



**Carbon/Conductive Polymer Nanocomposites for Energy Storage Systems – Training on Extreme Potential Test and Ageing of Electrodes under Cycling and Floating**

**PrInt – CAPES – ITA**

**Theme 4: Space and Fundamental Sciences**

**Project 2: Space Science and Engineering**

Call 2019 to Training of Professors

*Knowledge Dissemination Plan*

**Proponent: Prof. Dr. Emerson Sarmento Gonçalves**

**(PPG-ITA-CTE-Q)**

**Hosting Professor: Prof. Dr. François Béguin**

**(Power Sources Group – Poznan University of Technology)**

São José dos Campos, October 14<sup>th</sup> 2019

The proposal presented by Professor Emerson Sarmento Gonçalves is part of a work plan that is being developed between him and Professor François Béguin for a 4-year collaboration in the area of Batteries and Supercapacitors, involving systems that present possibilities of insertion into systems (main or auxiliaries) of rockets, satellites or aircraft. Naturally, the materials to be worked on in this Project will have numerous spin offs for sustainable cell, mobility and telecommunications applications.

Thus, the wealth of information and technological development to be gained is very large. The contribution of this area is even more highlighted when one of the most critical issues of this and the next decade will be the modes of energy storage, as demand becomes increasingly high and sources capable of offer tremendous amounts of power and energy. There are, however, relevant seasonality effects on these sources, which makes the development of increasingly robust systems necessary.

Even space systems such as rockets and satellites increase their storage demand because of their electronic subsystems, electric pumps and possible fuel cell use in some European systems that already act to save propellant tank mass and volume.

In any case, ITA's Graduate Programs will benefit from the approval and implementation of this Proposal because, despite the pressing need, some important vacancies are noticed:

- There are few groups involved in the development of materials for batteries and supercapacitors linked to the Programs (in fact, only GMAE, with its leader Emerson Gonçalves and its 11 students, 7 of them from PPG-CTE-Q);

- Moreover, the laboratory infrastructure does not yet allow the deepening of all the techniques foreseen for a precise evaluation of the developed materials;

- Thus, the opening of Poznan University of Technology's Power Sources Group structure for GMAE enables the impact of this group's scientific output to increase, directly impacting CAPES 'assessment of PPG-CTE-Q, and the ITA Programs;

- materials obtained that can be shared with the industry (the proponent has collaboration with the Moura Group of Batteries) open the possibility of patents and disruptive products in the energy market for Brazil in all the above areas (the Power Sources Group has dozens of patents in this area with several companies from different countries, including Honda);

- The strengthening of the collaboration makes it possible to answer other international calls, either from Brazilian, Polish or from the European Union, which has been launching calls involving Brazil annually, via FAPESP;

- The formation of students in this area, currently considered strategic, in Brazilian Universities and Research Centers is incipient, and students often have to take special courses outside these institutions, abroad or even in private institutes;

- Thus, the professor is willing to offer "Carbonaceous Materials as High Energy and High Power Storage - Batteries and Supercapacitors" as a Graduate Course, due to the intense contribution of graphite, graphene, glassy carbon, carbon blacks, nanotubes and carbon fibers, among others. These are highly electroactive materials, easily acting on these systems, and extremely light for aerospace functions..

Thus, some knowledge dissemination strategies are planned for at least the next 4 years:

- offer a discipline in this area, according to the topics presented by Professor Béguin, in the short course he will offer to attend Call 2 PVE - 2019, the topics learned in the laboratory in Poland, the demands of the teaching and student community of ITA and other collaborating institutes, and partners such as IFSP, INPE, UNIVAP and UNIFESP. To this end, Professor Emerson Sarmiento Gonçalves should offer from the second semester of 2020 a discipline called "Carbonaceous Materials as High Energy and High Power Storage - Batteries and Supercapacitors", being recommended as prerequisites the disciplines FQ-240 and FQ-242.

- the course menu would follow approximately the following topics:

- 1) Introduction to Carbon electrode materials for capacitive applications:
  - a. Formation of Carbon Materials
  - b. Nanotexture in the Graphite Family
  - c. Microtextures in Carbon Materials
- 2) Porous Texture of Carbons
  - a. Adsorption Theories and Analysis Methods
  - b. Assessment of Pore Size Distributions
  - c. Characterization of Pore Distribution in ACF Prepared from Isotropic Pitch-Based Carbon Fiber
  - d. Characterization of Pore Distribution in ACF Prepared by Chemical Activation of Anisotropic PAN-Based Carbon Fiber
- 3) Surface Chemical and Electrochemical Properties of Carbons
- 4) Carbons in Metal-Ion and Lead-Acid Batteries
  - a. Carbons as Conductive Additives in Positive Electrodes
  - b. Structure and Electrochemical Performance of Electroactive Carbons in the Negative Electrode
  - c. Electrode Engineering
  - d. Commercial Negative Electrode Materials
- 5) Electrical double-layer capacitors (EDLC) and Pseudocapacitors
  - a. Introduction
  - b. Principle and Properties of Electrochemical Capacitors
  - c. Electrical Double-Layer Capacitors
  - d. Influence of the Nanoporous Texture on the Performance of Ions Electrosorption

- e. Charge storage mechanisms in EDLCs with porous carbon electrodes
  - f. Carbon Materials in Pseudocapacitors
  - g. Hydrogen electrosorption in the pores of the negative electrode
  - h. Redox-activity of electrolytic species at the positive electrode
  - i. Nanotubes as Backbone of Pseudocapacitive Composite Electrodes .
  - j. Conducting Polymer/Carbon Nanotube Composites
  - k. Amorphous Manganese Oxide/Carbon Nanotube Composites
  - l. Asymmetric Systems
    - Asymmetric Systems Including a Battery Electrode
    - New Asymmetric Systems Working in Organic Electrolytes
    - New Asymmetric Systems Working in Aqueous Electrolytes
    - Asymmetric Systems Using Pseudocapacitive Oxides or Conducting Polymers
    - Asymmetric Systems Using Two Different Activated Carbons
- 6) Capacitive deionization (CDI)
- a. Introduction
  - b. EDLC and CDI: similarities and differences
  - c. Flow-electrode CDI
- 7) CNLS fittings of EIS to study Porous Carbon Electrodes

- - In addition, two scientific articles are provided per year in journals A, in collaboration with the Power Sources Group;
- - Exchanges are also foreseen (either by PrInt, BEPE, or eventually PROCAD-Defense) of at least two GMAE Sandwich PhD students and two Power Sources Group Postdoctoral Researchers;
- - Finally, as a result of this collaboration, ITA, CTE and GMAE will have papers presented at National and International Congresses;
- - It is also planned, in collaboration with the IFSP, the formation of undergraduate students in Chemistry in this area, through short courses to be offered periodically in their facilities by the teacher in mission.