

NF 和 RO 对致突变物 and 无机离子去除效果比较

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摘要 以自来水为原水, 采用反渗透(RO) 和纳滤(NF) 进行深度处理试验研究. 比较了2种膜对致突变物 and 无机离子的去除率. 结果表明, RO 和 NF 均能使 Ames 试验呈阳性的水转变为阴性; NF 对一价阳离子(K^{+} 、 Na^{+}) 的去除率比 RO 低10% 左右, 对二价阳离子(Ca^{2+} 、 Mg^{2+}) 的去除率略低于 RO, NF 比 RO 能多保留一些离子.

关键词 NF 膜, RO 膜, 致突变物, Ames 试验, 水深度处理, 无机离子.

NF 和 RO 对原水中天然有机物和消毒副产物母体的去除率很高, 可保证处理后水中三卤甲烷(THMs) 等符合标准^[1]. 目前 NF 在我国饮用水净化中的应用还未见报道. 本研究以市政自来水为原水, 分别以 RO 和 NF 组合工艺进行对比试验.

1 试验部分

1.1 原水水质

水源为湖泊水, 经水厂常规处理后, 出厂水中溶解性有机物、亚硝酸盐氮和氨氮仍超标. 其水质概况见表1.

表1 原水水质状况

色度/ 度	18	余氯/ $mg \cdot L^{-1}$	2. 2
浊度/ 度	1. 9	磷酸盐/ $mg \cdot L^{-1}$	0. 151
碱度/ $mg \cdot L^{-1}$	101	总铁(Fe^{3+})/ $mg \cdot L^{-1}$	0. 153
硬度/ $mg \cdot L^{-1}$	162	硫酸盐/ $mg \cdot L^{-1}$	91. 6
TDS/ $mg \cdot L^{-1}$	324	TOC/ $mg \cdot L^{-1}$	5. 74
DO/ $mg \cdot L^{-1}$	60	酚	未检出
NH_3-N / $mg \cdot L^{-1}$	5. 13	砷	未检出
NH_2-N / $mg \cdot L^{-1}$	0. 165	CN ⁻	未检出
耗氧量/ $mg \cdot L^{-1}$	3. 84	pH	6. 9

1.2 试验装置

试验流程如图1所示.

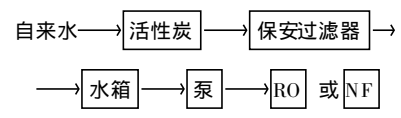


图1 RO 或 NF 试验流程

NF 和 RO 均为美国 TriSep 公司生产的卷式膜组件(由中联实业股份有限公司提供). 设置2级预处理是为了除去悬浮固体、胶体、不溶性有机物和余氯.

1.3 试验条件与技术指标

试验工艺所用的膜组件的进水条件与技术参数如表2所示.

2 运行结果与讨论

分别测定不同压力下2种膜的产水量、水回收率和脱盐率, 以确定适合原水水质的最佳操作压力, 得出 NF 为0. 9MPa, RO 为1. 35MPa. 运行稳定后2种膜的出水参数见表3.

表2 NF 和 RO 膜的进水条件与技术指标¹⁾

膜材质	压力/MPa	水温/	pH	SDI	产水量/ $L \cdot h^{-1}$	脱盐率/%
NF-TFC	0. 3—1. 4	2—45	4—11	5	50	80
RO-TFC	0. 3—2. 1	2—45	4—11	5	40	90

1) NF 和 RO 膜组件型号均为2521-T S80和2521-ACM 1.

从表3看出, 在相同压力(0. 9MPa) 下, RO 的产水量和回收率均是NF 的1/ 2, 即使在

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表3 RO和NF的产水参数

	压力	产水量	水回	电导率	脱盐率	TDS
	/MPa	/L·h ⁻¹	收率/%	μS·cm ⁻¹	/%	/mg·L ⁻¹
RO	0.9	19.4	9.17	9.83	98.1	6.07
NF	0.9	39.0	18.5	21.1	94.3	18.2
RO	1.35	30.2	14.17	8.35	98.3	5.16

1. 35MPa 压力下, 其产水量和回收率也低于 0.9MPa 压力下的 NF. 由此可知, NF 是比 RO 更节能的一种水处理技术. 其次, NF 膜的脱盐率比 RO 低4%左右, 其出水的电导率和 TDS

(总溶解固体) 均高于 RO. Sauer^[2] 分析了92座城市饮用水的23个特征, 发现人们喝 TDS 高的水, 死于心脏病、癌症和慢性病的机率比喝 TDS 低的水要少些. 从这方面来说, NF 膜优于 RO.

3 水样分析结果与讨论

3.1 常规项目的去除效果比较

在相同试验条件下, 分别对2种膜的进、出水进行同步取样分析, 结果见表4.

表4 NF和RO对常规项目去除效果比较

项目	RO			NF		
	进水	出水	去除率/%	进水	出水	去除率/%
色度/度	12	6	50	13	8	38.5
浊度/度	0.5	未检出	100	0.4	未检出	100
硬度/mg·L ⁻¹	130	未检出	100	132.5	5	96
碱度/mg·L ⁻¹	63.1	5.8	91	64.3	7.0	89
耗氧量/mg·L ⁻¹	2.4	0.34	86	2.4	0.18	92
NH ₃ -N//mg·L ⁻¹	0.01	未检出	100	0.34	未检出	100
NO ₂ -N//mg·L ⁻¹	0.061	0.007	89	0.0712	0.012	83
TDS/mg·L ⁻¹	321.5	6.07	98	323.6	18	94
TOC/mg·L ⁻¹	3.68	0.57	85	3.51	0.319	91

表4数据反映了 NF 对 TOC 的去除率比 RO 高, 并经反复试验验证, 说明 NF 对 TOC 的去除效果确实优于 RO. 由此可见, NF 对有机物的去除机理不能简单的用筛分原理解释. 目前对于有机物在 NF 膜上的迁移机理还未完全揭示, 笔者认为, 可能与有机物在膜面上的吸附和膜孔中发生的‘架桥现象’^[3] 等因素有关. 从对色度的去除率来看, 2种膜都不理想, 其中 NF 的去除率更低. 由于是采用比色法测定, 存在测定误差的可能, 这有待于进一步验证.

3.2 对致突变物的去除效果比较

试验采用 Ames 平板掺入法测定, 所用测试菌株为灵敏度较高的带 R 因子的 TA98 和 TA100 菌株. 各水样设3—5个剂量组, 每个剂量设3皿平行. 对于阳性或可疑阳性结果的样品, 至少重复试验1次. 各样品的致突变结果以诱变指数 MR 值(MR 为诱发回变菌落数与自发回变菌数之比值) 表示. 如果MR ≥ 2, 并呈剂量回

变关系者判定为阳性. 2种工艺各单元出水的 Ames 试验结果列于表5中.

从表5看出, 2种工艺的原水(自来水) 对 TA98 和 TA100 菌株均呈阳性反应(尤以 TA98 呈强阳性反应), 说明自来水中含有大量的移码型和少量碱基置换型致突变物. 经预处理单元后致突变物虽有一定的去除, 但对 TA98 和 TA100 菌株仍呈现阳性反应. 2种膜出水对 TA98 和 TA100 菌株均呈阴性反应, 表明膜对致突变物的去除较彻底.

3.3 对离子的去除效果比较

在0.9MPa 压力下分别对2种膜的出水进行了取样分析, 分析结果见表6.

表6中数据显示了 NF 对一价阳离子(K⁺、Na⁺) 的去除率比 RO 低10%左右, 对二价离子的去除率略低于 RO, 对三价离子(Al³⁺) 的去除率都为100%. 表明2种膜都可以把对人体有害的 Pb²⁺、Hg²⁺、Cr⁶⁺ 等元素有效去除.

表5 各水样的致突变结果(MR 值)¹⁾

水样	TA98				TA100			
	NF		RO		NF		RO	
	水样剂量/L·皿 ⁻¹	MR	水样剂量/L·皿 ⁻¹	MR	水样剂量/L·皿 ⁻¹	MR	水样剂量/L·皿 ⁻¹	MR
自来水	1	35.7	3	23.3	1	2.7	3	2.7
	0.5	15.5	1	7.5	0.5	2.3	1	1.9
	0.25	12.1	0.5	5.4	0.25	2.0	0.5	1.4
	r= 0.979		r= 0.9966		r= 0.9934		r= 0.9799	
膜 ²⁾ 进水	3	38.7	3	10.5	3	2.5	3	2.1
	1	16.6	1	8.6	1	2.0	1	1.7
	0.5	10.7	0.5	7.4	0.5	1.99	0.5	1.3
	r= 0.9999		r= 0.9734		r= 0.9929		r= 0.9188	
膜出水	5	1.18	5	1.5	3	1.4	3	1.8
	3	1.02	3	1.4	1	1.1	1	1.2
	1	0.97	1	1.0	0.5	0.9	0.5	0.95
	0.5	0.43	0.5	0.96				

1) 表中 r 为相关系数 2) 自来水经过活性炭柱和保安过滤器的预处理

表6 RO 与 NF 对离子的去除率比较/mg·L⁻¹

	膜	K ⁺	Na ⁺	Ca ²⁺	Mg ²⁺	Al ³⁺	F ⁻	Cl ⁻	NO ₃ ⁻	SO ₄ ²⁻
RO	进水	4.453	12.56	37.70	9.123	0.0038	0.615	31.751	15.966	58.78
	出水	0.0397	0.3161	0.007	0.0187	0.000	0.107	0.843	0.221	未检出
	去除率/%	99.11	97.13	99.98	99.80	100	82.60	97.34	98.62	100
NF	进水	4.516	12.64	39.37	9.281	0.0153	0.562	33.403	8.138	67.26
	NF 出水	0.5376	1.413	0.1648	0.0631	0.000	0.100	2.448	0.276	0.263
	去除率/%	88.10	88.82	99.58	99.32	100	82.21	92.67	96.61	99.61

4 结论

(1) 同等压力下, NF 的产水量和回收率比 RO 大1倍, 脱盐率比 RO 低4%左右。

(2) NF 对 TOC 的去除率高于 RO, 对常规项目的去除率与 RO 差别不大。2种膜对致突变

物的去除率都很高。NF 作为饮用水的深度处理技术上是可行的。

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A 2-dimensional pollutant transport model for groundwater pollution in the aquifer near ash ponds of Xutang Coal-fired Power Plant was established in this paper, and selecting F^- as the simulating factor, the variations of groundwater hydraulic heads and F^- concentration were simulated. At last, the polluted area and pollution degree of F^- were predicted by the model. According to the simulating results, the model is reasonable, reliable and practicable. It provides a scientific method to predict the polluted area and pollution degree caused by the waste ash ponds.

Key words: groundwater pollution, pollutant transport model, numerical simulation, pollution prediction, coal-fired power plant.

A Study of Pulsed Corona Discharges for Methylene Chloride Destruction. Zheng Lei and Jiang Xuanzhen (Dept. of Chemistry, Zhejiang University, Hangzhou, 310027): *Chin. J. Environ. Sci.*, **18**(5), 1997, pp. 62—64

In this paper, High voltage pulsed corona Discharges has been used for destruction of methylene chloride with concentration of $42.8 \mu\text{mol/L}$ in air. Both positive and negative pulse generators were tested and found that the positive one can give much higher destruction efficiency than that on the negative one. The value of capacitors for pulse formation (C_p) and the material of electrodes also influence the destruction efficiency. A packed bed corona reactor with 2—3 mm spherical BaTiO_3 pellets as a catalyst was used in this experiments. Enhancement of CH_2Cl_2 destruction and the conversion of 90% were demonstrated. It may be attributed to the partial corona discharge induced by the contacted points between BaTiO_3 pellets, and then the density of corona was enhanced. The corona and catalyst combined technology gives a better destruction efficiency compared with that without BaTiO_3 catalyst.

Key words: pulse corona discharge, destruction, CH_2Cl_2 , BaTiO_3 .

Comparison of Effect for Removing Mutagens and Inorganic Ions in Tap Water by Reverse Osmosis and Nanofiltration. Li Lingzhi (Dept. of Chem., Pingdingshan Teachers College, Henan, 467002), Zhou Rong and Wang Zhan-

sheng (Dept. of Environ. Eng., Tsinghua Uni., Beijing 100084): *Chin. J. Environ. Sci.*, **18**(5), 1997, pp. 65—67

In order to get superior drinking water, tap water was treated respectively by reverse osmosis (RO) and nanofiltration (NF) in the laboratory. The removal effects of mutagens and ions by RO and NF were compared. The Ames test results showed that both RO and NF could convert mutagenicity from positive to negative, while the ions removal effects of the RO and NF membranes are different, the removal rate of one-valence positive ions (Na^+ , K^+) by NF is tenpercent lower than that by RO, the removal rate of two valence positive ions (Ca^{2+} , Mg^{2+}) is a little lower than that by RO. More ions which are beneficial to human health pass through nanofiltration membrane into drinking water.

Key words: reverse osmosis, nanofiltration, advanced water, mutagens, inorganic ions, Ames test.

Study on Wet Desulphurization with Pyrolusite to Produce $\text{MnSO}_4 \cdot \text{H}_2\text{O}$ in Smelting Plant.

Ning Ping, Sun Peishi et al. (Dept. of Environ. and Chem. Eng., Kunming University of Science and Technology, Kunming 650093): *Chin. J. Environ. Sci.*, **18**(5), 1997, pp. 68—70

An additional experiment, in which reduced pyrolusite (made in laboratory) is used as absorption agent in wet desulphurization to produce $\text{MnSO}_4 \cdot \text{H}_2\text{O}$, has been done in a foam tower at a smelting plant. Optimum conditions for both reduction of pyrolusite and absorption of SO_2 are obtained and pure of 95% $\text{MnSO}_4 \cdot \text{H}_2\text{O}$ has been produced by primary crystallization of the absorption mother liquor.

Key words: sulfur dioxide, reduced pyrolusite, wet desulphurization, smelting gas, foam tower.

Study on the Low Pressure Wet Catalytic Oxidation Treatment of High Concentration and Refractory Organic Wastewater. Yang Run-

chang, Zhou Shutian (Dept. of Environ. Eng., Dept. of Chem. Eng. Xiangtan University, Xiangtan 411105): *Chin. J. Environ. Sci.*, **18**(5), 1997, pp. 71—74

Based on catalytic wet air oxidation and Fenton reagent, a new wet catalytic oxidation (LPWCO) method, which requires low pressure for the treatment of high concentration and refractory organic wastewater was studied. The method compared with general catalytic wet air oxidation, the pressure of the treatment is 0.1—0.6 MPa, and the latter is 3.5—10 MPa. In addition, its temperature is