TIME CURVES FOR CADMIUM DEPOSITED FROM ORGANIC ELECTROLYTES.

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The present work is supplemental to a paper published by Holmes and Dover[1] in which it was shown that with currents below one ampere, using the rotating spiral anode, cadmium could be deposited in a more or less satisfactory form from various organic electrolytes. Because the character of the deposits varied considerably with the electrolyte used, it seemed worth while to make a series of determinations in order to show clearly the progressive deposition of the metal, and the quantity of it that could be deposited from each electrolyte in a sufficiently adhesive form to weigh accurately.

As in the previous work, a platinum dish of about 200 cc. capacity served as cathode with a spiral anode, making about 400 revolutions a minute. Solutions of cadmium salts containing about 0.2 gram of the cadmium metal in 10 cc. of solution were used in each case.

Cadmium Acetate in Acetate Electrolyte.—The most satisfactory conditions for the deposition of cadmium seemed to be as follows: Ten cc. of cadmium acetate solution were diluted to 110 cc., 0.5 cc. acetic acid (conc.) and 2 grams of ammonium acetate were added. The whole was heated to incipient boiling and electrolyzed.

Observing the above conditions, the accompanying time curve was determined.

The first nine deposits were finely crystallin, smooth and white. In No. 9 (25 min., 0.1250 gram cadmium) there was the first suggestion of a few small crystal plates adhering to the white deposit, immediately under the electrode.

Cadmium Acetate in Acetate Electrolyte.

No.	Volts.	Ampere.	Time. Min.	Wt. of Cd in grams.
1	2.4	0.3	1	0.0099
2	2.4	0.3	2	0.0144
3	2.4	0.3	3	0.0192
4	2.4	0.3	5	0.0313
5	2.4	0.3	7	0.0447
6	2.4	0.3	10	0.0576
7	2.4	0.3	15	0.0798
8	2.4–2.5	0.3	20	0.1095
9	2.4–2.6	0.3	25	0.1250
10	2.4–2.6	0.3	30	0.1399
11	2.4–2.8	0.3	35	0.1601
12	2.4–2.8	0.3	40	0.1700
13	2.4–2.8	0.3	45	0.1764

[1] This Journal, **32**, 1251.

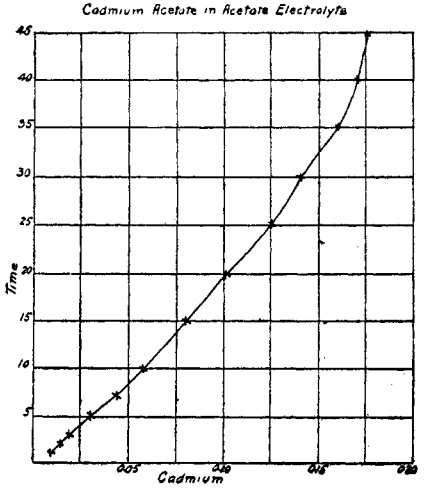

Fig. 1.

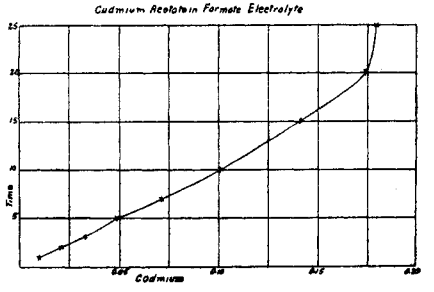

Fig. 4.

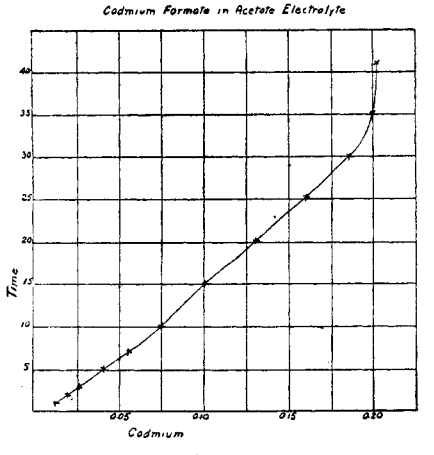

Fig. 5.

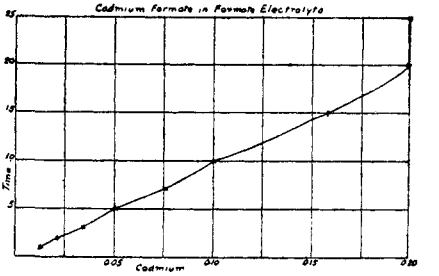

Fig. 2.

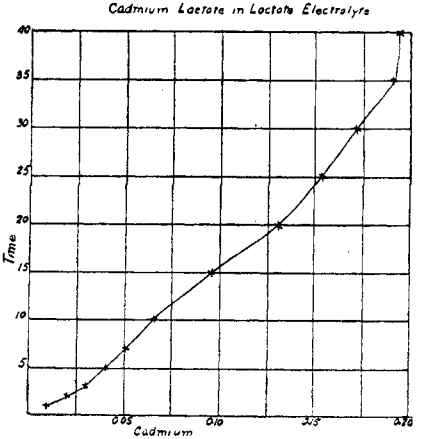

Fig. 3.

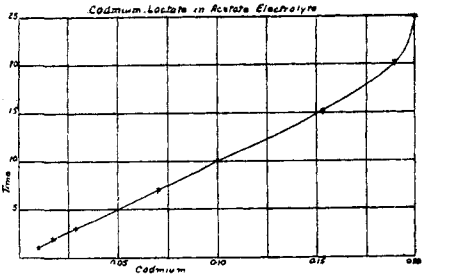

Fig. 6.

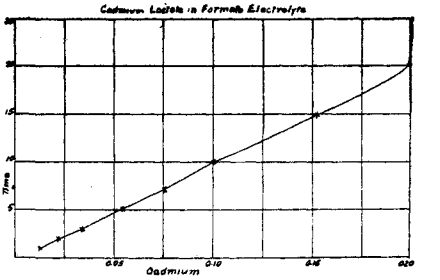

Fig. 7.

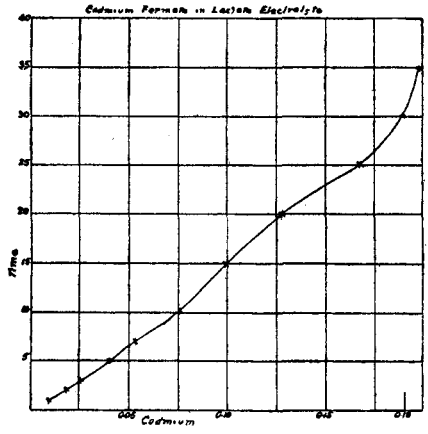

Fig. 8.

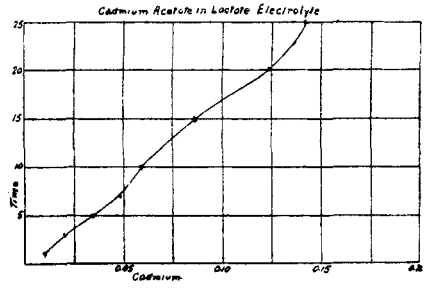

Fig. 9.

In No. 10 (30 min.) there were large crystals (plates) under the electrode, which were inclined to scale off. This was increasingly the case in Nos. 11, 12 and 13. It was necessary to wash these last three deposits with great care to avoid loss.

After 45 minutes no trace of cadmium could be detected in the solution by the addition of hydrogen sulfide.

Cadmium Formate in Formate Electrolyte.—Ten cc. of cadmium formate solution were diluted to about 110 cc.—0.5 cc. formic acid was added and 2 grams of sodium formate. The solution was kept hot during the deposition. The current was inclined to be unsteady.

In the first seven determinations (up to 15 min., 0.1577 gram Cd) the deposit was finely crystallin, white and adhesive with a few larger (adhesive) crystals immediately under the electrode.

No. 8 (20 min., 0.1938 gram cadmium), deposit as above, but crystals rather inclined to scale off.

No. 9 (25 min.), deposit as above, larger crystals inclined to scale off, though on the whole good and much more adhesive than No. 8. No trace of cadmium was found with hydrogen sulfide after twenty-five minutes.

CADMIUM FORMATE IN FORMATE ELECTROLYTE.

No.	Volts.	Ampere.	Time. Min.	Wt. Cd in grams.
1	1.4	0.3	1	0.0137
2	1.4	0.3	2	0.0218
3	1.4	0.3	3	0.0348
4	1.4	0.3	5	0.0507
5	1.4	0.3	7	0.0763
6	1.4–2.4	0.3	10	0.1025
7	1.2–2.4	0.3	15	0.1577
8	1.4–2.6	0.3	20	0.1938
9	1.4–2.6	0.3	25	0.1959

Cadmium Lactate in Lactate Electrolyte.—Ten cc. of the cadmium lactate solution were diluted to about 110 cc.—2 cc. lactic acid and 1 cc. of ammonium hydroxide (0.9 sp. gr.) were added. The solution was heated to incipient boiling and electrolyzed.

The first eight determinations (up to 20 min. depositing 0.1314 gram cadimum) were finely crystallin, white and adhesive. Excellent deposits.

No. 9 (25 min.) was for the most part like the first eight, but under the electrode a few larger crystals could be distinguished. These were apparently quite adhesive. The size of these crystals increased with the time during which the current was allowed to pass and showed an increasing tendency to scale off. Nos. 11 and 12 (35 min. and 40 min.) required very careful washing in order not to lose any of the metal. After 40 min. the solution showed no trace of yellow coloration with hydrogen sulfide. Current unsteady.

CADMIUM LACTATE IN LACTATE ELECTROLYTE.

No.	Volts.	Ampere.	Time. Min.	Wt. Cd in grams.
1	2.6	0.3	1	0.0097
2	2.6	0.3	2	0.0185
3	2.6–2.8	0.3	3	0.0290
4	2.6	0.3	5	0.0406
5	2.6	0.3	7	0.0488
6	2.4–2.6	0.3	10	0.0658
7	2.6–2.8	0.3	15	0.0954
8	2.4–2.8	0.3	20	0.1314
9	2.5–2.8	0.3	25	0.1536
10	2.6–2.8	0.3	30	0.1713
11	2.6–2.8	0.3	35	0.1909
12	2.6–3.0	0.3	40	0.1931

Cadmium Acetate in Formate Electrolyte.—Ten cc. of cadmium acetate solution were diluted to about 110 cc.—0.5 cc. formic acid and 2 grams of sodium formate were added. The solution was heated and electrolyzed.

The first six deposits (up to ten minutes and containing 0.1050 gram of cadmium) were finely crystallin, white and adhesive. No. 7 (15 minutes containing 0.1420 gram cadmium) showed a few larger adhesive crystals immediately under the electrode.

Nos. 8 and 9 (20 minutes and 25 minutes, 0.1748 and 0.1772 gram cadmium) showed a more or less porous, adhesive deposit, grayish in color and difficult to dry.

There was no trace of cadmium upon the addition of hydrogen sulfide after the current had been passing for 25 min. The current was more or less unsteady.

CADMIUM ACETATE IN FORMATE ELECTROLYTE.

No.	Volts.	Ampere.	Time. Min.	Wt. Cd in grams.
1	2.0	0.3	1	0.0094
2	2.0	0.3	2	0.0218
3	1.4	0.3	3	0.0330
4	2.0	0.3	5	0.0484
5	1.2	0.3	7	0.0713
6	1.0–1.6	0.3	10	0.1050
7	1.6	0.3	15	0.1426
8	1.4	0.3	20	0.1748
9	1.4–2.8	0.3	25	0.1772

Cadmium Formate in Acetate Electrolyte.—Ten cc. of the cadmium formate solution were diluted to 110 cc.—0.5 cc. acetic acid was added, also 2 grams of ammonium acetate. The solution was heated and electrolyzed as before.

Up to No. 10 (30 min., 0.1852 gram cadmium) the deposits were excellent, white, smooth, finely crystallin and perfectly adhesive.

Nos. 11 and 12 contained a few larger crystals, which were inclined to scale off, but with careful washing accurate results were obtained. After 40 min. there was no trace of cadmium upon the addition of hydrogen sulfide. Current unsteady.

CADMIUM FORMATE IN ACETATE ELECTROLYTE.

No.	Volts.	Ampere.	Time. Min.	Wt. Cd in grams.
1	2.6	0.3	1	0.0122
2	2.6	0.3	2	0.0187
3	3.2	0.3	3	0.0268
4	3.4	0.3	5	0.0401
5	2.8–3.0	0.3	7	0.0555
6	3.2–4.0	0.3	10	0.0759
7	3.0–3.2	0.3	15	0.1047
8	3.0–3.8	0.3	20	0.1301
9	2.8–3.4	0.3	25	0.1615
10	2.4–3.0	0.3	30	0.1852
11	3.4–3.8	0.3	35.	0.2002
12	3.0–3.6	0.3	40	0.2024

Cadmium Lactate in Acetate Electrolyte.—Ten cc. cadmium lactate solution were diluted to about 110 cc.–0.5 cc. of acetic acid was added and 2 grams of ammonium acetate. The solution was heated and electrolyzed as before.

The first six deposits (up to 10 min., 0.1011 gram cadmium) were easily washed (adhesive, but spotted in colors). No. 7 (15 min. containing 0.1532 gram cadmium) was difficult to wash, owing to tendency to scale off. Nos. 8 and 9 (20 and 25 min., 0.1925 gram cadmium) were porous and required very careful washing to prevent loss. No trace of cadmium was found by hydrogen sulfide after 25 min. Current generally unsteady.

CADMIUM LACTATE IN ACETATE ELECTROLYTE.

No.	Volts.	Ampere.	Time. Min.	Wt. Cd in grams.
1	2.8	0.3	1	0.0098
2	2.6	0.3	2	0.0168
3	2.6	0.3	3	0.0283
4	2.6	0.3	5	0.0449
5	2.8	0.3	7	0.0705
6	2.6	0.3	10	0.1011
7	2.6	0.3	15	0.1532
8	2.6	0.3	20	0.1897
9	2.4	0.3	25	0.1925

Cadmium Lactate in Formate Electrolyte.—Ten cc. cadmium lactate solution were diluted to about 110 cc.—0.5 cc. formic acid was added and 2 grams sodium formate. The solution was heated and electrolyzed as before.

The first seven deposits (up to 15 min., 0.1521 gram cadmium) were smooth, white and finely crystallin. Nos. 8 and 9 were as above for the most part, but showed larger gray, adhesive (apparently) crystals requiring careful drying.

CADMIUM LACTATE IN FORMATE ELECTROLYTE.

No.	Volts.	Ampere.	Time. Min.	Wt. Cd in grams.
1	1.8–2.8	0.3	1	0.0128
2	1.4–1.8	0.3	2	0.0218
3	2.4–3.8	0.3	3	0.0341
4	1.2–2.4	0.3	5	0.0543
5	1.2–2.6	0.3	7	0.0754
6	1.2–2.4	0.3	10	0.1015
7	1.0–2.4	0.3	15	0.1521
8	1.4–2.6	0.3	20	0.1969
9	1.2–2.6	0.3	25	0.2063

Cadmium Formate in Lactate Electrolyte.—Ten cc. cadmium formate solution were diluted to about 110 cc.—2 cc. lactic acid and 1 cc. ammonium hydroxide were added. The solution was heated and electrolyzed.

CADMIUM FORMATE IN LACTATE ELECTROLYTE.

No.	Volts.	Ampere.	Time. Min.	Wt. Cd in grams.
1	2.6	0.3	1	0.0089
2	2.2	0.3	2	0.0186
3	2.6	0.3	3	0.0267
4	2.6–3.0	0.3	5	0.0410
5	2.4–2.8	0.3	7	0.0531
6	2.6–2.8	0.3	10	0.0765
7	2.6–2.8	0.3	15	0.0991
8	2.4–3.0	0.3	20	0.1275
9	2.6–3.0	0.3	25	0.1673
10	2.6–3.0	0.3	30	0.1881
11	2.8–3.0	0.3	35	0.1984
12	2.4–3.0	0.3	40	0.2016

The first eight deposits (up to 20 min., 0.1275 gram cadmium) were light colored, smooth and adhesive. Nos. 9, 10, 11 and 12 became more and more porous (due to large crystal plates) and not entirely adhesive, requiring very careful washing. Current unsteady. No trace of cadmium was found with hydrogen sulfide after 40 minutes.

Cadmium Acetate in Lactate Electrolyte.—Ten cc. cadmium acetate solution were diluted to about 110–2 cc. lactic acid and 1 cc. of ammonium hydroxide was added. The solution was heated and electrolyzed as before. An ammoniacal electrolyte was tried as above, using 1 cc. lactic acid, but the deposit was too porous to weigh, and not at all adhesive. The current was passed for one hour.

The first seven deposits (up to 15 min., 0.0866 gram cadmium) were smooth and adhesive though not so light in color as the others. These, after 15 min., showed large crystals, which scaled off. This curve varies very much and is not of much value. Current very unsteady.

CADMIUM ACETATE IN LACTATE ELECTROLYTE.

No.	Volts.	Ampere.	Time. Min.	Wt. Cd in grams.
1	3.0	0.3	1	0.0101
2	3.0	0.3	2	0.0174
3	5.0	0.3	3	0.0206
4	5.0	0.3	5	0.0340
5	3.0	0.3	7	0.0480
6	3.0–6.0	0.3	10	0.0580
7	3.0–7.0	0.3	15	0.0866
8	3.0–4.0	0.3	20	0.1243
9	3.6–5.0	0.3	25	0.1423

Summary.

Acetate in acetate, 25 min., 0.1250 gram cadmium.
Formate in formate, 20 min., 0.1938 gram cadmium.
Lactate in lactate, 20 min., 0.1314 gram cadmium.
Acetate in formate, 10 min., 0.1050 gram cadmium.
Formate in acetate, 30 min., 0.1852 gram cadmium.
Lactate in acetate, 10 min., 0.1011 gram cadmium.
Lactate in formate, 15 min., 0.1521 gram cadmium.
Formate in lactate, 20 min., 0.1275 gram cadmium.
Acetate in lactate, 15 min., 0.0866 gram cadmium.

As may be seen, the quantity of cadmium that will form an adhesive deposit varies very much with the different electrolytes as does also the rate of deposition.

The above work would seem to indicate that the deposits are finer and more adhesive when the solution is decidedly acid. On the other hand, if too much acid is used it is apparently almost impossible to deposit the last traces of the metal.

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