eman ta zabal zazu

Universidad del País Vasco — Euskal Herriko Unibertsitatea

Red TES
Red española de almacenamiento de energia térmica

BioRP
Biorefinery Processes Research Group

High Temperature TES materials

Our research is focused on the proposal of **TES materials at high temperature**, mainly focused on CSP plants. We have experience and more than 70 papers on the development of **nitrate, carbonate and chloride molten salts**, testing their physicochemical and corrosive properties.

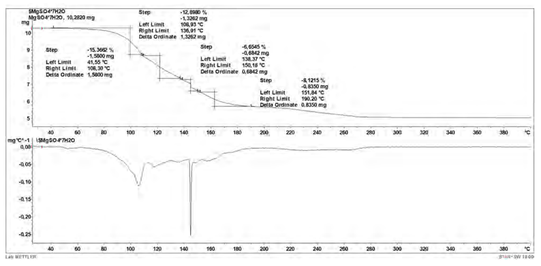
- **Low melting point formulation** using nitrate salt for CCP technology: $LiNO_3$ and $Ca(NO_3)_2$
- Ternary **carbonate** molten salts: 32 wt.%K_2CO_3+35 wt.% Li_2CO_3 + 33 wt.%Na_2CO_3 at 650ºC (inert or open atmosphere)
- Ternary **chloride** molten salts: 55.1wt.%$MgCl_2$ + 20.4wt.%KCl + 24.5wt.%NaCl at 720ºC under N_2 atmosphere

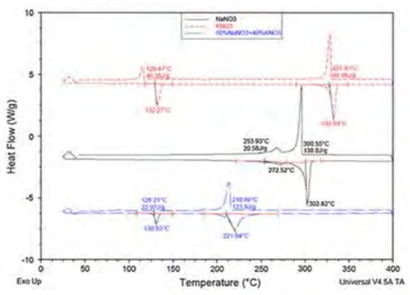
Also at medium temperature, we have experience on the development of **sorption salt** to be applied in the new generation of heat pumps:

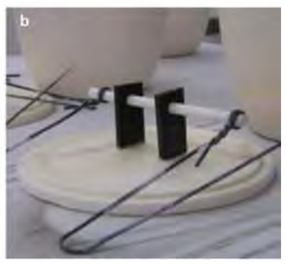
- $MgSO_4$*7H_2O
- SrBr*6H_2O
- $MgCl_2$*6H_2O

Development of **corrosion standard procedures**:

- Protocols **for dynamic corrosion tests in high temperature** molten salt (leading the **SolarPACES TCP working group "Structural materials and coatings"**)
- Proposal of **DRT methodology** for proper selection of ECM using electrochemical impedance spectroscopy.



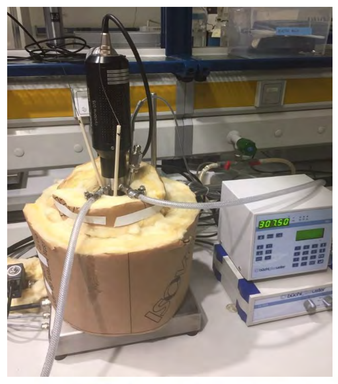


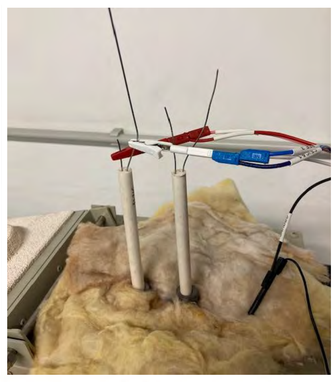


Advanced Corrosion Electrochemical Techniques

Development of **advanced corrosion electrochemical techniques for corrosion monitoring processes**:

- **Chronoamperometry (CA):** CA is used to study the **kinetics of chemical reactions, diffusion processes, and adsorption**. This innovative technique is applied in situ in the sorption conditions, defined for each salt and the potential is stepped to a value at which a redox reaction occurs and information of the de/hydration process is recorded on line during the experiment.
- **Electrochemical impedance spectroscopy (EIS):** Use of low intensity of excitation signal used which causes minimal disruption in the electrochemical system state, constituting a non-destructive technique. Impedance spectra obtained by this method is adjusted to an **electrical circuit** of a combination of resistors and capacitors (equivalent circuits), in order to interpret the corrosion processes and the behaviour of the coating formed.
- **Linear polarization resistance (LPR):** A small voltage (or polarization potential) is applied to an electrode in solution. The current needed to maintain a specific voltage shift (typically 10 mV) is directly related to the corrosion on the surface of the electrode in the solution, and the corrosion rate can also be calculated instantaneously, according the Butler-Volmer equation.
- **Electrochemical noise (ECN):** The electrochemical noise technique is based on the analysis of the very small voltage or current variations (in the range of microvolts) recorded during some time at the rest potential. This technique is applied to predict unplanned shutdowns of protective layers.
- -**Cyclic voltammetry (CV):** To monitor impurity concentrations and thus control the technological processes.





Power-to-heat

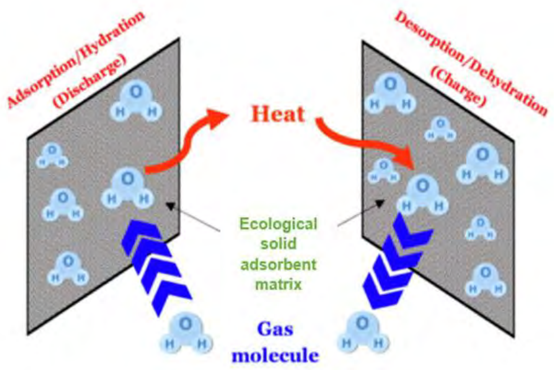
Proposal of **inorganic molten salts** for **decarbonisation systems:**

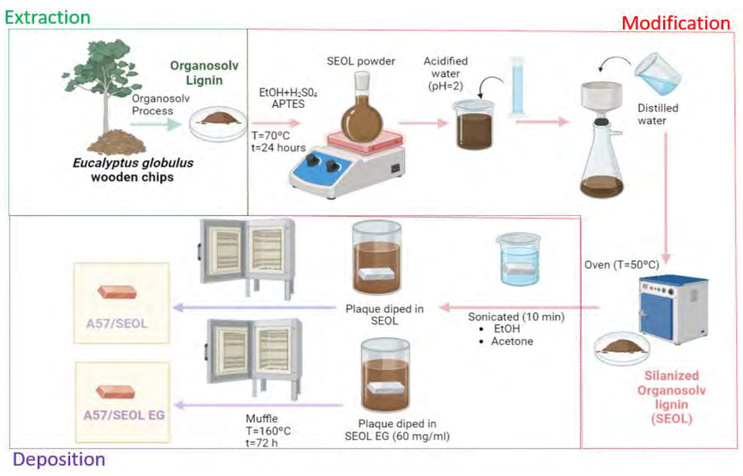
- **HITEC:** 40%$NaNO_2$+7%$NaNO_3$+53%KNO_3
- **Ternary lithium nitrate**: 20%$LiNO_3$ +52%KNO_3+28%$NaNO_3$

Study of **materials permeability** in contact with **hydrogen storage** systems

Development of **Carnot Batteries integrating sorption materials.**

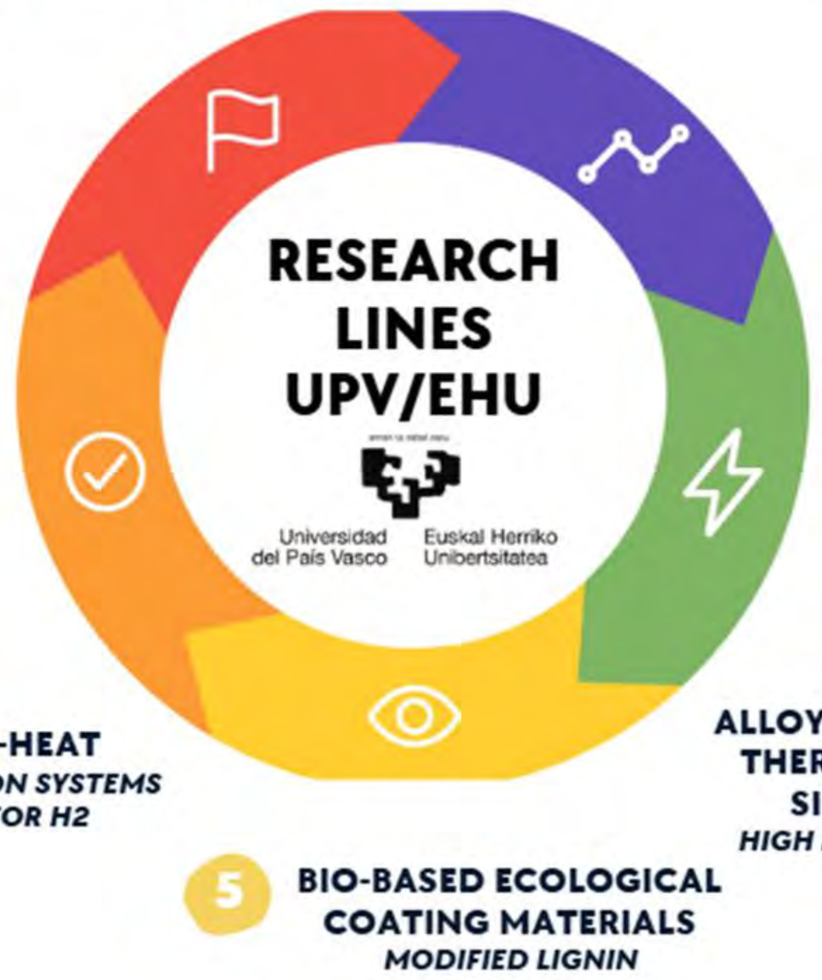
- Development of **ecological solid matrix**





1 HIGH TEMPERATURE TES MATERIALS
SENSIBLE
LATENT
SORPTION SALTS (MEDIUM T)

2 ADVANCED CORROSION ELECTROCHEMICAL TECHNIQUES
EIS, LPR, ECN, CV, CA



3 POWER-TO-HEAT
DECARBONISATION SYSTEMS
MATERIALS FOR H2

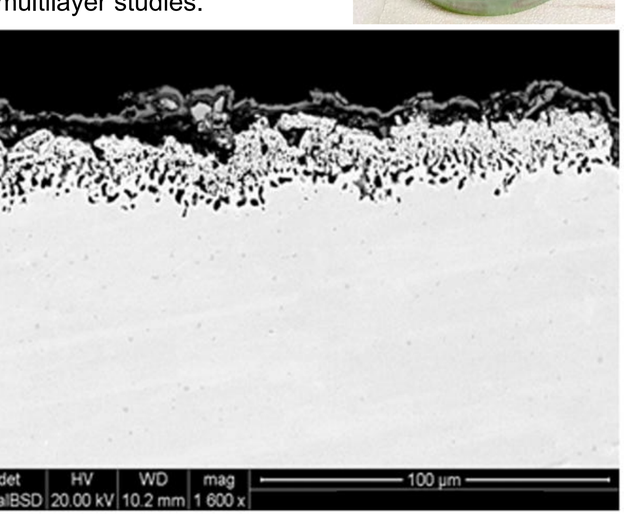
4 ALLOY DESIGN USING THERMODYNAMIC SIMULATION
HIGH ENTROPY ALLOYS

5 BIO-BASED ECOLOGICAL COATING MATERIALS
MODIFIED LIGNIN

Alloy design

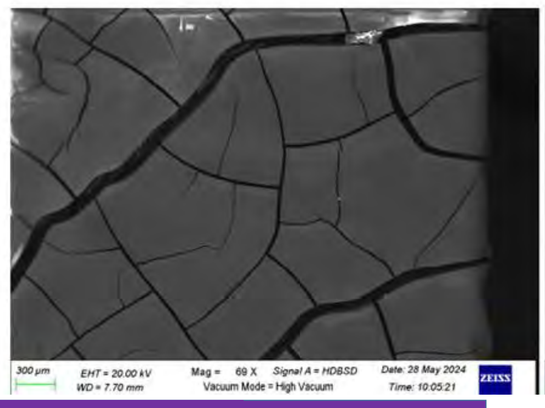
Different **high entropy alloys composition** are under development, studying the addition of different alloying elements in two metallic systems composed by Al-Co-Cr-Fe-Ni and the **Cantor system**, composed by Fe-Co-Mn-Cr-Ni.
Numerical and thermodynamic simulation using **Calphad and Thermocalc software** are used to fix the weight percentage of each element in the alloy and thermophysical properties calculation.

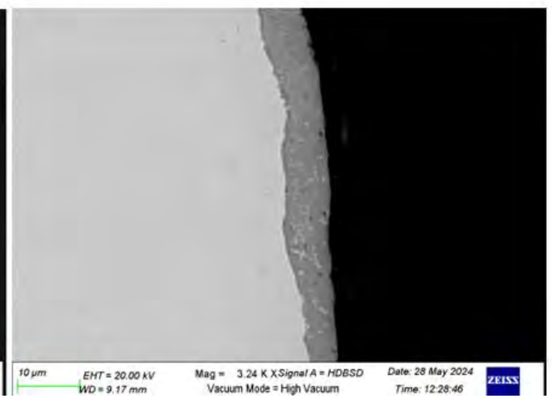
Development of austenitic forming alumina **AFA alloys** and testing of **coating materials** using thermal spray technique



Bio-Based Ecological Coating Materials

Valorisation of by-products from wastes from metals, pulp and paper industries, highlighting the use of **lignin** due to their interesting properties as corrosive protective coating. This research line proposes the use of coatings based on **modified (silanized) lignin** to reduce the corrosion rate of metal surfaces in sorption heat pumps using inorganic sorption salt. Additionally, some **ecological composite foams** are under study as **solid adsorption matrix** since they can facilitate the water vapour diffusion and prevents agglomeration of the active filler during hydration.





Grinding and polishing preparation for optical microscope and mounting of corrosion samples in **conductive resin** for cross sectional studies in SEM for multilayer studies.

Projects

- **Sistemas híbridos de calentamiento a alta temperatura para la descarbonización de la industria siderúrgica y cemento (DESGAS)**. Proyecto Elkartek financiado por SPRI- Gobierno Vasco, 2023-2025
- **Advanced corrosive and impurity monitoring digital tool to enhance the control of industrial thermal energy storage systems**, funded by UPV/EHU, 2024-2025.
- **Materiales avanzados, transporte sostenible y nuevas energías (ATLANTIS)**, funded by Basque Goverment, 2024-2025
- **Diseño, producción y evaluación de aleaciones y estructuras metálicas avanzadas en condiciones de servicio con hidrógeno (H2MAT+)**, funded by Basque Goverment, 2024-2025
- **Propuesta de nuevas Baterias Carnot con sistemas de sorción como solución de almacenamiento energético en la descarbonización de la industria de Gipuzkoa (DESCARTES)**, funded by Diputacion Gipuzkoa, 2024-2025

Contact information: Dr. Angel G. Fernández
angelgabriel.fernandez@ehu.eus

Angel Gabriel Fernandez Diaz
Ramón y Cajal Fellow at University of the Basque Country en UPV/EHU

Acknowledments

Dr. Angel G. Fernández wants to acknowledge the financial support from RyC 2020-28787-I funded by MCIN/AEI /10.13039/501100011033 and ESF "Investing in your future". And Red TES "Financiado por el Ministerio de Ciencia, Innovación y Universidades – Agencia Estatal de Investigación (AEI) (RED2022-134219-T)"

GOBIERNO DE ESPAÑA · MINISTERIO DE CIENCIA E INNOVACIÓN · UNIÓN EUROPEA · Fondo Social Europeo · El FSE invierte en tu futuro · AGENCIA ESTATAL DE INVESTIGACIÓN