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APPLICATION OF LOW-PRESSURE MEMBRANE PROCESSES TO DYE EFFLUENTS TREATMENT

The study was aimed at investigating the suitability of membrane modules for the decolourization of both synthetic and actual dye solutions by ultrafiltration. The process involved capillary and spiral-wound modules made of different polymers and characterised by various molecular cut-off. The modules investigated can successfully be applied in ultrafiltration of model solutions containing organic dyes as well as actual textile wastewater.

1. INTRODUCTION

Conventional treatment methods, formerly widely applied to the decolourization of dye-containing effluents, are now being rather generally replaced by pressure membrane processes, which have the advantage of yielding higher removal efficiencies. Pressure-driven membrane processes and their separation characteristics are shown in figure 1.

The application of pressure membrane techniques to wastewater decolourization enables an efficient colour removal and also allows a reuse of water and recovery of some valuable substances. The reuse of water in a dyehouse, which uses a variety of dyes, is best achieved by a number of closed-loop recycle systems within the plant rather than one end-of-line process. The reason is that the most suitable technology for the reuse of both water and chemicals depends on the dye class used. Moreover, the size of treatment plant is minimised if only highly concentrated effluents are treated.

Application of ultrafiltration to the treatment of textile effluents allows us to achieve two streams:

concentrate – contaminated with organic dyes,

permeate – rich in mineral salts.

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Dye wastewater fractionated in a such way can be reused in technological process or utilised.

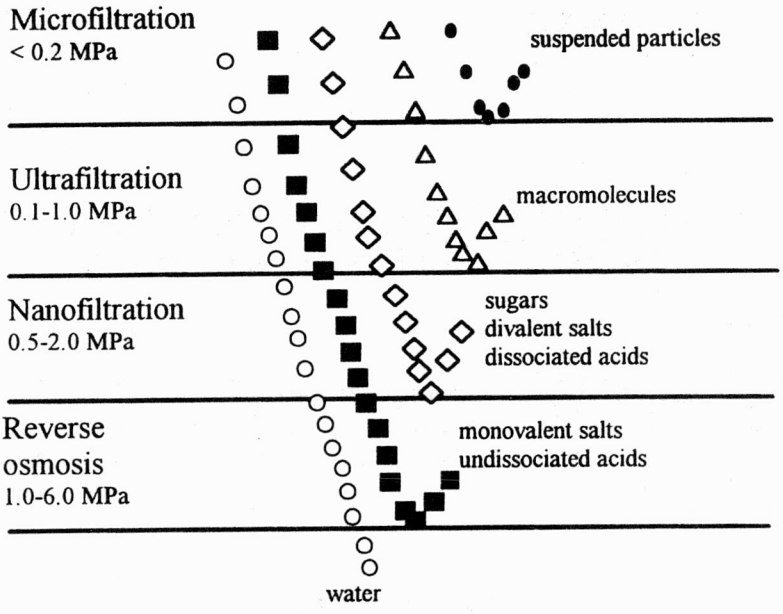

Fig. 1. Pressure-driven membrane processes and their separation characteristics [1]

The separation efficiency depends mainly on:
type of UF module applied,
pressure difference across the membrane,
macromolecule (dye) concentration in solution,
linear velocity in the module.

2. EXPERIMENTAL

The UF modules of different configuration with membranes made of various polymers were applied in the treatment of model solutions containing both organic dyes and actual textile wastewater. They are characterised in table 1. As it can be seen they are of spiral and capillary types with the cut-off ranging from 10 000 to 50 000 daltons. All experiments have been carried out in a semi-pilot UF installation which operates under a constant concentration of feeding solution.

The examples of the separation efficiencies for model dye solutions are given in table 2 [2]. The results obtained are quite satisfactory in the case of high-molecular (weight) dyes (over 617).

Table 1

Characteristics of UF membrane modules

Producer	Configuration	Membrane material	Cut-off	Membrane area (m^2)
Tatabanya Mines Company (Hungary)	Spiral	Polysulfone	10 000	0.1
		Polysulfone	30 000	0.1
		Modified polysulfone	50 000	0.1
Intersep Nadir (England)	Spiral	Polyethersulfone (PES10)	10 000	0.14
		Polyethersulfone (PES5)	5000	0.14
		Polyamide (PA10)	10 000	0.14
		Polyamide (PA5)	5000	0.14
		Polysulfone (PS10s)	10 000	0.14
		Polysulfone (PS5)	5000	0.14
Intersep Nadir (England)	Capillary	Polysulfone (PS10k)	10 000	0.2

Table 2

Volume flux and rejection coefficient for different dye particles (applied module: PS10k (capillary); linear velocity:1.0 m/s; dye concentration: 100 g/m^3)

Dye	Molecular weight	Δp (MPa)	Volume flux (m^3/m^2d)	Rejection coefficient (%)
Direct Black Meta (DB)	781.2	0.05	0.33	99.8
		0.1	0.57	99.0
		0.15	1.25	98.5
Helion Grey (HG)	617.0	0.05	0.38	98.1
		0.1	0.65	97.6
		0.15	1.32	95.8
Methyl Orange (MO)	327.0	0.05	0.42	65.4
		0.1	0.78	55.3
		0.15	1.63	50.1

Taking into account the molecular weight of separated compounds on the one hand, and the nominal cut-off of UF modules on the other hand, it should be anticipated that the molecular sieve mechanism alone is insufficient to explain the separation of organic dyes by UF process. The electrostatic interaction between the membrane and the macroparticle can be regarded as a factor supporting the efficiency of the UF process. Generally, the UF modules applied can be recommended to the treatment of dye effluents in order to recover both water and dye.

Mineral salts unfavourably affect the efficiency of dye ultrafiltration due to their interaction with the membrane and dye particles. The presence of NaCl in the separated solution decreased the membrane permeability and retention coefficient (figure 2) [3]. Of the modules applied the PA10 spiral-wound module and PS10k capillary module exhibited the best transport and separation properties.

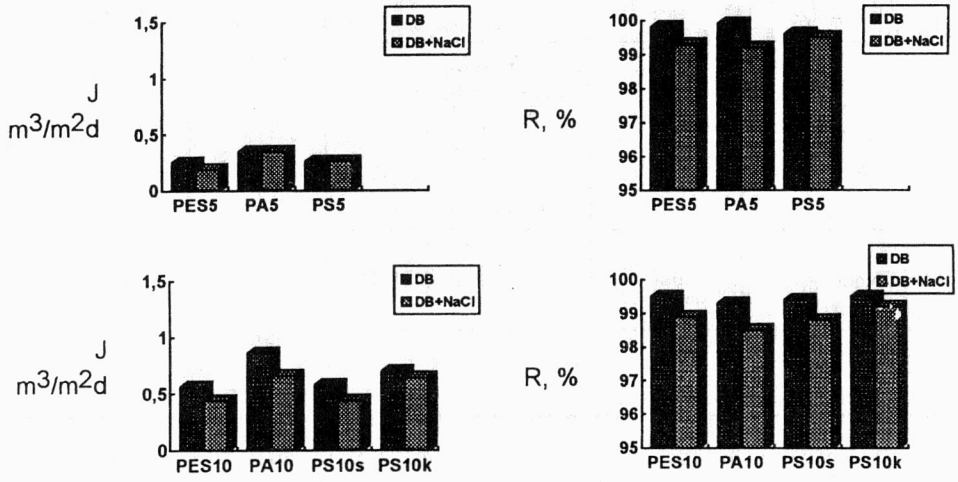

Fig. 2. The effect of mineral salt on the volume flux and dye (DB) rejection coefficient for Intersep Nadir modules (Δp = 0.1 MPa)

The experiments with real dye wastewaters (table 3) are also acceptable (figure 3). The efficiency of TOC removal ranged from 85 to 95%.

Table 3

Characteristics of the effluents treated

Parameters	Effluent A (exhausted dyeing bath)	Effluent B (rinsing bath)	Effluent C (mixed after prefiltration)
Main dye	direct green G	direct black CA	reactive dyes
TOC, g C/m^3	223	140	70
pH	7.4	8.5	8.5
Conductivity, mS/cm	11.8	1.71	0.094
SO_4^{2-}, g/m^3	8600	3900	150
Cl^-, g/m^3	9600	5000	300

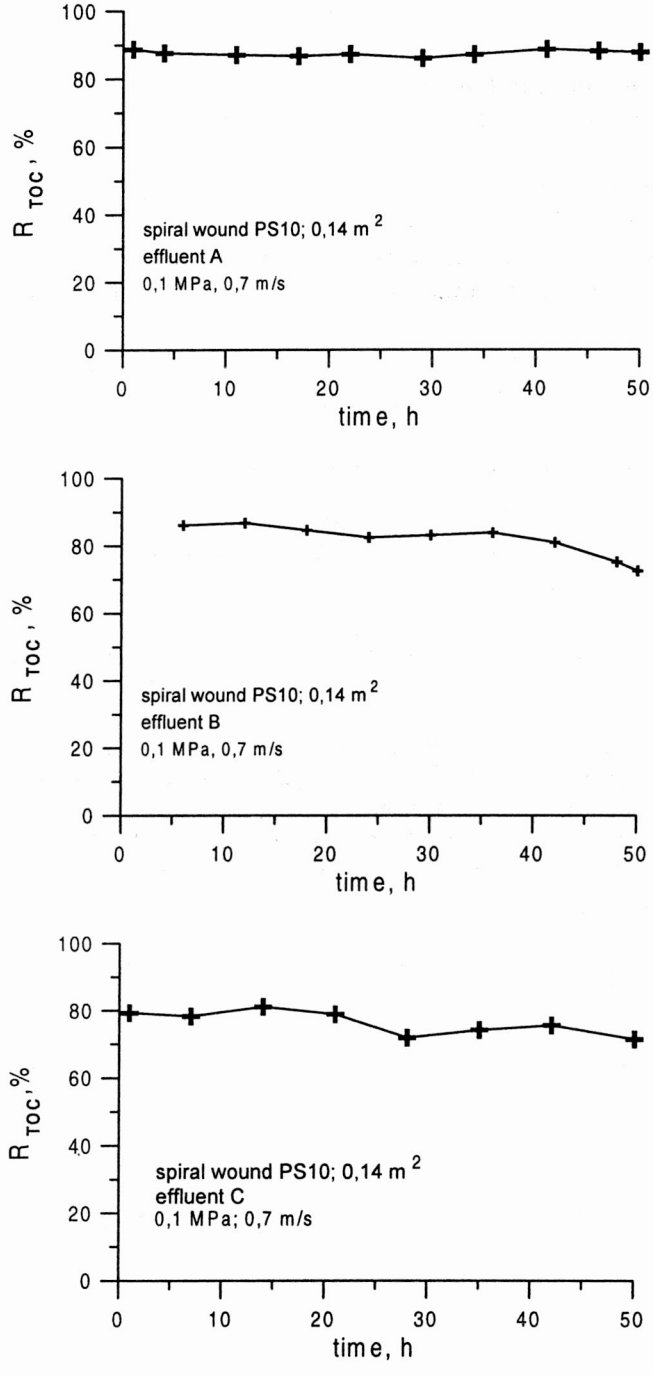

Fig. 3. TOC removal efficiency versus time of module operation

3. CONCLUSIONS

1. Commercial ultrafiltration modules can be used for separating organic dyes from model solutions. The membranes yielded over 95% retention of high-molecular (weight) dyes.

2. The presence of mineral salt in the solution being separated generally decreased the membrane permeability and rejection coefficient.

3. Ultrafiltration of textile dye effluents was characterised by a stable quality of permeate irrespective of the time of module operation. TOC removal efficiencies amounted to 80%.

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ZASTOSOWANIE NISKOCIŚNIENIOWYCH PROCESÓW MEMBRANOWYCH DO OCZYSZCZANIA ŚCIEKÓW FARBIARSKICH

Celem przeprowadzonych badań było określenie przydatności komercyjnych modułów membranowych do separacji barwników z roztworów modelowych oraz kąpieli rzeczywistych. Do badań użyto modułów o konfiguracji kapilarnej oraz spiralnej wytworzonych z wielu polimerów i charakteryzujących się różnymi wartościami *cut-off*. Stwierdzono, że testowane moduły mogą służyć do skutecznego odbarwiania roztworów modelowych oraz kąpieli farbiarskich.