PROJECT TITLE: Water Harvesting Membranes for Precision Agriculture

DTP Research Theme: Changing Planet

Lead Institution: University of Bath

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Project keywords: Agricultural Chemistry, Electrochemistry, Materials Science, Mechanical Engineering, Environmental Science, Agronomy & Soil Science

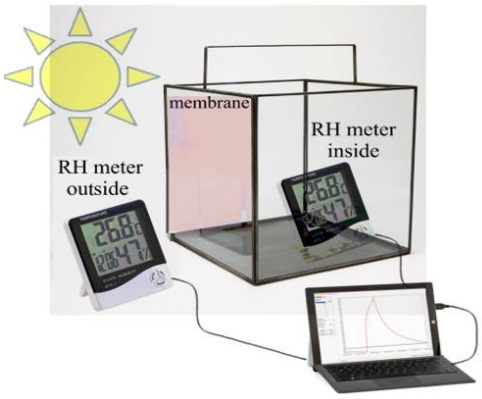

Figure 1. Schematic of the light-driven solar water harvesting mechanism followed by relative humidity.

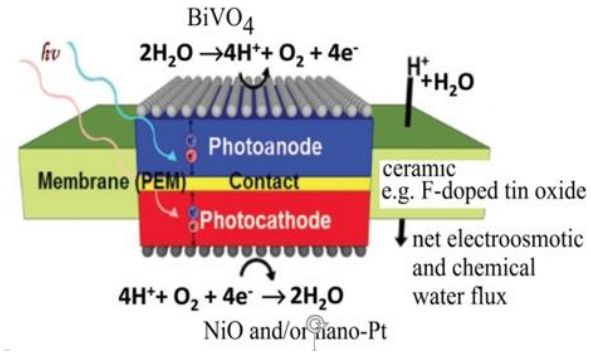

Figure 2. Schematic of the photo-driven solar water harvesting mechanism with a catalyst coated membrane.

Project Vision

A membrane (as part of a green house or simply spread over the ground) that in the presence of sunlight can capture water from the atmosphere to allow plant growth, artificial irrigation, or drinking water provision. This project is interdisciplinary and will have considerable impact on the management of the natural environment.

Project Background

As the available solar energy on earth (200000 TW p.a.) is essentially inexhaustible, it is vital for new science and new technologies to be targeted towards solar-driven mechanisms. Our biggest fresh-water reserves (10^{13} m^3) are in the atmosphere. A radical approach to provide drinking and irrigation water is proposed based on electroosmotic membranes to employ sunlight directly to drive the capture of water from the atmosphere and to provide a low-cost means for drinking, cooling, and for irrigation in agriculture to produce food. This highly interdisciplinary PhD project focuses on exploiting new electro-osmotic membrane mechanisms and porous materials for water transport. The energy of the sunlight will be converted to electricity. The electricity will provide the driving force for electroosmotic flow, and this in combination with good catalysts will pump water across the membrane. The project will allow the student to explore the science, engineering aspects, implementation, commercial potential, and compare to related technologies such as thermal/pressure cycle systems, bio-mimetic fog capture systems, or solar stills.

Project Aims and Methods

The PhD researcher will gain experience from molecular design of materials all the way up to electroosmotic membrane pumps for irrigation in precision agriculture and management of the natural environment. The main project aims are (i) to develop multi-layered porous membranes with attached electrodes for electroosmosis, (ii) to establish catalytic processes based on oxygen reduction and oxygen evolution ideally with a single bifunctional catalyst, (iii) to design small scale prototypes as proof-of-concept based on relative humidity changes (see Figure 1 and 2), (iv) to bring this technology into the engineering sector and then to potential end users, and (v) to assess the impact of this technology on the natural environment. The methods are based on electrochemical measurements, materials testing, developing new tools to monitor humidity changes, and exploring scale up of materials. The project is based on a new concept of rectified electroosmosis. Different types of membranes/techniques for water transport could be developed or compared. New ideas developed during the project will be essential.

Candidate requirements

The candidate should bring into the project a good understanding of chemistry and electrochemistry, and enthusiasm for porous materials and membranes, as well as engineering, catalysis, entrepreneurship, and passion for the natural environment and global challenges.

CASE partner

This project is based on a four-way partnership between the University of Bath, Exeter University, PV3Technologies, and Spin-Up Science in Bristol. The PhD researcher will work with chemists, electro-chemists, engineers, in catalysis development, and finally get trained in entrepreneurial aspects. The CASE partner PV3Technologies will provide industry experience in catalyst development.

Collaborative partner

The opportunities provided by the project collaborators are in taking the laboratory concept (Bath) into realistic engineering application (Exeter, potentially with a link to Egypt), to work with a catalyst company (PV3Technolgoies), and to learn entrepreneurial skills (Spin-Up Science, Bristol). The collaborative partner, Spin-up Science, will provide training in entrepreneurship and help developing a commercial perspective.

Training

The PhD researcher will get trained in electrochemical methods, in membrane science, in porous materials and in making membranes, in catalyst development, in engineering of water harvesting systems, and in entrepreneurial aspects. Depending on progress there could be opportunities to work with test systems with international partners for example in Egypt.

Background reading and references

See “Future challenges in electrochemistry: linking membrane-based solar energy conversion mechanisms to water harvesting” Frank Marken, J. Solid State Electrochemistry 24 (2020) 2137-2140.

Useful links

Enquiries relating to the project should be directed to the lead supervisor (see email address above for Project Enquiries). Enquiries relating to the application process should be directed to doctoraladmissions@bath.ac.uk.

In order to apply, you should select the relevant University of Bath PhD online application form found here: https://www.bath.ac.uk/study/pg/applications.pl. When completing the form, please state in the ‘Finance’ section that you wish to be considered for GW4+ DTP funding and quote the project title and lead supervisor’s name in the ‘Your research interests’ section.

Further information about the application process may be found here: http://www.bath.ac.uk/topics/postgraduate-research/

The application deadline is Friday 8 January 2021 at 2359 GMT. Interviews will take place from 8th to 19th February 2021. For more information about the NERC GW4+ Doctoral Training Partnership please visit https://www.nercgw4plus.ac.uk.

Natural Environment Research Council