INNOVATIVE PROCESS TO OBTAIN METAL NANOPARTICLES FROM COCOA RESIDUE

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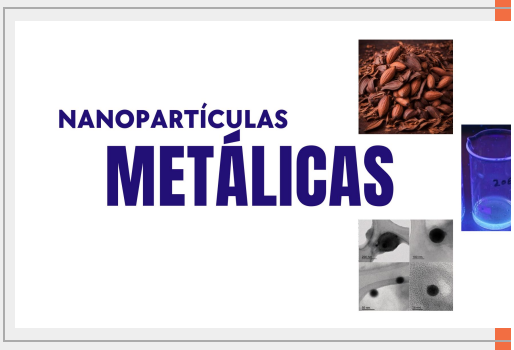
ABSTRACT

Researchers at the University of Alicante have developed an innovative process to revalorise waste from the chocolate industry and synthesise metal nanoparticles from cocoa shells, in addition to obtaining other high added-value compounds such as water-soluble proteins, antioxidants and lignocellulosic material.

The system allows selenium-doped carbon quantum dots and zinc oxide nanoparticles with interstitial zinc to be obtained using a sequential microwave-assisted process. This process lowers nanoparticle production costs, reduces the number of steps and produces higher extraction yields.

This system is of particular interest to the chocolate industry as it allows the reuse of its main waste product. It is also of interest to the chemical, cosmetics, food, medical and pharmaceutical industries.



INTRODUCTION

Cocoa shells are the main residue produced during chocolate production after roasting cocoa beans, accounting for 12% of the total weight. This waste is usually destined for animal feed or as fertiliser and no high value-added products are extracted from it.

Cocoa husk is composed of 70% carbohydrates, mainly cellulose and pectin, and is also rich in antioxidant compounds and pigments, with a high potential for application in multiple industries.

Over the last few years, different extraction procedures have been developed for the compounds present in cocoa shells. Conventional extraction methods are simple and efficient, but involve long extraction times and high solvent consumption. On the other hand, sequential extraction methods increase the efficiency and sustainability of the overall process.

For the synthesis of metallic nanoparticles, the use of microwaves has also been identified as a suitable method, compared to conventional methods, as it improves the microstructure of the particles, increases their yield, generates energy savings, reduces manufacturing costs and allows new materials with different properties to be obtained.

There are some procedures that achieve the extraction and synthesis of these elements using other processes, but in comparison, the procedure developed by the researchers has notable advantages. Among them, the procedure is much more sustainable, minimising the consumption of solvents and steps, and allows obtaining nanoparticles with a more optimal structure.

TECHNICAL DESCRIPTION

Researchers have developed a **sequential microwave-assisted process** to extract high value-added compounds and synthesise **selenium and zinc oxide nanoparticles from cocoa husks**. These compounds are very interesting for the development of

nanotechnology and therefore have a high market value. In addition, other by-products are obtained that also have a high industrial applicability.

The process consists of a series of **stages**, which are described below:

1. Grinding of the cocoa husk.

2. Addition of an alkaline or acid solution, depending on whether zinc oxide or selenium nanoparticles are to be synthesised.

3. Microwave-assisted extraction (MAE), without the need to pre-treat the ground agri-food waste, to obtain a first extract rich in pectins or water-soluble proteins and other value-added compounds, as well as a solid lignocellulosic residue.

4. The solid lignocellulosic residue obtained above can be used as a metal adsorbent without prior treatment or as a dietary fibre.

5. The extract rich in pectins and proteins can be used as a reducing and stabilising agent for the synthesis of selenium and zinc oxide nanoparticles, respectively.

6. In this way, zinc oxide nanoparticles with interstitial zinc with low particle size, high stability and high antioxidant properties are obtained.

7. In the case of selenium, a microwave-assisted synthesis and a hydrothermal treatment are carried out to obtain selenium-doped carbon quantum dots with low particle size, high stability and high antioxidant and fluorescent properties.

TECHNOLOGY ADVANTAGES AND INNOVATIVE ASPECTS

ADVANTAGES OF THE TECHNOLOGY

- **Sustainable synthesis** method that incorporates the principles of the circular economy by taking advantage of a waste product from the chocolate industry.
- It makes it possible to obtain **metallic nanoparticles of high value** for industry, such as selenium and zinc oxide nanoparticles.
- The process is carried out in an **aqueous medium**, thus avoiding the use of organic solvents, which are common in this type of process.
- Significant **reduction in nanoparticle production costs** by increasing extraction yields, reducing the number of stages and requiring less energy.
- The process also makes it possible to obtain **other multifunctional products with great potential**, such as water-soluble proteins, pectin, antioxidants and lignocellulosic material.
- The nanoparticles obtained have a **unique structure and an exceptional particle size**, making them more interesting for industrial application than other structures obtained by other processes.

INNOVATIVE ASPECTS OF THE TECHNOLOGY

The main innovation of the technology is its **capacity to take advantage of a waste** generated in large quantities by the chocolate industry **and obtain multiple by-products with high added value**. Among these, **zinc oxide and selenium nanoparticles** are of particular interest to the nanotechnology industry.

The process is substantially more interesting than the existing ones, as it is much more sustainable, has a lower production cost and the resulting products have more interesting properties.

CURRENT STATE OF DEVELOPMENT

The research group has optimised the extraction process and obtained a remarkable extraction yield. The process has been implemented at **pilot plant scale** and is ready for industrial scale-up and application in a production plant.

MARKET APPLICATIONS

The technology is of direct application for **chocolate production** companies as it allows them to treat their waste and generate high added-value products.

It is also of interest to **waste treatment** companies and, in general, to **chemical, pharmaceutical, medical, food, materials and cosmetics companies**, as the products obtained are of great use in these industries.

In particular, selenium and zinc oxide nanoparticles are very interesting compounds for application in the **nanotechnology industry**.

COLLABORATION SOUGHT

Companies interested in acquiring this technology for **commercial exploitation** are sought:

- Patent licensing agreements.
- R&D project agreement (technical cooperation) to undertake projects related to the technology.

INTELLECTUAL PROPERTY RIGHTS

This technology is protected by a **patent application**. In this case, the processes for obtaining zinc oxide and selenium nanoparticles have been separated into **two process patents**:

- *Patent title: "process for obtaining selenium-doped carbon quantum dots and a lignocellulosic solid fraction, and selenium-doped carbon quantum dots and lignocellulosic solid fraction obtained".*
- *Application number: P202330992*
- *Application date: 30/11/2023*

- *Patent title: "Process for obtaining zinc oxide metal nanoparticles with interstitial zinc and a lignocellulosic solid fraction, and zinc oxide with interstitial zinc and lignocellulosic solid fraction obtained".*
- *Application number: P202330993*
- *Application date: 30/11/2023*

MARKET APPLICATION (4)

Agri-food and Fisheries
Pharmacology, Cosmetics and Ophthalmology
Materials and Nanotechnology
Chemical Technology

TECHNICAL IMAGES (1)

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