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STUDIES OF REACTION GEOMETRY IN OXIDATION AND REDUCTION OF THE ALKALINE SILVER ELECTRODE

EIGHTH QUARTERLY REPORT

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ABSTRACT

A model pore electrode of a new and larger design was constructed to facilitate the correlation of observed electrode phenomena with the corresponding section of the constant-current oxidation curve. Alternate dark and light bands have been observed at the same time potential oscillations were being recorded. These phenomena are discussed in terms of the theoretical oxide growth pattern proposed in the previous report.[2] Qualitative descriptions of some other electrode phenomena are also given.

Charge acceptance measurements were made for a series of potentiostatic oxidations of a silver wire electrode by three different methods: (1) Simpson's Rule of Thirds, (2) the graphical cut and weigh method, (3) subsequent reduction at constant current. The results are compared and the problems observed are discussed. The same wire electrode was taken through thirty-five oxidation-reduction cycles. The increase of charge acceptance (at potentials 0.3 - 0.4 v.) from about 150 mcoul/cm^2 reported previously[6] when a new wire was used for each run to about 330 mcoul/cm^2 reported here probably reflects the increase in surface area of the electrode with cycling.

Some preliminary experiments on the manner in which a short oxidation at one potential influences subsequent charge acceptance at a different potential are presented.

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SECTION I

OXIDATION OF MODEL PORE ELECTRODES

Introduction

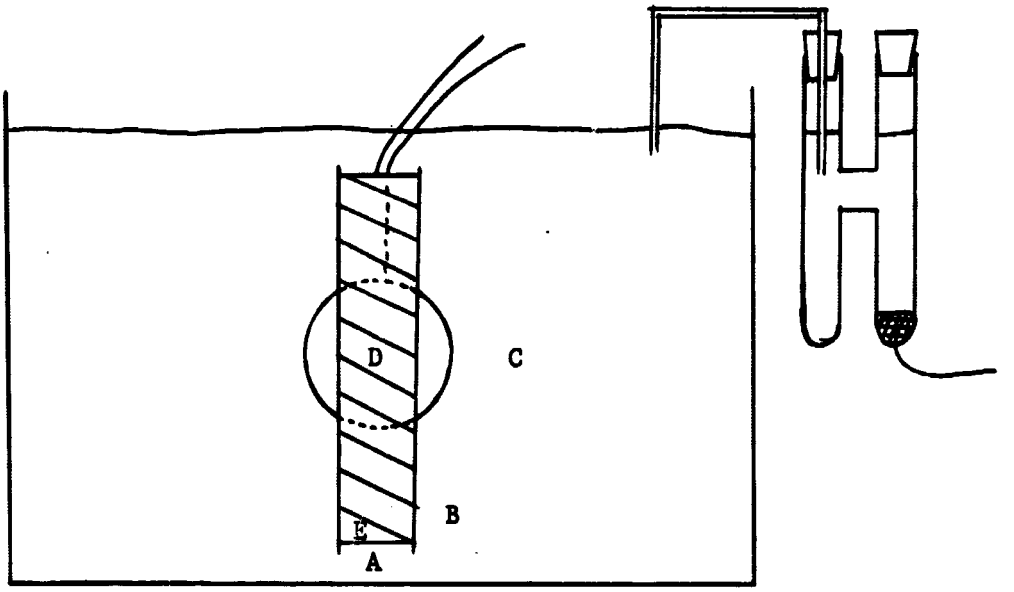
Our previous work with model pore electrodes has involved circular and hexagonal holder designs, flowing and stationary electrolyte, and electrodes composed of seven to nineteen wires.[1,2]

In both of the previous designs the small diameters of the wires made the detailed observation of oxide growth very difficult. During this report period we have employed a model electrode of a third design which has larger dimensions. As before, the electrode was oxidized and reduced at various constant currents.

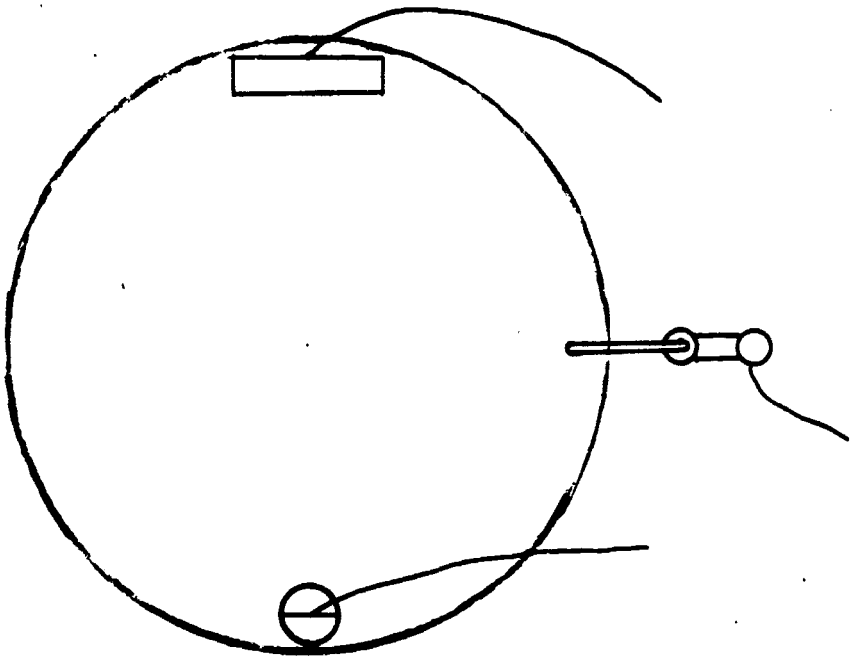
Experimental

The experimental apparatus is illustrated in Figure 1. The electrode (A) was a 0.10 mm thick strip of silver, 110 mm long and 18 mm wide. The strip was fitted tightly into a glass tube (B) (I.D. = 18 mm) of equal length. The electrode was immersed in the KOH electrolyte and positioned as shown in Figure 1. The cylindrical platinum counter electrode was positioned at the back of the container. The Hg/HgO reference electrode was placed in the right hand side of the container midway between the other two electrodes.

The following experimental procedure was used. The KOH electrolyte was prepared from 45% KOH solution (Baker Chem. Co.) analyzed by the supplier to be 0.01% in K_2CO_3. The electrolyte was flushed with pure nitrogen gas and placed in the container. The electrode was then oxidized and reduced at constant currents ranging from 10 to 240 ma. In any cycle the reducing current was equal to the oxidizing current. Subsequently, the electrolyte was replaced by that of a different concentration. The electrode was again cycled at the constant currents mentioned. The procedure was repeated for



Front View
(a)



Top View
(b)

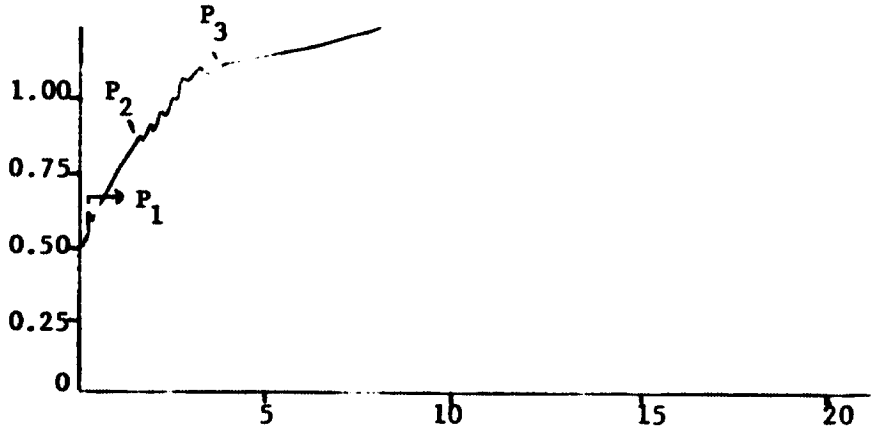
Figure 1. Oxidation Apparatus

KOH molar concentrations of 0.1, 0.2, 0.3, 0.4, 0.5, 1.0, 5.0, and 11.5. The growth of the oxides in the pore was followed with the aid of a cathetometer. A total of over 200 oxidation-reduction cycles were made in these experiments.

Results and Discussion

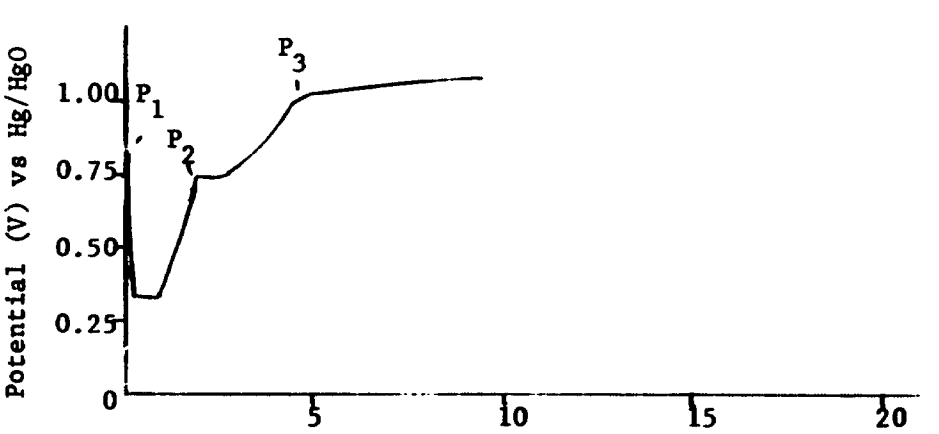
Representative constant current oxidation curves are illustrated in Figure 2. Points P_1 through P_3 are labeled for easy reference in the following discussion. The "oscillations" recorded between P_2 and P_3 were present in each oxidation, though their number and magnitude varied with changes in applied current and KOH concentration. Changes were also observed in the first few cycles after the electrode had relaxed for three hours or more. Descriptive data on these changes are recorded in Table I. The "I, P, F and T" stand for inflection, plateau, full oscillation, and total. These types of curvatures are illustrated in Figure 3. As Table I indicates, the total number of oscillations increased through the first 3-4 oxidations. At the same time, the oscillations became more pronounced; i.e. inflections developed into plateaus, plateaus developed into full oscillations, and full oscillations increased in amplitude.

In the previous report we suggested a nucleation model for the oxide growth that fit the appearance of the oscillations.[2] We have applied this model more precisely since for the first time in our model pore work we were able to observe a physical change on the electrode that corresponded with the oscillations. The change was observable without the cathetometer, and consisted of the appearance of horizontal bands on the electrode, alternately dark gray and light gray. The greater the amplitude of an oscillation, the more pronounced was the band; the longer the period of oscillation, the wider was the band. The growth of the dark band occurred at the same time



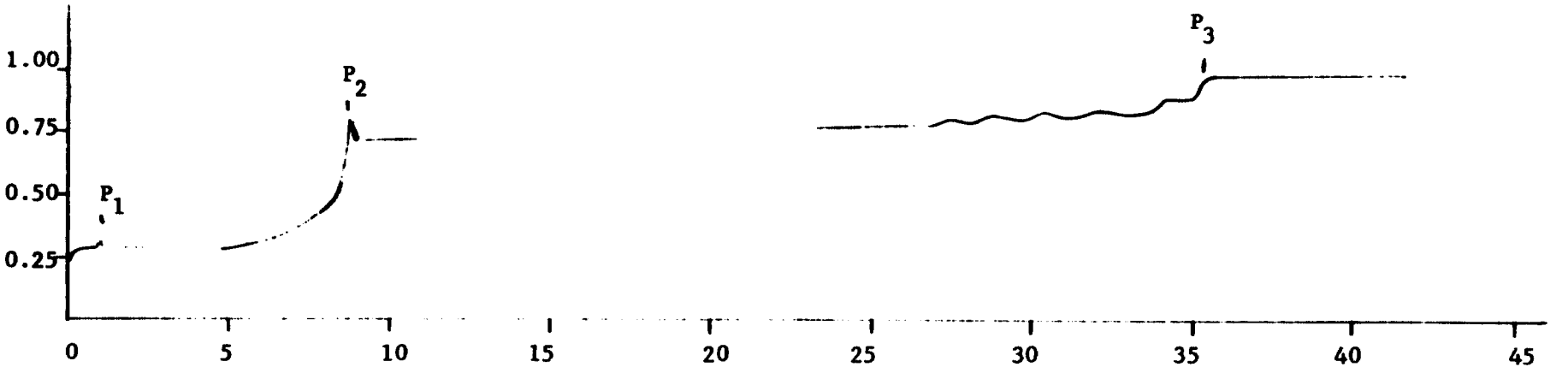
$[OH^-]$ = 0.4 Current = 50 ma

(a)



$[OH^-]$ = 11.5 Current = 95 ma

(b)



$[OH^-]$ = 5.0 Current = 30 ma

(c)

Figure 2. Representative Oxidation Curves

TABLE I

Oxidation Runs on a Relaxed Electrode

Run Number (Relative to Relaxation time)

CHARTS / i / [OH⁻]	1				2				3				4			
	I	P	F	T	I	P	F	T	I	P	F	T	I	P	F	T
55-58 / 50 / 0.3	1	8	2	11	1	5	5	11	1	6	5	12	1	5	6	12
69-71 / 50 / 0.4	0	3	4	7	1	2	5	8	1	2	6	9				
73,75,87 / 50 / 0.4	1	1	5	7	1	2	5	8	0	2	7	9				
79-82 / 65 / 0.4	1	8	0	9	1	7	4	12	1	6	5	12	1	7	4	12

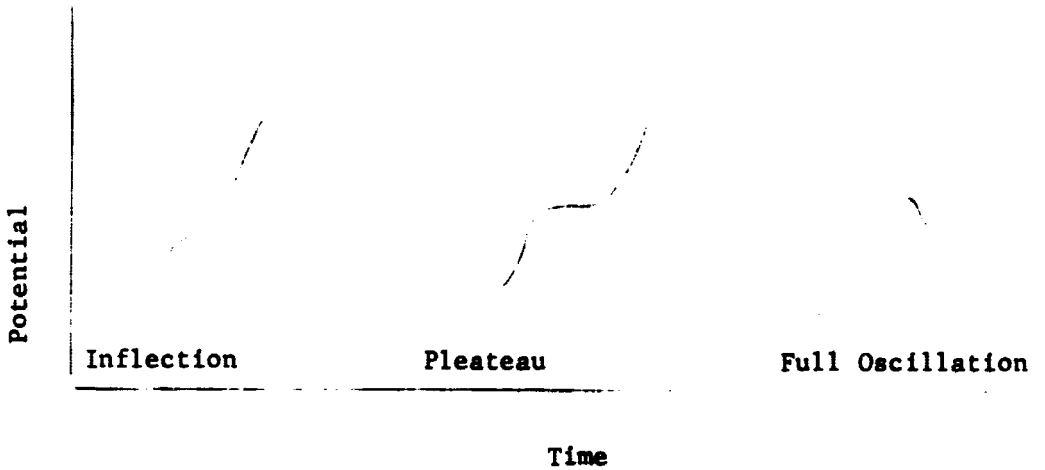


Figure 3. Representative Curvatures

that the potential was rising to the oscillation peak, while the light gray formed as the potential descended to the oscillation valley.

This observation of the correlation of the band development and the potential fluctuations is not incompatible with the model proposed by Thirsk and discussed in the preceding report,[2] in which a critical overpotential is required for initiation of the $Ag_2O \rightarrow AgO$ process. Consider two regions D and E along the electrode of Figure 1. If at D, deep in the pore, metallic silver is being oxidized to Ag_2O, then at E the potential will of necessity be at a higher value because of the iR drop in the solution. The oxide front at D progresses into the pore as current flows and there is a consequent increase in the potential at E. If a critical overpotential is required for AgO nucleation, then when this overpotential is reached nucleation occurs and reaction can begin at E around those sites where nucleation occurred. If the potential required to cause AgO growth is lower than that for nucleation, there should be two observations: 1) the observed potential is lowered and 2) the current flowing to D is decreased since now a significant fraction of the current is effective at E. This process of potential increase until the nucleation overpotential is reached followed by a potential drop while growth occurs would be repetitive until at the mouth of the pore the gassing potential is reached. This is the observed sequence of events.

Theories have been proposed in the literature to describe the concentration changes that occur in a pit or crevice of an electrode undergoing corrosion.[3,4,5] These theories are involved and can be simplified only by making the assumption, as did Vermilyea and Tedmon,[5] that the walls of the crevice are inert. The authors emphasize that a theory describing concentrations in the pore of an electrode undergoing oxide film formation rather than corrosion would be much more complex.

In Table I we showed how the oscillations changed in a series of runs on a relaxed electrode (one that had rested for 3 hours or more). Table II gives descriptions of oscillations produced during oxidation runs at various currents and electrolyte concentrations. The data for the curves obtained in 11.5 N KOH were omitted because there were few oscillations. Most of the curves were of the shape illustrated in Figure 2b. It is interesting to note that at 0.1 N KOH and 5.0 N KOH the total number of oscillations is small and constant. At the other concentrations the number of oscillations increases with increasing current to a maximum, past which the number decreases with increasing current. Another trend can be observed by looking at the effect of $[OH^-]$ changes on the oscillations in runs made at the same current. At low concentrations the oscillations are primarily inflections and plateaus. As the concentration is increased they develop into full oscillations. Another "maximum" in the total number of oscillations is observed in going across a current row.

A first effect to be expected from a concentration increase is a decrease in the resistance of the solution, which would result in a greater distance between the regions D and E of Figure 1, where D is the region of band formation and E the region of AgO nucleation. A pronounced mechanism effect could also result from the concentration change. The present data do not provide conclusive evidence as to why the nature of the potential fluctuations changes with concentration. The future work section contains proposals for augmenting the information.

As mentioned earlier, some full oscillations had greater amplitude than others. It was also noticed that the position of the oscillation of greatest amplitude in the total number of oscillations varied with current and electrolyte concentration. These data are recorded in Table III. The amplitude is measured in millivolts, while the position of the peak with

Table II

Description of Oscillations Occurring in Oxidation Runs at Various Currents and Electrolyte Concentrations

i	[OH⁻]																											
	0.1				0.2				0.3				0.4				0.5				0.6				0.7			
(ma)	I	P	F	T	I	P	F	T	I	P	F	T	I	P	F	T	I	P	F	T	I	P	F	T	I	P	F	T
10					0	0	2	2	0	0	2	2	0	0	2	2												
20	2	0	0	2	0	1	4	5	0	0	3	3	0	0	2	2	0	0	2	2	0	1	1	2				
30	2	0	0	2	1	3	4	8	1	2	3	6	0	1	3	4	0	0	2	2	0	1	2	3	0	2	6	8
50	2	0	0	2	3	4	0	7	1	5	6	12	0	2	7	9	0	2	4	6	0	1	2	3	0	1	2	3
65	2	0	0	2	6	5	1	12	1	9	4	14	1	4	6	11	1	1	6	8	0	1	3	4	0	0	2	2
80	2	0	0	2	7	0	0	7	3	7	0	10	2	11	0	13	2	2	7	11	0	2	3	5	0	0	3	3
95													3	0	0	3	3	10	0	13	0	2	4	6	0	2	1	3
110																	2	2	0	4	1	1	5	7	0	2	2	4
125																					1	1	6	8	0	2	2	4
140																					1	3	5	9	0	2	2	4
155																					6	6	0	12	1	1	2	4
170																									1	0	3	4
185																									1	1	2	4
200																									1	0	3	4
215																									0	2	2	4
230																									1	3	0	4
245																									1	4	0	5

Table III

Largest Difference (in mV) between a Peak and the Previous Valley

	[OH^-]													
	0.1		0.2		0.3		0.4		0.5		1.0		5.0	
i	Pot.	No.	Pot.	No.	Pot.	No.	Pot.	No.	Pot.	No.	Pot.	No.	Pot.	No.
10	—	—	98	2/2	95	2/2	—	—	—	—	—	—	—	—
20	—	—	90	5/6	119	3/3	108	2/2	114	2/2	—	—	—	—
30	—	—	34	6/8	93	6/7	108	4/5	79	2/3	87	2/3	24	7/9
50	—	—	—	—	45	6/12	40	8/9	90	6/7	116	3/4	69	2/4
65	—	—	—	—	42	3/4	42	7/12	74	7/9	143	5/5	79	2/2
80	—	—	—	—	—	—	37	5/12	58	7/11	138	6/6	135	2/2
95							—	—	—	—	135	6/7	108	2/2
110									—	—	135	7/8	93	3/3
125											111	7/9	58	3/3
140											98	8/11	50	3/3
155											—	—	127	4/4
170													108	4/4
185													106	4/4
200													103	4/4
215													90	4/4
230													—	—
245													—	—

— = No Full Oscillations

N/T, T = The number of the oscillation of maximum difference

N = Total number of inflections, plateaus, and full oscillations

respect to the total number of oscillations is shown by the ratio N/T. One trend observed here is that in the oxidations at the lowest currents and in the oxidations at the highest concentration ($[OH^-] = 5.0$), the fullest oscillation is the last one to appear. As one moves across a current row a maximum potential difference is observed. The position of this maximum in the row shifts to the right as one moves down to the rows of higher current.

Current changes, like concentration changes, alter the iR drop in the pore and are expected to alter the distance between the regions D and E of Figure 1. Here too, there is the possibility of a mechanism change; additional data are needed to clarify the reasons for the observed modifications in the potential fluctuations.

The plateau illustrated between P_1 and P_2 of Figure 2 was present in every oxidation. In Figure 4 the potential of this plateau is plotted against the applied constant current. Each electrolyte concentration is represented by its labeled curve. It will be noticed that the curves are found in descending order on the plot corresponding to increasing $[OH^-]$. There is also a decreasing slope observed with increasing $[OH^-]$.

The following part of this discussion is a number of qualitative observations.

Preferential Growth. As shown in Figure 1a the electrode was positioned such that the distance between the top of the electrode and the electrolyte level was equal to the distance between the bottom of the electrode and the bottom of the container. This was done to provide equivalent current paths to both ends of the electrode. When this condition is not met, preferential growth is observed at the end of the electrode having the shortest current path to the counter electrode. However, there still seems to be preferential growth from the bottom of the electrode even when the current paths are equidistant. This effect is more noticeable at the lower electrolyte concentrations.

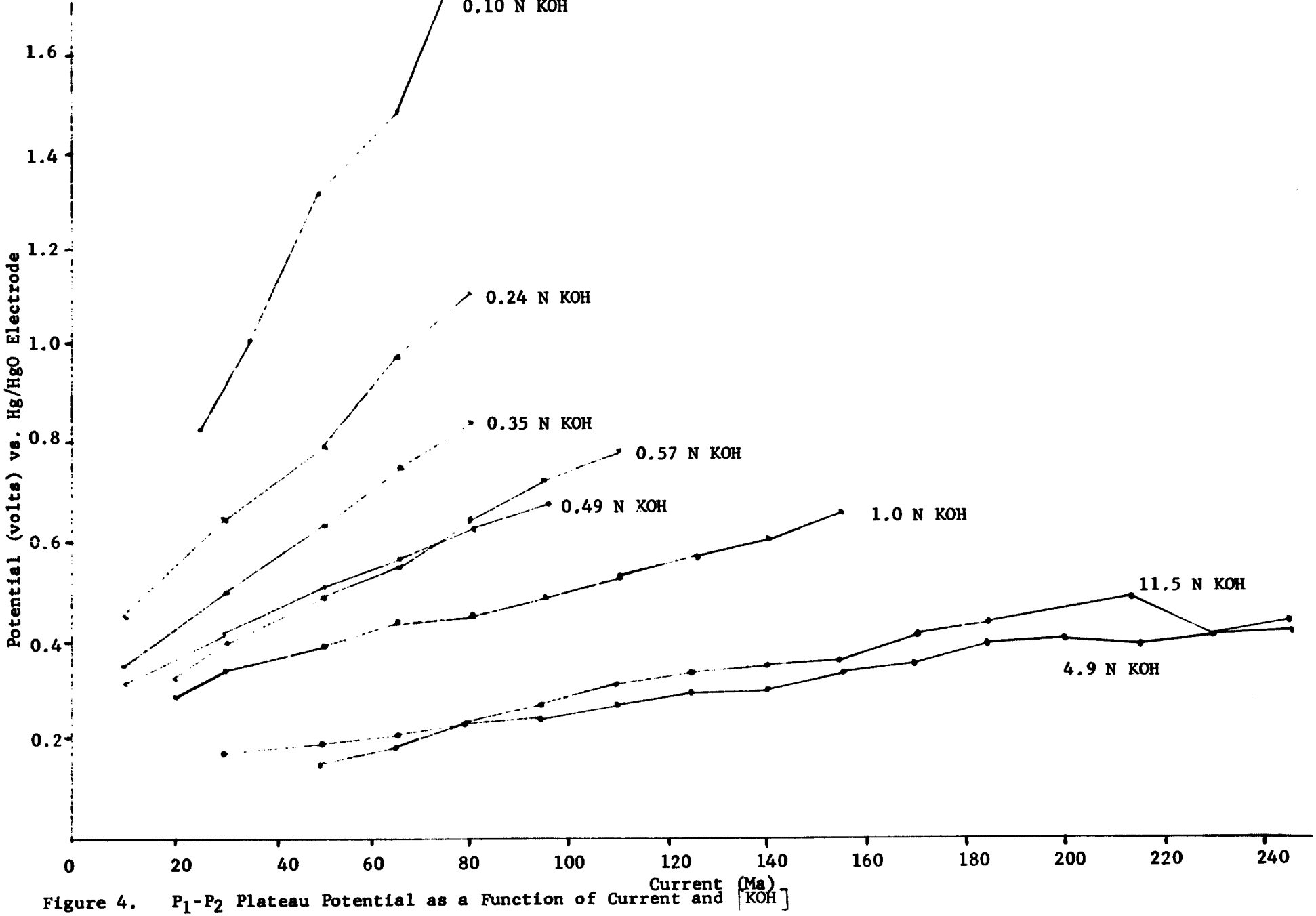


Figure 4. P_1-P_2 Plateau Potential as a Function of Current and $[KOH]$

Electrolyte Depletion. When the electrolyte near the faces of the electrode was stirred during an oxidation, the potential dropped by approximately 0.02 v.

Initial Peak. This peak is designated P_1 in Figure 2. When a relaxed electrode is first oxidized the peak appears in the position shown in 2b. On the next cycle it has moved up the curve to the position shown in 2a. The peak and the plateau that follows it become smaller as they progress up the curve. By the fourth oxidation the peak has reached a fairly permanent position at about 25 seconds on the time scale.

Shape of Oxidation Curve. At very low currents (10-30 ma) in dilute electrolyte and at most of the currents in concentrated electrolyte (11.5 N KOH) the oxidation curve had the shape one usually obtains in the oxidation of exposed wires and sheets at constant current. This is probably caused by the decreased iR drop in both circumstances. An illustration of this curve is Figure 2c.

Oxidation. During an oxidation at high currents where the chart records no full oscillations, the oxidation of the Ag_2O to AgO can be followed because the appearance of the AgO is preceded by a thin dark band. It has the same appearance as the dark gray band observed during oscillations, but differs from it in that it is constantly present and moving during the oxidation.

Bands. The bands observed to form during oxidation accompanied by oscillations remain there during reduction and can still be distinguished on the reduced electrode. The bands retain their dimensions and position during cycling, changing only when a different current is applied. Possibly the different crystal structures of AgO reduce to different crystal structures of elemental silver.

Electrolyte. The 5.0 N and 11.5 N KOH solutions were viscous enough to prevent the rapid escape of the H_2 and O_2 formed during the cycling. Most of the bubbles were suspended in the top half of the electrolyte.

Future work on this electrode will involve cycling over the same range of constant currents and electrolyte concentrations, but with the electrode in a different configuration. The working electrode will be in the same position in the container but will be moved up so that the top 1 mm of the electrode is above the electrolyte. Thus the electrode will be oxidized at one end only. Luggin capillaries will be placed close to the electrode surface at the mouth of the electrode, and at points 1/3 and 1/2 the distance up the pore, to follow the potential at these points during the oxidation.

SECTION II

CHARGE ACCEPTANCE OF SILVER ELECTRODES

Introduction

In our efforts to measure precisely the charge acceptance of the silver electrode under potentiostatic conditions some problems have been encountered. Of an instrumental nature are the problems of measuring the rapid rise of current to a peak value, followed by the rapid drop of current to an intermediate value which then decreases much more slowly, and of measuring the much smaller current during the long time before reaching the background current. Of an electrochemical nature is the problem of controlling surface characteristics of an electrode so that reproducible measurements of current can be made. If the rate of change of current during the first few seconds of a potentiostatic oxidation is so great that the recorder lags behind, some errors are introduced into the integration of current. If a low level of faradaic current continues for a long time before the background current is reached questions arise concerning the significance of this component of charge to the overall charge acceptance. If the surface characteristics of an electrode depend markedly on the previous history of the electrode and these in turn markedly influence the rate of charge acceptance, some difficulty will be encountered in making reproducible measurements. The results of the potentiostatic oxidations which are discussed in this section give experimental evidence of these problems.

An adequate understanding of these problems seems necessary as we design and conduct experimental work to answer the following question. Can a

particular surface effect be produced at one potential which will then control or determine the subsequent reactions when the electrode is subjected to a potential different from the initial one? Thirsk, Fleischmann and Lax have suggested that a randomly-oriented crystalline oxide layer is formed initially on potentiostatically oxidized silver.[8] If this basal layer is characteristic of the potential at which it is formed it may influence the final charge acceptance of the electrode as well as the time required to oxidize the electrode. Some preliminary results are presented concerning this interpretation.

Experimental

A cell was constructed as shown in Figure 5, which isolates the electrolyte from the CO_2 in the air and retains the uniform current density afforded by concentric electrodes. The silver wire is held in the top of the cell by a brass set screw which also makes the electrical contact. The electrode can be positioned very accurately because the lid of the cell holds the top of the wire in the center of the cell. The bottom end of the wire can be positioned in the center of the opening to the reference electrode which is in the bottom center of the cell. The cell design eliminates IR drop between the anode and the reference electrode by locating the opening of the reference electrode very close to the end of the anode and concentric with the wire.

The equipment used for the oxidation of the electrode and the measurement of the current is shown in Figure 6. The potentiostat is an Analog Devices Model 119A 20ma operational amplifier. The current through the cell is measured by amplifying the voltage across a 10 ohm precision resistor by a factor of 100 and recording the resulting signal on a Varian multi-

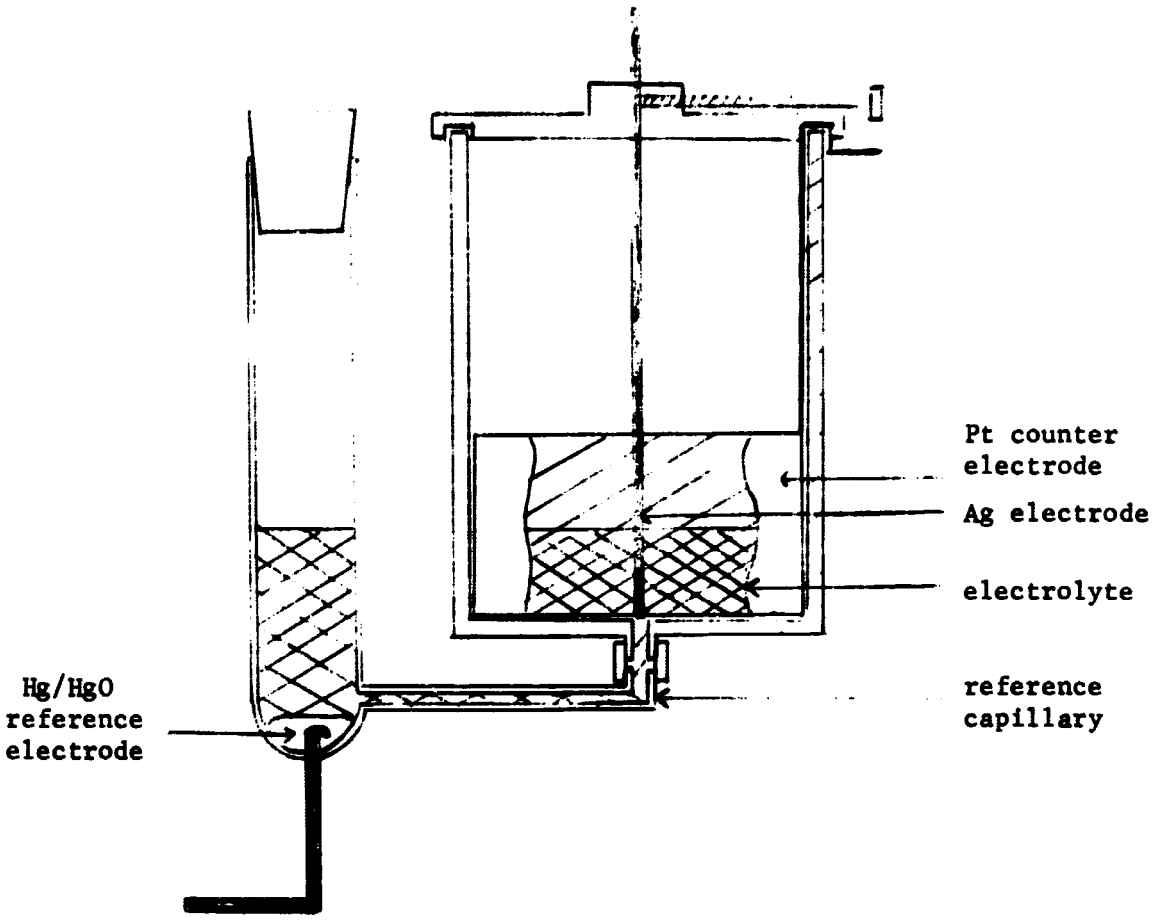


Figure 5. Cross sectional view of cell used in study of potentiostatic oxidation of silver.

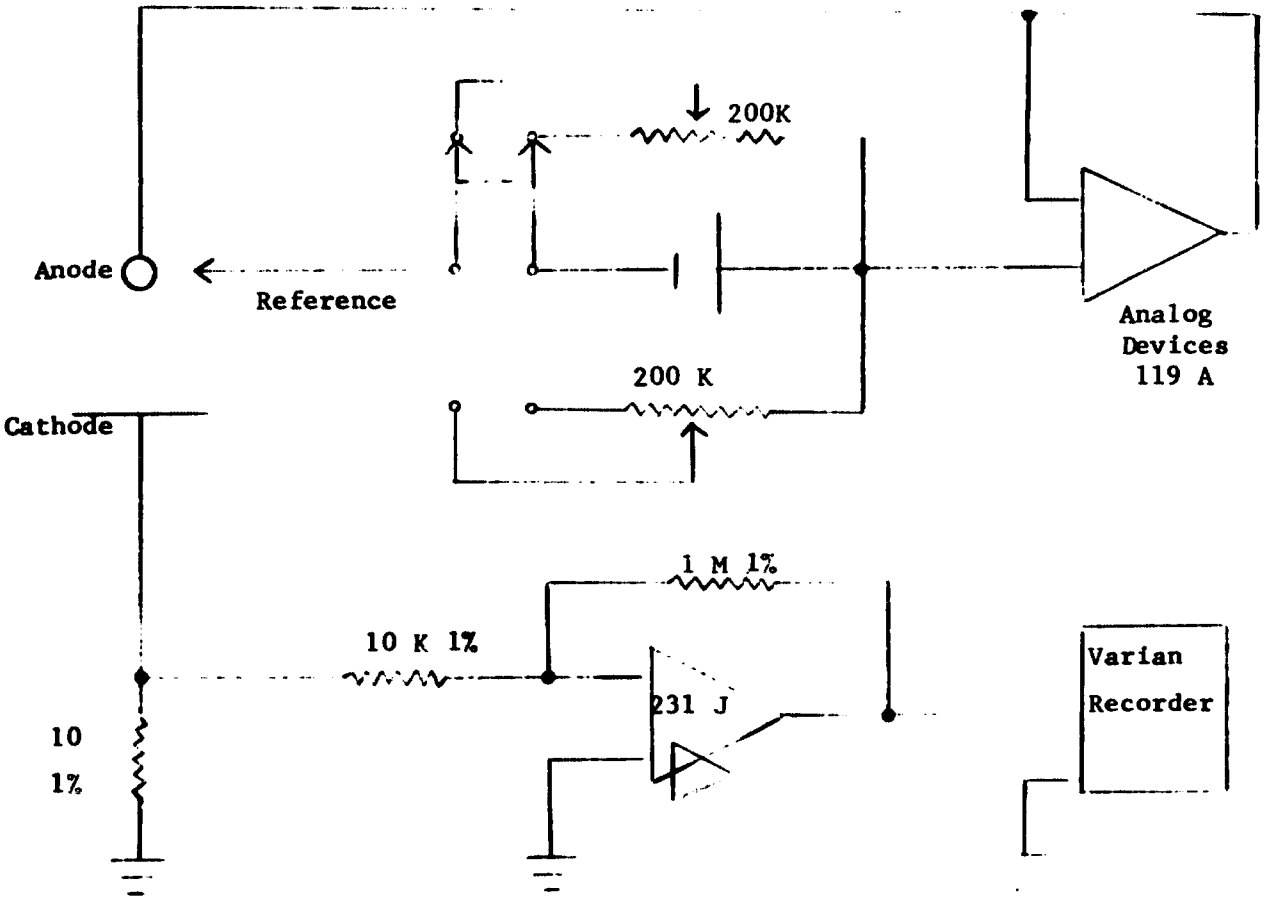


Figure 6. Dual potential potentiostat used in fixed potential and step potential oxidations of silver. The gain of 100 current measuring circuit is included.

range strip chart recorder. An Analog Devices Model 231J chopper-stabilized operational amplifier is used in a gain-of-100 amplifier configuration in order to accurately record signals as small as 0.1 microvolt using a 10 mv recorder. The oxidations were made in 0.100M KOH and were stopped when the current fell to 5.0 μamps (about 33 μamps/cm^2.) The electrode (0.010 inch silver wire) was immediately reduced at a constant current of 0.100 ma to the evolution of hydrogen. The time required for constant current reduction was used as a measure of total charge on the electrode. The record of oxidizing current vs. time was also analyzed by numerical integration using Simpson's Rule of Thirds and by the graphical cut and weigh method.

The potentiostat was constructed with two potential sources, V_1, and V_2, as shown in Figure 6. A switch selects which potential will be used to oxidize the electrode. The potential step experiments were made by starting the oxidation at one potential and switching to the other potential when the current had dropped to 1.0 ma (about 5 seconds after the start of the run.)

Results and Discussion

Potentiostatic oxidations of individual electrodes (discussed in previous reports)[6] which were continued until a steady background current of about 1.5 μa/cm^2 was reached required from four to thirty hours. However, the oxidations reported here in Tables IV and V were continued until a current of 5 μa (about 33 μa/cm^2) was reached, thus reducing the time required for oxidation to less than an hour at the potentials indicated. Another change from the procedure previously reported was the use of the same electrode taken through many oxidation-reduction cycles rather than the use of a new electrode for each run.

Cycling of the Electrode. Results for a series of runs made potentiostatically at 0.28 v. (vs Hg/HgO) are given in Table IV. Before the first run given in this table the electrode had been oxidized at 0.36 v through seven cycles. The first run required 12.4 minutes to reach the current of 5 μa with charge acceptances of 67.7, 50.2 and 41.7 mcoul/cm^2 given by the three methods discussed earlier. The second and third runs show a decrease in time and a decrease in charge acceptance. The trend continues with cycling but levels to approximately 1.0 minute with charge acceptances of 17, 6, and 3 mcoul/cm^2. These data show: (1) that some structural feature established at the potential 0.36 v. persists and is changed only gradually with cycling at 0.28 v; (2) that the three methods for determining charge acceptance are not in good agreement; and (3) that at the potential 0.28 v. where the charge acceptance is rather small, the electrode is particularly sensitive to its previous history.

Potentiostatic oxidations at four potentials are summarized and compared in Table V. The order given is the order in which the runs were made. Two sets of runs were made at 0.36 volts. The difference in the charge acceptance (272, 326 μcoul/cm^2) probably reflects the increase in surface area of the electrode with the 25 oxidation-reduction cycles in between these two sets of runs. The trends observed at 0.32, 0.36, and 0.40 volts were not as striking as that observed at 0.28 v. After the first run at each of these higher potentials the charge acceptance became reasonably uniform. The standard deviation was computed without the first run in each case. However, at 0.28 volts only the last six of the ten runs were used in calculating the standard deviation.

The values of charge acceptance noted here are higher than previously reported.[6] In the range 0.30 v. to 0.40 v. values of charge acceptance up to 150 mcoul/cm^2 were observed. The values up to 330 mcoul/cm^2 noted here are probably due to the surface increase through cycling.

TABLE IV

The time required for oxidation and the charge acceptance as measured by Simpson's Rule, cut and weigh, and constant current reduction for a potentiostatically oxidized silver wire electrode at 0.28 volt .

CHARGE ACCEPTANCE (mcoul/cm^2)

Run Number	Time (min.)	Simpson's Rule	Cut and weigh	Constant Curre Reductio
1	12.42	67.7	50.2	41.7
2	8.50	48.5	22.0	20.4
3	2.83	25.1	11.9	6.7
4	3.00	25.7	12.9	7.5
5	1.80	22.2	7.7	4.3
6	1.92	20.6	8.4	3.9
7	1.48	18.9	6.7	3.5
8	0.90	17.5	6.6	3.1
9	1.00	17.2	5.6	3.1
10	0.88	16.5	4.4	2.8

TABLE V

The time required for oxidation and the charge acceptance as measured by Simpson's Rule, cut and weigh, and constant current reduction for a potentiostatically oxidized silver wire electrode at four potentials.

CHARGE ACCEPTANCE (ma/cm^2)

Potential	Number of runs	Time (min.)	% s.d.	Simpson's Rule	% s.d.	Cut and Weigh	% s.d.	Constant Current Reduction	% s.d.
0.360 v.	6 (7)	14.1	9.2	304.7	3.1	271.6	3.1	234.0	3.7
0.400	4 (5)	20.9	4.8	315.2	1.5	287.9	6.9	246.0	1.3
0.280	6 (10)	1.3	35.0	18.8	11.7	6.6	21.9	3.5	16.4
0.320	9 (10)	42.5	5.9	350.0	3.5	328.3	7.6	309.5	2.7
0.360	2	12.2		365.8		326.1		312.9	

Methods of Determining Charge Acceptance. In all cases it can be seen that the charge acceptance as measured by Simpson's Rule is the highest, while the charge acceptance as measured by electronic integration and constant current reduction reported in the Fifth Quarterly Report also show the reduction method yielding lower results.[7]

The high values of charge acceptance obtained by applying Simpson's Rule may be caused by the fact that this method of numerical integration breaks down when rapidly changing curves are encountered. In the potentiostatic oxidation of silver the current drops very rapidly during the first 15 seconds. Thus a small error in approximating the shape of the curve during this period of high current could result in a significant error in charge acceptance.

The limited response time of the servo-recorder also causes an error in both the numerical integration and the cut and weigh integration. An initial current peak of 20 ma (which has been accurately measured on an oscilloscope) results in an apparent current peak of only 4 or 5 ma on the servo-recorder. The significance of this error is estimated to be negligibly small because of the short duration of the high current (a 20 ma peak current drops to 5 ma in about 10 msec.)

Oxidations with Potential Step. The charge acceptance at 0.32 volts is approximately the same as at 0.36 volts (and also at 0.40 volts if the change in surface area is taken into account.) The time required for the oxidation, however, is significantly different. Table V shows an average time of 42.5 minutes at 0.36 v. The oxidations at 0.40 v. required an average of 20.9 minutes.

The difference in oxidation times at 0.32 v. and 0.36 v. allows a potential step study to be made. Table VI shows the effect on oxidation

TABLE VI

Comparison of time of oxidation of step potential oxidations with fixed potential oxidations

Potential	Number of Runs	Time (min)	% s.d.	Time / Time at 0.32 v.	Time / Time at 0.36 v.
0.32 v.	9	42.5	5.9		
0.36 v.	2	12.2	2.9		
0.32 v. → 0.36 v.	5	13.3	8.2	0.31	1.09
0.36 v. → 0.32 v.	3	34.6	7.3	0.81	2.84

time and charge acceptance which results from a potential step from 0.32 v. to 0.36 v. and from 0.36 v. to 0.32 v.

The average oxidation time for runs where the potential was changed from 0.32 v. to 0.36 v. is 13.3 minutes which is close to the average of 13.7 minutes for cycles oxidized at a fixed potential of 0.36 v. However, the average oxidation time for runs where the potential was changed from 0.36 v. to 0.32 v. is 34.6 minutes which is intermediate between the 13.7 minute time at 0.36 v. and the 42.5 minute time at 0.32 v. This shows that the few seconds of oxidation at 0.36 v. have an effect on the oxidation of the electrode even after the potential has been changed to 0.32 v. Further investigation is necessary to determine the extent of this effect.

Future Work

Potentiostatic oxidations at other potentials between 0.28 v. and 0.56 v. will be studied to compare the charge acceptance and time of oxidation at these potentials. Potential step oxidations will be made at potentials found suitable for this method. The point in the oxidation at which the potential is changed will be varied in order to learn what effect this has on oxidation time and charge acceptance.

We will continue to investigate methods of current integration which can be used to determine absolute charge acceptance at the potentials studied.

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