# **READER project: Applying AORFB to decoupled electrolysis** for hydrogen production

<u>Eduardo Sánchez-Díez<sup>1</sup>, Anu Jacob<sup>1</sup>, Paramaconi Rodriguez<sup>1,2</sup></u>

<sup>1</sup>CIC Energigune. Parque Tecnológico de Alava, Albert Einstein 48, 01510 Miñano, Álava, Spain <sup>2</sup>IKERBASQUE, Basque Foundation for Science. Plaza Euskadi, 5, 48009 Bilbao, Spain esanchez@cicenergigune.com

#### Introduction

**READER** project aims to develop a solution based on **precious metalfree catalysts** and stable **anthraquinone redox mediators** to meet the demand for efficient and cost-competitive **alkaline** or **near-neutral pH decoupled electrolyzers**. One of the main outcomes of the project is the development of anthraquinone type redox mediators with **high solubility (>0.5 M)** and excellent stability (>3000 cycles). Advanced spectroelectrochemical techniques, including in situ FTIR and electrochemical mass spectrometry (EC-MS) will be applied for the selection of the best organic materials upon understanding of degradation mechanism.

### **Project methodolog**



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## Traditional vs. READER Decoupled electrolyzer



Traditional electrolyzer with simultaneous H<sub>2</sub> and O<sub>2</sub> production

 $H_2$  ORM<sup>Red</sup> ORM<sup>Red</sup>  $H_2O$ Decoupled electrolyzer with production of  $H_2$ and  $O_2$  independently coupled to organic

redox mediator (ORM) oxidation/reduction

	Traditional	Decoupled
SAFETY	Gass crossover. Explosive O <sub>2</sub> /H <sub>2</sub> mixtures	Complete separation of O <sub>2</sub> and H <sub>2</sub> gases
POWER DENSITY	Governed by sluggish kinetics of OER	HER coupled with fast kinetics organic material 0.8 A cm <sup>-2</sup> E <2.1 V
MATERIALS	Precious metal catalyst (Pt)	<0.3 mg W <sup>-1</sup> precious metals
рН	Acid (PEMEL) Alkaline (AEMEL)	Neutral to Alkaline

### Scientific approach: Anthraquinone study



Symmetry

- Effect on solubility: symmetry, hydrophilic groups
- Effect on Ered: position and electronic nature of substituents
- Effect on stability: position and electronic nature of substituents

Science, 2015, 349, 6255, 1529; Joule 2018, 2, 1894; J. Mater. Chem. A, 2021,9, 26709

• Effect on solubility: acid pka

- Effect on operation conditions: pH dependence
- Effect on stability: side reactions

ACS Energy Lett. 2022, 7, 226; Adv. Energy Mater. 2019, 9, 1900039; Joule 2018, 2, 1894.

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- Effect on solubility: hydrophilic groups
- Effect on Ered: electronic nature of substituents
- Effect on stability: lability of the bonds
- Joule 2018, 2, 1894; Energy Storage Materials 36 (2021) 417.

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