# HYBRID POLYMERS FOR NUTRIENTS RELEASE: PREPARATION, CHARACTERIZATION AND *IN SITU* EVALUATION OF NUTRIENTS RELEASE IN THE SOIL

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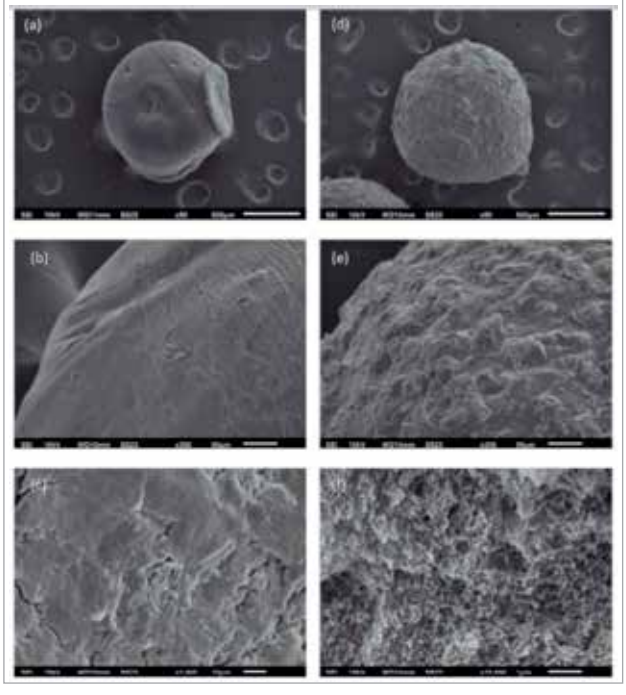

*Figure 1. FEG-SEM images of (a-b) Ch and (d-e) ChMMt33 microspheres and (c) Ch and (d) ChMMt33 fracture region*

The main goal of this project is the preparation, characterization and application of hybrid polymeric materials for nutrients release in soil and plant. The project comprises three main targets: 1) Preparation and characterization of hybrids polymeric materials as microspheres and with macronutrients (nitrogen and potassium), 2) Evaluation of the mechanism and kinetics of the release of the nutrient in the water, 3) Evaluation of the release in soil (laboratory and field) by TDR (time Domain Reflectometry) technique. The motivation is to prepare microspheres from natural materials (chitosan, montmorillonite clay and sugar cane bagasse) and nutrients. Also,the nutrients delivered in soil will be in situ evaluated by an electromagnetic technique which evaluates the ion motion in particulate systems such as soil. The increase of the fertilizer efficiency, reduction in soil toxicity and the decrease in adverse effects associated with overdosage are a few of advantages of the controlled release material. Chitosan is a natural biopolymer and has the ability to form films, fibers, gels and microspheres, responsible for its various applications. It is a multifunctional polymer containing amine groups (NH2) and hydroxyl (OH-) able to interact with different molecules and ions. The addition of layered silicates such as natural clays is a highly promising alternative to improve the mechanical properties and increase the sorption capacity of both water and chemical compounds. The sugar cane bagasse is a biomass with high water and chemicals sorption capacity and its mixture with chitosan can provides stiffness to the material to use it directly in the soil in a suitable proportions. It is noteworthy that the synergy of the properties of chitosan / clay materials and chitosan/ bagasse combines the properties of biopolymer and natural fillers for the sustainability of its use in soil as a function of the biodegradable properties of chitosan. Importantly, the use of TDR technique for monitoring the in situ release of the nutrient in the soil is innovative in the area of materials applied to agriculture and it is believed that it will provide quickly information about the effectiveness of the material in the soil and plant from short to long term.

## SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

Microspheres of chitosan and chitosan/clay composites prepared by inversion phase present the ability to deliver the fertilizer in the soil in a controlled and slow mode. The initial results show the perspective to modulate the material depending on the plant and soil. Additionally, the use of biopolymer and biomass guarantee the sustainability of the process in the role cycle, i.e., to prepare and to use the material. The biopolymer with biodegradability properties is an important factor since after the release of the fertilizer no residue must be in the soil. The first prepared material shows a rough and porous surface which provides better sorption of fertilizer, as demonstrate by the sorption-desorption results. Finally, TDR shows the profile of $KNO_3$ release and the relationship with the material structure could be described. The TDR technique used to determine the fertilizer release will be useful for determining the real profile of nutrient release in soil and help in the design of the best fertilizer delivery formulations. Spray dryer methodology is being now used to prepare microsphere and microcapsules and as perspectives we are evaluating this methodology in the release mechanism in the soil and plant system.

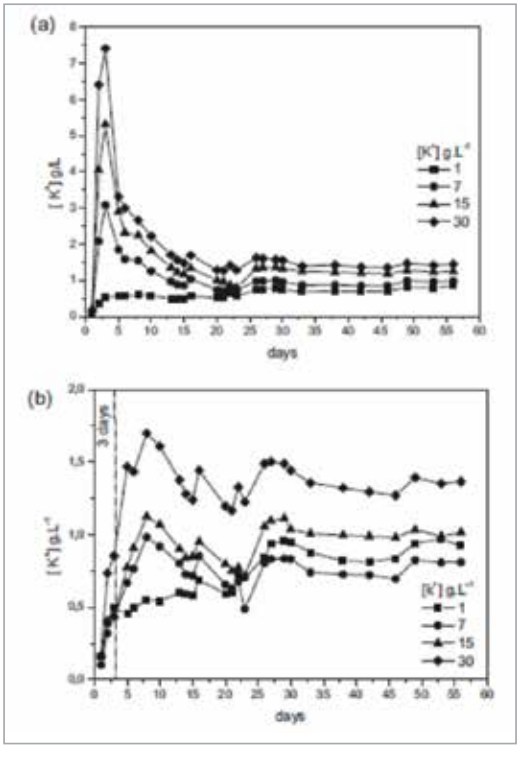


*Figure 2. Determination of the potassium concentration release in the soil using TDR (a) central and (b) lateral probes*

## MAIN PUBLICATIONS

Rodrigues B, Bacalhau FB, Pereira TS, Souza CF, Faez R. 2015. Chitosan-montmorillonite microspheres: a sustainable fertilizer delivery system. *Carbohydrate Polymers.* **127**: 340-346.

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