Open Journal of Applied Sciences, 2026, 16(2), 522-536
https://www.scirp.org/journal/ojapps
ISSN Online: 2165-3925
ISSN Print: 2165-3917

Use of the Ash and Water Solution as Electrolyte for the Production of Hydrogen

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How to cite this paper: Adihou, C.W., Edah, L.T., Vodounnou, E.C., Houngan, C.A., Anjorin, M. and Odélien, A.D. (2026) Use of the Ash and Water Solution as Electrolyte for the Production of Hydrogen. *Open Journal of Applied Sciences*, **16**, 522-536.
https://doi.org/10.4236/ojapps.2026.162032

Received: January 22, 2026
Accepted: February 3, 2026
Published: February 6, 2026

Abstract

This study focuses on hydrogen production through water electrolysis using an ash solution. Hydrogen is increasingly being used as a replacement for fossil fuels in various applications, including transportation and industry. The study involves using an ash solution as an electrolyte instead of potassium hydroxide. Electrolyte solutions were prepared using 100g of ash per 1L of water. For the experiment, 0.2 L, 0.5 L, 1 L, and 2 L of this prepared solution were respectively taken and diluted with water to obtain 3 L of electrolyte for hydrogen production. During the tests, production parameters such as temperature, current intensity, voltage, and hydrogen production time were measured because of their influence on the quantity and continuity of hydrogen production through water electrolysis. The results reveal that, for a volume of 0.2 L of ash solution, hydrogen production was 0.058 L/min, the voltage was 13.41 V, the current was 26 A, and the temperature varied from 30˚C to 35˚C over a period of 4 minutes and 10 seconds. For a volume of 0.5 L of ash solution, hydrogen production was 0.494 L/min, the voltage was 13.30 V, the current was 36.6 A, and the temperature varied from 30 to 34˚C over a period of 1 minute and 31 seconds. For a volume of 1 L of ash solution, hydrogen production was 0.5 L/min. Parameters such as temperature varied from 30 to 36˚C, with an electrical voltage of 12.5 V and a current of 68 A over a period of 1 minute and 35 seconds. A 2 L volume of ash solution provides rapid and abundant hydrogen production. Production parameters such as temperature vary from 30 to 40°C with an electrical voltage of 11.07 V and a current of 90

A for a duration of 1 minute 15 seconds. In conclusion, a 0.5 L volume of ash solution in the tank allows for stable operation of the hydrogen generator with minimal variation in production parameters.

Keywords

Air Pollution, Clean Energy, Electrolysis, Ash Solution, Hydrogen Production

1. Introduction

The difficulties facing the fossil fuel market, linked to a global economic crisis and environmental constraints, make the use of clean and sustainable energy sources, known as renewable energies, essential. The use of fossil fuels is responsible for 82% of current CO_2 emissions (coal 35%, oil 31%, gas 16%) [1]. Their use causes numerous serious accidents and pollution of water and air, which are vital resources for human health and ecosystems. In particular, coal is by far the most dangerous energy source used by humans, causing 1 to 2 million deaths worldwide each year through fume inhalation, work-related accidents during its production, etc [2]. We have as examples the major disasters of Honkeido in 1942 in Manchuria which caused 1542 deaths, of Clydestale in 1960 in South Africa which caused 435 deaths, of Luisenthal in 1962 in Germany which caused 284 deaths, and of Marcinelle in 1956 in Belgium which caused 273 deaths [2], Lignite mining in Germany caused 1500 km^2 of land to be gutted, disrupted a hydrological system over 3000 km^2, and displaced 100,000 people in 1945 [3]. Furthermore, their use in coal-fired power plants is a source of air pollution. The solid waste generated from their extraction and use amounts to hundreds of millions of tons each year [4].

1) On the other hand, the negative impact of hydrocarbon exploitation on the environment creates pronounced soil degradation and slows down the production of food crops. This was the case in California in the 1950s, where plants and crops sensitive to ozone suffered significant damage [5].

2) In energy contexts Given current energy and environmental challenges (tensions in energy markets, greenhouse effect, pollution, etc.), the interest in developing "clean" energy production technologies has been revived. Thus, new perspectives such as solar energy or waste recovery are offered to research on "renewable energies".

3) Some authors have worked in this field and obtained significant results. In their work, hydrogen, which was previously underutilized, is considered the fuel of the future. This fuel, whose production is usually ensured by reforming natural gas, can now be obtained through the electrolysis of water.

Water electrolysis for hydrogen production is the most widespread and popular process [6] but very rarely used. The electrolytic solution is often obtained by dissolving potassium hydroxide in water that has been freed of impurities and heavy metals [7]. An electrolytic substance is a compound that, once dissolved, dissociates (partially or completely) to form ions capable of moving under the influence of an electric field. Conversely, a non-electrolytic substance is a compound that does not conduct electricity in solution. Two types of electrolytes are used: strong electrolytes, which are substances that dissociate completely in water to produce ions with high electrical conductivity. Examples include sodium chloride (NaCl), sulfuric acid (H_2SO_4), and potassium hydroxide (KOH). Weak electrolytes are substances that only partially dissociate in water, producing ions with lower electrical conductivity. Examples include weak acids and weak bases: acetic acid (CH_3COOH), carbonic acid (H_2CO_3), and ammonium hydroxide (NH_4OH).

In the literature, the most commonly recommended electrolyte in alkaline electrolyzers is potassium hydroxide (KOH) due to its very good conductivity, which improves energy efficiency, and its high hygroscopicity, which helps maintain a stable electrolyte concentration by absorbing moisture from the air [7]. Potassium hydroxide, or caustic potash, with the chemical formula KOH, is a strong alkali compound used in many industries. It is a white, odorless solid that is highly soluble in water, making it very versatile. It is often used in the manufacture of soaps and detergents for its ability to dissolve fats, oils, fertilizers, batteries, and pharmaceuticals. In laboratories, it serves as a reagent, and in the food industry, it is used to prepare certain foods. According to the same authors, potassium hydroxide can come from natural sources or be synthesized in the laboratory. Natural potassium hydroxide is extracted from the ashes of various plants such as wood or algae, which contain potassium salts. These salts can then be processed to produce potassium hydroxide.

Ash is an alkaline residue resulting from the combustion, incineration, or pyrolysis of a wide range of organic and mineral materials. It can also originate from substances such as coal, lignite, coke, or various waste materials burned in incinerators, outdoors, or in chimneys and furnaces. The main components of this ash are calcium, silicon, potassium, magnesium, aluminum, and sodium [8] [9].

The author Finagnon Crépin Alexis TOGBE, and his research team conducted a physico-chemical study of the ashes of some plants from Benin used in the manufacture of "ACOTO" soap. This study revealed that the pitted fruit bunches of oil palm, also known as oil palm clusters, contain more potassium than other types of ashes. Therefore, we chose to use oil palm cluster ash solution as an electrolyte for our research [10].

The aim of this study is to produce hydrogen by water electrolysis using ash solution as the electrolyte. Specifically, it will involve utilizing oil palm bunch ash and studying the influence of parameters (current, voltage, concentration, and time) on hydrogen produced.

2. Materials and Methods

In this part of the study, we will present the equipment used for the tests and the research methodology.

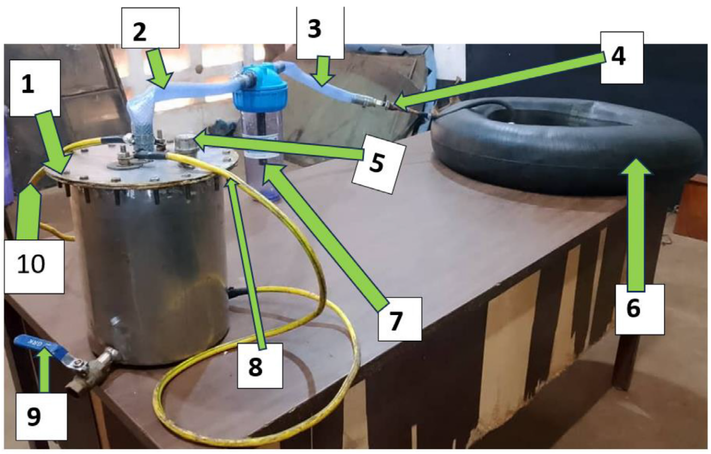
2.1. Materials

The following equipment was used for the hydrogen production test using the ash solution:

1) Electrolytes: The electrolyte used is ash from the combustion of the pitted fruit of the oil palm or oil palm bunch (Figure 1).

Figure 1. Ashes from pitted oil palm fruit.

2) Hydrogen Generator: The hydrogen generator is shown in **Figure 2**.



1: Solution reservoir

2: Generator gas discharge connection to the filter

3: Gas discharge connection to the engine or storage tank

4: Production shut-off valve

5: Solution tank filling cap

6: Inner tube used as a gas storage tank

7: Gas filter or bubbler

8: Power supply wire (cathode)

9: Saturated solution drain valve

10: Power supply cable (anode)

Figure 2. Hydrogen generator.

3) Measuring devices: As shown in **Table 1**, they are used to measure various parameters during our work.

Table 1. Measuring and power supply devices.

MATERIALS	DESCRIPTION
	Mechanical balance: It allowed the ash sample to be measured before being immersed in water.
	Clamp ammeter: It is used to measure the current in the circuit during experimentation.
	Multimeter: It allowed the voltage in the circuit to be measured during the experiment.
	Thermocouple: It allowed the operating temperature of the electrolyzer to be measured during the experiment.
	Stopwatch: It is used to measure the time it takes for the inner tube to fill during the experiment.
	Battery 12 V, 75 Ah: was used as the power source for our electrolyzer.
	Power supply cable for the hydrogen generator, made of copper with a cross-section of 6 mm^2.

2.2. Methods

Preparation of the electrolytic solution: To obtain the electrolytic solution, we dissolved 100 g of ash in 1 L of water and let the solution stand for 24 hours. During this time, we stirred it at least 10 times to ensure the potassium dissolved completely. After this time, we filtered the solution and let it stand for another 24 hours. A sediment formed at the bottom, leaving a clear solution above. Finally, from 100 g of ash in 1 L of water, we obtained 0.75 L of electrolytic solution. **Figure 3** below illustrates the different steps of the process in order.

Experiments and calculations carried out as part of our research: As part of the experiment, we have set up an experimental protocol for the production of hydrogen.

Experimental Protocol: The established experimental protocol is as follows:

1) Open the tank;

2) Add a precise volume of water to the tank;

3) Introduce a defined volume of the electrolyte solution into the reservoir;

4) Close the tank;

5) Open the bubbler;

6) Fill the bubbler halfway with water;

7) Close the bubbler;

8) Place a container equipped with a valve on the lid to prevent the return of the produced gas, at the end of the bubbler outlet pipe, for the collection of the produced gas;

9) Connect one terminal of the electrolyzer to the battery;

10) Start the vehicle;

11) Start the electrolyzer by connecting the second terminal to the battery;

12) Start the timer.

A: Soak 10 g of ash in one liter of water. Shake or stir several times over 24 hours.

B: Solution obtained after filtering

C: Solution obtained after the filtered mixture has rested for 24 hours

D: Electrolytic solution of 1 liter of water which yields 0.75 liters of solution

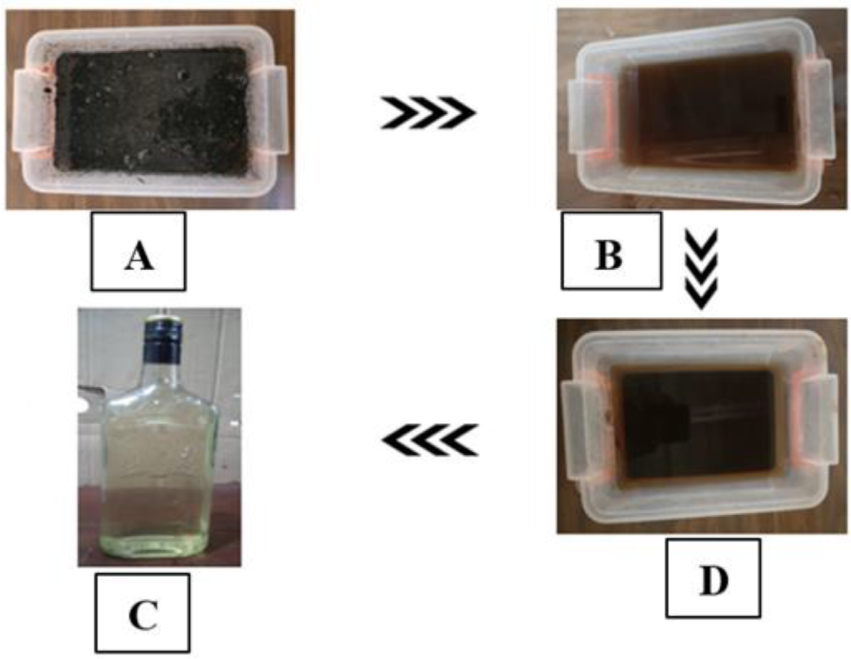


Figure 3. Preparation of the electrolyte solution before filtration.

After installing the required equipment, the following electrical diagram is obtained (**Figure 4**).

The gas produced is not pure hydrogen but a mixture of gases due to the absence of a separating membrane.

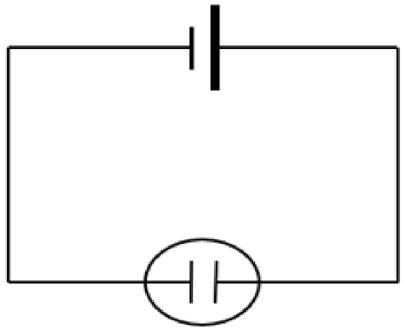


Figure 4. Electrical diagram of the system.

The experiment was carried out with a 12 V and 75 Ah battery while respecting 3 liters of the mixture (water + electrolyte solution) in the reservoir. The power source for the device is the current supplied by the battery. To prevent the battery from discharging during the experiment, we start the vehicle so that the alternator continuously charges the battery.

Other calculated parameters: Some parameters essential for analyzing the operation of production subsystems cannot be measured directly. To determine them, mathematical relationships must be used.

1) Actual power absorbed by electrolysis: This is the power used by the electrolyzer to perform the electrolysis of water; in our case, it corresponds to the power at the output of the voltage generator.

$$P_m = V \times I \tag{1}$$

2) Useful power of electrolysis: This is the useful thermal power generated by the combustion or use of hydrogen (H_2) in the context of fluid engineering or energy, often applied to electrolyzer systems or heat engines [11].

$$P_u = \text{PCI} \times Qv\text{H}_2 \times \rho \tag{2}$$

P_u : Useful power, expressed in watts (W) or kilowatts (kW), representing the thermal energy delivered.

PCI : The lower heating value of hydrogen, typically 120 to 286 kJ/mol or 10 to 13 kWh/kg depending on the units, measures the energy released per unit mass without condensation of water vapor.

$Qv\text{H}_2$: Volumetric flow rate of hydrogen (in m^3/s or m^3/h), indicating the quantity of H_2 gas consumed per unit of time.

ρ: Reference density of hydrogen under normal conditions (in kg/m^3, often 0.0899 kg/m^3 at 0˚C and 1 atm).

3) Electrical energy consumed: The electrical energy consumed is obtained by multiplying the power at the output of the voltage generator by time.

$$E_{ele} = P_m \times t \tag{3}$$

4) Useful yield: This is the ratio of useful power to the power of the voltage generator.

$$R_u = \text{PCI} \times \left(Qv\text{H}_2 / P_m \right) \times \rho \tag{4}$$

5) Electrolyzer efficiency: The operating efficiency of the electrolyzer can be calculated using the formula below [12].

$$\varepsilon = \dot{V}_{\text{HHO},r} / \dot{V}_{\text{HHO},t} \quad (5)$$

$\dot{V}_{\text{HHO},t}$ is the theoretical volumetric flow rate and $\dot{V}_{\text{HHO},r}$ the real volumetric flow rate.

The total volume of HHO gas produced by the cells of an electrolyzeris given by the following equation [11].

$$V_{\text{HHO},t} = V\text{H}_2 + V\text{O}_2 \quad (6)$$

$V_{\text{HHO},t}$: defines the total volume of an HHO gas (oxygen and hydrogen mixture produced by electrolysis of water);

$V\text{H}_2$: volumes of dihydrogen;

$V\text{O}_2$: volumes of dioxygen.

According to Faraday's law, in the case of water electrolysis at a constant current, we have the following formula which defines the moles number (n) of substance produced or consumed during an electrochemical reaction.

$$n = I \times T / F \times Z \quad (7)$$

with *n*: Quantity of substance released (mol).

I: Current intensity (A).

t: Time during which the current is applied (s).

F: Faraday constant ($A \cdot s \cdot mol^{-1}$), F = 96485 $A \cdot s \cdot mol^{-1}$.

Z: Number of moles of electrons exchanged ($ZH_2 = 2$ and $ZO_2 = 4$).

Under standard temperature and pressure (STP), hydrogen is considered an ideal gas. Therefore, we have:

$$P \times V = n \times R \times T \quad (8)$$

with P: Gas pressure (atm).

V: Volume of the gas (L).

R: Ideal gas constant ($L \cdot atm \cdot mol^{-1} \cdot K^{-1}$), R = 0,08205746 $L \cdot atm \cdot mol^{-1} \cdot K^{-1}$.

T: Temperature (K).

By combining equations (6)-(8), we obtain the theoretical volume of the gas produced, which is:

$$V_{\text{HHO}} = \left(I \times t \times R \times T / F \times P\right)\left(Z_{\text{H}_2}^{-1} + Z_{\text{O}_2}^{-1}\right) \quad (9)$$

By taking the chosen current value for the operation of electrolyzer, the theoretical volumetric flow rate is given by the formula [11] below:

$$\dot{V}_{\text{HHO}} = V_{\text{HHO}} \times I \times Nc \quad (10)$$

3. Results and Discussion

3.1. The Effect of the Concentration of the Electrolytic Solution on Voltage and Current

In this experiment, we varied the concentration of the electrolyte in order to record the parameters of hydrogen production, namely: voltage and current. The unit

Ls/Le stands for "liters of core solution per liter of water." For example, 0.5 Ls/Le means 0.5 liters of core solution per liter of water. The total volume of the electrolyte solution is 1.5 liters in this case.

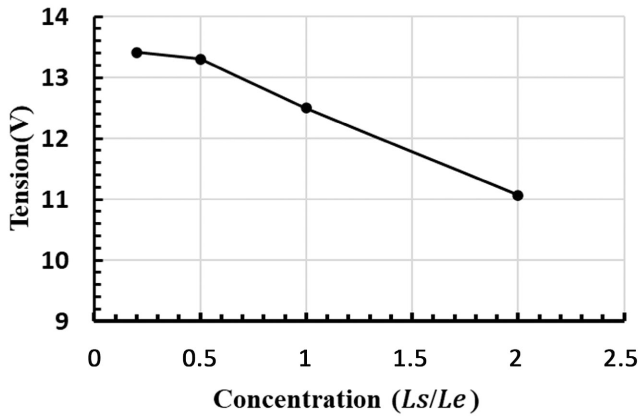


Figure 5. Evolution of voltage as a function of the concentration of the electrolytic solution.

Figure 5 illustrates the voltage evolution as a function of the concentration of the mixture (water with electrolyte solution). A progressive decrease in voltage is observed with increasing concentration. The voltage drops from approximately 13.41 V to 11.07 V when the concentration varies from 0.2 to 2 Ls/Le. This trend can be explained by the improvement in the conductivity of the electrolyte solution as the concentration increases, which reduces the internal resistance of the system. Thus, for each given concentration, the voltage remains stable. For a battery being charged in a vehicle with the engine running, the voltage varies between 13 and 14 V. Therefore, the voltages obtained for concentrations of 0.2 and 0.5 during the tests are reliable.

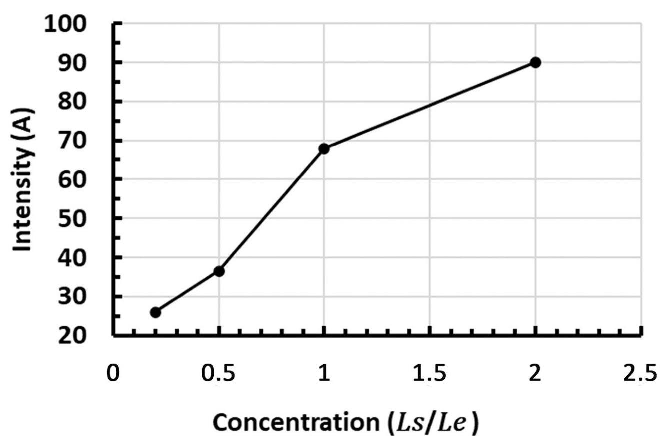


Figure 6. Evolution of intensity as a function of the concentration of the electrolytic solution.

Figure 6 shows the evolution of current intensity as a function of the mixture concentration. An increase in current intensity is observed as the concentration increases. The current intensity varies from 26 to 90 A for concentrations ranging from 0.2 to 2 Ls/Le. This suggests that increasing the concentration improves the conductivity of the solution, thus facilitating the flow of electric current. This behavior could be attributed to a greater availability of ions in the solution, increasing the efficiency of the electrochemical process. High current intensity in the electrical circuit of a motor vehicle causes the connecting wires to heat up. Therefore, the current intensities of 26 A and 36.6 A obtained in our experiments are favorable.

3.2. Temperature Evolution

The temperature evolution during the production time is shown in **Figures 7-11** according to the concentrations used. The temperature during production increases with the production time for the different concentrations.

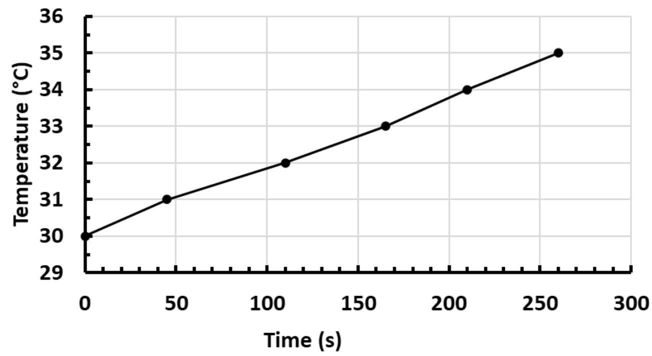


Figure 7. Temperature evolution over time for 0.2 Ls/Le.

Figure 7 illustrates the temperature evolution over time for a concentration of 0.2 Ls/Le. A gradual, linear increase in temperature is observed as time passes. The temperature varies from 30˚C to 35˚C during the production time of 4 minutes and 10 seconds. For a concentration of 0.5 Ls/Le (**Figure 8**), the temperature varies from 30˚C to 34˚C during the production time of 1 minute and 31 seconds. Similarly, the graph reveals a more moderate temperature increase compared to the case of concentration 0.2 Ls/Le.

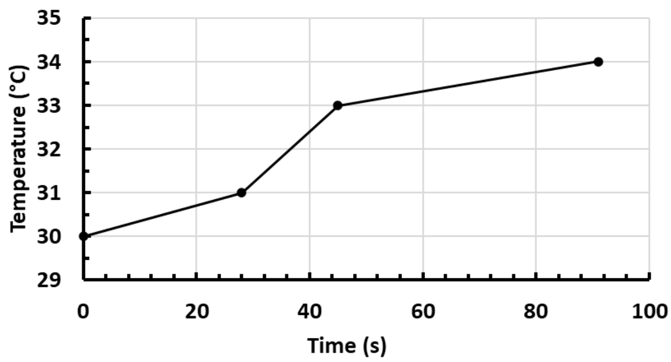


Figure 8. Temperature evolution over time for 0.5 Ls/Le.

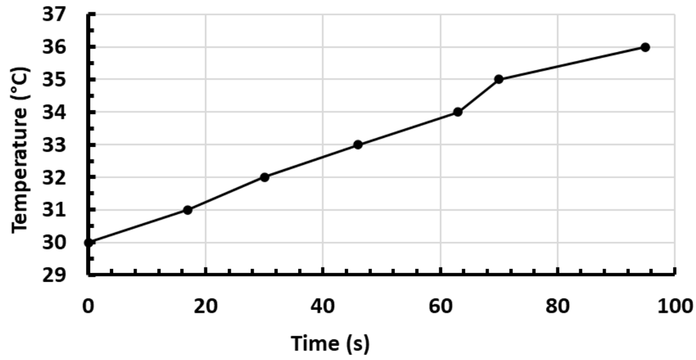


Figure 9. Temperature evolution over time for 1 Ls/Le.

Figure 9 illustrates the temperature evolution over time for a concentration of 1 Ls/Le. The temperature varies from 30˚C to 36˚C during the production time of 1 minute and 35 seconds. The graph also shows a relatively rapid temperature rise, suggesting a higher intensity, probably due to the increased concentration of the solution, which promotes electrical exchange and exothermic chemical reactions. This result highlights the importance of monitoring the temperature to avoid any risk of overheating.

Evolution of temperature for concentration 2 Ls/Le is shown on **Figure 10**.

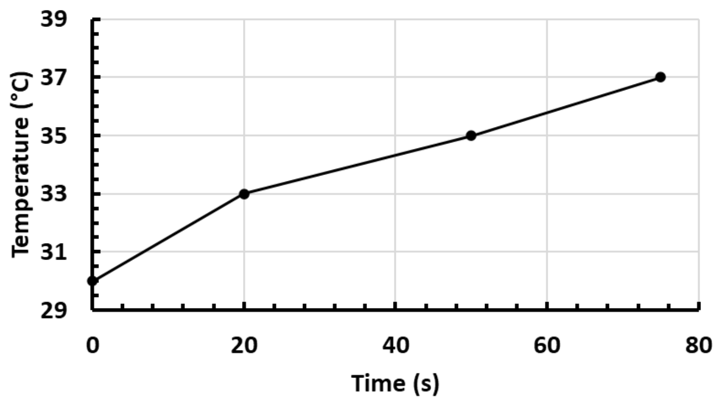


Figure 10. Temperature evolution over time for 2 Ls/Le.

This graph shows a gradual and almost linear increase in temperature over time, rising from 30˚C to 37˚C between 0 and 75 seconds. The relatively rapid temperature rise suggests a higher intensity, likely due to an increased volume of solution facilitating electrical exchange and exothermic chemical reactions. This result also highlights the importance of monitoring the temperature to prevent any risk of overheating.

Analysis of **Figures 5-10** shows that the electrolysis parameters, particularly voltage, current, and temperature, vary depending on the concentration of the electrolytic solution. A higher concentration improves the conductivity of the mixture (electrolytic solution + water), reducing the required voltage (**Figure 5**) while increasing the current for better gas production (**Figure 6**). **Figures 7-10** show that the 0.5 Ls/Le concentration exhibits a smaller temperature variation than other concentrations. To ensure stable electrolysis parameters, choosing 0.5 Ls/Le appears to be a good compromise, as it allows for a moderate and better-controlled temperature increase while offering a reasonable filling time (1 minute 31 seconds). This volume thus guarantees stable and efficient electrolyzer performance.

3.3. Estimation of Production Throughput

The actual gas flow rate produced by the electrolyzer increases rapidly up to the optimal concentration point of 0.5. After 0.5, the growth is slow with increasing concentration. From 0.2 to 0.5 L/min, production increases rapidly from 0.058 to 0.494 L/min. From 0.5 to 2 L/min, this production increases from 0.494 to 0.56 L/min.

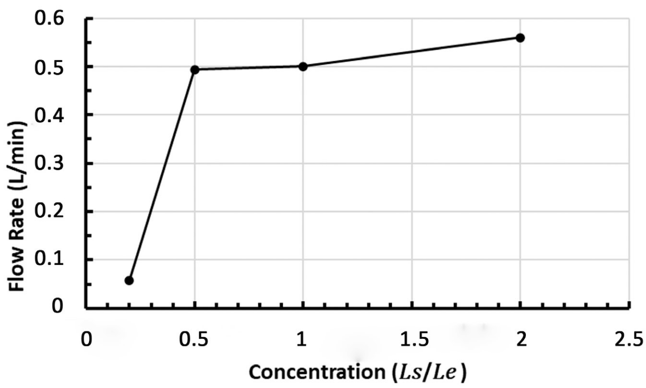


Figure 11. Flow rate variation as a function of concentration.

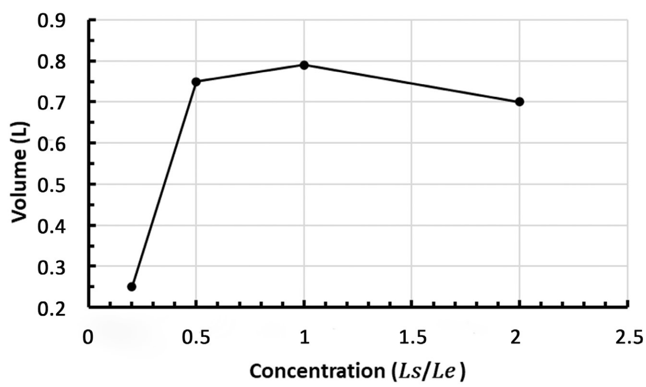


Figure 12. Production volume as a function of concentration.

The production volume curve in Figure 12 shows three zones: a zone of rapid increase between concentrations of 0.2 Ls/Le and 0.5 Ls/Le, a zone of slow growth increase 0.5 Ls/Le and 1 Ls/Le, and a zone of decrease from 1 Ls/Le to 2 Ls/Le. The point at coordinates (0.5 Ls/Le, 0.75 Ls/Le) constitutes an inflection point for the production volume curve.

We can also note from Figure 13 that the production time of hydrogen for the concentration of 0.2 Ls/Le is high while those of the concentrations of 0.5 Ls/Le, 1 Ls/Le and 2 Ls/Le are relatively low.

In terms of hydrogen production, a concentration of 0.5 Ls/Le represents optimal production.

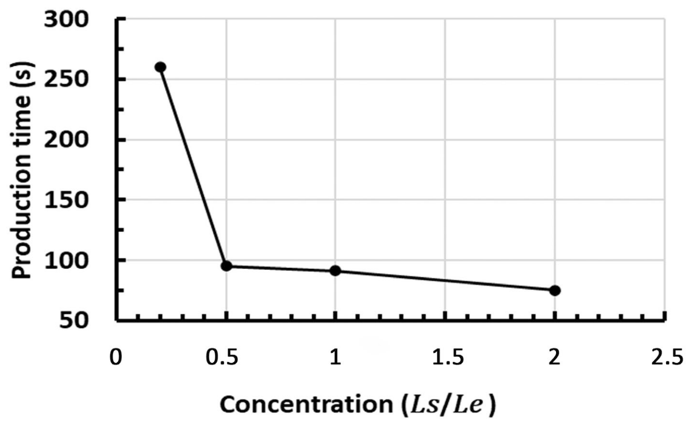


Figure 13. Evolution of production time as a function of concentration.

In order to determine parameters not directly measurable, the voltage and current are those obtained at a concentration of 0.5 Ls/Le. The theoretical volume is determined assuming that the electrolyzer operates under standard temperature and pressure (STP) conditions, with a current of 1 A for 1 minute [11].

To determine the energy efficiency of the electrolyzer, 10 tests were carried out for a concentration of 0.5 Ls/Le, the production times of which are recorded in **Table 2** below.

Table 2. Table type styles.

Test number	Time (s)
1	90
2	88
3	91
4	92
5	90
6	93
7	89
8	93
9	92
10	92

The average time obtained is 91 seconds. The production for this average time is 0.75 L.

Using these different data points, we have the calculated parameters which are grouped in Table 3 below:

Table 3. Table type styles.

Calculated parameters	Value
P_m	490.806 W
E_{ele}	44663.346 J
$V_{\text{HHO},t}$	0.0105 L
$\dot{V}_{\text{HHO},t}$	1.14 L/min
$\dot{V}_{\text{HHO},r}$	0.494 L/min
P_u	88.81 W
ε	43%

For this concentration, the efficiency of the electrolyzer is 43% with the use of the ash solution. This efficiency confirms that ashes can indeed be used to produce hydrogen for the operation of internal combustion engines and for industrial use.

4. Conclusions

The results of these tests allowed us to analyze the parameters of hydrogen production such as concentration, current intensity, electrical voltage, temperature and production time.

The results clearly show that the voltage decreases with increasing concentration, the current increases with increasing concentration, and the production time decreases with increasing concentration. Therefore, the ideal concentration for optimal production is 0.5 Ls/Le.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Durand, B. (2014) Les combustibles fossiles (charbon, pétrole, gaz naturel…). Sauvons le Climat-Conseil Scientifique. https://www.sauvonsleclimat.org/fr/ressources/base-doc/les-combustibles-fossiles-charbon-petrole-gaz-naturel

[2] Durand, B. (2012) Les dangers du charbon (autres que l'effet de serre). Sauvons le Climat. Les dangers du charbon. https://www.sauvonsleclimat.org/images/articles/pdf_files/etudes/lesdangersducharbon.pdf

[3] Durand, B. (2014) Les dangers des Combustibles fossiles (Autres que l'effet de serre). Sauvons le Climat. Comparaison des augmentations de risques de mort prématurée par les effets des particules fines, de la radioactivité, et du tabac.

[4] Puits Couriot/Parc-Musée de la Mine (2017) Les dangers dans une mine de charbon. Bd Maréchal Franchet D'Esperey, Ville de Saint Etienne.

[5] Guy, L. (2014) Les impacts des énergies fossiles sur l'environnement. INERIS.

[6] Négrou, B., Settou, N., Chennouf, N. and Dokkar, B. (2009) Etude d'une installation de production d'hydrogene solaire par l'electrolyse de l'eau. *Annales de la Faculté des Sciences et Sciences de l Ingénieur*, **1**, 43-49.

[7] See, D.M. and White, R.E. (1997) Temperature and Concentration Dependence of the Specific Conductivity of Concentrated Solutions of Potassium Hydroxide. *Journal of Chemical & Engineering Data*, **42**, 1266-1268. https://doi.org/10.1021/je970140x

[8] Ludovic, C. (2025) Valorisation des cendres de bois: Transformer un résidu en ressource. Valbiom.

[9] Couturier, M.C. and Brasset, M.T. (2005) Gestion et Valorisation des Cendres de Chaufferies Bois. ADEME, SOLAGRO.

[10] Togbe, F., Azandegbe Eni, C., Josse, R. and Dimon, B. (2012) Étude physico-chimique des cendres de quelques végétaux du Benin utilisées dans la fabrication du savon *«ACOTO». International Journal of Biological and Chemical Sciences*, **6**, 454-460. https://doi.org/10.4314/ijbcs.v6i1.41

[11] Cifuentes, J.I. (2020) Design and Manufacture of an Electrolyser for Its Application in Obtaining Hydrogen as Fuel. *Evolutions in Mechanical Engineering*, **3**, 4-7. https://doi.org/10.31031/eme.2020.03.000558

[12] Soldi, B., Gökalp, I., Zeroual A., Lachgar, M.A. and Aymard, A. (2009) Conception et réalisation d'un système de production d'hydrogène à l'aide d'un dispositif de catalyse. *Revue des Energies Renouvelables*, **12**, 149-162.