Electronic Supplementary Material (ESI) for Chemical Communications

Supporting information

Self-Propelled Chemical-Powered Plant-Tissue Biomotors

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Supporting Video Captions

***SI video 1*:** Self-propelled plant tissue motors: potato coated with epoxy resin, carrot coated with chitosan and millet sputtered with Ti.

***SI Video 2*:** Uncoated potato rods in different concentrations of H_2O_2: a) 0%, b) 5% c) 10%.

***SI video 3*:** Potato motors with different coatings (from left to right and top to bottom): epoxy resin, nail lacquer, Nafion, and chitosan.

***SI video 4*:** The effect of H_2O_2 concentration on the performance of the potato motors.

***SI Video 5*:** The effect the temperature on the functionality of potato motors.

SI video 6: Thermostability of potato rods.

Experimental Section

Materials

Potato tuber (*Solanum tuberosum*), carrot root (*Daucus carota*) and millet (*Panicum miliaceum*) were purchased from a local market. Hydrogen peroxide, sodium dodecyl sulfate (SDS) and chitosan were purchased from Sigma-Aldrich. Nafion and epoxy resin were obtained from Fluka and Devcon, respectively.

Tissue Biomotors Preparation

Plant tissue motors were designed in a way that would attempt to maximize the number of active sites on the rocket that would not produce competing forces since too many equal and opposite forces would result in no net movement when placed in H_2O_2. The initial plant tissue motor

structure was created by cutting on cross section of potato and carrot with a ~2 mm thickness. Small cylindrical motors were punched out of the plant cross section using a 1.0 mm-diameter Harris puncher (Redding, CA). The small cylindrical tissue structures was then covered with epoxy resin, nail lacquer, Nafion or 0.5% w/v chitosan, providing as inert coating for creating an asymmetric structure. The asymmetric propulsion forces resulted from the catalase catalyzed O_2 generation in H_2O_2 solution.

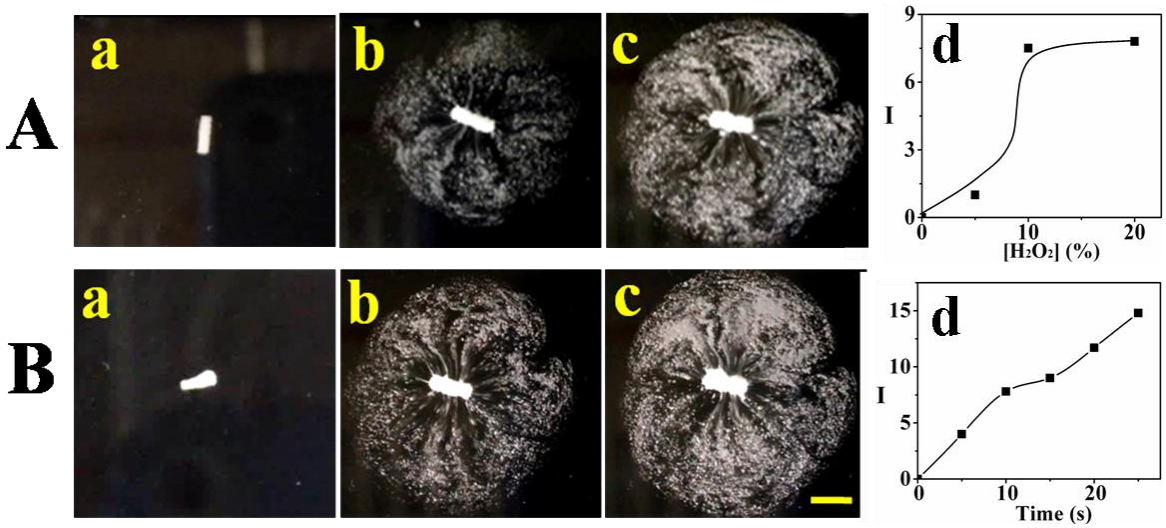
In order to make asymmetric millet rice motors, millet beads were sputtered with Ti to create Janus structures. A benefit of this method is the ability to precisely control the coverage area of each motor.

Tissue motor propulsion

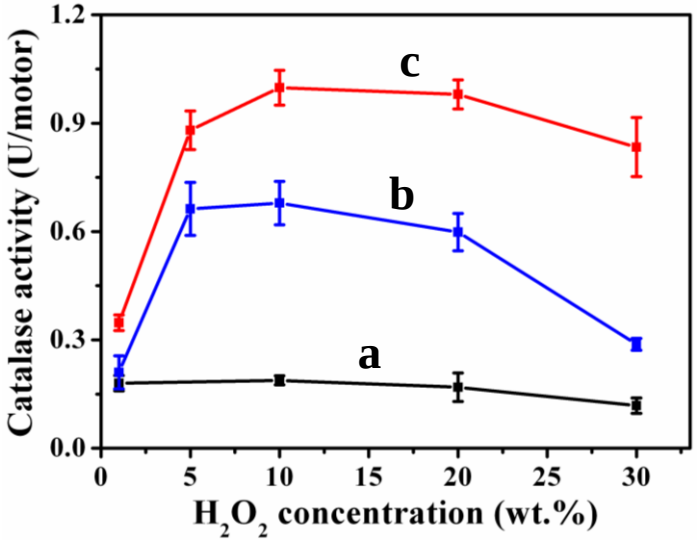
In order to propel biocatalytic tissue motors, aqueous hydrogen peroxide solutions were used as chemical fuels. All solutions contained 1.0% (w/v) sodium dodecyl sulfate (SDS) to reduce the surface tension, hence facilitating the tissue motors propulsion. The propulsion of the tissue motors was tested in various H_2O_2 concentrations (1%, 10%, and 30%). For each set of conditions, coated and non-coated motors were immersed into the H_2O_2 solution. The bubble generation and movement of the tissue motors were recorded using an iPhone 4S camera. Millet motors were sputtered with Ti using Emitech K575X Sputter Coater.

Evaluation of the Catalase activity

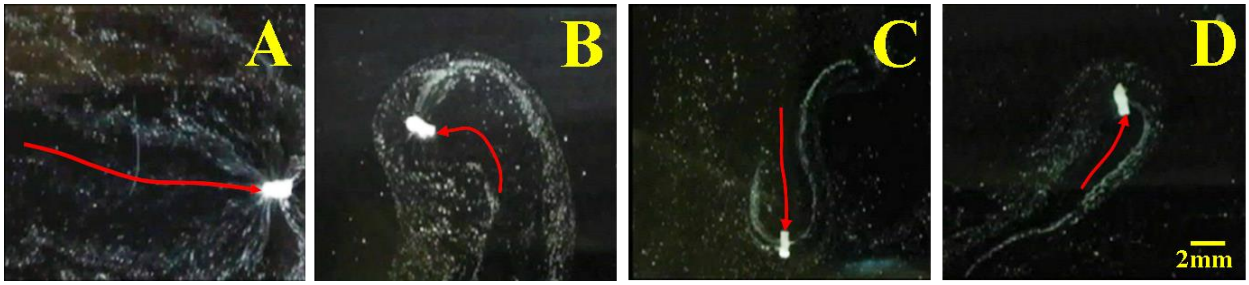
The activity of plant tissue motors was estimated by measuring oxygen generation using a manometer (UEi EM151 electronic manometer, OR, USA) attached to a sealed bottle containing a specific H_2O_2 concentration. The effect of concentration of H_2O_2 on catalase activity of plant rods was determined. The catalase activity is reported as U/rod of tissue in which the enzymatic units were defined as μmoles of O_2 produced per minute per plant tissue motor.



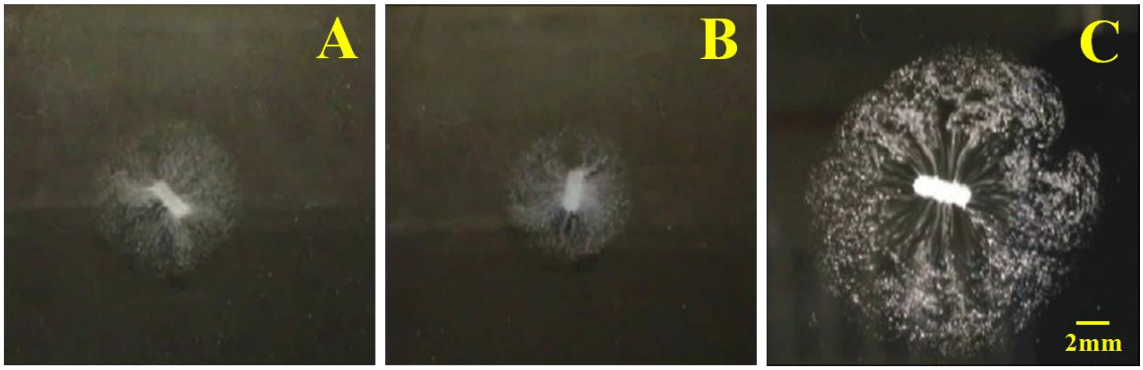
SI Fig. 1 Bubble generation from potato rods in different H_2O_2 concentrations (A) and times (B). Peroxide concentration (A): a) 0%, b) 5% c) 10% and d) normalization intensity of bubbles generated as a function of H_2O_2 concentration. (Images were taken after being subjected for 10 s to H_2O_2 solution in Video 2); B) Bubble generation from potato motors in 10% H_2O_2 following: a) 0, b) 10, c) 20s and d) normalization intensity of bubbles generated as a function of time. Scale bar is 3mm



SI Fig. 2 Evaluation of the catalase activity of per small tissue rod or seed : a) millet, b) potato and c) carrot in different H_2O_2 concentrations.



SI Fig. 3 Time lapse images of potato motors with different coatings in 10% H_2O_2: A) epoxy resin, B) nail lacquer, C) 5% Nafion and D) 0.5% (w/v%) chitosan. Images were taken from SI Video 3 after a 5 s exposure to H_2O_2 solution.



SI Fig. 4 Bubble generation by the potato tissue: 10 (A) and 20 (B) min storage at 50°C, along with the behavior of the untreated tissue (C). Images were taken from SI Video 4 after a 5 s exposure to 10% H_2O_2 solution at room temperature.