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Influence of inorganic salts on the rejection and transport of organic compounds through a reverse osmosis membrane

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The increasing human pressure on the water resources is nowadays leading to the appearance of persistent and dangerous compounds in natural rivers streams [1]. Among this kind of compounds are identified several types of pharmaceuticals drugs, total or partial metabolized, that are excreted every day, into urban sewage. Conventional wastewater treatment plants are generally not designed to deal with such low levels of cytotoxic compounds and these effluents may be, eventually, discharged into the water cycle downstream.

A group of pharmaceutical drugs that exhibit high cytotoxicity, both in their parental and metabolized forms are the antineoplastic compounds, anti-cancer drugs used in chemotherapies. This group of drugs are characterized by a generally low biodegradability, high carcinogenic and mutagenic potential.

To prevent the possible adverse impact of such cytotoxic compounds on human health and on the environment, an integrated reverse osmosis/electro-oxidation hospitalar wastewater treatment process is being developed for removal and degradation of these organic pollutants.

The reverse osmosis (RO) process will permit the pre-concentration of organic compounds and of inorganic salts, permitting the reduction of volume and the increase of the electrical conductivity of the wastewater to be treated, thus reducing the energy demands and improving the efficiency of a subsequent electro-oxidation process.

In this sense, it is important to gain more insight on how, the interactions between inorganic salts and organic affects the RO membrane rejection of the target organic (cytotoxic) compounds.

5-Fluorouracil (5FU) is one of the most commonly used anti-cancer drugs. It is also one of the smallest molecular (130 g/mol) and relatively hydrophilic molecules (log K_{ow}= -0.81) among the existing antineoplastic compounds. In order to mimic a hospitalar wastewater matrix with antineoplastic compounds, model solutions containing 5-aminouracil (5AU), a chemical and structural analogue of 5FU with lower toxicity, and the inorganic salts NaCl and Na_2SO_4, in concentrations that simulate the urine conductivity and osmolarity, were used.

RO studies to investigate the influence of the concentration and chemical nature of these inorganic salts on the 5AU rejection were conducted using the SW30 reverse osmosis flat membrane (Filmtec, DOW) in a cross-flow operation mode. The experiments were conducted for transmembrane pressures from 0 to 20 bar and solution pH and temperature between at 5.9 ± 0.3 and 27 ± 2 ºC, respectively.

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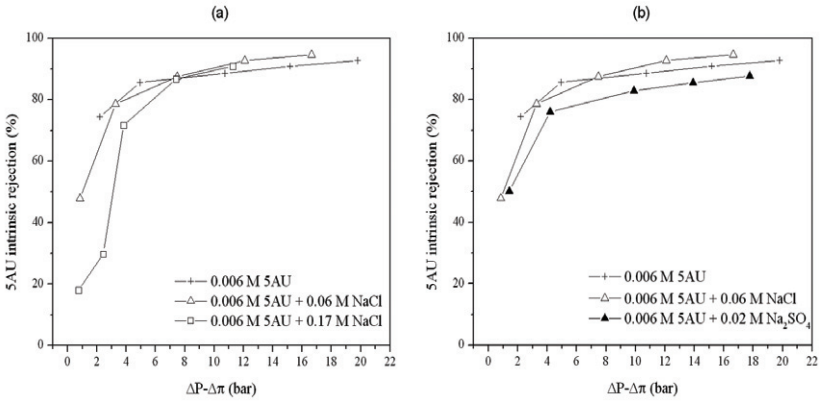

Figure 1. 5AU rejection by SW30 (Filmtec, DOW) membrane using NaCl solutions at different concentrations (a) and Na_2SO_4 and NaCl solutions with identical ionic strength of 0.06 M (b).

The results obtained show that the intrinsic rejection of 5AU increases with the increase of the transmembrane pressure and decreases at increasing salt concentrations (Figure 1 a). As can be expected, this effect is more pronounced at low transmembrane pressures. The decrease in the rejection of organic compounds, due to the presence of inorganic salts and their increasing concentration, may be attributed to the increase of counter-ions concentration in the membrane electrical double-layer, which decreases the electrostatic repulsion between the membrane active layer and the organic solutes [2-4].

A comparative analysis of the rejection of 5AU in the presence of mono- and divalent salts, NaCl and Na_2SO_4, respectively at an identical ionic strength of 0.06 M (Figure 1 b), shows that the 5AU rejection obtained is higher in the presence of NaCl. The reasons underlying the distinct influence of these two salts are not yet totally clear. The effect might be possibly ascribed to differences in the hydration energies of Cl^- and SO_4^{2-} anions [4] leading to different degrees of 5AU hydration in the presence of each salt. In the light of this hypothesis, a higher 5AU hydration degree might be expected in the presence of NaCl, leading to higher 5AU apparent molar volumes and, correspondingly, higher rejection coefficients. Alternatively, the higher 5AU rejection may be due to the formation of higher membrane electrostatic repulsion forces in the presence of NaCl, because it is less charged than Na_2SO_4 [5], what would suggest that the relative charge of the salt is influencing the 5AU rejection. The effect observed could also be due to combined contributions of more than one mechanism previously described.

Systematic studies are currently being performed in order to acquire a better insight into the mechanisms responsible for the phenomenon observed.

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References:

[1] Johnson, A. et al. (2008) Do cytotoxic chemotherapy drugs discharged into rivers pose a risk to the environment and human health? An overview and UK case study, Journal of Hydrology, 348, 167-175.

[2] Bargman, G. et al. (2005), Nanofiltration of multi-component feeds. Interactions between neutral and charged components and their effect on retention, Journal of Membrane Science, 247, 11-20.

[3] Zazouli, M. et al. (2008), Studies on rejection and fouling of polyamide reverse osmosis membrane in the treatment of water solutions containing humic acids, World Applied Sciences Journal, 3, 434-440.

[4] Bouchoux, A. et al. (2005), Nanofiltration of glucose and sodium lactate solutions. Variations of retention between single- and mixed-solutes solutions, Journal of Membrane Science, 258, 123-132.

[5] Mandale, S. and Jones, M. (2008), Interaction of electrolytes and non-electrolytes in nanofiltration, Desalination, 219, 262-271.

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