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REVERSIBLE TRAPPING OF EMERGING WATER CONTAMINANTS

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A wide variety of organic compounds that are used in domestic, agricultural and industrial applications are present at trace concentrations in wastewater effluents[1,2,3]. These micro pollutants include personal-care products, plasticizers, reproductive hormones, pesticides and pharmaceuticals. Adsorption properties of activated carbons (AC) offer great potentialities for water purification, particularly in the case of tertiary treatments as they appear as the most prevailing and competing adsorbents, especially at low pollutant concentration. However, the major encountered disadvantage is their short lifetime due to the low and expensive regeneration capacities.

Specifically, as compared to powder or granules, activated carbon cloths (ACC) or felts show numerous advantages, regardless to their easily handling, high mechanical integrity and regeneration potentialities. Additionally, due to their microtexture and their small fiber diameters (around 10 micrometers), they are ideal candidates for an adsorption purpose as they show minimal diffusion limitation and greater adsorption rates.

In previous studies, we have shown that the desorption of pesticides like bentazon loaded on ACC could be conducted successfully by applying a cathodic polarization of the carbon electrodes [4,5]. We were able to conclude that a local pH increase, due to water reduction, is crucial by favoring the dissociation of surface groups and therefore strengthening electrostatic repulsions. We didn't notice any modification of either nanotextural or chemical properties of the carbon cloth material while a negative polarization was applied. We demonstrated also that desorption kinetics were increased in the case of ACC possessing a significant amount of mesopores or oxygenated surface groups, or in basic medium when oxygenated surface groups are totally dissociated.

In the present work, the adsorption properties of some micropollutants and emerging pollutants, especially pharmaceuticals residues, have been investigated using activated carbon cloths and felts having different nanotextural and chemical properties. An electrochemical polarization has been applied to realize the reversible desorption of adsorbed species and the regeneration of the adsorbent porosity.

The regeneration ability has been characterized and correlated to: the physico-chemical properties of the system (adsorbat, electrolyte), the dissociation state of the pollutant, the nanotextural and the chemical properties of the adsorbent. Gas adsorption (N_2 and CO_2) experiments performed before and after electrochemical regeneration, on cloths loaded with organic contaminants, allowed to determine the size of the pores involved in the process.

The desorption kinetics of aspirin, clofibric acid and ibuprofen are presented in figure 1, showing that within one hour a very high regeneration level, nearly 85%, can be reached depending on the considered pollutant. We assume that the desorption is performed through electrostatic repulsions occurring between the negatively charged carbon surface and dissociated organic molecules, reinforced by the presence of dissociated carbon groups and the electrical field (Fig. 2).

The involved mechanisms have been examined carefully in light of nanoporous texture and surface functionality of carbons but also on adsorbat speciation. The desorption kinetics of the different contaminants could be directly correlated to their pK_A and Log K_{ow} values.

It appears that the reversible electrochemical desorption of induced charged molecules offers great potentialities, and its application to emerging pollutants is now under consideration and will be discussed. Such systems could find a place of choice in industrial processes for tertiary treatment and for the treatment of hospital effluents, but also for underground water exploitation.

References:

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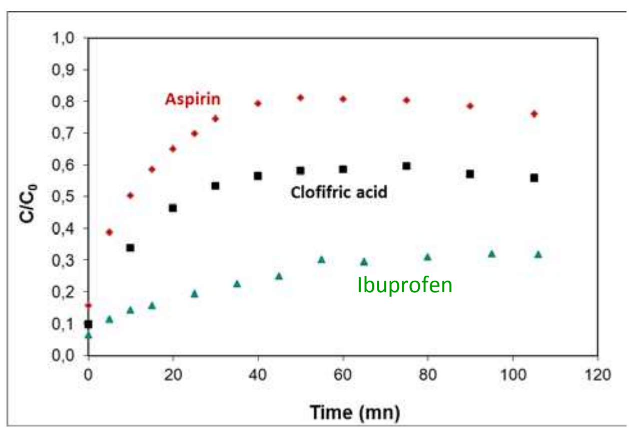

Figure 1: Desorption kinetics at -10 mA/g of Aspirin, Clofibric acid and ibuprofen, loaded on CT13 carbon cloth (Mastcarbon, UK) at 20 ppm. Detection is made by UV spectroscopy.

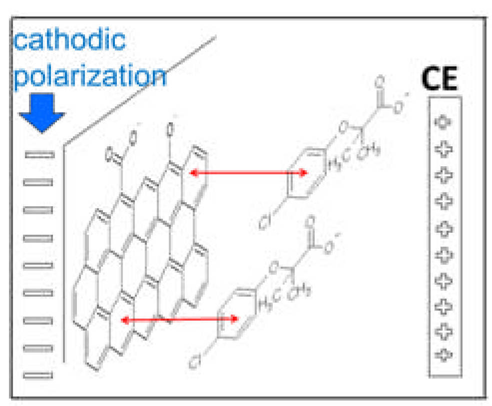

Figure 2: Schematic representation of the electrostatic repulsions involved in the desorption process of clofibric acid during negative polarization of the carbon electrode surface.