universidad de león

COMPARISON OF DIFFERENT BIOCATHODE START-UP STRATEGIES AND EVALUATION OF THEIR MICROBIAL COMMUNITY

Raúl Mateos, Ana Sotres, Adrián Escapa, Antonio Morán

Chemical and Environmental Bioprocess Engineering Group

Natural Resources Institute (IRENA)

University of León (Spain)

Junta de Castilla y León

FONDO EUROPEO DE DESARROLLO REGIONAL

UNIÓN EUROPEA

INTRODUCTION

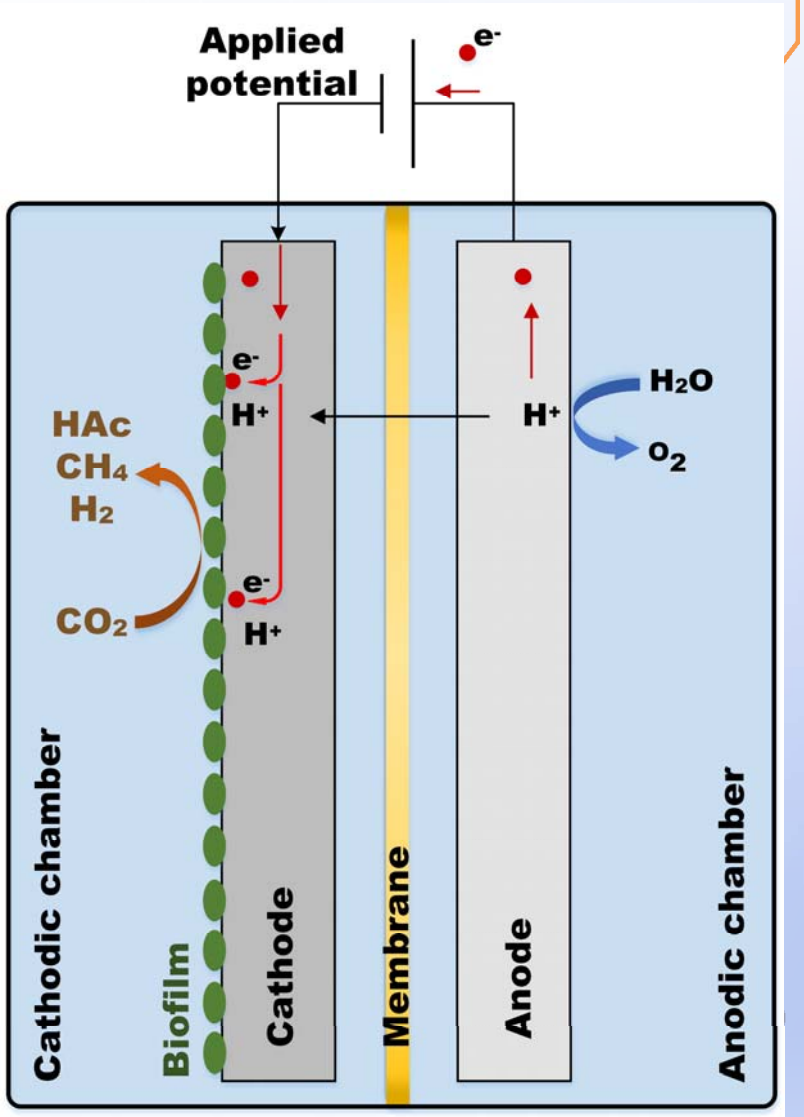
- Carbon capture & utilisation is one of the major challenges nowadays.
- Novel ideas to generate value added chemicals from CO_2: Microbial Electrosynthesis (MES)
- CO_2 bioreduction:

  Variety of possible products (HAc, H_2…)
- Microbial community: Pure cultures or mixed cultures
- MES is a young technology: Currently in proof of concept

Junta de Castilla y León
FONDO EUROPEO DE DESARROLLO REGIONAL
UNIÓN EUROPEA

INTRODUCTION

- Several unknown behaviours and internal processes
- Non established conditions to direct the production of some of the possible products
- Diverse inoculums and start-up strategies reporting good results



OBJECTIVES

Main objective

Evaluation of different biocathode start-up strategies

Evaluation in terms of:

Current production

Production of valuable chemicals: VFAs, H_2…

Microbial community analysis: inocula and evolution on working electrodes

Junta de Castilla y León

FONDO EUROPEO DE DESARROLLO REGIONAL

UNIÓN EUROPEA

START-UP STRATEGIES

1. Inoculum: River Mud

Biocathode -0,8V t = 0 → Biocathode -0,8V t = 3 weeks → Biocathode -0,8V t = 13weeks

1 Inoc.: RM Cathode → Cathode

2. Inoculum: Anaerobic Digestate

Biocathode -0,8V t = 0 → Biocathode -0,8V t = 3 weeks → Biocathode -0,8V t = 13weeks

2 Inoc.: AD Cathode → Cathode

3. Inoculum: River Mud

Bioanode +0,2V t = 0 → Potential change: Biocathode -0,8V t = 3 weeks → Biocathode -0,8V t = 13weeks

3 Inoc.: RM Anode → Cathode

4. Inoculum: Anaerobic Digestate

Bioanode +0,2V t = 0 → Potential change: Biocathode -0,8V t = 3 weeks → Biocathode -0,8V t = 13weeks

4 Inoc.: AD Anode → Cathode

Junta de Castilla y León

FONDO EUROPEO DE DESARROLLO REGIONAL

UNIÓN EUROPEA

MATERIALS & METHODS

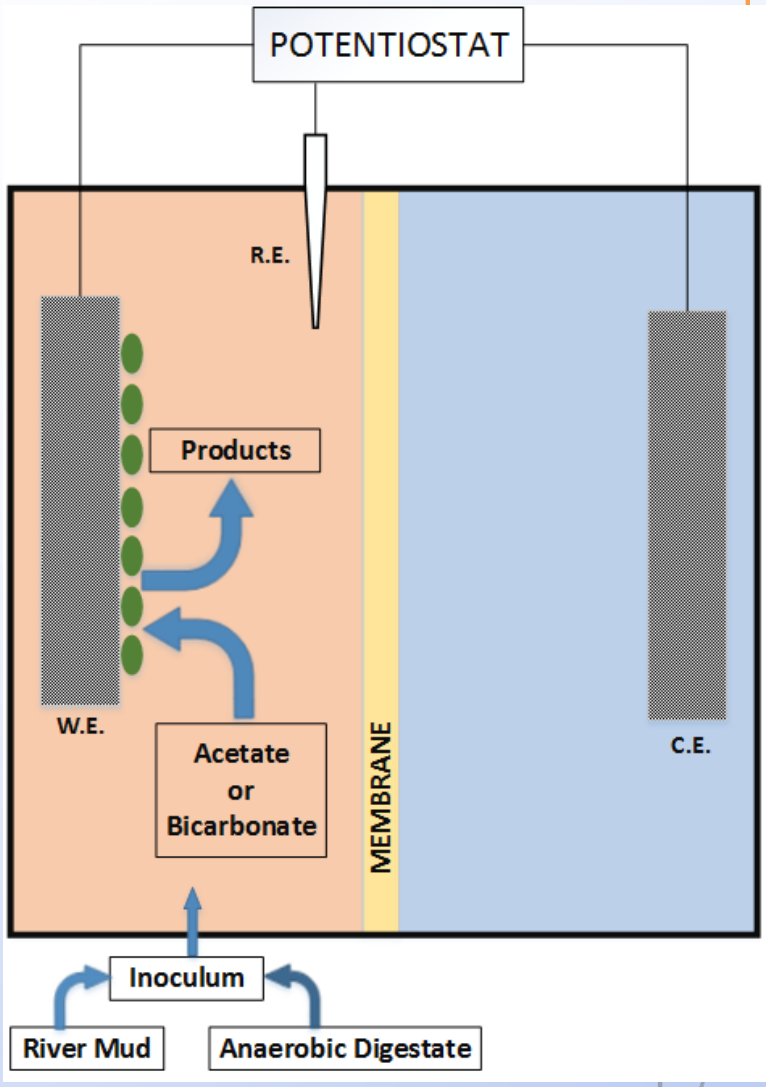
- **Batch operation**
- **Feed:** Synthetic medium

  Biocathodes: 2.5g/L sodium bicarbonate

  Bioanodes: 0.5g/L sodium acetate

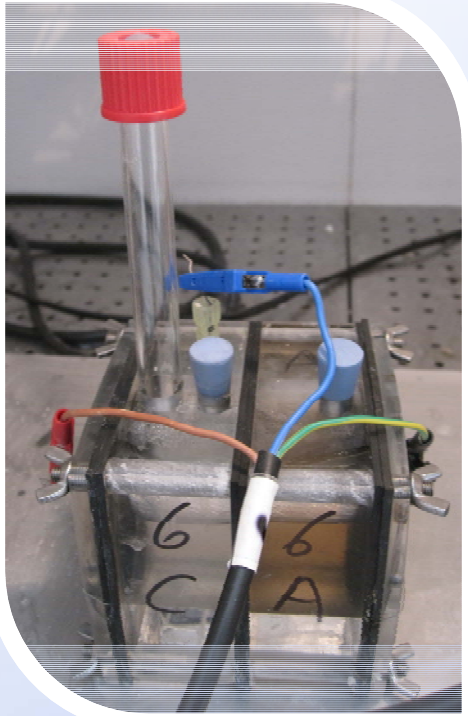
- **Inocula:** River Mud (RM) or Anaerobic Digestate (AD)
- **Evaluated parameters:**

  Physicochemical, Electrical and Biological



Junta de Castilla y León
FONDO EUROPEO DE DESARROLLO REGIONAL
UNIÓN EUROPEA

MATERIALS & METHODS



- 4 different start-up strategies
- Strategies tested in triplicate for a total of 12 cells

Junta de Castilla y León

FONDO EUROPEO DE DESARROLLO REGIONAL

UNIÓN EUROPEA

RESULTS

Strategy	Maximum current (A/m^2)		Comments
	3 weeks	13 weeks	
1st strategy	<0.01	<0.01	No current or products
2nd strategy	0.4	0.5	Around 2 weeks to firstly produce current
3rd strategy	0.6	1.0	Bioanodes produced current at the first cycle. Biocathodes took 4 days to produce current
4th strategy	0.7	0.4	Bioanodes produced current at the first cycle. Biocathodes took 3 days to produce current

1 **Inoc.: RM Cathode → Cathode**

2 **Inoc.: AD Cathode → Cathode**

3 **Inoc.: RM Anode → Cathode**

4 **Inoc.: AD Anode → Cathode**

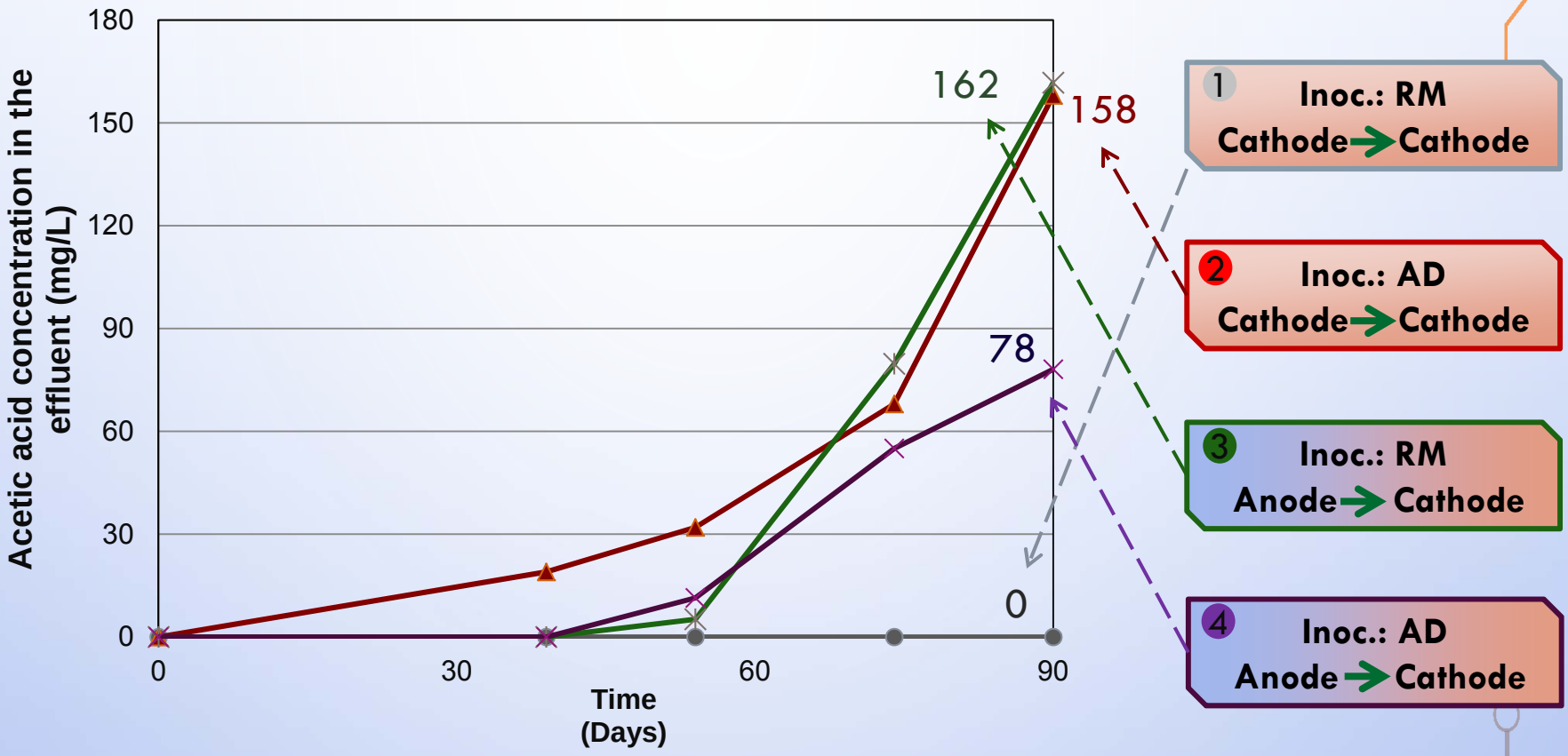
Junta de Castilla y León

FONDO EUROPEO DE DESARROLLO REGIONAL

UNIÓN EUROPEA

RESULTS

- **Chemicals production:**



- No gas production quantified due to leakages
- Hydrogen gas detected on cathode chambers after week 3 (Strategies 2, 3 & 4)
- No alcohols were detected in the effluent

Junta de Castilla y León

FONDO EUROPEO DE DESARROLLO REGIONAL

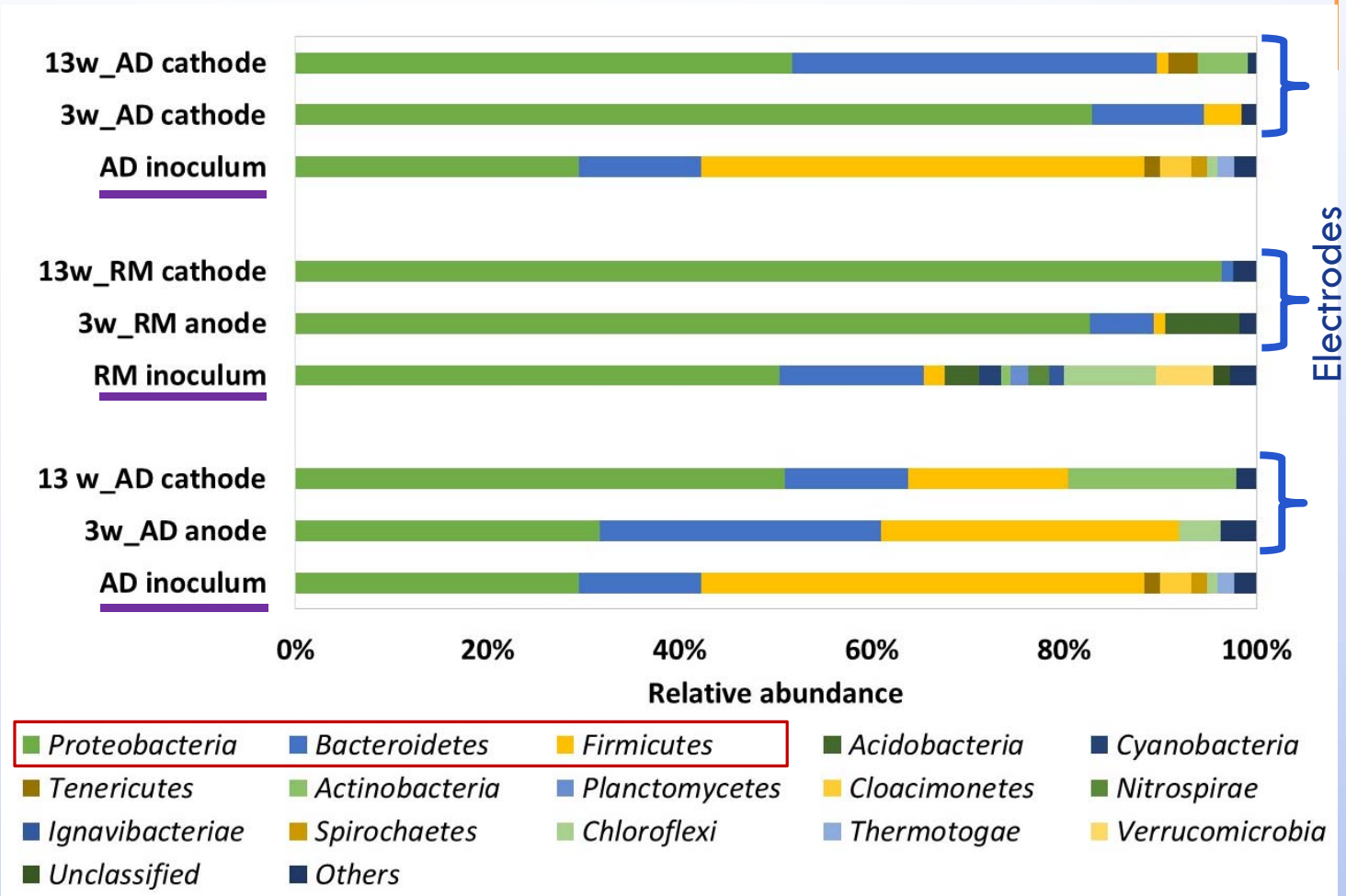
UNIÓN EUROPEA

MICROBIOLOGY RESULTS

2 **Inoc.: AD Cathode → Cathode**

3 **Inoc.: RM Anode → Cathode**

4 **Inoc.: AD Anode → Cathode**



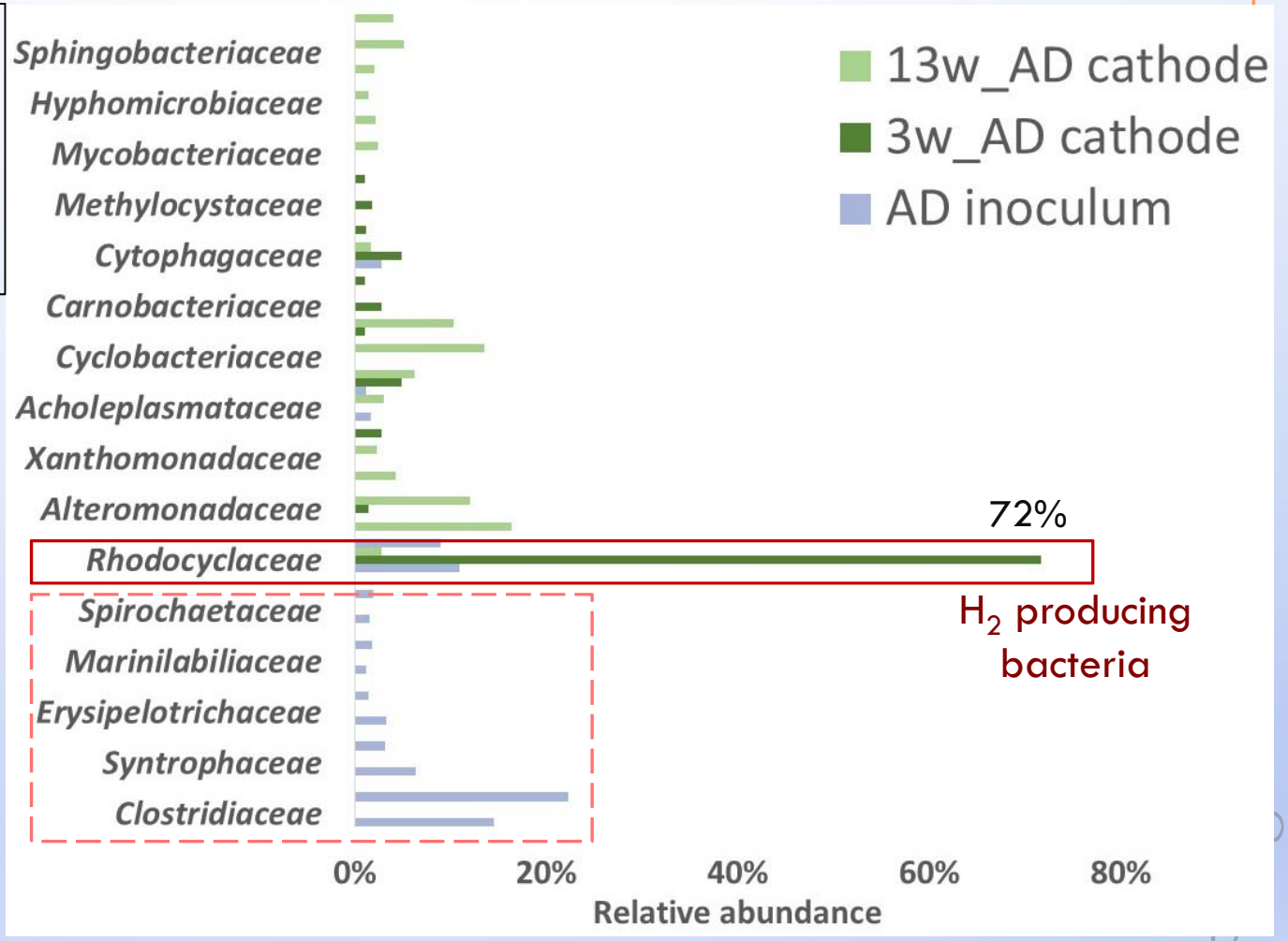
	2		3			4		
Sample / Diversity	AD Inoc	13w_AD cathode	RM Inoc	3w_RM anode	13w_RM cathode	AD Inoc	3w_RM anode	13w_AD cathode
1/Simpson	33	20 ↓	172	37	3.5 ↓	33	46	34

MICROBIOLOGY RESULTS

➢ 2nd STRATEGY: 2 **Inoc.: AD Cathode → Cathode**

No microbial analysis was performed for 1st Strategy due to absence of biofilm

Inoculated biocathode appearence

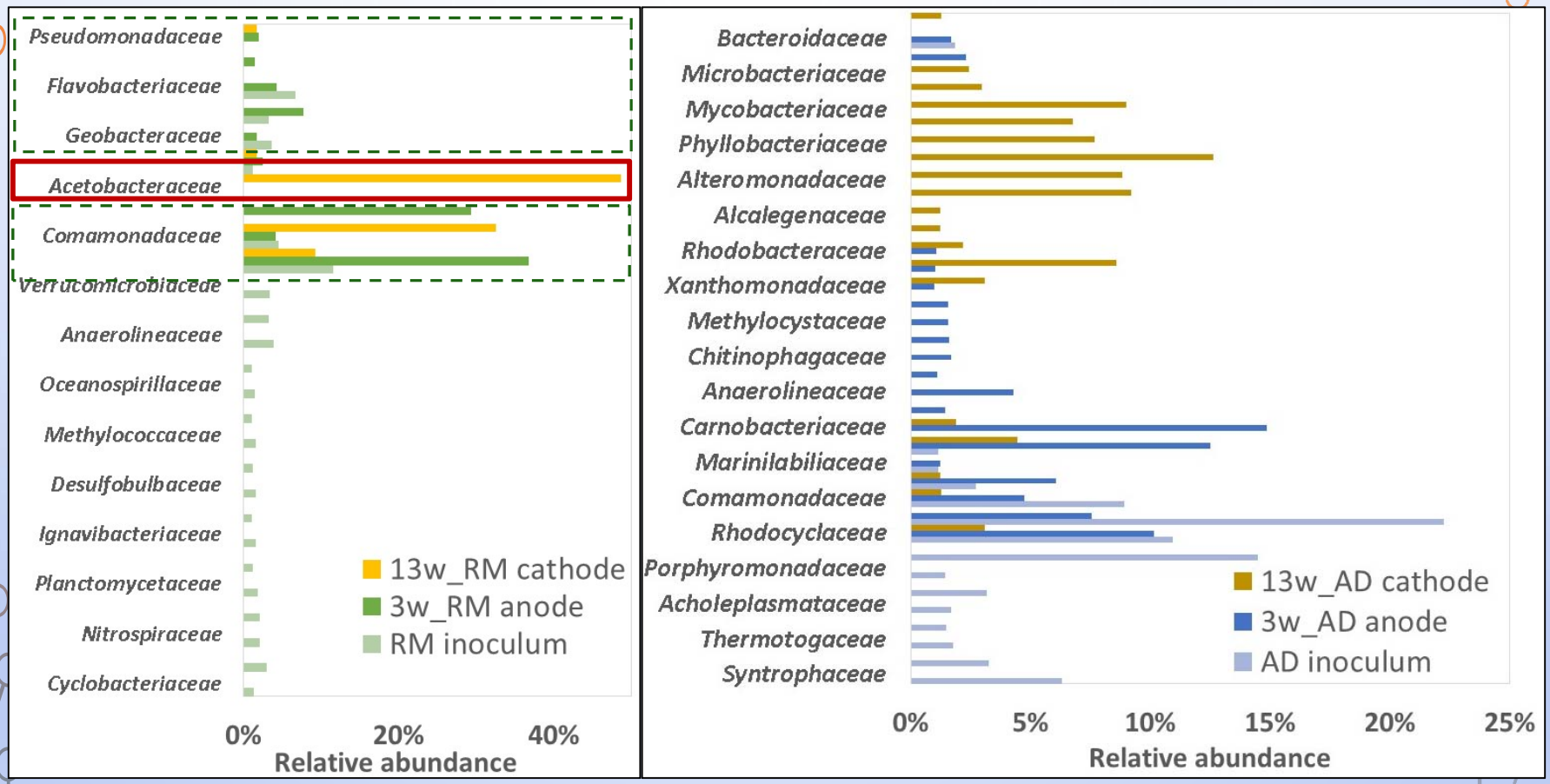


Junta de Castilla y León
FONDO EUROPEO DE DESARROLLO REGIONAL
UNIÓN EUROPEA

MICROBIOLOGY RESULTS

➢ 3rd STRATEGY: **3 Inoc.: RM Anode → Cathode**

➢ 4th STRATEGY: **4 Inoc.: AD Anode → Cathode**



SHARP ENRICHMENT

HIGHLY DIVERSE BIOFILM

Junta de Castilla y León

FONDO EUROPEO DE DESARROLLO REGIONAL

UNIÓN EUROPEA

MICROBIOLOGY RESULTS

Strategy 2:

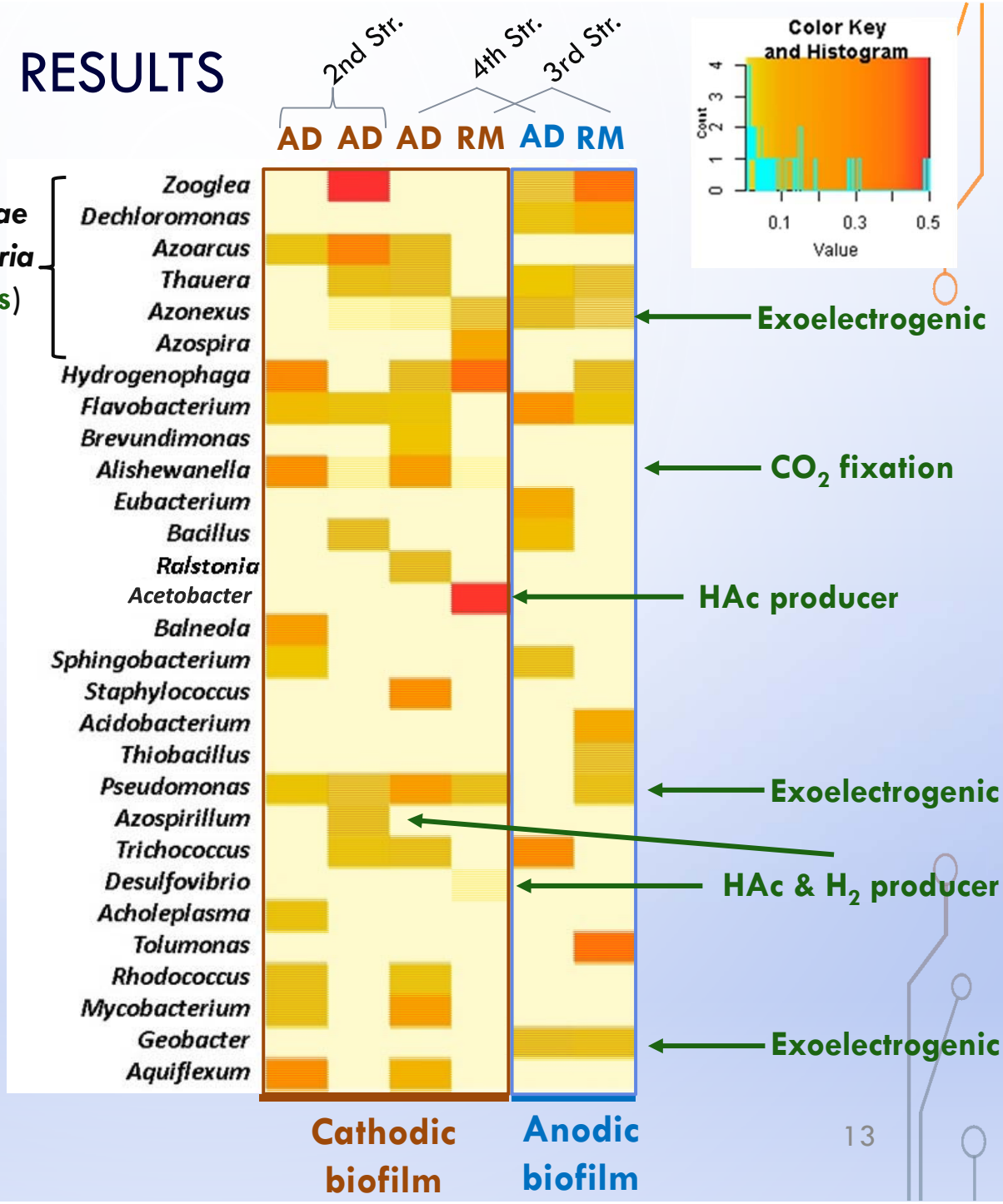
Enriched in a short period of time in hydrogen producing bacteria

Strategy 3:

Enrichment in AAB & H_2 producers

Strategy 4:

Less specified than other strategies



CONCLUSIONS

Strategy	Electrical behaviour	Chemicals production	Microbiology	Strategy Outline
1st strategy	No current generation	No chemicals generation	No biofilm	1 **Inoc.: RM Cathode→Cathode**
2nd strategy	**Lower current generation**	**High HAc production. H_2 detected.**	**Specialised biofilm. Predominancy of H_2 producing bacteria.**	2 **Inoc.: AD Cathode→Cathode**
3rd strategy	**Highest current generation**	**High HAc production. H_2 detected.**	**Specialised biofilm. Predominancy of HAc producing bacteria.**	3 **Inoc.: RM Anode→Cathode**
4th strategy	High current generation	Lower Acetic Acid production. H_2 detected.	Non specialised biofilm. No predominancy of one single type of bacteria.	4 **Inoc.: AD Anode→Cathode**

Junta de Castilla y León

FONDO EUROPEO DE DESARROLLO REGIONAL

UNIÓN EUROPEA

THANK YOU FOR YOUR ATTENTION

The authors acknowledge the funding of the Spanish "Ministerio de Economía y Competitividad" via project CTQ2015-68925-R.

Raúl Mateos thanks the Spanish "Ministerio de Educación, Ciencia y Deporte" for the FPU predoctoral grant FPU14/01573.

Junta de Castilla y León

FONDO EUROPEO DE DESARROLLO REGIONAL

UNIÓN EUROPEA