PLAN DE INVESTIGACIÓN

DOCTORANDO:

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PROGRAMA DE DOCTORADO: "Electroquímica: Ciencia y Tecnología"

DIRECTOR: Dr. Toribio Fernández Otero.

TÍTULO DE LA PROPUESTA DE TESIS: Proprioceptive Artificial Muscles

RESUMEN DE LA PROPUESTA:

One of the dreams of engineers and robot designers is the design and construction of sensing motors mimicking haptic muscles. In this search for dual sensing-motors electrochemical artificial muscles sense, through the consumed energy, chemical and physical working conditions. They only need two wires to transmit both, the sensing and the actuating information, between the tool and a control system. Driven by oxidation/reduction reactions conducting polymers suffer reversible volume changes leading to bending or linear motion. While moving the evolution of the muscle potential and the consumed energy sense energetic working conditions as temperature, concentration or presence of obstacles.

Our aim is to develop dual and simultaneous sensing-actuators from different materials working for thousands of cycles. Thus, one motor and several sensors (thermal, chemical, mechanical, electrical) will work simultaneously in a physically uniform device driven by the same electrochemical reaction. Different families of conducting polymers, exchanging anions or cations during reaction will be checked. The theoretical description of artificial proprioception will be improved to implement a control system getting artificial proprioceptive tools.

OBJETIVOS ESTIMADOS DEL TRABAJO:

The main aim of this thesis is the development of dual and simultaneous sensing-actuator (proprioceptive muscles) from different materials and in different electrolytic media, as well as the theoretical description of experimental results (proprioceptive equations) and the design, fabrication and control of different tools and robotic components.

ESTADO DEL ARTE DEL PROBLEMA:

Around 60 years ago Katchalsky observed bending motion in a gel polymeric film immerse in an electrolyte and placed between two metallic electrodes when an electric field was established. From that time, different kinds of actuators based on these materials have been developed.

In the 90s of the past century it was discovered that films created from conducting polymers are able to respond to different changes in the surrounding environment such as temperature, electric field, or electric currents while actuation.

Recently, the group of the Professor Otero has developed an artificial proprioceptive equation that relates actuation variables such as angular position or angular relate to sensing magnitudes like temperature or electrolyte concentration.

PLAN DE TRABAJO CON UNA ESTIMACIÓN DE CALENDARIO Y METODOLOGÍA QUE SE VA A UTILIZAR:

1st year

- State of art of the field.
- Learning of the electrochemical techniques used to generate and characterize films of conducting polymers.
- Learning of the techniques employed to study the suitability of the different materials for their used as artificial muscles.
- Study of different materials assessing their possible used as artificial muscles.
- Publication of the attained results.

2nd year

- Choice of a material to develop a control system.
- Developing of a control system.
  - Design of a control system.
  - Building of the control system.
  - Implementation of the control system.
  - Improvement of the control system.
- Developing of a methodology to compare different materials and their possible use as artificial muscles.
- Improvement of the theoretical model for artificial proprioception
- Publication of the attained results if appropriate.

3rd year

- Developing of a patentable sensing-actuator prototype.
- Publication of the attained results if appropriate.
- Writing and presentation of the thesis.

INVESTIGACIÓN BIBLIOGRÁFICA:

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PUBLICACIONES MÁS RELEVANTES REALIZADAS EN EL ÁMBITO DE ESTUDIO:

The PhD candidate has participated in two papers that are currently accepted in internationals magazines

- "Biomimetic reaction-driven conformational movements sense working electrochemical energy: Sweep rate influence" accepted by Electrochemical Acta. Authors: T.F. Otero, V.H Pascual, J.G. Martinez, L. Valero.
- "Construction and coulodynamic characterization of PPy-DBS-MWCNT/tape bilayer artificial muscles" accepted by RSC Advances. Authors: T.F. Otero, J. Schumacher, V.H Pascual.

The PhD candidate has also participated in congresses communications:

Authors: Victor H. Pascual, Toribio F. Otero, Jose G. Martinez, Laura Valero, Johanna Schumacher
Title: Electrochemical reactions from conducting polymers sense available electrochemical energy: sweep rate influence
Participation type: Oral communication and poster
Congress: VI International Conference on Electrochemically Active Polymer (EAP) transducers and artificial muscles
Venue: Helsingor (Denmark) June 2016

Authors: Jose G. Martinez, Toribio F. Otero, Victor H. Pascual, Laura Valero, Johanna Schumacher
Title: A single electro-chemo-physical equation explains dual sensing and actuating properties of conducting polymer actuators: theoretical description of sensing-motors
Participation type: Oral communication and poster
Congress: VI International Conference on Electrochemically Active Polymer (EAP) transducers and artificial muscles
Venue: Helsingor (Denmark) June 2016

Authors: Johanna Schumacher, Toribio F. Otero, Victor H. Pascual, Jose G. Martinez, Laura Valero.
Title: Polypyrrole-carbon nanotube composite/tape bilayer sensing-muscles: electrochemical and electrochemo-dynamical characterization at different sweep rates
Participation type: Oral communication and poster
Congress: VI International Conference on Electrochemically Active Polymer (EAP) transducers and artificial muscles
Venue: Helsingor (Denmark) June 2016

COMPLEMENTOS DE FORMACIÓN:

The PhD candidate took the module "Fundamentos de Electroquímica I" of the master "Electroquímica: Ciencia y Tecnología".