

# Transport and retention of anionic dye through hematite -coated quartz sand

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## Introduction

Organic dyes are widely used in textile, tanning the leather, paper, plastic and other industries (Umpuch Ch., 2013). These organic dyes represent one of the problematic pollutants in wastewater. Dyes which usually have a synthetic origin are generally characterized by complex aromatic molecular structures which resist to environmental conditions such as light and microbial attack (McKay G. et al. (1985)). Most dyes have toxic as well as cancerogenic, mutagenic and teratogenic effects (McKay G. et al. (1985)) on aquatic life and also on humans (Gregory A.R et al. (1991)). Thus, the removal of dyes such as anionic dye from aqueous effluents is of great importance. Various methods of organic pollutants removal were used in industry and by several authors, such as, biodegradation (Saitoh, T. et al 2011), photo-catalytic degradation (Chong, M.N., et al. 2010), adsorption (Apul, O.G. et al. 2015). Among these methods, adsorption is considered as an attractive and favourable technique because its low costs, easy operation and high efficiency (Chowdhury, S. et al. 2014.). In addition, very few studies have concerned the use of modified clays minerals as adsorbent materials for the removal of dye from water (Umpuch Ch., et al. 2013). In the present work, we carry out column adsorption experiments (open flow-through reactor) of Eriochrome Black T (EBT) from water onto hematite -coated quartz sand (HCQS). The aim of this study is to investigate various parameters, such as the flow velocity, the ionic strength, the aqueous phase pH, the initial EBT concentration and the electrolyte anion nature, that affect the transport and the retention of EBT through hematite -coated quartz sand porous medium. The use of HCQS as adsorbent will allow us to mimic the natural conditions found in hydro-systems (soils, aquifers, etc.).

## Materials and methods

The dye used as adsorbent in this study is Eriochrome Black T (EBT). Its chemical formula is  $C_{20}H_{10}O_7N_3Na$ .

### Preparation and characterization of hematite coating- quartz sand (HCQS)

Synthetic hematite-coated quartz sand used as porous medium was prepared according to the method described by several authors (Scheidegger et al 1993). This method is based on the adsorption of hematite onto natural quartz sand under well- defined experimental conditions. The coating hematite-covered quartz sand particles were characterized by MEB, IR and XRD techniques in order to get further insight into hematite-coated natural quartz sand structure and morphology.

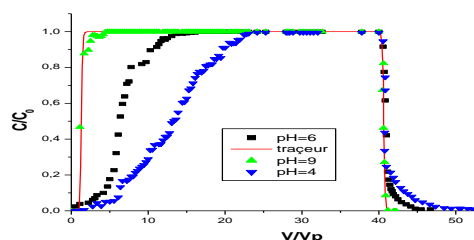
### Column experiments

The column setup used for step-input breakthrough experiments was described in elsewhere (Ait Akbour et al. (2013)). The set-up consisted of an Altuglas column, having a length of 9.9 cm and an intern diameter of 2.6 cm, packed with soil material; two syringe pumps to control the flow rate; a three way valve; a pH-meter allowing for the continuous measurement of the column effluent pH; and a fraction collector.

## Results and discussions

### Effect of the aqueous phase pH

The breakthrough curves of sorption of EBT onto hematite-coated quartz sand are shown in figure 1. These curves combine the adsorption and desorption of EBT at the solid-water interface. This figure indicates clearly the influence of pH on the transport and retention of EBT through the hematite-coated quartz sand column. As can be observed in Figure 1, the mobility is highly dependent on the pH of the solution, which affects the surface charge of the HCQS adsorbent. Thus, it is obvious that decrease occur for the adsorbed EBT amounts with increasing the pH value above the IEP of hematite-coated quartz sand. The variation of the EBT adsorption with the pH of the aqueous solution phase can be explained by considering mainly the electrostatic repulsions which are involved in the interaction of the anionic dye, with the negatively charged HCQS surface.



**Figure 1. Effect of pH on the adsorption and desorption of EBT on HCQS, (Flow velocity  $Q = 1\text{ml/min}$ , EBT initial concentration  $C_0 = 50\text{mg/l}$ , Ionic strength,  $I = 10^{-2}\text{M}$  as fixed by NaCl)**

**Effect of the ionic strength:** The effect of NaCl concentration on the sorption of EBT from water onto the hematite-coated quartz sand at ambient temperature and at  $\text{pH} = 4$ , was studied. The results obtained show that the EBT adsorbed amount increase with the increasing of the NaCl concentration. These results are consistent with the reported work (Ait Akbour et al (2013)), dealing with the transport of anionic Humic acid through quartz sand.

**Effect of the flow velocity:** The EBT adsorbed amounts were measured and they were found to increase with decreasing of the flow rate.

#### **Effect of the electrolyte anion nature**

The data obtained indicate that the adsorption capacity of EBT is function and dependent of the nature of anion present in solution. The result show that the MB adsorbed amount decreases with increasing of anion affinity toward of the hematite-coated quartz sand surface. This behaviour can be explained by competition between the EBT and anion towards the positive sites of hematite-coated quartz sand surface.

#### **Conclusions**

In this work, the effects of various factors such as the aqueous phase pH, the ionic strength, the flow velocity and the electrolyte anion nature, on the retention, mobility and release of EBT through hematite-coated quartz sand, used as porous medium, were examined. The data show that the retention of EBT dye in the HCQS porous medium increases with decreasing, either the pH of the aqueous solution, the flow velocity, or the initial EBT concentration. However, a decrease of EBT sorption through the HCQS porous medium is observed when the aqueous phase ionic strength decreases. Further, the EBT retention depends on the electrolyte anion nature. This dependence seems to due to difference in the affinity of anion toward hematite-coated quartz sand.

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