ELECTRIC CALCIUM REACTOR FOR MARINE AQUARIUMS

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RESUMEN

The research group of the University of Alicante "Group of Electrocatalysis and Polymer Electrochemistry" (GEPE) has developed a device of special practical use in marine aquariums and aquaculture, since it enables the production of calcium, alkalinity, and micronutrients for the maintenance of aquarium conditions, in order to keep the necessary levels for the development of aquatic organisms.

The device, based on an electrochemical reactor, works in a simple and controllable way without the need of gaseous CO_2 streams, thus allowing automatic and precise dosing of nutrients by regulating the applied current of the device.

The device, which is protected by a patent and utility model application, has been developed on a laboratory scale, and a demonstration prototype has been used to generate calcium in a 100-litre aquarium.

Companies manufacturing calcium reactors or other reactors or devices for marine or reef aquariums interested in the commercial exploitation of this technology are being sought.

INTRODUCCIÓN

Calcium reactors are devices capable of generating fundamental nutrients (calcium, magnesium, bicarbonates, trace elements, etc.) necessary for the growth of carbonate skeleton-forming species such as reef corals, molluscs, or crustaceans. A variety of designs of these calcium reactors are commercially available.

These reactors can be automated and are widely used in both marine and reef aquaria because they promote the growth of these marine species and provide alkalinity to the water.

A conventional calcium reactor is a vessel filled with solid substrates containing calcium carbonate, magnesium, and other trace elements. In commercial equipment, the addition of carbon dioxide (CO_2) reduces the pH of the water in the reaction chamber, dissolving the calcium carbonate and the rest of the elements of the solid substrate. In this way, the stream of water enriched with these elements is returned to the aquarium. The gaseous CO_2 stream comes from a cylinder of this pressurised gas that is bubbled into a chamber containing the mineral. The major complexity of this type of reactor comes from the handling of this carbon dioxide stream. In addition to the pressurised CO_2 cylinder, a pressure reducer is required, while solenoid valves are used to introduce the CO_2 into the reactor vessel.

To control the dissolution process of the substrates, it is necessary to use a pH probe inside the reactor or the use of an alternative method to determine the dissolved CO_2. A needle valve and a droplet counter are also necessary to make fine adjustments to the CO_2 bubbling rate.

The extreme difficulty of this control produces a non-precise dosage of the nutrients. Additionally, it requires the intervention of qualified personnel in the use of the devices, to avoid incidents due to excess acidification or other nutrients, which negatively affects the living species present in the aquarium, possibly resulting in their death.

Because of the great complexity of commercial calcium reactors, they are rarely used in aquarium keeping, particularly in small and medium-sized aquariums for domestic or ornamental use.

DESCRIPCIÓN TÉCNICA

To satisfactorily solve the aforementioned problems, **the "Group of Electrocatalysis and Polymer Electrochemistry" has developed a device that makes it possible to provide alkalinity, calcium and other micronutrients** by contact with a calcareous mineral bed of an electrochemically acidified aquarium water stream, which has significant advantages over conventional systems that use gaseous CO_2 streams.

The nutrients generated are necessary for the development of aquatic organisms, mainly coral skeletons.

This device, which can be configured in different ways, consists of the following elements:

- an **electrochemical reactor** with a reaction chamber containing the solid mineral substrate and at least one anode and one cathode, which are physically separated to avoid electrical contact;
- a **power supply** to which the anode and cathode are connected;
- at least **two pipes**, one leading water from the aquarium to the anode and one leading water from the reaction chamber to the aquarium.

Thus, from the aquarium or the aquarium sump, a flow of water is circulated through a pipe to the electrochemical reactor.

The nutrients are generated by dissolving the solid mineral substrate (usually calcium carbonate) within the reaction chamber. This chamber may have a tubular geometry or other geometries, based on the different types of aquarium filters that are already commercially available: backpack filters, canister filters, internal filters, bioreactors, etc.

After passing through it, the outflow of the return water, already enriched with nutrients, is led back to the aquarium or to the filtration sump.

Reactions taking place in the reaction chamber:

The power supply applies a current that causes oxidation of the aquarium water at the anode, producing protons (H^+) that electrolytically acidify the water that enters to the reaction chamber from the aquarium or aquarium sump:

$$2\,H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$$

The acidified water dissolves the solid mineral substrate contained in the reaction chamber and at least Ca^{2+} ions and bicarbonate ions (HCO_3^-) are released into the water, and this enriched water is subsequently returned to the aquarium:

$$CaCO_3(s) + H^+(aq) \rightarrow HCO_3^-(aq) + Ca^{2+}(aq)$$

The rate at which the dissolution of the solid substrate particles contained in the reaction chamber takes place depends on the current applied by the power supply, so that the supply of salts can be precisely regulated by electronic control.

Finally, the use of this device would not alter the chemical composition of the aquarium water, since in all the configurations envisaged, undesired secondary reactions of water reduction at the cathode, which would affect the composition and pH of the aquarium water, are avoided.

VENTAJAS Y ASPECTOS INNOVADORES

MAIN ADVANTAGES OF THE TECHNOLOGY

- It is an **easy-to-use** device, mainly because it dispenses nutrients without the use of CO_2 gas, thus avoiding the need to regulate its flow and the components and mechanisms required: pressurised CO_2 cylinder, gas pipes, pressure reducer, solenoid valves, pH probes, etc.
- The fact of dispensing without the use of CO_2 gas results in a **simplification of its design** and a **reduction in the cost** of production (as it has fewer components) and **maintenance**.
- Its great **simplicity** favours and facilitates its use in medium and small domestic or ornamental aquariums.
- The **control of the acid** needed to dissolve the appropriate doses of calcium and **alkalinity** can be **regulated automatically in a very precise way**, by means of an **electronic control system of the current/voltages applied**, without the need for costlier and complex gas storage and supply systems.
- Since the dosage of nutrients can be easily and precisely regulated, **the intervention of qualified personnel would not be necessary**, avoiding incidents related to excess of acidification or nutrients, thus preventing negative effects on the living species present in the aquarium.
- The device is very **versatile** since the electrochemical reactor can adopt different configurations without affecting its performance. Likewise, the reaction chamber can also have different designs, depending on the type of aquarium filter. In this way, the device could be installed in any type of aquarium.

• The device could be easily coupled to the conventional calcium reactors already installed, and the gas conduction and control systems could be replaced by the electrical reactor.

• The use of the device does **not alter the chemical composition of the aquarium water**, thus avoiding unwanted side reactions that could affect the composition and pH of the aquarium water.

• The device is easily scalable as all **components** are **commercially available** in different sizes.

• The electronic control facilitates its coupling with other automatic measuring devices for alkalinity, calcium or other nutrients, allowing its **use to be managed automatically and/or remotely**.

INNOVATIVE ASPECTS OF THE TECHNOLOGY

The main innovative aspect of the technology described is the use of electrochemical technology to supply calcium, carbonic alkalinity and other micronutrients to the aquarium water without the need to introduce any CO_2 gas stream into the system, thus avoiding all the inconveniences involved.

In addition, this simple way of operating allows precise control of the nutrients supplied and the acidity generated by simply regulating the current supplied to the system via the power supply.

ESTADO ACTUAL

The technology is developed at **laboratory scale**. The research group has a demonstration prototype.

This device was used in a 100-litre marine aquarium for 3 months. During this period, electricity consumption was around 1 Wh/day, providing 2.4 grams of calcium for each KWh of electricity consumption.

APLICACIONES DE LA OFERTA

This device finds application in any type of **recirculating aquaculture system** (coral farms, mollusc and fish farming, etc.), and more specifically in the field of **ornamental aquaculture**.

COLABORACIÓN BUSCADA

Companies interested in acquiring this technology for **commercial exploitation** through:

- Patent licensing agreements.
- R&D projects to adapt the device to the client's needs.

Types of companies sought:

- Companies manufacturing calcium reactors for marine aquariums or reef aquariums.
- Companies that manufacture other types of reactors or devices for marine aquariums or reef aquariums.

DERECHOS DE PROPIEDAD INTELECTUAL

This technology is protected by **patent and utility model application**.

- *Title: "Calcium, alkalinity and micronutrient production device for marine aquariums".*
- *Application number: P202330990 and U202432219*
- *Application date: 29/11/2023*

SECTORES DE APLICACIÓN (2)

Agri-food and Fisheries
Chemical Technology

IMÁGENES TÉCNICAS (1)