Cyclodextrins: an eco-friendly contribution to management of herbicide MCPA

E. M. Garrido[1,2], S. Benfeito[1,2], C. Fernandes[1,2], J. Garrido[1,2] and F. Borges[2]

[1] Department of Chemical Engineering, School of Engineering (ISEP), Polytechnic Institute of Porto, 4200-072 Porto, Portugal– emg@ipp.isep.pt
[2] CIQ/Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, 4169-007 Porto, Portugal.

Keywords: *Cyclodextrins, pesticides, MCPA, bioremediation*

Nowadays, 10 % of agricultural yields are estimated to be destroyed by animal pests before harvest[1]. Thus, intense research has been focused in the development of new pesticides or in the improvement of the efficiency of the marketed ones.

Pesticides constitute a heterogeneous category of chemicals specifically designed for the control of pests, weeds or plant diseases. Some pesticides have been considered potential chemical mutagens, due to their capacity to induce mutations, chromosomal alterations or DNA damage. Furthermore, studies showed that only 0.1 % of the applied pesticide reaches the targeted area and that a great amount is deviated to surrounding areas and for underground water[2]. These facts associated to the low solubility of some pesticides, can lead to the bioaccumulation of this type of toxic organic compounds in soils, water and air. Hence, seriously consequences to environment and human health are expected to occur[3].

4-Chloro-2-methylphenoxyacetic acid, commonly named as MCPA, is frequently used in agricultural and household sectors worldwide. This type of pesticide is in the top five of the most commonly used active ingredients in the home and garden sector in the US and herbicide active ingredients in the EU[4]. MCPA has been classified by IARC as carcinogenic to humans (category 2B) and actually human exposure to MCPA has been linked with an increased risk of cancer in humans, namely soft-tissue sarcoma, non-Hodgkin's lymphoma, among others[5].

Some strategies have been employed to remove or eliminate the presence of MCPA in water or soil, namely through the use of advanced oxidative processes[6,7].

A recent approach to reduce herbicides levels in the environment involves the development of controlled release formulations (CRFs) since less active ingredient need to be applied for maintaining the herbicidal efficacy. In fact, controlled-release technology is being used for environmental pollution due to their advantages over conventional formulations such as reducing pesticide losses from degradation, leaching, or volatilization.

Cyclodextrins have emerged as a new tool to improve pesticide photostabilization and solubility. Cyclodextrins are substances obtained from the enzymatic degradation of starch and are suitable for pesticide microencapsulation by molecular inclusion. Due to its hydrophobic internal cavity cyclodextrins can complex with molecules which have dimensions compatible with and thereby can change some of its physico-chemical properties as water solubility, stability and bioavailability.

In addition, being circular polymers of the sugar glucose, cyclodextrins complexes can also contribute to the biodegradation of organic pollutants.

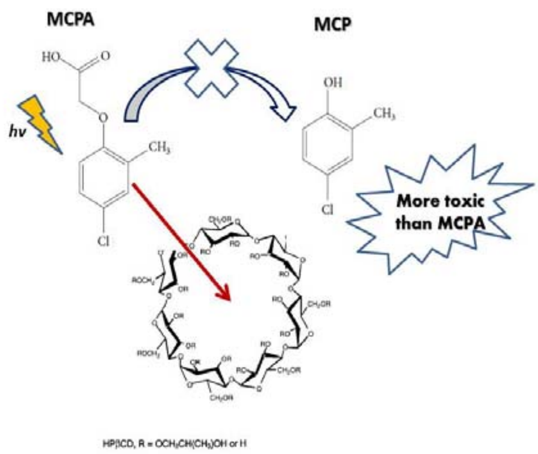

Fig. 1 – Schematic representation of the aim of the work.

The aim of this work was to evaluate the contribution of different cyclodextrins to the management of herbicide MCPA (Fig. 1). The process of herbicide inclusion in the cyclodextrin and the evaluation of the photostabilization MCPA-cyclodextrin complexes in ultrapure and river water were also performed.

Acknowledgements

The financial support from Fundação para a Ciência e Tecnologia FCT/MCTES Project PTDC/AGRAAM/105044/2008, National Funds PIDDAC also cofinanced by the European Community Fund FEDER through COMPETE, Programa Operacional Factores de Competitividade (POFC), is gratefully acknowledged.

References

(1) E. A. Martin, B. Reineking, B. Seo, I. Steffan-Dewenter, *P. Natl. Acad. Sci. USA*, 2013, **110**, 5534.
(2) M. Arias-Estévez, E. López-Periago, E. Martínez-Carballo, J. Simal-Gándara, J.-C. Mejuto, L. García-Río, *Agr. Ecosyst. Environ.*, 2008, **123**, 247.
(3) C. A. Damalas and I. G. Eleftherohorinos, *Int. J. Environ. Res. Public Health,* 2011, **8**, 1402.
(4) T. Kiely, D. Donaldson, A. Grube, Pesticides industry sales and usage – 2000 and 2001 market estimates. *U.S. Environmental Protection Agency,* Washington DC, USA, 2004.
(5) C. Costa, S. Maia, P. Silva, J. Garrido, F. Borges, E. M. Garrido, *Int. J. Photoenergy*, 2013, **2013**, 8.
(6) S. Garcia-Segura, L. C. Almeida, N. Bocchi, E. Brillas, *J. Hazard. Mater*., 2011, **194**, 109.
(7) A. Topalov, B. Abramović, D. Molnár-Gábor, J. Csanádi, O. J. Arcson, *Photochem. Photobiol. A: Chemistry*, 2001, **140**, 249.