ABSTRACT – Little advance has been achieved on the evaluation of the appropriate treatment for the effluent of laundering processes. Its complexity and variability in terms of quality parameters renders great importance to the development of alternative treatment processes. Nanofiltration is a good alternative, but the evaluation of the interaction between the surfactants present in the wastewater and the membrane surface is extremely important. The present work aims to evaluate those interactions effects on the transport and separation performance of the selected membranes.

1. INTRODUCTION

Laundering processes use and discard a great amount of water with a great variability in terms of quality parameters. The pollution caused by surfactants that are part of the formulation of detergents for the laundering processes can lead to modifications of the biota, since the activities of most aquatic organisms depend fundamentally on water surface tension. Moreover, the formation of foams can cause toxic effects to the aquatic ecosystem and alter the biodiversity involved in pollutants degradation (Dentel et al., 1993).

Membrane processes have been considered among the available alternatives for the treatment of this type of effluent, producing a water free of microorganisms, contaminants and particulate matter (Madaeni, 1999). It is well known that the membrane charges influence the separation performance and the interaction between organic and inorganic substances with the membrane surface in aqueous media. The present work aims to evaluate the interactions of surfactants found in real effluents with the membrane surface, in order to select the appropriate nanofiltration membrane for the treatment and reuse of the effluent from domestic laundry.

2. MATERIALS AND METHODS

2.1. Membranes, collection and storage of the real effluent and reagents
The nanofiltration membranes selected were NF90 and SR90, from Dow Filmtec. The effluent was collected from a domestic washing machine operating with the recommended dosages of powder detergent and softener. Wastewater was collected at the beginning and at the end of both rinsing and washing processes, and then mixed. Approximately 143 L of water was used in each operation cycle. The sample was refrigerated, after the addition of about 1.0 g of sodium azide. In order to evaluate synthetic surfactant solutions, cetyltrimethylammonium bromide (CTAB) (98%) and sodium dodecyl sulfate (SDS) (99%) were purchased from Vetec (Brazil), while the nonionic surfactants, Triton X-100 (90%) and Tween 80 (97%), were obtained from Sigma Aldrich (Brazil) and Tedia (USA), respectively.

2.2. Permeation tests

Permeation tests were carried out in a nanofiltration unit, recycling both concentrate and permeate streams, with a heat exchanger for temperature control, a feed tank and a flat membrane module. Most of the experiments were carried out at a pressure of 15 bar. Feed flow rate was 48.8 L/h in all the experiments, and the hydraulic permeability was also evaluated at 5-20 bar pressure range, at room temperature.

2.3. Contact angle and zeta potential

The measurements of contact angle were made in triplicate, with a Goniometer OCA15EC (Dataphysics), at room temperature, using the sessile drop method. Electrokinetic potentials were analyzed using SurPASS (Anton Paar, Austria).

2.4. Characterization Analysis (DQO, TOC)

Chemical Oxygen Demand (COD) was measured by the colorimetric method 5220 D, with a digester model CE-350 and a spectrophotometer HACH DR 2800. Total Organic Carbon (TOC) was analyzed using a SHIMADZU model TOC-VPN equipment (APHA, 2005).

3. RESULTS AND DISCUSSION

3.1 Effect of the surfactants adsorption on the membrane charge

The NF90 membrane presented a lower hydraulic permeability than the SR90 membrane, besides a greater change of contact angle with the real effluent, compared to the contact angle with water, pointing out the importance of studying a possible influence of surfactants adsorption on the performance of the NF90 membrane (Table 1).

Table 1 – Hydraulic permeability and contact angle with water and real effluent, for NF90 and SR90 membranes.

|                      | NF90   | SR90   |
|----------------------|--------|--------|
| Hydraulic Permeability (L/(m².h.bar)) | 2.5    | 10.8   |
| Contact angle (water) | 43.2°  | 29.7°  |
| Contact angle (real effluent) | 25.8°  | 27.8°  |
Surfactants adsorption was evaluated individually, and as a mixture, for the NF90 membrane, with a concentration range of the surfactants based in literature for the real effluent, as seen in Figure 1.

![Figure 1. Zeta Potential of the NF90 membrane as a function of total surfactants concentration, (a) CTAB, (b) Tween 80, (c) SDS, (d) mixture of surfactants (equal proportion of each surfactant in the solution) (at pH 6-7).](image)

From the promising results it was observed that the adsorption of the mixture (Fig. 1d) was similar to the adsorption of the cationic surfactant (Fig. 1a), reversing the potential from negative to positive. Therefore, the adsorption of the cationic surfactant showed to be predominant, compared to the other surfactants.

### 3.2 Performance tests

The highest hydraulic permeability was observed for the SR90 (10.8 L/(h.m².bar)). This membrane also presented higher hydrophilicity, in comparison to the other membranes (with a contact angle with pure water of 29.7°). Therefore, SR90 membrane was selected for the test with the real effluent. The result of the permeation test is presented in Figure 2.
Figure 2. Permeate flux variation with time (▲) – SR90 membrane; pressure difference: 20 bar; Effluent feed flow rate: 48.8 L/h. (■) Pure water flux stabilized at a pressure of 20 bar, and feed flow rate: 48.8 L/h.

After permeating the real effluent, a drop of the initial permeate flux was observed, due to the concentration polarization. In addition, throughout the permeation, there is a subsequent and continuous decline in flux, which can be attributed to the phenomenon of fouling. This flux drop can be related to the high fouling potential of the real effluent, hindering its direct permeation without a previous treatment, since it contributes to the reduction of the membrane lifetime. Comparing the effluent before and after the direct nanofiltration treatment, the SR90 membrane achieved a removal of 84.8% of COD and 99.5% of TOC.

4. CONCLUSIONS

It was demonstrated that the cationic surfactant has a major effect on the adsorption of the nanofiltration membranes, therefore altering its surface charge. The SR90 membrane was chosen for its higher permeability and hydrophilicity, and great removals of COD and TOC, despite the significant drop in the permeate flux in the beginning of the test. The effluent from the direct nanofiltration could be reused for irrigation purposes, toilet flushing, floor washing and also for laundering processes. Further studies considering pretreatments before nanofiltration are suggested to minimize the fouling effect.

5. REFERENCES

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