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EDITORIALS.

USES FOR RARE ELEMENTS AND SPECIAL COMPOUNDS.

It frequently happens that investigators have put aside and regarded as impracticable, the suggested use of many of the more difficultly obtained chemical elements and compounds, in consequence of the fact that some of these are at present regarded as unavailable—whether such unavailability is the result of either a very limited present supply, or a cost which is prohibitive for the purpose for which the material is desired.

Manufacturers are throwing away many materials which are, at present, looked upon as waste products, and would gladly welcome any suggested use for the same. Through the coöperation of the investigator and the manufacturer, mutual difficulties might be overcome. With a more intimate coöperation, the requirements of the investigator might be supplied by utilizing the waste products of the manufacturer.

The fundamental step towards obtaining this coöperation must be the securing of information concerning the availability of the materials needed and the uses which may be made of them.

When we consider the marvelous improvements recently brought about by the application of electricity to chemical industry, and the accomplishment

thereby of results hitherto unobtained, we must be prepared to revise some of our information concerning materials previously regarded only as "museum specimens," and place many of these in the category of substances practical for industrial purposes.

Twenty-five years ago aluminum was not commercially available; to-day, millions of pounds are used in the industries. Only a few years ago, the element silicon was regarded as a curiosity; to-day it may be purchased by the ton—uses having been found for it and convenient methods devised for its preparation. The same might be true of many other elements and compounds, which, at the present time, have but little application.

The Division of Industrial Chemists and Chemical Engineers now has a committee which is endeavoring to deal with this problem. This committee will probably act in the capacity of a clearing-house between the manufacturer and consumers. The committee is composed of former President W. R. Whitney, of Schenectady, N. Y., M. C. Whittaker, of Gloucester, N. J., and Gellert Alleman, *Chairman*, of Swarthmore, Pa. The members of this society are asked for suggestions regarding the scope of the investigations to be undertaken, and we hope that all will aid in this important work.

The committee proposes to publish as complete a list of the prices and availableness of the chemical elements as it can obtain, and would be glad to get information to add to this list. It will later probably take up relatively novel or newly available compounds. Such new compounds as come to the notice of members will receive attention by the committee if they are informed of them. GELLERT ALLEMAN.

ORIGINAL PAPERS.

A COMPARISON OF THE METHODS FOR DEPOSITING IRON ELECTROLYTICALLY.

By S. A. TUCKER AND E. SCHRAMM.

Received April 1, 1910.

The experiments herein described include the sulphate and chloride baths as these have been used by most investigators. Other electrolytes have been tried without much success, such as ferrous fluor-silicate, but it was considered best to restrict the experiments to the more promising methods and, by comparing them under certain conditions, to decide which would be the most practical for the deposition of metallic iron.

The first solution tried was made by dissolving 200 grams of $\text{FeSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$ in one liter. This gives about 29 grams of iron per liter, or a concentration of 2.9 per cent. of iron. This is the solution as used by Amberg,¹ and probably by Burgess² and Hambuechen. The cathodes were clean sheet iron and the anodes consisted of wrought iron bars. The experiments were carried on at room temperature and the results are given in Table I:

TABLE I.—IRON.

| Volts. | Amp. | Amps. [] ^{dem.} | Amps. [] ^{ft.} | Lbs. kw. hr. |
|--------|------|---------------------------|--------------------------|--------------|
| 0.50 | 0.2 | 0.176 | 1.63 | 4.4 |
| 0.56 | 0.25 | 0.22 | 2.02 | 3.94 |
| 0.58 | 0.30 | 0.264 | 2.45 | 3.76 |
| 0.64 | 0.35 | 0.308 | 2.96 | 3.44 |
| 0.68 | 0.40 | 0.352 | 3.27 | 3.21 |
| 0.70 | 0.45 | 0.396 | 3.68 | 3.12 |
| 0.74 | 0.50 | 0.44 | 4.09 | 2.95 |
| 0.90 | 0.75 | 0.66 | 6.04 | 2.42 |
| 1.10 | 1.00 | 0.88 | 8.26 | 1.98 |

The current efficiency was determined by inserting a copper coulombmeter in series and gave an efficiency of 95.5 per cent.

The last column in this table shows the effect of increased current density on the energy efficiency. The current was changed temporarily to obtain these figures. In computing the figures for lbs. per kw. hr., the current efficiency was assumed to be the same throughout.

The deposit obtained was silvery white and of a fine crystalline structure. After a while it became badly pitted. The electrolyte kept in condition for a long time; the basic precipitate which formed by oxidation of the air was allowed to collect in the bottom of the vessel. The electrodes were 1 1/2" apart and the current density at the anode was about double that at the cathodes.

Another run was made with the solution and all conditions kept the same as the above except the current density, which was raised to 1 amp. per sq. dcm. The deposit was crystalline and silvery white like that obtained at lower current densities, but showed a greater tendency to form nodules. The current efficiency was nearly 100 per cent., but the voltage drop was 1.2, giving 1.705 lbs. per kw. hour.

A third run was made with ferrous ammonium sulphate solution, with the addition of a small quantity of glycerine. The deposit in this case was smoother and more solid.

Ryss,³ in his investigations, used a solution containing 200 grams ferrous ammonium sulphate, 50 grams MgSO_4 , and 4 grams NaHCO_3 per liter. Ryss claimed that such a solution gave a smoother and thicker deposit of iron than could be obtained with ordinary ferrous ammonium sulphate.

¹ Zeit. Elektrochem., 14, 326 (1908).

² Trans. Am. Electrochem. Soc., 5, 201 (1904). Electrochem. and Met. Ind., 2, 183 (1904).

³ Ryss, Zeit. Elektrochem., 12, 697 (1906).

A trial failed to show any improvement in the character of the deposits using such additions, but it did show that the bath had a much greater tendency to form basic precipitate and the time in which it could be maintained in good condition was less than that possible with the simple bath.

The next solution tried was one containing 30 grams $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, 21 grams $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ per 100 cc. as described by Kern.¹

A current density of 1 amp. per sq. dcm. was used. The deposit was dark gray and formed large nodules. At the end of 15 hours the electrolyte was in bad condition owing to the formation of a heavy precipitate.

The net results of the experiments with different sulphate solutions were the conclusion that a solution containing 200 grams per liter of Mohr's salt was the best as regards character of deposit, permanent good condition of electrolyte, and energy efficiency. Attention was next turned to the electrolysis of chloride solutions. The first solution used contained 100 grams $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ and 50 grams NH_4Cl per liter. The cathodes, as before, being of clean sheet iron and the anodes wrought iron bar. The electrodes were 1 1/2" apart and the bath maintained at room temperature. The current efficiency as determined by a copper coulombmeter was found to be 96.5 per cent. and the following data was obtained:

Time of run 21 1/2 hours.

Average current during run = 0.237.

Average voltage during run = 0.42.

Weight of iron actually deposited, 5.14 grams.

Weight of iron theoretically deposited, 5.32 grams.

Current density during run = 0.304 amp. []^{dem.}

No. watt hours = $0.237 \times 21 \frac{1}{2} \times 42 = 2.14$.

1 watt hour = 2.4 grams iron.

1 kw. hour = 5.28 lbs.

The current was varied temporarily to obtain the following readings:

| Volt. | Amp. | Amps. [] ^{dem.} | Amps. [] ^{ft.} | Lbs. kw. hr. |
|-------|------|---------------------------|--------------------------|--------------|
| 0.40 | 0.2 | 0.260 | 2.42 | 5.55 |
| 0.44 | 0.25 | 0.321 | 2.98 | 5.05 |
| 0.46 | 0.3 | 0.385 | 3.58 | 4.83 |
| 0.54 | 0.36 | 0.450 | 4.18 | 4.10 |
| 0.57 | 0.40 | 0.513 | 4.76 | 3.89 |
| 0.60 | 0.45 | 0.577 | 5.36 | 3.70 |
| 0.60 | 0.5 | 0.642 | 5.97 | 3.70 |
| 0.72 | 0.75 | 0.962 | 8.94 | 3.08 |
| 1.00 | 1.00 | 1.280 | 11.90 | 2.22 |

In the next run a solution of double the strength was used, i. e., 200 grams $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ and 100 grams NH_4Cl per liter. The other conditions were kept much the same as before, excepting that the length of time of the run was increased:

Time of run, 141 hours.

Average current during run, 0.323 amp.

Average voltage during run, 0.67.

Weight of iron actually deposited, 47.145 grams.

¹ Kern, Trans. Am. Electrochem. Soc., 13, 103 (1908).

Weight of iron theoretically deposited, 47.6 grams.

Current efficiency = 99 per cent.

Current density = 0.56 amp. [] dcm. = 5.2 amps. []'.

No. watt hours = $0.323 \times 141 \times 0.67 = 30.5$.

1 watt hour = 1.55 grams iron.

1 kw. hour = 3.4 lbs.

The following readings were taken:

| Volt. | Amp. | Amps. [] dcm. | Amps. []'. | Lbs. kw. hr. |
|-------|------|----------------|-------------|--------------|
| 0.42 | 0.2 | 0.345 | 3.2 | 5.42 |
| 0.50 | 0.25 | 0.432 | 4.01 | 4.55 |
| 0.64 | 0.3 | 0.517 | 4.08 | 3.66 |
| 0.70 | 0.35 | 0.604 | 5.64 | 3.26 |
| 0.72 | 0.4 | 0.69 | 6.4 | 3.16 |
| 0.82 | 0.45 | 0.726 | 6.75 | 2.78 |
| 0.84 | 0.5 | 0.862 | 8.0 | 2.71 |
| 0.90 | 0.75 | 1.29 | 12.0 | 2.53 |
| 0.98 | 1.00 | 1.725 | 16.0 | 2.32 |

A comparison of the two runs given above with the run on ferrous ammonium sulphate solution shows that while the current efficiency is practically the same in both cases, the energy efficiency at any given current density is much higher for the chloride solutions. Comparing the two chloride solutions, we see that the more concentrated solution gives a higher energy efficiency at any given current density.

The physical character of the deposit from the chloride solution was somewhat different from that deposited from the sulphate solutions, being more crystalline than the latter excepting that to which glycerine had been added.

The next electrolyte tried was the ferrous sodium chloride solutions described by E. F. Kern.¹ This was made by dissolving 285 grams $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ and 102 grams NaCl per liter, giving 8 per cent. Fe and 4 per cent. Na. The solution may also be made by dissolving iron in the equivalent weight of HCl. The cathode used was thin sheet iron plate $3 \frac{3}{4}'' \times 3 \frac{1}{2}''$. The anodes were bars of wrought iron $3'' \times 2'' \times \frac{1}{2}''$. The electrolysis was carried on in a beaker placed on an asbestos pad with a hole cut in it, and heated by placing an incandescent lamp underneath. This kept the temperature between 50° and 70°C .

Previous runs having all shown a high current efficiency of over 95 per cent., it was not considered necessary to use a copper coulombmeter in this run. The object of the run was to:

- (1) Compare the voltage required by this process with the others described.
- (2) To find the effect of heating the electrolyte on the energy required.
- (3) To find the effect of heating on the physical character of the deposit.
- (4) To secure a thick deposit in a short time.

The cathode area was 13.15 square inches.

The electrolyte was kept in condition by adding a little HCl to the bath every day to dissolve the basic precipitate which formed. Water was fed to the bath automatically to make up for evaporation.

The following readings were taken:

| Volt. | Amps. | Temp. | Current density. Amps. [] ft. | |
|-------|-------|-----------------------|-----------------------------------|---------------------|
| 0.42 | 1.4 | 60°C . | 15 | Taken at start. |
| 0.46 | 1.4 | 50° | 15 | |
| 0.54 | 1.4 | 40° | 15 | |
| 0.64 | 1.4 | 30° | 15 | |
| 0.36 | 1.8 | 60° | 19.3 | 9 days after start. |
| 0.34 | 1.6 | 60° | 11.15 | |
| 0.32 | 1.4 | 60° | 15.0 | |
| 0.30 | 1.2 | 60° | 12.85 | |
| 0.28 | 1.0 | 60° | 10.72 | |
| 0.26 | 0.8 | 60° | 8.57 | |
| 0.24 | 0.6 | 60° | 6.43 | |
| 0.22 | 0.4 | 60° | 42.9 | |
| 0.20 | 0.2 | 60° | 2.14 | |

The above tables show: that the voltage decreases with increased temperature; and that the voltage decreases as the run proceeds.

Comparison of this process with the others tried shows the best energy efficiency for the ferrous sodium chloride electrolyte working at 50° – 70°C .

This bath also gave the best and thickest deposits, the iron being gray and non-crystalline.

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STUDIES IN ASPHALT, I.

By C. J. FRANKFORTER.

Received March 23, 1910.

While engaged in testing asphalt for the City Engineer of Lincoln, Nebraska, it was observed that the temperature of the asphaltic mixture, as brought to the street, varied as much as 100°C . maximum to minimum. It was also noticed that the per cent. of bitumen was by no means constant. This seemed a little unusual, and the author decided to experiment and determine if possible the effect of such variations on the paving material.

Literature was consulted, but nothing bearing on the work in mind was found. Paving specifications from Chicago, Brooklyn, New Orleans, and several other large cities, were obtained and consulted. Without exception, these specifications condemned the overheating of an asphaltic cement. Just how hot such material might be heated without injury, or what the harmful effects of overheating really were, was not stated. In all cases the per cent. of bitumen was to be reasonably constant, usually about 10 per cent. of the surface mixture was called for.

Samples of Trinidad, Texas, Cuban Rock, Obispo and Sarco asphalts were collected. Results on two samples only, Obispo and Trinidad, will be presented, since the data on the other brands are as yet insufficient to warrant definite conclusions.

In this paper the author wishes to be distinctly understood as neither recommending nor condemning the asphalts mentioned.

Obispo refined asphalt was a hard substance resembling coal tar in general appearance, but it did not have the "tarry" odor nor was it "sticky" at

¹ *Trans. Am. Electrochem. Soc.*, **18**, 103 (1908).