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Hydrogels as carriers for the controlled release of paraquat

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Abstract – The objective of this work was to study the capability of hydrogels constituted by polyacrylamide and methylcellulose for controlled release of paraquat in aqueous solution. The released amount of paraquat was measured spectrophotometrically from the absorbance spectra applying a typical standardization curve. The results showed that the release of paraquat becomes slower when the MC content is increased, due to the strong interaction between hydroxyl groups from MC segments and cationic groups from the paraquat. The mechanism of paraquat transport through the hydrogels synthesized with different formulations was also explored.

The aims of controlled release formulations are to protect the supply of the agent to allow the automatic release of the agent to the target at a controlled rate and to maintain its concentration in the system within the optimum limits over a specified period of time, thereby providing great specificity and persistence [1].

The objective of this work was to study the capability of hydrogels constituted by polyacrylamide (PAAm) and methylcellulose (MC) for controlled release of paraquat in aqueous solution. PAAm-MC hydrogels were synthesized by the free radical polymerization method. The released amount of paraquat was measured spectrophotometrically (λ = 258 nm) from the absorbance spectra applying a typical standardization curve. Paraquat cumulative released (CR) from the hydrogel was obtained from this Eq. - CR = $(M_t / M_\infty) \times 100$, where M_t is the cumulative amount of paraquat released at time "t" and M_∞ is the amount of paraquat loaded onto hydrogel. Fickian and Non-Fickian diffusion can be analyzed from the Eq. developed by Ritger and Peppas [2], $M_t / M_\infty = k\, t^n$, where k is the constant characteristic of the pesticide-polymer system, and n is the diffusion exponent characteristic of the release mechanism.

It is possible to see in Fig. 1 that the paraquat release from hydrogel constituted by 6.0 % AAm is 100 % after 1 day. This fast release is attributed to the weak interaction between matrix-paraquat. PAAm-MC hydrogels presented values of cumulative release of 41; 73; 60 and 24 % for MC = 0.25; 0.5; 0.75 and 1.0 % (in w:v%), respectively. The values of k presented in Tab. 1 showed that the release of paraquat becomes slower when the MC content is increased, due to the strong interaction between hydroxyl groups from MC segments and cationic groups from the paraquat. The equilibrium of release was achieved after 15-20 days. The values of n remained in a range corresponding to Fickian diffusion (n = 0.45 – 0.5) until MC = 0.5 %. After this concentration, the release of paraquat occurred through non-Fickian diffusion. Non-Fickian or anomalous diffusion occurs when the diffusion and relaxation rates are comparable. Thus, the paraquat release depends on two simultaneously rate processes, water migration into the beads and diffusion through continuously swelling hydrogels [2].

Table 1: Diffusion exponent n, constant k for the release of paraquat.

Hydrogel	n	Mechanism	k (h^{-1})
6.0 % AAm	0.44	Fickian	0.529
6.0 % AAm_0.25 % MC	0.44	Fickian	0.0678
6.0 % AAm_0.5 % MC	0.50	Fickian	0.0404
6.0 % AAm_0.75 % MC	0.63	Non-Fickian	0.0541
6.0 % AAm_1.0 % MC	0.58	Non-Fickian	0.0375

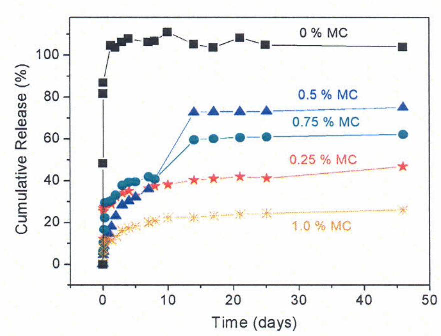

Figure 1: Release of paraquat from PAAm and PAAm-MC hydrogels with different MC concentrations. [AAm] = 6.0 % (w:v%).

References
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