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# A high-energy-density sugar biobattery based on a synthetic enzymatic pathway


## Abstract (summary)

**High-energy-density, green, safe batteries are desirable for meeting the rapidly growing needs of portable electronics. Previously-made sugar batteries have low energy densities. We have made a fuel cell in which maltodextrin sugar is broken down by enzymes in the presence of air. Its maximum power output is 0.8 mW/cm², far higher than previous systems. Its energy-storage density is 298 Wh/kg, much greater than that of lithium-ion batteries. Sugar-powered biobatteries could serve as next-generation green power sources for portable electronics.**


## Introduction

The widespread use of lithium-ion and other metal-containing batteries raises many concerns, mainly related to safety, toxic metal pollution and the availability of costly and limited resources.

Enzymatic fuel cells (EFCs) are emerging devices that use enzymes to help generate electricity from energy stored in natural substances such as sugars.

Sugars are appealing fuels because they are abundant, renewable, cheap and carbon neutral. Maltodextrin is a sugar made from starch. It is an excellent EFC fuel because it is cheap and has a high energy density.

## Methods

We built EFC apparatus that allowed air to enter. We produced 13 enzymes for use in our fuel cell. We compared the current, power and energy densities of fuel cells set up in different ways and operating in different conditions.

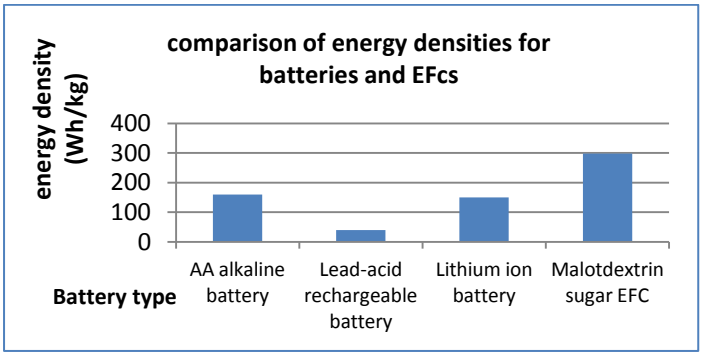
## Results

We found that a stack of two EFCs could power a digital clock and light-emitting diode (LED). This suggests that these EFCs could be used to power electronic devices in the near future.

## Discussion

The energy density of one of our EFCs was 298 Wh/kg, much greater than for a lithium-ion battery.

The bar chart compares the energy densities of different batteries with our maltodextrin EFC.




The data show that maltodextrin has a higher energy density than other types of battery.

An important issue for sugar biobatteries is extending their lifetime. This must be resolved before EFCs can be used on a large scale.

To summarise, high-energy-density sugar biobatteries could represent the next generation of environmentally-friendly power sources, because of their high energy density, safety, biodegradability and low cost.

### Supplementary information

The bar chart is based on data in the table.

| Battery type | Energy density (Wh/kg) | Reference |
|---|---|---|
| AA alkaline battery | 160 | Wikipedia |
| Lead-acid rechargeable car battery | 40 | Wikipedia |
| Lithium ion rechargeable phone battery | 150 | Wikipedia |
| Maltodextrin sugar battery | 298 | This study |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