DIY Hydrogen Generator: Optimisation of electrolysis in a Modular 3D-Printed System

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Introduction

This project investigates the design and optimization of a modular DIY hydrogen generator using alkaline water electrolysis, where an applied electrical potential splits water into hydrogen gas and oxygen gas at two inert electrodes.

$$2\,H_2O(l) \xrightarrow{\Delta E} 2\,H_2(g) + O_2(g)$$

A 3D-printed cell was developed to ensure chemical resistance, gas-tightness, and safe gas separation. The study examined how electrode spacing, electrolyte concentration, stirring, voltage, and current influence hydrogen gas output, showing that both chemical and mechanical factors determine small-scale generator efficiency.

Materials and methods

The setup used a sealed 3D-printed electrolysis cell with stainless-steel electrodes, NR seals, and custom spacers for chemical resistance and gas-tightness. Hydrogen gas and oxygen were collected in graduated cylinders via tubing. Demineralized water with KOH or KCl served as the electrolyte, mixed using a 4-L reservoir, a regulated power supply, and heated magnetic stirrers. Gas production was tested under varying chemical, electrical, and mechanical conditions.

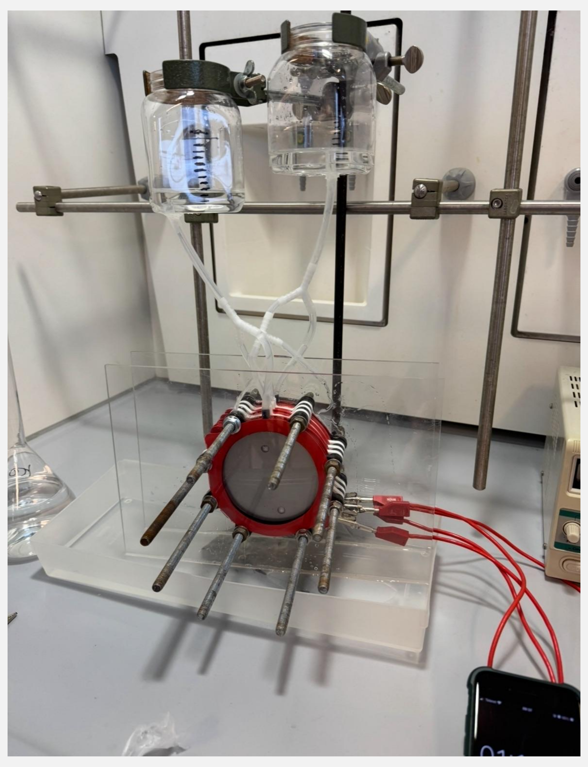

Figure 1: Prototype III

Figure 2: Electrolysis setup

Results and discussion

This study evaluated factors affecting a DIY hydrogen generator's efficiency. Prototype 1 yielded no measurable results, while Prototype 2 produced hydrogen gas but could not be quantified accurately due to the low resolution of the 25 mL cylinder. Prototype 3 delivered stable, repeatable data and was used for systematic testing, although system-level evaluation was limited by gas-outlet leakage, where pressure caused fluid loss and tube detachment. Adhesive sealing did not maintain a reliable seal.

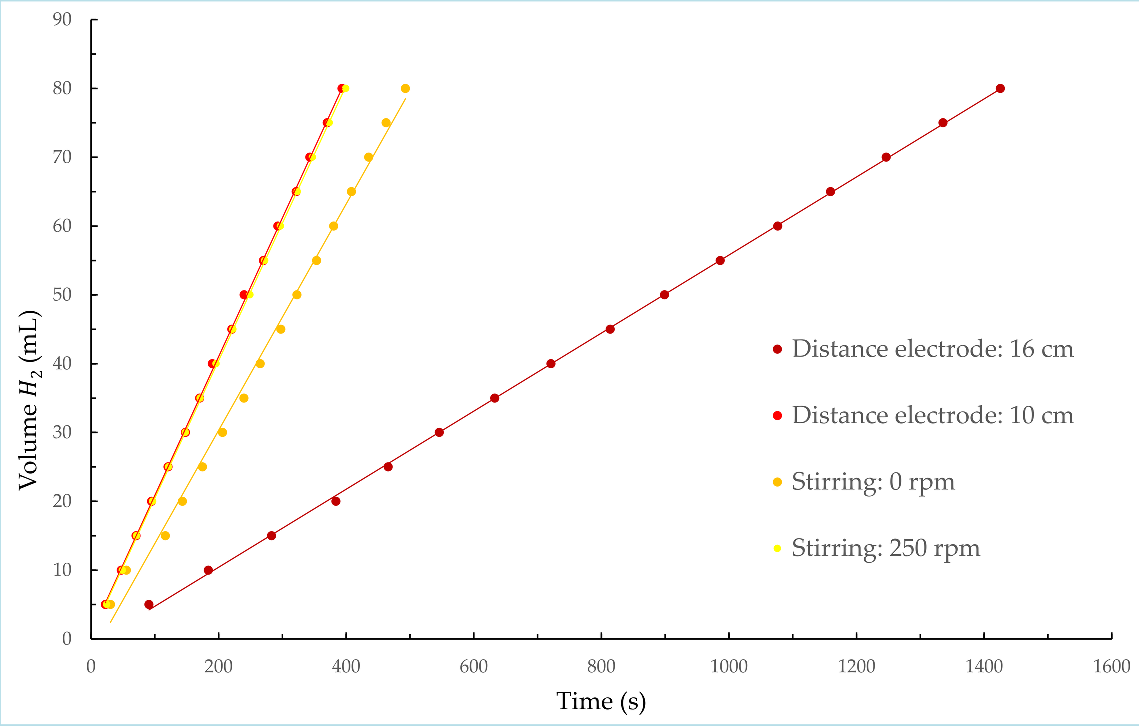

Figure 3: Effect of electrode distance and stirring

Reducing electrode spacing from 16 cm to 10 cm tripled hydrogen gas flow by lowering internal resistance. Stirring at 250 rpm produced only a minor additional increase via improved mass transport and bubble removal.

Higher voltage and current increased hydrogen gas output, with only small differences at low voltages but a clear rise at 22.8–24.4 V. Above 15 V, electrolyte heating indicated overpotential losses and reduced efficiency.

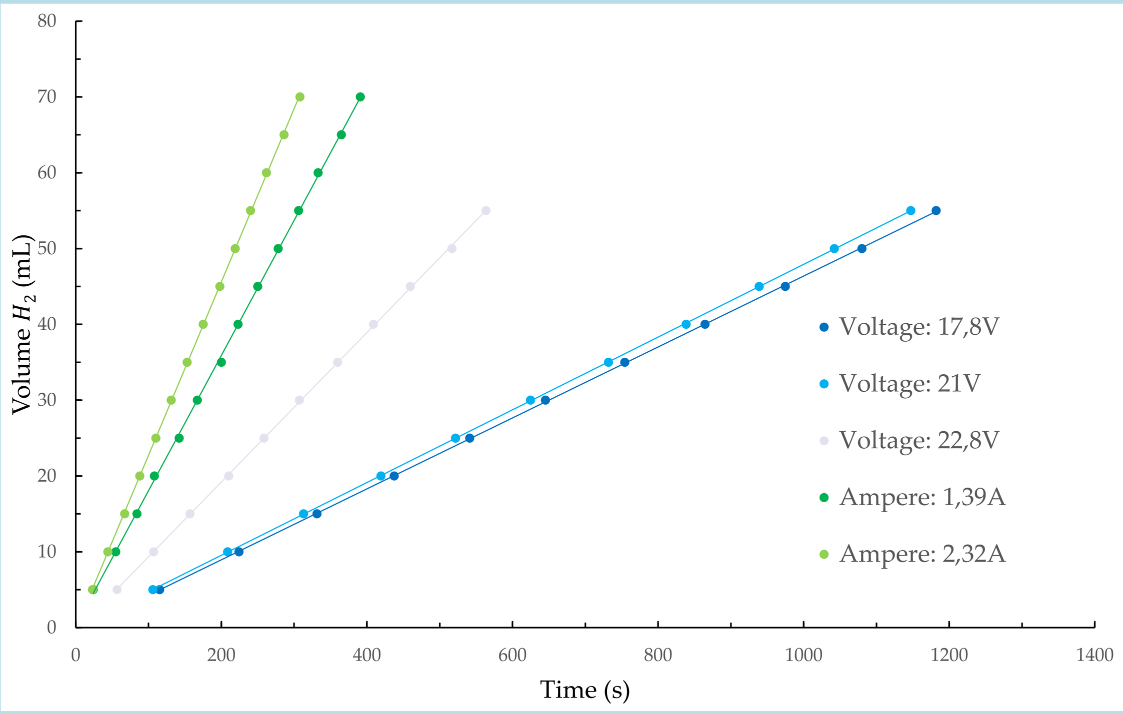

Figure 4: Effect of voltage and current

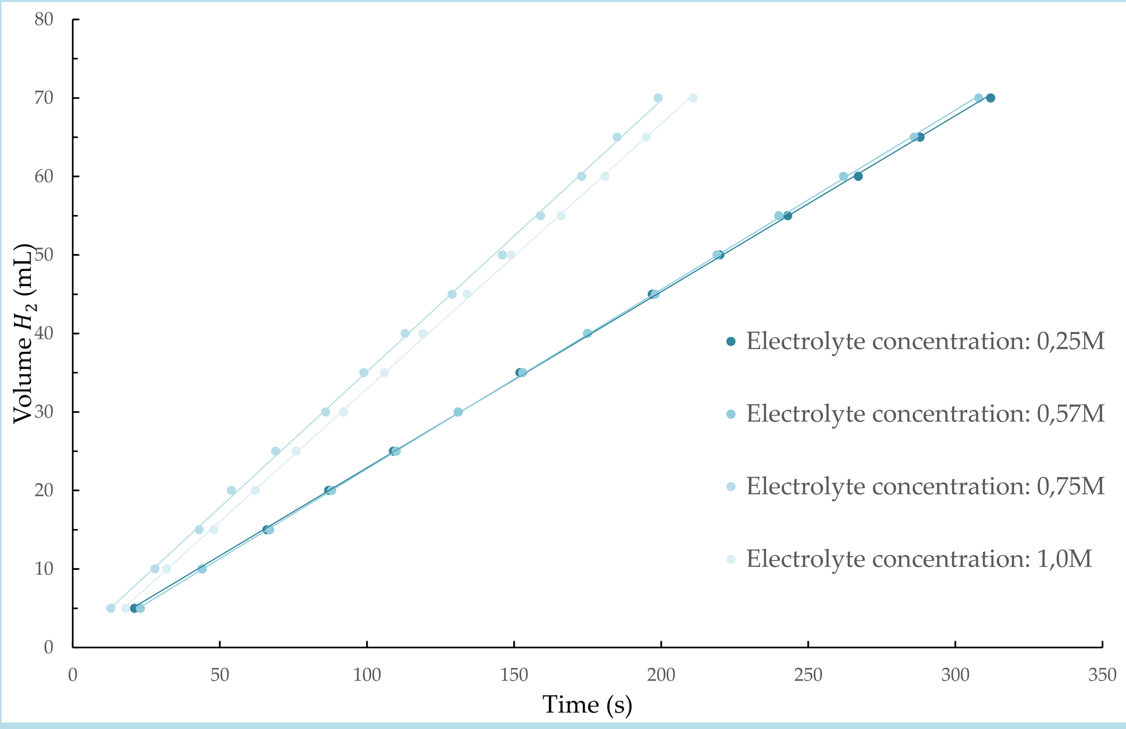

Figure 5: Effect of electrolyte concentration

Hydrogen gas production increased with KOH concentration up to 0.75 M, after which efficiency declined.

Conclusion

This study shows that mechanical and electrochemical factors strongly influence DIY hydrogen-generator efficiency. Prototype 3 enabled reliable testing. Reduced electrode spacing, higher current, and an optimal electrolyte concentration (0.50–0.75 M KOH) increased gas flow, while stirring had minimal impact. Higher voltages improved output but caused heating and overpotential above 15 V. Tube detachment and weaknesses in 3D-printed parts caused fractures and leakage, indicating a need for stronger materials and improved design. Further optimization of operating conditions and component strength is required.

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