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Nanofiltration treatment for boron removal from ceramic industry wastewater

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Short Introduction

Water is a limited natural resource and in many regions of the planet, it is also scarce. Consequently, water management has become a very important issue in many traditional industrial sectors which are water consumers and wastewater generators. The ceramic sector is concerned because it consumes fresh water and generates wastewater in significant quantities. In addition, the main European ceramic sectors, with great importance at the world level, are located in Spain and Italy. For this reason, the present work focused on the application of nanofiltration technology (NF) through polymer membranes to obtain treated wastewater with a Boron concentration equal or less the 3 mg/l needed to comply with legal requirements.

Material and Methods

Research development is divided into two parts: the characterization of the chosen membranes and a case study which has consisted in the application of nanofiltration to the removal of boron from the wastewater generated in ceramic tile manufacturing.

Firstly, several commercial Dow-Filmtec nanofiltration membranes have been characterized: NF, NF-90, NF-200 and NF-270. For each of them, pure water permeability (L_p^0), pore radius (r_p) and normalized charge density (X_i) have been determined. The last two parameters were calculated with the aid of the Nanoflux® modeling software.

During the case study the wastewater of a model ceramic tile manufacturing company was characterised. Next, laboratory-scale nanofiltration tests were performed to determine the rejection of boron. The pH was increased in the tests to turn boron from boric acid into borate in order to optimize boron retention. After laboratory tests, the technology was scaled to the industrial level.

Results and Discussion

Membranes characterization tests were carried out. The results were then input to the Nanoflux® software in order to determine the membrane characterization parameters, as shown in Table 1. A good fit of the model to experimental data was observed.

Table 1. Pure water permeability, pore radius and normalized charge density for each membrane. The normalized charge density is defined as the membrane charge density, in moles of elementary charge per unit pore volume, divided by the total salt concentration.

Membrane	Pure water permeability (L_p^0) (l/h m² bar)	Pore radius (r_p) (nm)*	Normalized charge density (X_i)**
NF	10,4	0,41	-3,371
NF-90	10,1	0,32	-8,488
NF-200	11,6	0,42	-3,181
NF-270	19,6	0,39	-2,000

*Temperature is 25°C. ** This parameter has been obtained with a NaCl 0,01M solution and pH=7.

NF-90 is the best membrane for boron removal because it shows the smallest pore radius together with the highest (negative) normalized charge density [*Simon et al (2013)*]. From the results obtained, it can be concluded that the NF-90 membrane may be the most suitable one for boron rejection.

Boron rejection ranging from 30 to 99% have been obtained when the pH is increased from 7 to 11 (Figure 1) [*Dydo et al (2005)*], whereas boron concentration and filtration pressure variations did not show any significant effects.

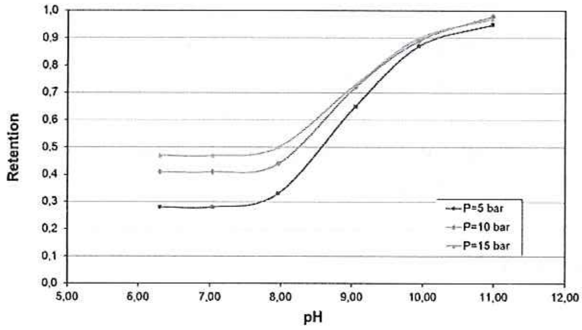

Figure 1. Boron retention dependent on pH and pressure. Flat NF-90 and boron concentration10 mg/L.

In industrial tests, the amount of boron in wastewater could be reduced from 19 mg/l to 3 mg/l, the target value.

Conclusions

Nanofiltration membranes can represent a good alternative for Boron removal from wastewater of tile manufacturing industries. A previous pH adjustment is necessary to maximise rejection at a relatively low membrane pressure and suitable permeate flow. Under these conditions, treated wastewater can comply with legal requirements or be reused in the manufacturing process.

References

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