TRANSFORMING AGRICULTURAL WASTE INTO CLEAN, SUSTAINABLE ENERGY - HOW BIOMASS CAN REVOLUTIONISE THE FUEL CELL INDUSTRY

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ABSTRACT

The *Materiales Carbonosos y Medio Ambiente* (MCMA) research group at the University of Alicante has developed a new method to obtain high quality electrocatalytic powder materials from agricultural waste.

The procedure is very simple, it is easy to scale up to industrial level, it has a low manufacturing cost and the materials obtained are characterised by high durability and selectivity towards the oxygen reduction reaction, reasons why they may become very promising candidates to replace current commercial platinum-based catalysts for use them in fuel cells.

We are looking for companies interested in acquiring this technology for commercial exploitation.

ADVANTAGES AND INNOVATIVE ASPECTS

ADVANTAGES OF THE TECHNOLOGY

The main **advantages** of this novel procedure are listed below:

1) It is **easier** and it has **fewer steps** than currently used procedures.

2) **Porosity** development and **surface functionalisation** is carried out in a **single step**.

3) **It does not require special equipment**: the equipment used is commercially available and affordable for any laboratory or industry.

4) Catalysts are obtained in **fine powder form**, so they are **easy to handle** and to **disperse in aqueous media at room temperature**, which facilitates their conformation as electrodes. In addition, the prepared suspensions are **stable over time**.

5) The **precursors** used are very **cheap** and **abundant**, among them:

- **Agricultural waste** or any type of **vegetable biomass** (almond shells, coconut shells, cocoa shells, olive pits, peach pits, date pits, plum pits, etc.).
- **Transition metals** such as: iron, cobalt, nickel, etc.

6) **Platinum** group metals are **not used**, including: iridium, osmium, palladium, platinum, rhodium and ruthenium.

7) The **final cost** of the prepared materials is **lower than commercial platinum-based catalysts**.

8) The process can be **easily scaled up to industrial level**.

9) The carbonaceous materials obtained have **high physico-chemical and mechanical properties**:

- They are **very stable** (as commercial catalysts).
- **Electrocatalytic activities similar** to commercial platinum electrocatalysts are achieved in the oxygen reduction reaction in an alkaline medium.
- They show **excellent durability** after many reaction cycles (200 cycles).
- They are **very robust**, as they do not inactivate after the demanding durability tests to which they have been tested.
- They are characterised by their **high selectivity** to form water by the **mechanism of transferring four electrons** per oxygen molecule.

- The **generation of by-products** such as hydrogen peroxide, which limits energy yield and is damaging to the working of fuel cells, **is prevented**.
- They have **specific surface areas greater than 500 $m^2 \cdot g^{-1}$**.

10) **Conventional activating agents are not used**.

11) The carbonaceous materials obtained **do not contain residues** (usually formed in the conventional activation process).

12) Only **a single stage at high temperature** is required.

13) **No subsequent catalyst washing steps are required**.

14) The process has a low environmental impact. It is **sustainable** and **environmentally friendly**.

15) It reduces dependence on fossil fuels and it reduces the carbon footprint, thus contributing to the **transition towards an economy based on renewable energies**.

16) The synthesis method is **versatile** and it can be applied to **other electrochemical reactions of interest** by modifying the metallic precursor or by introducing other metals in the form of alloys.

17) The synthesis method has a **high yield**.

18) These materials are **well suited to replace platinum electrocatalysts in low-temperature fuel cells in alkaline media**.

INNOVATIVE ASPECTS OF THE TECHNOLOGY

The main innovation concerns the **use of agricultural waste** (biomass) **to obtain low-cost carbonaceous materials with excellent electrocatalytic properties** to replace current commercial platinum-based catalysts in the oxygen reduction reaction in an alkaline medium in fuel cells.

Furthermore, the present invention differs from current synthesis methods in two fundamental aspects:

1) **Conventional activating agents involving subsequent washing steps are not employed**. Thus, this invention provides a simple method of synthesis.

2) The **chemical activation** of the carbonaceous precursor and the **incorporation of the active sites** is carried out **during the same thermal treatment**, using just the right amount of the metal precursors and nitrogen.

On the other hand, in contrast to this invention, current synthesis methods require several washing steps, which increases the price of catalysts and contributes to a deterioration of the environment.

Through the appropriate selection of metal precursors (e.g. metals such as iron), nitrogen and appropriate biomass residues, catalysts for the oxygen reduction reaction in alkaline media can be obtained with **similar features to commercial platinum catalysts**.

Moreover, it is important to note that in this novel synthesis procedure:

- **No washing steps** (with water, acid solutions or organic solvents) **are required** after heat treatment, which it reduces the environmental impact and manufacturing cost.
- Only **a single heat treatment at high temperature is required**.

MARKET APPLICATIONS

This invention is part of the **energy** and **circular economy** sectors. Specifically, it focuses on the use of agricultural waste (biomass) to obtain **high-performance carbonaceous materials** (electrocatalysts) for **industries that manufacture or use fuel cells**.

This technology allows obtaining carbonaceous materials free of platinum group metals, including iridium, osmium, palladium, platinum, rhodium and ruthenium, for application as **excellent electrocatalysts in the oxygen reduction reaction at the cathode of the alkaline polymer membrane fuel cell**.

These novel electrocatalysts are **potential candidates to replace commercial platinum electrocatalysts** in the oxygen reduction reaction in alkaline media, thus decreasing the overall cost of low-temperature fuel cells.

Sectors of interest:

1. **Energy**: this technology can be used for the production and storage of renewable energy (distributed and stationary) using green hydrogen, contributing to the decarbonisation of the energy system and the reduction of greenhouse gas emissions.
2. **Transport**: the technology can be used in the manufacture of fuel cells for electric vehicles, contributing to the transition towards more sustainable and environmentally friendly transport.
3. **Chemical industry**: the technology can be used in the synthesis of chemical products of commercial interest.
4. **Pharmaceutical industry**: the technology can be used in the synthesis of pharmacological molecules of interest to the health sector.
5. **Waste management**: the technology can be used in the valuation of biomass waste, which it contributes to the reduction of the amount of waste sent to landfills and the reduction of the carbon footprint.

COLLABORATION SOUGHT

We are looking for companies interested in acquiring this technology for **commercial exploitation** through:

- Patent licensing agreements.
- Development of new applications.
- Agreements regarding technology and knowledge transfer.

Company profile sought:

- Manufacturers of catalysts and electrocatalysts for fuel cells.