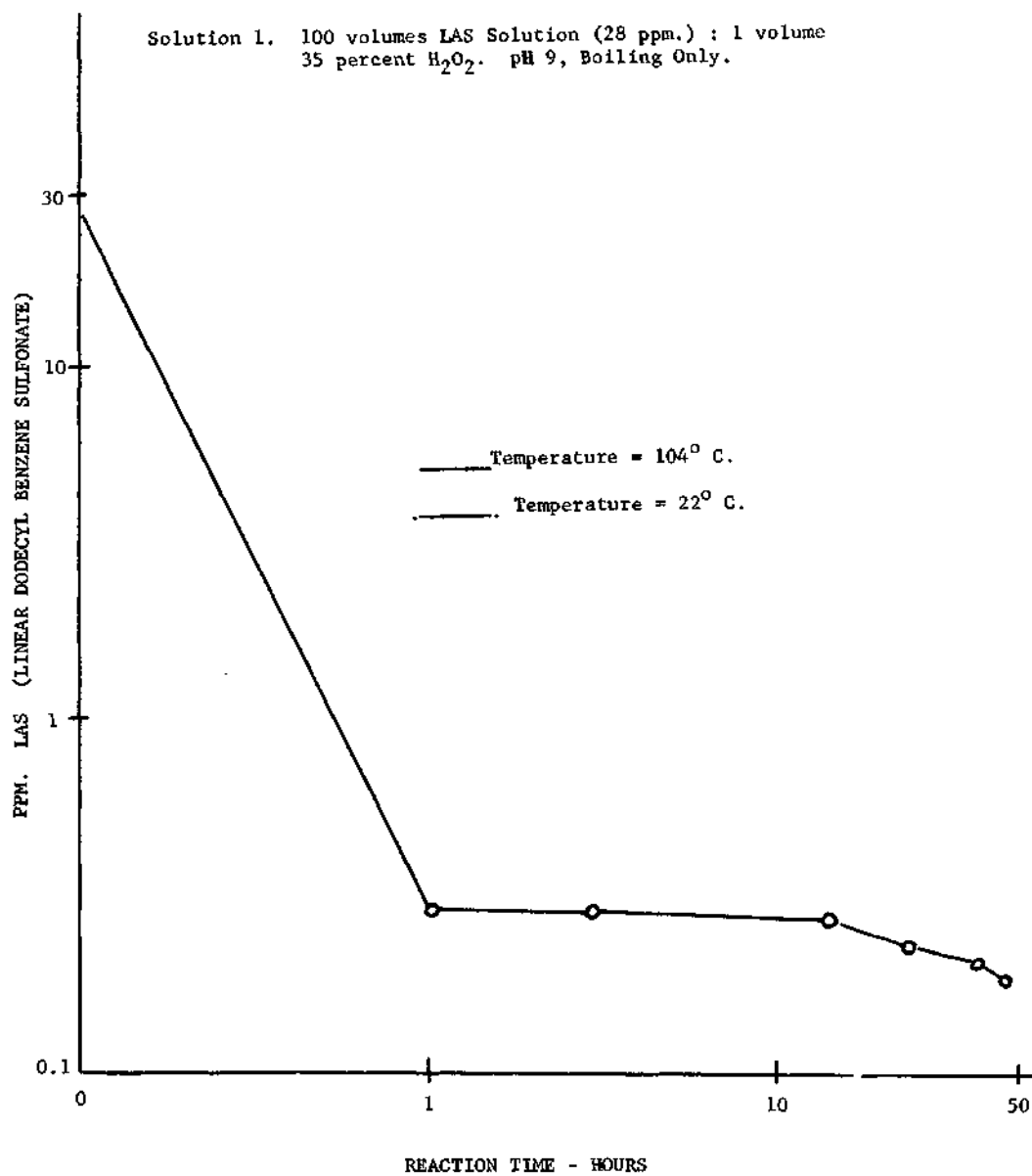
Figure 1. Chemical Degradation of Solution 1.

Solution 2. 100 volumes LAS Solution (28 ppm.) : 1 volume
35 percent H_2O_2. pH 9, Boiling and 12 Hours UV.

PPM LAS (LINEAR DODECYL BENZENE SULFONATE)

Temperature = 104° C.

Temperature = 22° C.
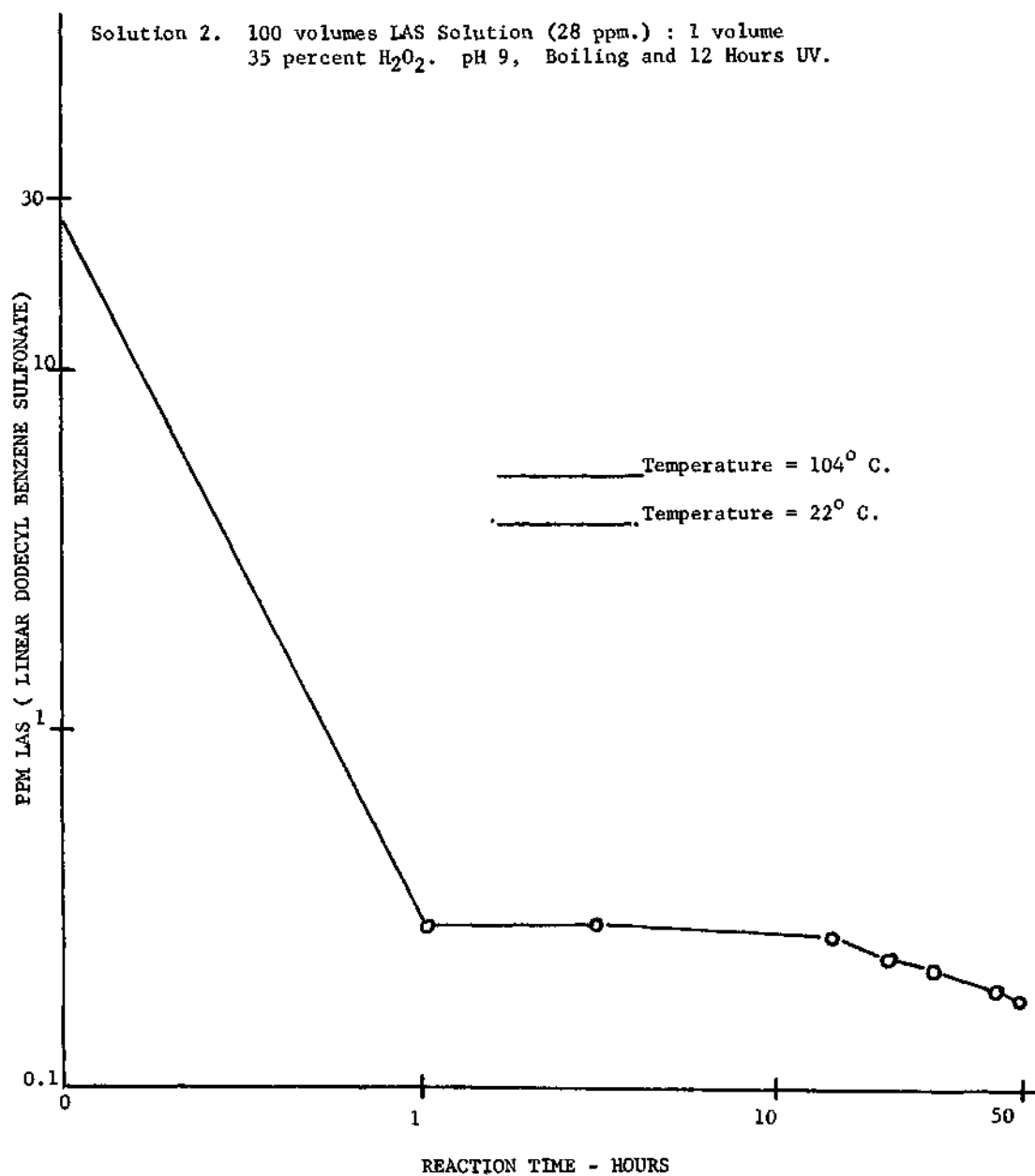
REACTION TIME - HOURS
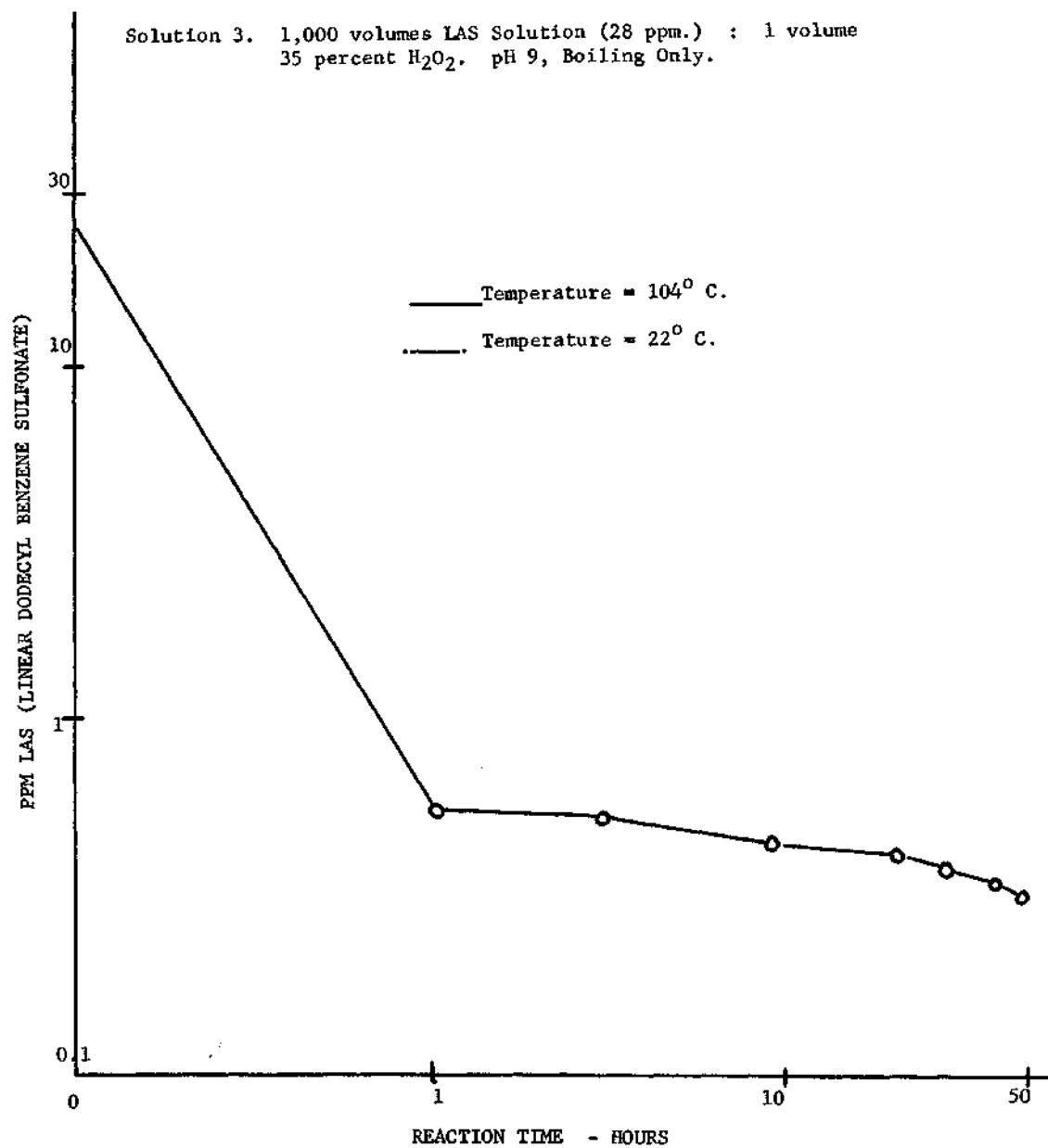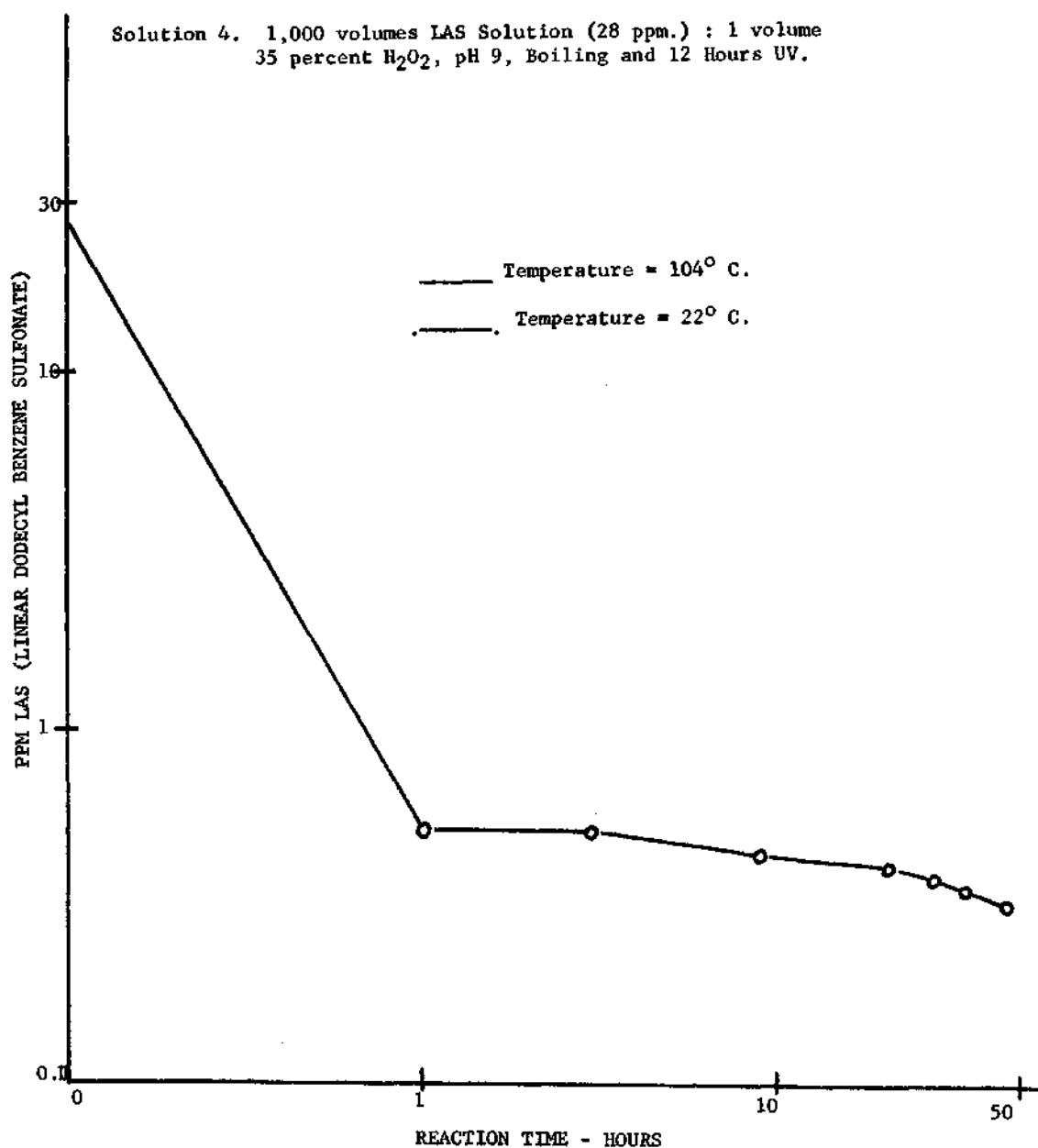
Figure 2. Chemical Degradation of Solution 2.

Figure 3. Chemical Degradation of Solution 3.
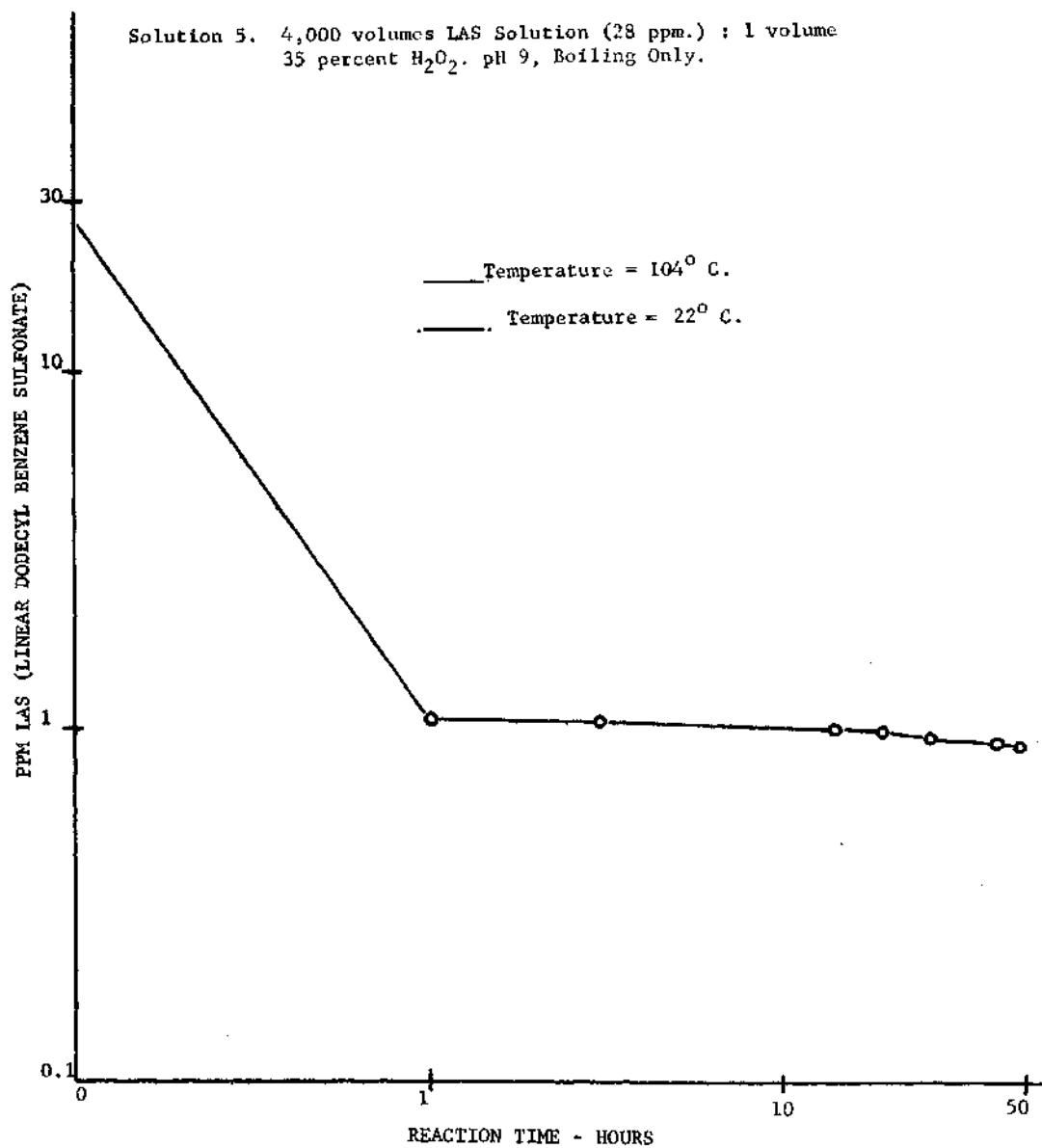
Figure 4. Chemical Degradation of Solution 4.

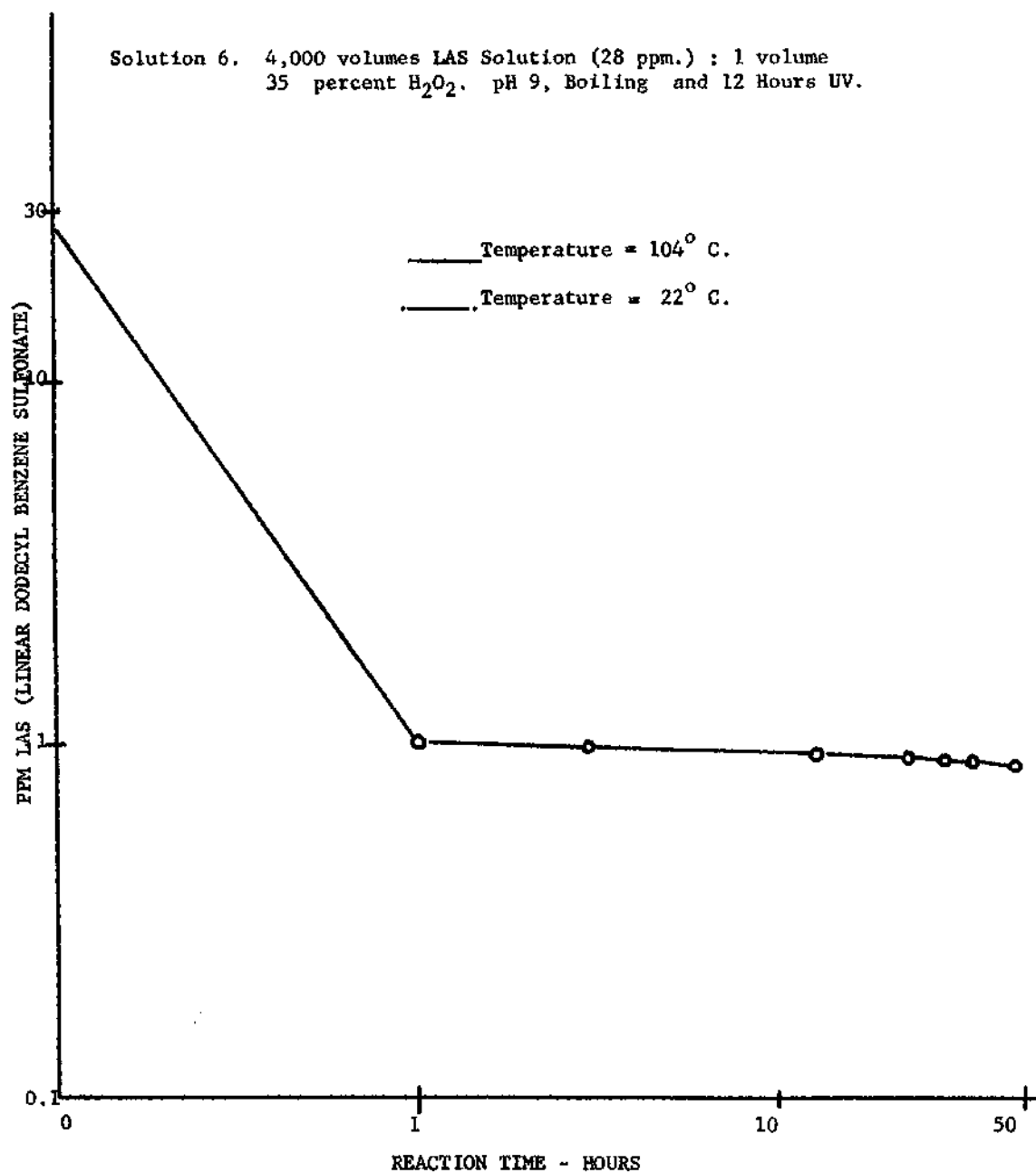Figure 5. Chemical Degradation of Solution 5.

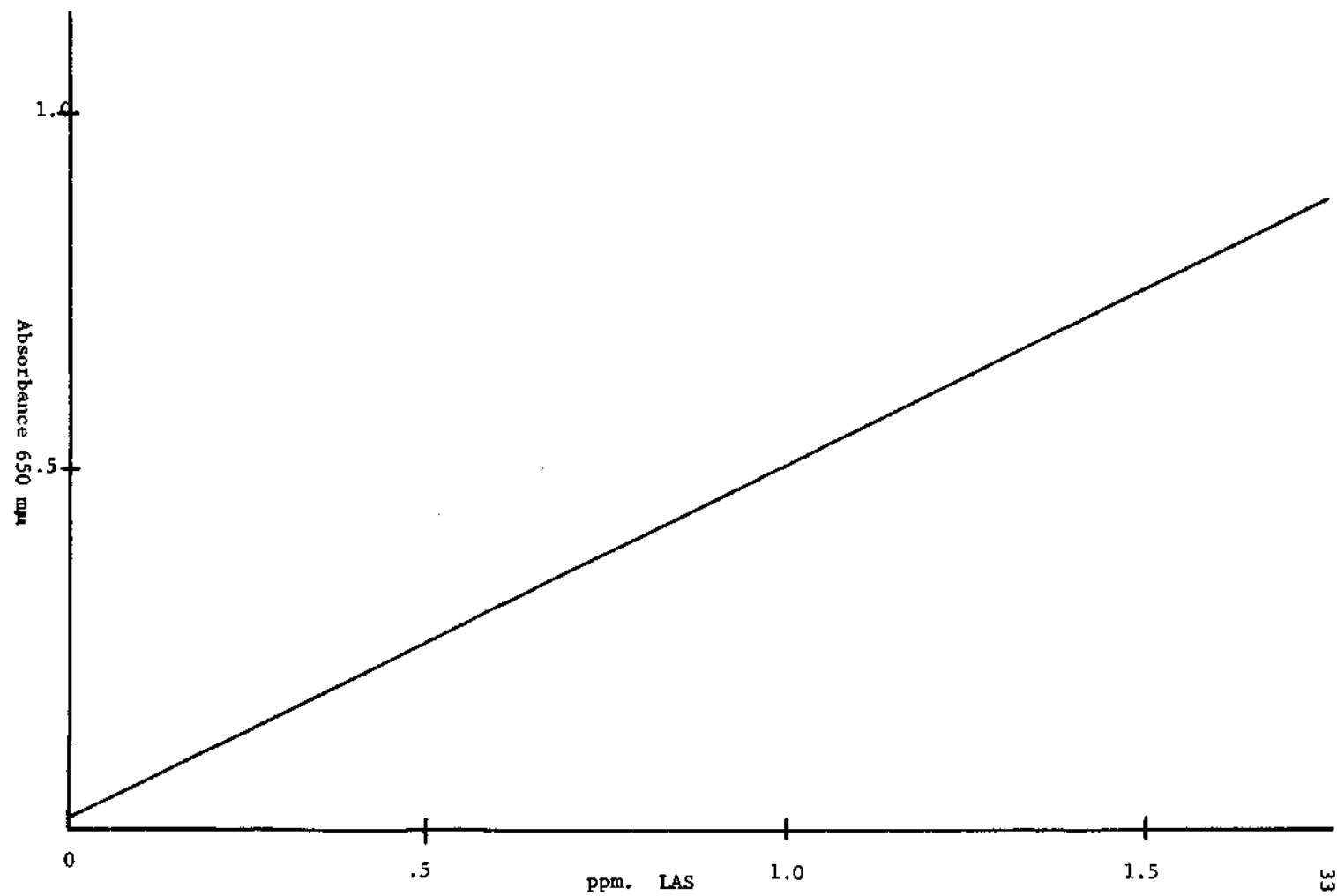Figure 6. Chemical Degradation of Solution 6.

Figure 7. Standard LAS Reference Curve

BIBLIOGRAPHY

REFERENCES CITED

1. Rubinfeld, J. and Cross, H.D., "New Trends in Synthetic Detergents", Soap and Chemical Specialties, March 1967, p. 41.

2. Graham, Frank, Disaster by Default, M. Evans and Co., Inc., New York, 1966, pps. 157-164.

3. Lockwood, J.C., "The Detergent Industry and Clean Waters", Soap and Chemical Specialties, December 1965, pps. 67-70.

4. Swisher, R.D., "Straight Chain ABS Biodegration", Soap and Chemical Specialties, August 1963, p. 60.

5. Perlman, J.L., "Detergent Biodegradability", Soap and Chemical Specialties, September 1963, pps. 68-70, 206.

6. Booman, K.A., Dupre, J., and Lashen, E.S., "Biodegradable Surfactants for the Textile Industry", American Dyestuff Reporter, January 30, 1967, pps. 30-32.

7. Swisher, R.D., "Chemical Mechanism of Straight Chain ABS Biodegradation", Soap and Chemical Specialties, July 1963, pps. 47-50, 95.

8. Shansky, A., "Soap and Syndet Foam Evaluation", Soap and Chemical Specialties, April 1964, pps. 57-61.

9. Schwartz, A.M. and Perry, J., Surface Active Agents, Interscience Publishers, Inc., 1949, pps. 328-329.

10. Shansky, A., op. cit., p. 59.

11. Abbot, D.C., "The Colorimetric Determination of Anionic Surface Active Materials in Water", The Analyst, April 1962, pps. 286-293.

12. Anonymous, "Biodegradable Detergents by 1965", Soap and Chemical Specialties, July 1963, p. 44.

OTHER REFERENCES

Anonymous, "A Clearer Look at Water", Monsanto Magazine,
October 1963, pps. 1-5.

Anonymous, "How to Treat Textile Wastes", Wastes Engineering,
April 1961, pps. 188-189.

Cook, H.E.B., "Surface Active Agents Market", Soap and Chemical
Specialties, March 1964, pps. 67-70, 128.

Foster, D.J., and Fields, R.F., "Synthetic Detergents Based on LAS",
Soap and Chemical Specialties, August 1964, pps. 49-52.

Masselli, J.W. and Burford, G., "Pollution Reduction Program for
the Textile Industry", Sewage and Industrial Wastes, Volume 28,
pps. 1223-1243, 1956.

McKinney, R.E., "Syndets and Waste Disposal", Sewage and Industrial
Wastes, Volume 29, pps. 654-666, 1957.

Sawyer, C.N., "Effects off Synthetic Detergents on Sewage Treatment
Processes", Sewage and Industrial Wastes, Volume 30, pps. 757-775,1958.

Souther, R.H. and Alspaugh, T.A., "Textile Wastes-Recovery and Treat-
ment", Sewage and Industrial Wastes, Volume 29, pps. 918-935, 1957.