KNOW-HOW IN SODIUM ION/SODIUM METAL BATTERIES

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ABSTRACT

The *Photochemistry and Electrochemistry of Semiconductors* research group at the University of Alicante has extensive experience in the preparation of materials for use as both cathodes and anodes in a rechargeable sodium ion (Na^+) and sodium metal (Na^+) battery. In this line, the research group has also developed expertise in the preparation of electrolytes based on both organic and inorganic solvents. The ultimate goal is the development of both mobile and stationary batteries, with special emphasis on the latter.

With regard to the active materials of the positive electrode or cathode, the research group has focused on the preparation of thin films based on the use of organic (quinones, anthraquinones, organic polymers, anhydrides, etc.) as well as inorganic (transition metal oxides, sulphides, etc.) active materials, using various techniques for the preparation of the materials and thin films. Different types of additives have been used in the preparation of the cathode material, including different types of carbon (carbon nanotubes, super P carbon, super C65 carbon, graphene oxide, etc.) and different types of binders (PTFE, PVDF, Na-CMC, PEO, etc.).

With reference to the negative electrode or anode, the research group has extensive experience in the preparation of metallic Na anodes on copper (Cu) from the electrodeposition of Na^+ from the electrolyte, whether the electrolyte is of an organic nature (NaClO4 in propylene carbonate, $NaCF_3SO_3$ in dimethoxyethane...), or of an inorganic nature ($NaI{\cdot}3.3NH_3$, $NaBF_4{\cdot}2.5NH_3$, $NaBH_4{\cdot}1.5NH_3$, $NaAlCl_4{\cdot}2SO_2$). In addition, the research group has also developed skills in the use of additives in conventional organic electrolytes for the enhancement of metallic Na deposition.

ADVANTAGES AND INNOVATIVE ASPECTS

ADVANTAGES OF THE TECHNOLOGY

The main **advantages** offered by this technology are:

1) **High coulombic efficiency** for the deposition and dissolution process of Na in inorganic electrolytes described as ammonates.

2) **High chemical stability** of the metallic Na in the ammonates.

3) **High coulombic efficiency** for the process of deposition and dissolution of Na in inorganic electrolytes on a Cu substrate, which offers the possibility of **assembling the device in an unloaded state**, thus avoiding the use of metallic sodium.

4) Work with highly concentrated inorganic electrolytes, which avoids limitations due to the transport of matter in the devices and facilitates the **reversibility** and **homogeneity** of the metal deposit.

5) Design of a sodium ion and sodium metal battery at **room temperature**.

6) Deposition and dissolution of Na with **high coulombic efficiency** in conventional organic electrolytes with additives.

7) **Cost-competitive** developments avoiding the use of expensive solvents, electrolytes and materials.

INNOVATIVE ASPECTS OF THE TECHNOLOGY

The first innovative aspect of the presented technology focuses on the **very high stability of sodium metal** in the studied inorganic electrolytes both chemically and electrochemically. These are quasi-ionic liquids consisting of simple sodium salts and ammonia. The **low cost of the electrolyte**, together with the possibility of working with metallic sodium, should allow the development of batteries with:

- **High energy density.**
- **Very high response speed.**
- **Very low cost.**

Another innovative aspect focuses on the use of **organic molecular or polymeric materials** with quinonic groups with the capacity to sodiumate easily. These organic electrodes are a viable alternative to electrodes based on oxides and sulphides.

MARKET APPLICATIONS

Rechargeable energy storage devices based on sodium ion and sodium metal (Na^+/Na) in:

- **Electric vehicles**.
- **Grid energy** storage.

COLLABORATION SOUGHT

The research group is looking for companies/organisations to:

- Provide technical reports and scientific advice to the company.
- Offer specific training in subjects related to the synthesis and/or characterisation of electrodes, and the development and characterisation of devices.
- Training of scientific and technical personnel through the organisation of specialisation courses, seminars, technical conferences, etc.
- Offering technological support in those techniques that require a high level of training or sophisticated instruments that are not within the reach of the applicant company.
- Exchange of personnel for defined periods of time (for learning a technique, setting up a process, etc.).
- Establishing R&D&I projects with research organisations (public or private), with the aim of opening up new lines of research.