

LEAD ELECTRODEPOSITION ON GRAPHITE FELT IN A REVERSABLE FLOW-THROUGH REACTOR

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Reducing lead-acid battery (LAB) weight is one of the ways to increase the energy and power density of this battery technology. One of the ways this can be achieved is by replacing heavy lead grids, which do not participate in the electrochemical reactions with lightweight, conductive, chemically inert materials such as graphite felt (GF) [1]. However, large surface area of carbon materials in composite electrodes can lead to greater gas evolution at charging and faster self-discharge of LAB [2]. This can be mitigated by electrodepositing lead on carbon substrates and thus reducing the surface area of carbon [3].

Electrodeposition was performed in a flow-through reactor with one GF cathode (2.5 mm thickness) in the middle surrounded with two soluble lead anodes. Each electrode had a geometric surface area of 20 cm². Electrolyte consisted of 0.5 M lead(II) methanesulfonate, 0.5 M methanesulfonic acid, and 1 g L⁻¹ sodium ligninsulfonate as surfactant. A peristaltic pump was used to circulate the electrolyte at 120 mL min⁻¹ with the reversion of flow direction every 5 minutes. In some experiments, pulsating current was applied with a 1 second on period followed by 1 second rest. Total electrodeposition time was 1 hour when 15 mA cm⁻² current density was used and 30 minutes when 30 mA cm⁻² was used. After electrodeposition, the modified GF samples were washed with excess of distilled water and dried under constant 2 L min⁻¹ flow rate of nitrogen gas at 60 °C for 2 hours.

Table 1. Electrodeposition result summary

No.	Mass increase, g g ⁻¹ GF	Current efficiency, %	Electrolyte flow	Current impulse	Cathodic current density, mA cm ⁻²
20	1.62	86.5	→*	No	15
21	1.77	94.8	↔**	No	15
22	1.59	84.8	↔	Yes	15
25	1.80	96.1	↔	No	30
26	1.72	91.7	↔	Yes	30

* - one-direction; ** - periodically reversed

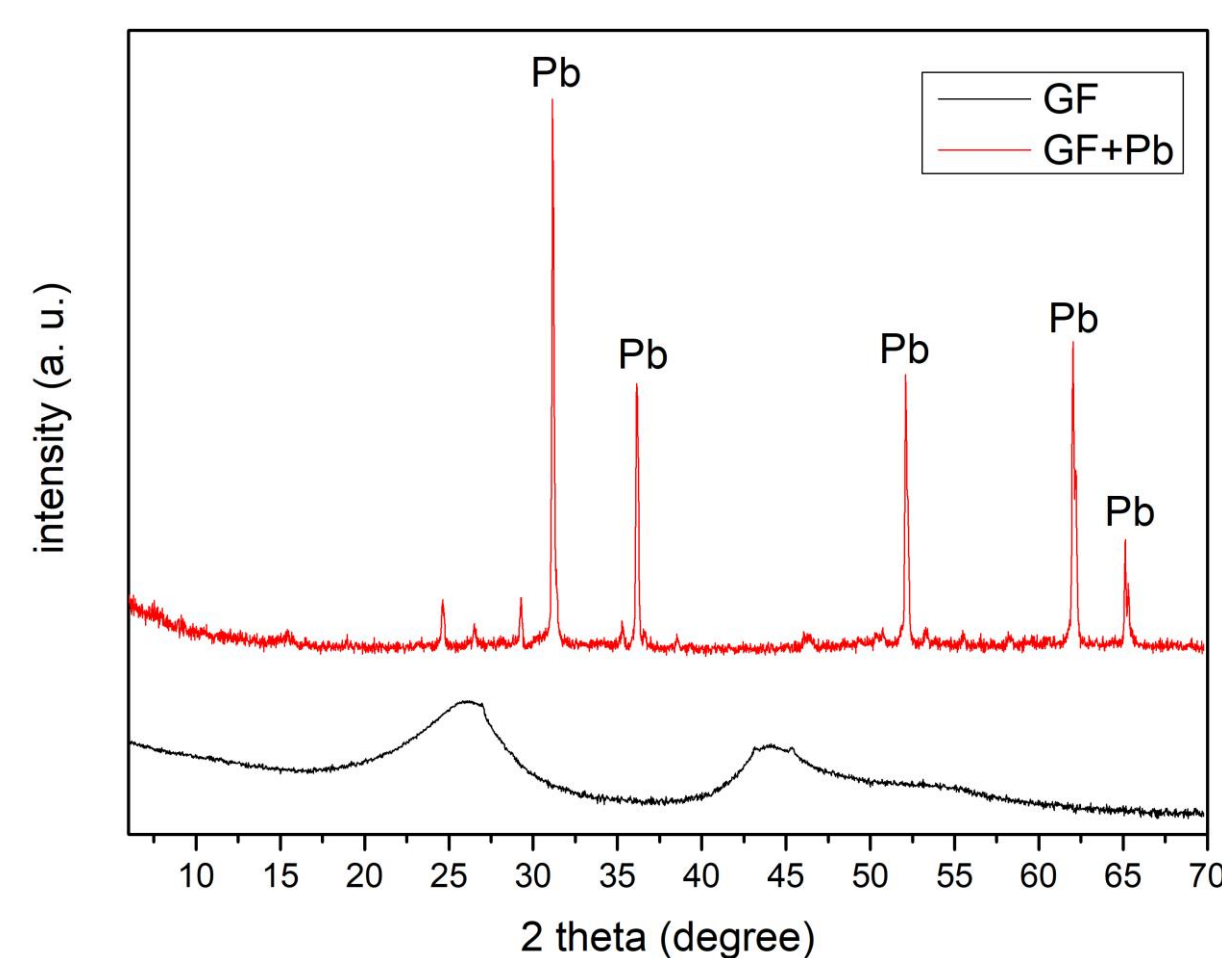


Fig. 1. XRD of raw GF and GF electrochemically coated with Pb

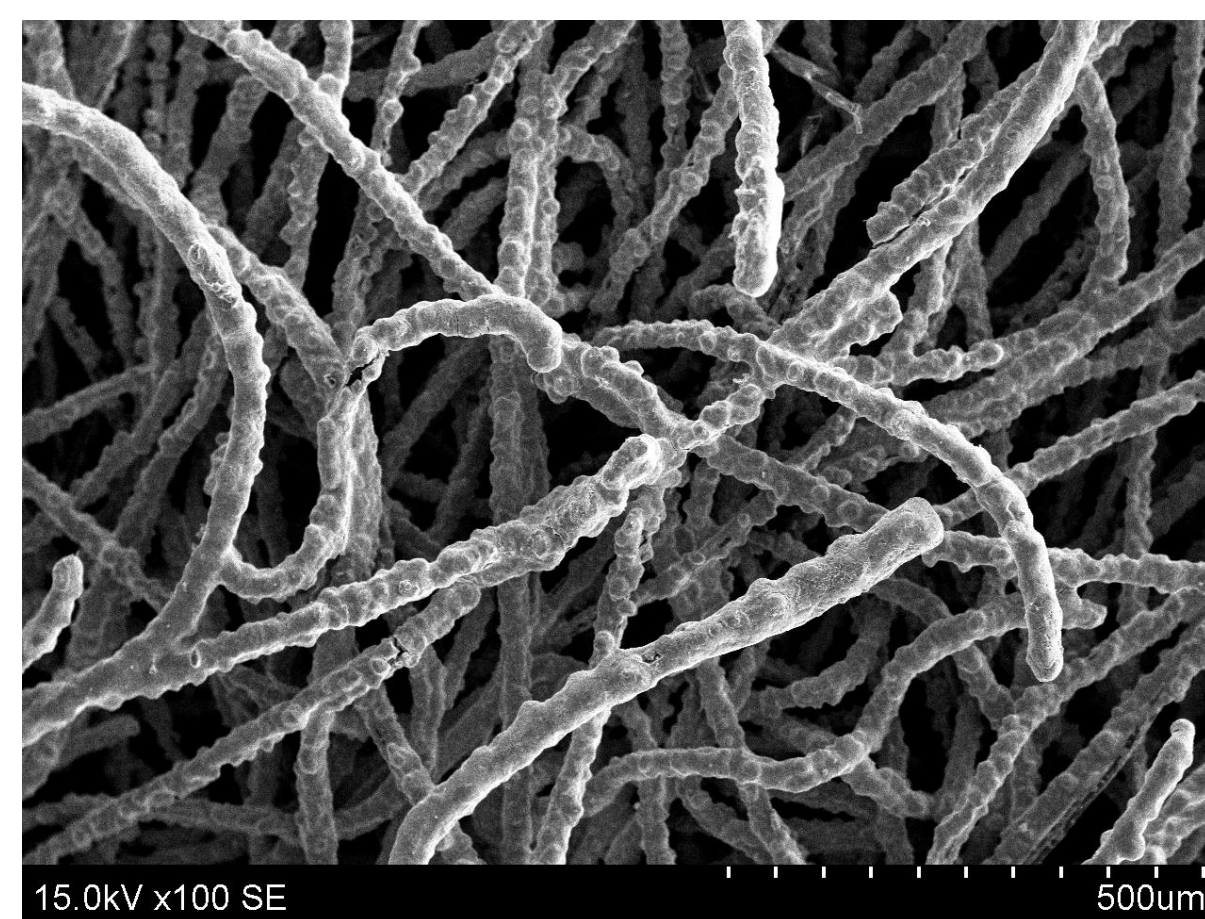


Fig. 2. SEM image of GF electrochemically coated with Pb

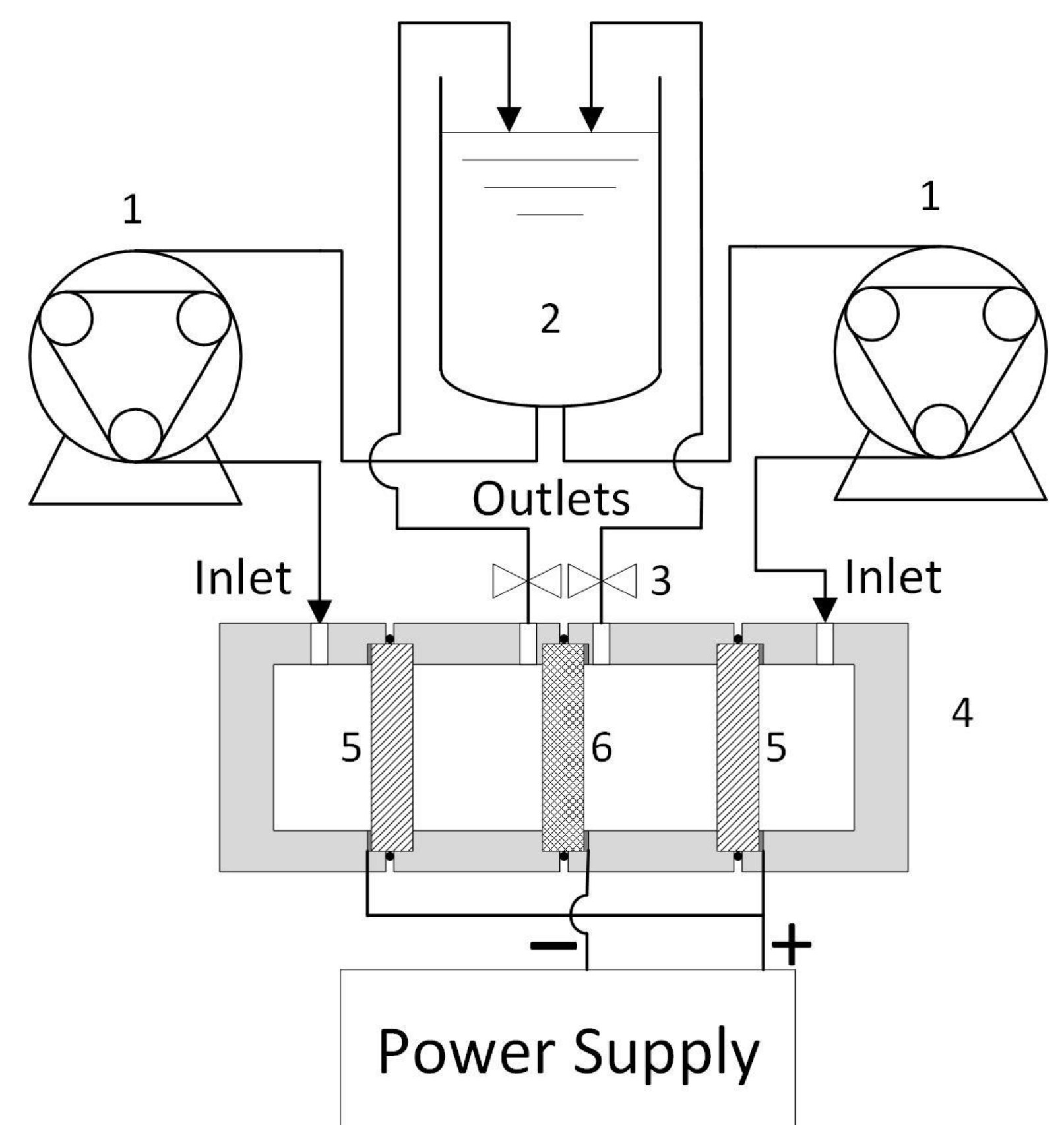
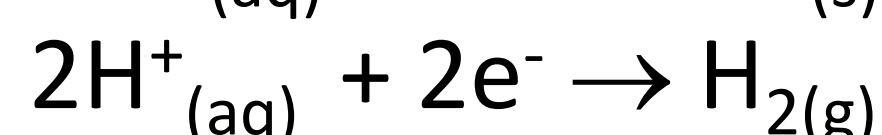
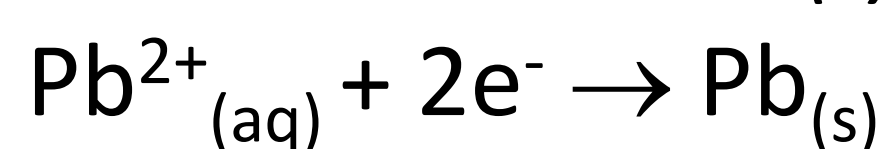


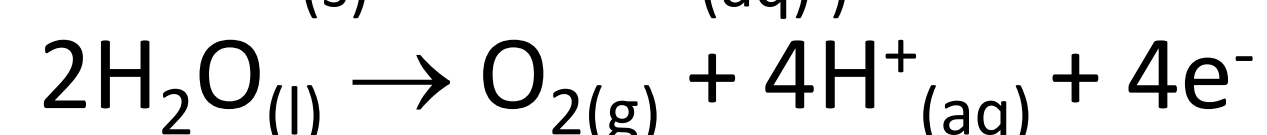
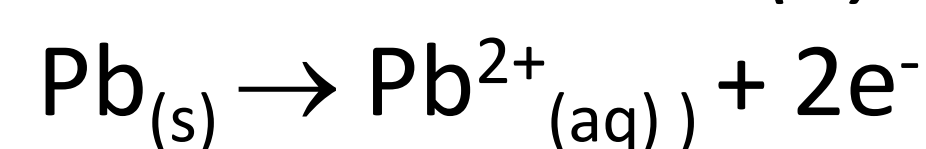
Fig. 3. Flow-through reactor scheme. Here: 1 – peristaltic pumps, 2 – electrolyte tank, 3 – flow control valves, 4 – PTFE reactor body, 5 – Pb anodes, 6 – GF cathode.

Main and side electrochemical reactions on electrodes

On the GF cathode (-):



On the Pb anodes (+):



The results provided in Table 1 shows that electrodeposition at continuous current and when the flow of electrolyte in the reactor was not reversed periodically, the current efficiency of electrodeposited Pb was significantly lower compared to the efficiency that was achieved when the electrolyte flow was reversed periodically every 5 minutes. Furthermore, when pulsing current were used the current efficiency of Pb decreased considerably even lower than when the flow was not reversed. This indicating that dissolution of the deposited Pb was occurring while the current impulse was on the rest stage. Doubling the cathodic current density to 30 mA cm⁻² lead to an increased current efficiency in both continuous and pulsed current experiments.

References

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