Data Article

Data on energy consumption in the production of layered double hydroxides

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ABSTRACT

Electrocoagulation consists of the in-situ generation of the coagulant by the electro dissolution of sacrificial electrodes (Mg and Al). This technique, besides being normally used for water treatment, can be used to synthesize Layered Double Hydroxides (LDH) or Hydrotalcites (HT) such as green rust, MgAlCl/LDH, and other oxides as Magnetite. The HT has a high tendency for water in the interlayer to be replaced by anions, these exchange characteristics generate a high interest in the fields of drug administration, photodegradation, catalyst supports, supercapacitors, and water oxidation. There are several routes of synthesis for these compounds such as co-precipitation, hydrolysis of urea, hydrothermal treatment and a novel route by electrocoagulation (EC).

This work discloses the data of the energy consumption at laboratory-scale production in the synthesis of hydrotalcite (HT) or Layered Double Hydroxides (LDH) by electrocoagulation, the values obtained through these experiments are intended to provide support due to the lack of information on the energy consumption of this novel production method. Aluminum and AZ31 electrodes were used as a cations source during two- and four-hours operation, at 50 °C with 5 mA cm⁻² of current density, and 5 minutes of polarity change for Aluminum and 8 minutes for AZ31 (Magnesium alloy).

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1. Data

The electrocoagulation (EC) process is generally used as wastewater treatment, this technique produces sludge and this use is related with the waste solid disposal. A new focus in the production of new materials by EC is emerging [2–4]. The LDH materials was prepared by Electrocoagulation according to methodology reported by Molano et al. [1], Figs. 1 and 2 shows the typical FTIR and XRD spectra of synthesized materials. These raw data can be found in the attached supplementary data.

Tables 1 and 4 below show the values of the tension and power obtained during the synthesis of Mg–Al layered double hydroxides by using electrocoagulation with polarity change. Tables 1 and 2 contains data of nine experiments effectuated for 2 hours of production, while Tables 3 and 4 includes ten experiments made for 4 hours of production in equal operational conditions. The experimental conditions were: 50 °C, 5000 mg L\(^{-1}\) of NaCl as electrolyte and 1.84 A.

Table 5 shows the weight of LDH obtained during each experiment on the other hand, Table 6 presents the total operational energy consumption in bench-scale testing.

2. Experimental design, materials, and methods

NaCl solution was prepared by dissolving 5000 mg of sodium chloride (Sigma Aldrich-reagent grade) in 1 L of purified water obtained by drinking water distillation, previously filtered (0.45 μm) and subjected to adsorption with activated carbon, in a Water Pro PS Labalcon equipment. To measure the pH and electrical conductivity (mS cm\(^{-1}\) at 25 °C) a multiparameter sensor Thermo Scientific Orion Star A329 was used [5,6].

2.1. Experimental assembly

A 2000 mL beaker was used as an electrolytic cell with 1400 mL of initial solution volume. AZ31 alloy (weight composition: 95.56% Magnesium, 3.0% Aluminum, 1.0% Zinc, 0.043%
Fig. 1. FTIR of a sample of the synthesized products.

Fig. 2. XRD spectra of the synthesized products. (a) Pattern LDH [1]. (b) Sample LDH.

Table 1
Energy consumption for LDH production, 2 hours process time. Experiment 1 to 5.

| Time Hours | Experiment 1 | Experiment 2 | Experiment 3 | Experiment 4 | Experiment 5 |
|------------|--------------|--------------|--------------|--------------|--------------|
|            | Tension V    | Power kW (10^3) | Tension V    | Power kW (10^3) | Tension V    | Power kW (10^3) | Tension V    | Power kW (10^3) | Tension V    | Power kW (10^3) |
| 0.00        | 1.30         | 2.39         | 1.30         | 2.39         | 1.00         | 1.84         | 0.90         | 1.66         | 1.40         | 2.58         |
| 0.08        | 2.00         | 3.68         | 1.90         | 3.50         | 1.70         | 3.13         | 1.80         | 3.31         | 1.80         | 3.31         |
| 0.22        | 1.00         | 1.84         | 0.90         | 1.66         | 1.30         | 2.39         | 0.90         | 1.66         | 0.90         | 1.66         |
| 0.30        | 1.80         | 3.31         | 1.80         | 3.31         | 1.70         | 3.13         | 1.60         | 2.94         | 1.80         | 3.31         |

(continued on next page)
Manganese, 0.01% Silicon, Copper <0.01%, nickel <0.001% and 0.003% Iron) and Aluminum were used as electrodes. These plates, with an effective area of 168 cm², respectively, were suspended and clamped together using polyethylene belts, guaranteeing an interelectrode distance of 0.5 cm. For heating and stirring, a Thermo Scientific brand plate model SP131635Q was used, with a 3 cm long and 0.5 cm in diameter magnetic stirrer, and a Brisco thermometer. The electrodes were connected to a direct current power source BK Precision DC Regulated Power Supply model 1665 with a maximum amperage of 5 A, in a monopolar arrangement connected to a polarity inverter followed by the power source [6].

Table 1 (continued)

| Time Hours | Experiment 1 | Experiment 2 | Experiment 3 | Experiment 4 | Experiment 5 |
|------------|--------------|--------------|--------------|--------------|--------------|
|            | Tension V Power kW (10³) | Tension V Power kW (10³) | Tension V Power kW (10³) | Tension V Power kW (10³) | Tension V Power kW (10³) |
| 0.43       | 0.90 1.66    | 0.90 1.66    | 0.90 1.66    | 0.70 1.29    | 1.00 1.84    |
| 0.52       | 1.80 3.31    | 1.80 3.31    | 1.70 3.13    | 1.60 2.94    | 1.80 3.31    |
| 0.65       | 1.00 1.84    | 0.80 1.47    | 1.60 2.94    | 0.60 1.10    | 1.10 2.02    |
| 0.73       | 1.80 3.31    | 1.80 3.31    | 1.60 2.94    | 1.60 2.94    | 2.00 3.68    |
| 0.87       | 1.00 1.84    | 1.00 1.84    | 1.70 3.13    | 0.70 1.29    | 1.20 2.21    |
| 0.95       | 1.80 3.31    | 1.80 3.31    | 1.70 3.13    | 1.70 3.13    | 2.00 3.68    |
| 1.08       | 1.10 2.02    | 1.10 2.02    | 0.80 1.47    | 0.70 1.29    | 1.20 2.21    |
| 1.17       | 1.80 3.31    | 1.90 3.50    | 2.00 3.68    | 1.70 3.13    | 2.10 3.86    |
| 1.30       | 1.10 2.02    | 0.90 1.66    | 1.30 2.39    | 0.80 1.47    | 1.20 2.21    |
| 1.38       | 1.80 3.31    | 1.80 3.31    | 1.70 3.13    | 1.70 3.13    | 2.10 3.86    |
| 1.52       | 0.90 1.66    | 1.00 1.84    | 0.80 1.47    | 0.70 1.29    | 1.20 2.21    |
| 1.60       | 1.70 3.13    | 1.90 3.50    | 1.70 3.13    | 1.70 3.13    | 2.10 3.86    |
| 1.73       | 0.80 1.47    | 1.10 2.02    | 1.00 1.84    | 0.80 1.47    | 1.20 2.21    |
| 1.82       | 1.80 3.31    | 1.90 3.50    | 1.90 3.50    | 1.70 3.13    | 2.10 3.86    |
| 1.95       | 0.90 1.66    | 1.00 1.84    | 1.00 1.84    | 0.70 1.29    | 1.20 2.21    |
| 2.03       | 1.80 3.31    | 1.80 3.31    | 1.90 3.50    | 1.70 3.13    | 2.10 3.86    |

Table 2

Energy consumption for LDH production, 2 hours process time. Experiment 5 to 9.

| Time Hours | Experiment 6 | Experiment 7 | Experiment 8 | Experiment 9 |
|------------|--------------|--------------|--------------|--------------|
|            | Tension V Power kW (10³) | Tension V Power kW (10³) | Tension V Power kW (10³) | Tension V Power kW (10³) |
| 0.00       | 1.00 1.84    | 1.40 2.58    | 1.43 2.63    | 1.29 2.37    |
| 0.08       | 2.00 3.68    | 1.90 3.50    | 1.97 3.62    | 1.99 3.66    |
| 0.22       | 0.90 1.66    | 0.90 1.66    | 0.84 1.55    | 2.25 4.14    |
| 0.30       | 1.80 3.31    | 1.80 3.31    | 1.68 3.09    | 2.03 3.74    |
| 0.43       | 0.90 1.66    | 1.00 1.84    | 1.19 2.19    | 1.18 2.17    |
| 0.52       | 1.60 2.94    | 1.80 3.31    | 1.68 3.09    | 1.95 3.59    |
| 0.65       | 0.90 1.66    | 0.80 1.47    | 0.91 1.67    | 1.18 2.17    |
| 0.73       | 1.90 3.50    | 1.80 3.31    | 1.71 3.15    | 1.98 3.64    |
| 0.87       | 1.20 2.21    | 0.80 1.47    | 0.80 1.47    | 1.79 3.29    |
| 0.95       | 2.10 3.86    | 1.80 3.31    | 1.72 3.16    | 2.03 3.74    |
| 1.08       | 1.10 2.02    | 1.10 2.02    | 0.99 1.82    | 1.03 1.90    |
| 1.17       | 2.00 3.68    | 1.81 3.33    | 1.72 3.16    | 2.00 3.68    |
| 1.30       | 1.10 2.02    | 1.02 1.88    | 0.86 1.58    | 1.46 2.69    |
| 1.38       | 2.10 3.86    | 1.86 3.42    | 1.69 3.11    | 2.04 3.75    |
| 1.52       | 1.20 2.21    | 1.05 1.93    | 0.79 1.45    | 0.98 1.80    |
| 1.60       | 2.10 3.86    | 1.84 3.39    | 1.73 3.18    | 2.11 3.88    |
| 1.73       | 1.20 2.21    | 1.08 1.99    | 0.98 1.80    | 0.96 1.77    |
| 1.82       | – –          | 1.81 3.33    | 1.58 2.91    | 2.05 3.77    |
| 1.95       | – –          | 0.96 1.77    | 0.80 1.47    | 1.07 1.97    |
| 2.03       | – –          | 1.81 3.33    | 1.58 2.91    | – –          |
Table 3
Energy consumption for LDH production, 4 hours process time. Experiment 10 to 14.

| Time Hours | Experiment 10 | Experiment 11 | Experiment 12 | Experiment 13 | Experiment 14 |
|------------|---------------|---------------|---------------|---------------|---------------|
|            | Tension V     | Power kW (10³) | Tension V     | Power kW (10³) | Tension V     | Power kW (10³) |
| 0.00       | 1.18          | 2.17          | 1.16          | 2.13          | 1.26          | 2.32          |
| 0.08       | 1.86          | 3.42          | 2.00          | 3.68          | 2.02          | 3.72          |
| 0.22       | 1.53          | 2.82          | 1.09          | 2.01          | 1.53          | 2.82          |
| 0.30       | 1.81          | 3.33          | 1.96          | 3.61          | 2.00          | 3.68          |
| 0.43       | 1.18          | 2.17          | 1.05          | 1.93          | 1.20          | 2.21          |
| 0.52       | 1.74          | 3.20          | 1.92          | 3.53          | 2.07          | 3.81          |
| 0.65       | 1.90          | 3.50          | 1.02          | 1.88          | 1.01          | 1.86          |
| 0.73       | 1.80          | 3.31          | 1.95          | 3.59          | 1.95          | 3.59          |
| 0.87       | 1.97          | 3.62          | 1.10          | 2.02          | 1.27          | 2.34          |
| 0.95       | 1.80          | 3.31          | 1.97          | 3.62          | 2.04          | 3.75          |
| 1.08       | 0.92          | 1.69          | 1.35          | 2.48          | 1.13          | 2.08          |
| 1.17       | 1.61          | 2.96          | 2.00          | 3.68          | 1.99          | 3.66          |
| 1.30       | 0.90          | 1.66          | 1.05          | 1.93          | 1.04          | 1.91          |
| 1.38       | 1.75          | 3.22          | 1.99          | 3.66          | 2.15          | 3.96          |
| 1.52       | 0.97          | 1.78          | 1.09          | 2.01          | 1.11          | 2.04          |
| 1.60       | 1.74          | 3.20          | 2.04          | 3.75          | 1.93          | 3.55          |
| 1.73       | 1.04          | 1.91          | 1.42          | 2.61          | 1.04          | 1.91          |
| 1.82       | 1.75          | 3.22          | 1.97          | 3.62          | 2.09          | 3.85          |
| 1.95       | 0.94          | 1.73          | 1.22          | 2.24          | 1.20          | 2.21          |
| 2.03       | 1.77          | 3.26          | 1.99          | 3.66          | 1.97          | 3.62          |
| 2.17       | 0.93          | 1.71          | 1.22          | 2.24          | 1.11          | 2.04          |
| 2.25       | 1.73          | 3.18          | 1.99          | 3.66          | 2.03          | 3.74          |
| 2.38       | 0.90          | 1.66          | 1.16          | 2.13          | 1.06          | 1.95          |
| 2.47       | 1.78          | 3.28          | 2.00          | 3.68          | 2.05          | 3.77          |
| 2.60       | 1.37          | 2.52          | 1.15          | 2.12          | 1.10          | 2.02          |
| 2.68       | 1.93          | 3.55          | 2.00          | 3.68          | 2.09          | 3.85          |
| 2.82       | 0.98          | 1.80          | 1.38          | 2.54          | 1.15          | 2.12          |
| 2.90       | 1.82          | 3.35          | 2.07          | 3.81          | 2.16          | 3.97          |
| 3.03       | 0.86          | 1.58          | 1.34          | 2.47          | 1.09          | 2.01          |
| 3.12       | 1.85          | 3.40          | 2.02          | 3.72          | 1.98          | 3.64          |
| 3.25       | 0.97          | 1.78          | 1.32          | 2.43          | 1.95          | 3.59          |
| 3.33       | 2.03          | 3.74          | 1.94          | 3.57          | 1.99          | 3.66          |
| 3.47       | 1.10          | 2.02          | 1.19          | 2.19          | 1.09          | 2.01          |
| 3.55       | 1.18          | 2.17          | 2.00          | 3.68          | 1.96          | 3.61          |
| 3.68       | 0.95          | 1.75          | 1.15          | 2.12          | 1.12          | 2.06          |
| 3.75       | 2.05          | 3.17          | 2.00          | 3.68          | 2.02          | 3.72          |
| 3.90       | 0.96          | 1.77          | 1.32          | 2.43          | 1.13          | 2.08          |
| 3.98       | 1.95          | 3.59          | 1.94          | 3.57          | 2.05          | 3.77          |

Table 4
Energy consumption for LDH production, 4 hours process time. Experiment 15 to 19.

| Time Hours | Experiment 15 | Experiment 16 | Experiment 17 | Experiment 18 | Experiment 19 |
|------------|---------------|---------------|---------------|---------------|---------------|
|            | Tension V     | Power kW (10³) | Tension V     | Power kW (10³) | Tension V     | Power kW (10³) |
| 0.00       | 1.68          | 3.09          | 1.37          | 2.52          | 0.98          | 1.80          |
| 0.08       | 2.16          | 3.97          | 2.01          | 3.70          | 1.74          | 3.20          |
| 0.22       | 1.25          | 2.30          | 2.07          | 3.81          | 0.82          | 1.51          |
| 0.30       | 1.97          | 3.62          | 1.91          | 3.51          | 1.76          | 3.24          |
| 0.43       | 1.28          | 2.36          | 0.99          | 1.82          | 0.83          | 1.53          |
| 0.52       | 2.07          | 3.81          | 1.93          | 3.55          | 1.76          | 3.24          |
| 0.65       | 1.21          | 2.23          | 1.34          | 2.47          | 0.80          | 1.47          |
| 0.73       | 2.04          | 3.75          | 1.98          | 3.64          | 1.66          | 3.05          |
| 0.87       | 1.47          | 2.70          | 1.03          | 1.90          | 0.70          | 1.29          |
| 0.95       | 2.10          | 3.86          | 1.88          | 3.46          | 1.68          | 3.09          |

(continued on next page)
Table 4 (continued)

| Time Hours | Experiment 15 | Experiment 16 | Experiment 17 | Experiment 18 | Experiment 19 |
|------------|---------------|---------------|---------------|---------------|---------------|
|            | Tension V     | Power kW (10³) | Tension V     | Power kW (10³) | Tension V     | Power kW (10³) |
| 1.08       | 1.35          | 2.48          | 1.12          | 2.06          | 1.94          | 3.57          | 1.17          | 2.15          | 1.18          | 2.17          |
| 1.17       | 2.31          | 4.25          | 1.99          | 3.66          | 1.78          | 3.28          | 1.18          | 2.17          | 1.72          | 3.16          |
| 1.30       | 1.64          | 3.02          | 1.18          | 2.17          | 1.07          | 1.97          | 2.23          | 4.10          | 1.10          | 2.02          |
| 1.38       | 2.08          | 3.83          | 1.93          | 3.55          | 1.75          | 3.22          | 1.83          | 3.37          | 1.62          | 2.98          |
| 1.52       | 1.66          | 3.05          | 1.18          | 2.17          | 2.09          | 3.85          | 1.40          | 2.58          | 1.11          | 2.04          |
| 1.60       | 2.28          | 4.20          | 1.87          | 3.44          | 1.79          | 3.29          | 1.87          | 3.44          | 1.76          | 3.24          |
| 1.73       | 1.52          | 2.80          | 1.13          | 2.08          | 0.85          | 1.56          | 1.04          | 1.91          | 1.24          | 2.28          |
| 1.82       | 2.19          | 4.03          | 1.86          | 3.42          | 1.76          | 3.24          | 1.81          | 3.33          | 1.78          | 3.28          |
| 1.95       | 1.42          | 2.61          | 0.98          | 1.80          | 0.86          | 1.58          | 1.32          | 2.43          | 1.12          | 2.06          |
| 2.03       | 2.33          | 4.29          | 1.67          | 3.07          | 1.71          | 3.15          | 1.78          | 3.28          | 1.74          | 3.20          |
| 2.17       | 1.51          | 2.78          | 1.21          | 2.23          | 1.02          | 1.88          | 1.08          | 1.99          | 0.93          | 1.71          |
| 2.25       | 2.16          | 3.97          | 1.92          | 3.53          | 1.78          | 3.28          | 1.81          | 3.33          | 1.77          | 3.26          |
| 2.38       | 1.54          | 2.83          | 0.97          | 1.78          | 0.93          | 1.71          | 1.09          | 2.01          | 0.97          | 1.78          |
| 2.47       | 2.23          | 4.10          | 1.91          | 3.51          | 1.74          | 3.20          | 1.84          | 3.39          | 1.81          | 3.33          |
| 2.60       | 1.49          | 2.74          | 1.40          | 2.58          | 1.15          | 2.12          | 1.15          | 2.12          | 1.03          | 1.90          |
| 2.68       | 2.23          | 4.10          | 1.96          | 3.61          | 1.80          | 3.31          | 1.84          | 3.39          | 1.29          | 2.37          |
| 2.82       | 1.24          | 2.28          | 1.19          | 2.19          | 0.90          | 1.66          | 0.96          | 1.77          | 0.97          | 1.78          |
| 2.90       | 2.35          | 4.32          | 2.00          | 3.68          | 1.77          | 3.26          | 1.85          | 3.40          | 1.74          | 3.20          |
| 3.03       | 1.33          | 2.45          | 1.07          | 1.97          | 0.78          | 1.44          | 1.37          | 2.52          | 0.80          | 1.47          |
| 3.12       | 2.30          | 4.23          | 1.86          | 3.42          | 1.76          | 3.24          | 1.85          | 3.40          | 1.88          | 3.46          |
| 3.25       | 1.56          | 2.87          | 1.70          | 3.13          | 1.12          | 2.06          | 0.99          | 1.82          | 1.06          | 1.95          |
| 3.33       | 2.36          | 4.34          | 1.90          | 3.50          | 1.77          | 3.26          | 1.74          | 3.20          | 1.87          | 3.44          |
| 3.47       | 1.52          | 2.80          | 1.64          | 3.02          | 1.05          | 1.93          | 1.36          | 2.50          | 1.31          | 2.41          |
| 3.55       | 2.30          | 4.23          | 1.94          | 3.57          | 1.84          | 3.39          | 1.84          | 3.39          | 1.87          | 3.44          |
| 3.68       | 1.55          | 2.85          | 1.70          | 3.13          | 1.26          | 2.32          | 0.93          | 1.71          | 1.11          | 2.04          |
| 3.77       | –             | –             | 1.93          | 3.55          | 1.85          | 3.40          | 1.76          | 3.24          | –             | –             |
| 3.90       | –             | –             | 1.28          | 2.36          | –             | –             | –             | –             | –             | –             |
| 3.98       | –             | –             | –             | –             | –             | –             | –             | –             | –             | –             |

Table 5

Weight production of LDH.

| Experiment | Weight (g) |
|------------|------------|
| 1          | 8.29       |
| 2          | 8.50       |
| 3          | 7.75       |
| 4          | 7.78       |
| 5          | 8.04       |
| 6          | 8.09       |
| 7          | 8.48       |
| 8          | 8.82       |
| 9          | 8.00       |
| **Total (2 h)** | **73.75** |
| 10         | 14.97      |
| 11         | 16.66      |
| 12         | 15.50      |
| 13         | 15.95      |
| 14         | 13.50      |
| 15         | 13.60      |
| 16         | 16.76      |
| 17         | 13.42      |
| 18         | 13.32      |
| 19         | 13.60      |
| **Total (4 h)** | **147.28** |
Before each experimental test, the electrodes were manually polish with sandpaper gauge 150, 400 and 600. The cell tension, pH, temperature, and electrical conductivity were continuously monitored.

2.2. Characterization

The HT synthesized were characterized by X-ray diffraction (XRD) and Fourier Transform Infrared (FTIR), the FTIR spectra were recorded with a JASCO FT/IR-4100 brand equipment, in a range between 500 and 4000 cm\(^{-1}\), the X-ray diffraction pattern (XRD) was performed with an analytical diffractometer called X’pert PRO - PANalytical at conditions of 45 kV, 40 mA, monochromatic CuK\(\alpha\) radiation at a \(\lambda = 0.1542\) nm and in a \(2\theta\) range of 4\(^\circ\)–90\(^\circ\) [1].

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2019.104408.

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