Development of nanospheres as carrier systems for herbicides aiming agricultural applications

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INTRODUCTION

Herbicides are molecules used worldwide for weed control. They account for about 70% of all agricultural pesticide use and many herbicides that have been used in agriculture present problems related to their availability, such as: chemical stability, low water solubility, photodecomposition, soil sorption process (Khot et al. 2012). Regarding to herbicides, these compounds and their degradation products: show persistence and mobility in the environment, have a toxic, carcinogenic, mutagenic and teratogen potential and some herbicides present endocrine effects on several non-target organisms. One possibility to reduce problems caused by herbicide is the use of controlled release systems. These systems can change some physico-chemical properties of herbicides, modify their release profile and consequently agricultural management practices and decrease their toxicity and in this way, decrease their environmental impacts (Grillo et al., 2011). Therefore, it is desirable to develop carrier systems that enable modification of some of the properties described above. Modified release systems changed the amount of the herbicide as function of the time and keep it constant around the active zone concentration for more time than conventional applications (Nair et al. 2010). In this way, these systems may offer the following advantages for herbicides too: reduction of the amount of chemical substance required for pest control, diminished risk of environmental contamination, reduction of energy consumption, since fewer applications are needed when compared to conventional formulations, increased safety of the people applying the product in the field (Silva et al., 2011). So in the present work our focus were the preparation and characterization of polymeric nanoparticles containing the herbicides in order to produce a modified release system that can be used as a possible alternative, enabling these herbicides to be used safely in agriculture and minimizing its environmental impact.

MATERIALS AND METHODS

The nanoparticles were prepared by interfacial deposition, using the nanoprecipitation method and the encapsulation efficiency (EE %) was calculated by ultrafiltration-centrifugation technique using HPLC. The mean diameter of the nanoparticles and polydispersion in the dispersion were determined by photon correlation spectroscopy (PCS), using a laser light scattering instrument (Zetasizer, Malvern Inc.) at a fixed angle of 90^{o} at 25^{o}C. The zeta potential was determined using a Zeta potential analyzer (Zetasizer, Malvern Inc.) at the same temperature. In order to understand the interaction between herbicide (encapsulated or not) and a soil layer we have been investigated the release profile of the herbicide and herbicide loaded nanospheres (Figure 1).

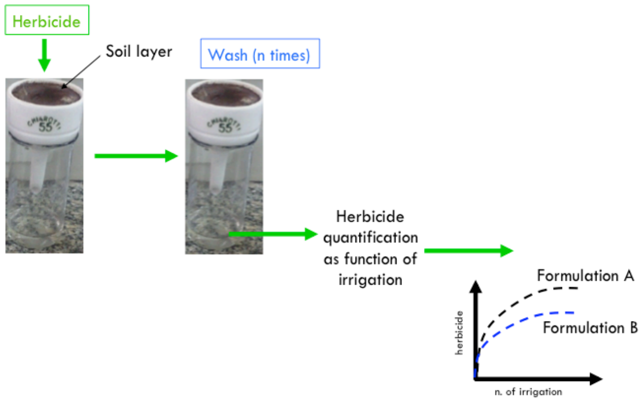


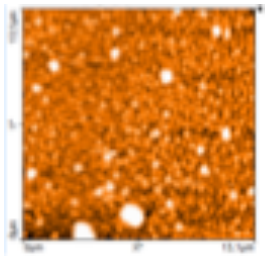
Figure 1: Schematic representation herbicide release profile in soil layer.

RESULTS AND DISCUSSION

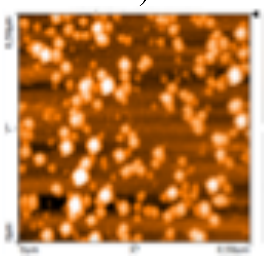
In this work we have been prepared three different nanospheres loaded atrazine herbicide and characterized them (Table 1) by mean size diameter (measured by photo correlation spectroscopy) and by the determination of the herbicide encapsulation efficiency (determined by HPLC technique). Also, the nanoparticles were investigated by atomic force microscopy (Figure 2) in order to verify the shape of the nanoparticles. The results (Table 1 and Figure 2) showed that the size range for nanospheres were similar but the encapsulation efficiency of the herbicide in the nanoparticles were different and that in all formulations the nanoparticles were spherical and do not present aggregates.

Table 1: Physico-chemical characterization of the nanoparticles loaded atrazine herbicide.

Formulation	Size (nm)	Encapsulation Efficiency (%)
A	195±6	49±1
B	207±12	45±2
C	191±1	40±1



A)



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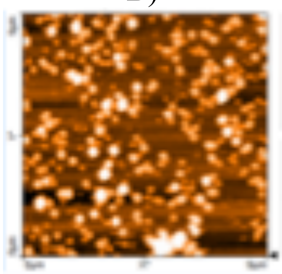

C)

Figure 2: Characterization results obtained for three poly-epslon caprolactone nanospheres formulations loaded atrazine herbicide.

After physico-chemical characterization we have been investigated the release profile of atrazine in a soil layer and the results are showed in Figure 3.

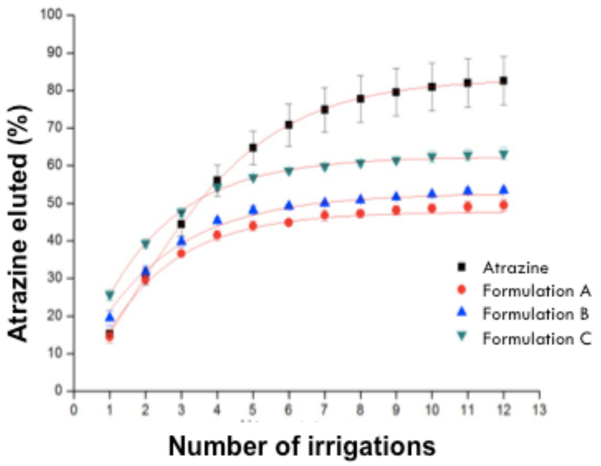

Figure 3: Release profile of atrazine free and loaded in formulation A, B and C as function of the number of irrigations.

In the atrazine release profiles showed in Figure 3 were possible to see that the herbicide atrazine release 100% with 11 irrigations and that for the herbicide loaded nanoparticles (with the same number of irrigations) the release profile were changed and showed a good correlation with encapsulation efficiency data obtained (Table 1). These results are interesting, since, for this herbicide, the soil mobility across a layer was changed and dependent of the encapsulation efficiency parameter.

CONCLUSIONS

As a conclusion the results showed a good encapsulation efficiency of atrazine herbicide into nanospheres and that the herbicide changed the release profile in a soil layer depend on the encapsulation efficiency. In this way, this study provides new perspectives for future experiments using polymeric nanocarriers for herbicides in order to reduces the harmful effects of these, thus creating a safer handling system.

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ACKNOWLEDGMENTS

Authors would like to thanks Fapesp, CNPq and Fundunesp for finantial support.