Proceedings of ECOpole
Vol. 4, No. 1 2010

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APPLICATION OF MICROFILTRATION MEMBRANE MODULE FOR AMMONIA REMOVAL PROCESS

ZASTOSOWANIE MIKROFILTRACYJNEGO MODUŁU MEMBRANOWEGO DO PROCESU USUWANIA AMONIAKU

Abstract: The aim of this work was to investigate the applicability of membrane distillation for ammonia removal from its aqueous solutions. The hollow-fiber, hydrophobic microfiltration membrane module was applied in order to assess its performance. The effects of different operating parameters on ammonia removal from aqueous solutions of different concentrations were investigated. Ammonia was absorbed in strong inorganic acid, in all tests that were taken.

Keywords: ammonia removal, membrane contactor, hydrophobic membrane

Ammonia is a common and unwelcome contaminant in wastewater. When excessive amount of ammonia (NH_3) is being emitted to the atmosphere or discharged with wastewater effluent streams, it is considered to be harmful pollutant constituents that damage seriously the environment. The main source for ammonia emission to the atmosphere comes from agriculture (ie from livestock urine and manures and from some nitrogen fertilizers and crops) [1]. The main source for wastewater contaminations by ammonia or nitrogen compounds comes from city wastewater and from industrial wastewater effluent streams (ie fertilizer manufacture, ceramics and cement works, petroleum refining and combustion processes).

The accumulation of ammonia in surface water results in eutrophication (ie the enrichment of water by nutrients causing an accelerated growth of algae) and depletion of oxygen due to nitrification and thus toxic for the water organisms such as fish [1].

There are several well-established technologies dealing with ammonia/nitrogen removal from wastewater effluents. Each one has its advantages and disadvantages but most of them are dependent on relatively large amount of energy for operation. Conventional methods of ammonia removal by aeration, leaching with an acid in a scrubber tower, air- or steam-stripping may be in some situations costly and inefficient [2, 3]. Membrane contactors seems to be a good solution for ammonia stripping process because they provide a large surface area that facilitates fast separation of ammonia from wastewater [4, 5].

Featured paper presents the possibility of ammonia removal from its aqueous solution with hollow fiber, hydrophobic microfiltration (MF) membrane configuration. The effect of different temperature of ammonia aqueous solution as well as different solution concentrations have been investigated as the influence on ammonia mass transfer. In each case ammonia was absorbed in strong inorganic acid.

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Experimental

The CM set-up used for ammonia removal is shown schematically in Figure 1. The main part was the hollow fiber membrane module.

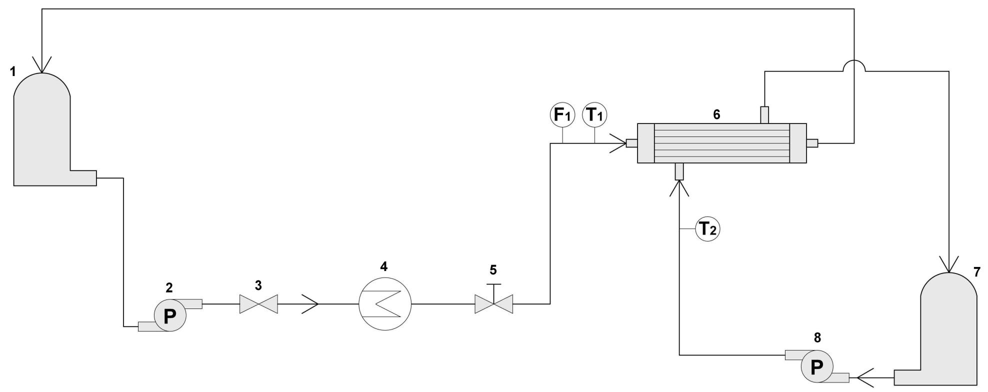

Fig. 1. Schema of the hollow-fiber membrane configuration (1 - feed tank, 2 - pump, 3 - sampling valve, 4 - heat exchanger, 5 - needle valve, 6 - hollow-fiber membrane module, 7 - acid tank, 8 - pump, T1 and T2 - feed and acid thermometer, F1 - flowmeter)

Hollow fiber module configuration

The feed container (5 dm^3 glass tank), that was placed on the 20 cm bench to provide gravity flow to the centrifugal feed pump (NEMP 80/6, Totton Pumps Ltd., Southampton/UK) which was connected to the bottom outlet of feed container. The outlet of pump was connected to the tube side of heat exchanger (Alfa-Laval), which was useful to keep the constant temperature of ammonia solution. A T-branch fitted with a valve and hose was installed in the hose between pump outlet and heat exchanger inlet, to provide a means to take the samples.

The inlet and outlet of heat exchanger shell side was connected to the water bath equipped with thermostat and heater.

The output of the tube side of the heat exchanger was connected to the flowmeter, which could measure up to 10 dm^3/min. Between them a needle valve was installed, which was necessary for feed flow adjustments.

The output of the flowmeter was connected to the lower, tube side inlet of the hollow fiber membrane (MD020CP2N Microdyn-Nadir GmbH). In the hose between membrane inlet and flowmeter outlet, standard thermometer (0.5 degree accuracy) was installed to monitor the temperature of feed solution entering the membrane tube side.

The upper side of the membrane module was directly connected with feed tank inlet. The hose was placed into the feed liquid to provide well mixing of solution to induce constant ammonia concentration in whole volume of feed solution.

The stripping solution container (5 dm^3 glass tank, the same as feed container) was connected with centrifugal pump (NDP14/2 Totton Pumps Ltd., Southampton/UK), by the bottom output. The acid solution was pumped to the lower, shell side of the membrane. On the hose just before shell side entry, thermometer was installed for monitoring the stripping solution temperature. The upper shell side output was directly connected with the stripping tank inlet.

Results and discussion

The point of experiment was to investigate of how the initial ammonia concentration and temperature of feed solution influence the ammonia transfer through the membrane.

Hollow fiber configuration

<u>Effect of feed initial ammonia concentration</u>

Although aqueous feed solution of ammonia in the range from 0.09 to 0.25 M have been considered in the experiment, the highest ammonia removal efficiency have been achieved for the feed solution of 0.25 M, which can be seen in the Figure 2.

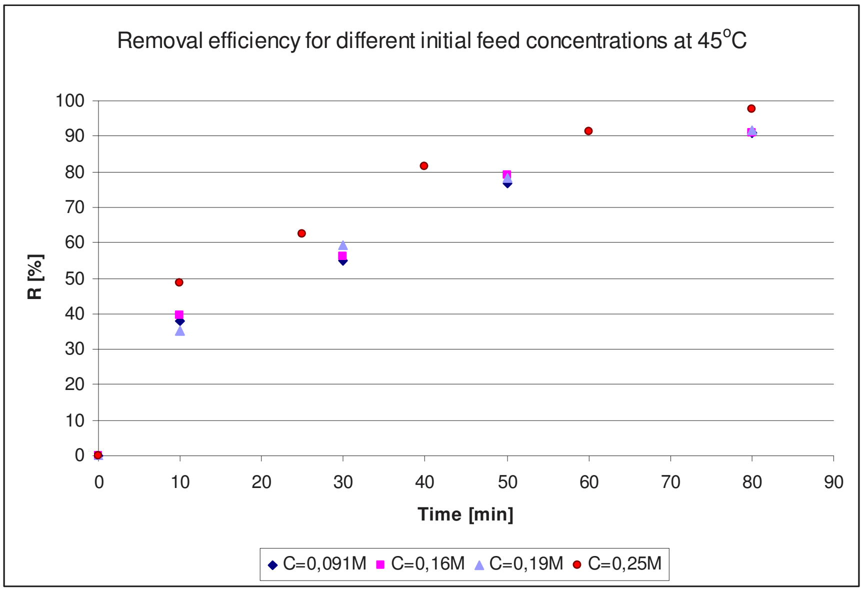

Fig. 2. Ammonia removal efficiency (R%) as a function of time (T) for different initial feed concentrations at T = 45°C

The concentrations lower than 0.25 M resulted in lower removal efficiency. The increase in ammonia removal efficiency may be related with more ammonia species becoming available at the feed solution as the concentration increase.

<u>Effect of feed temperature</u>

It was mentioned before that the ammonia solubility in water decreases when the temperature increase. In order to investigate the effect of feed temperature on the ammonia removal process, several experiments were carried out at ambient feed temperatures.

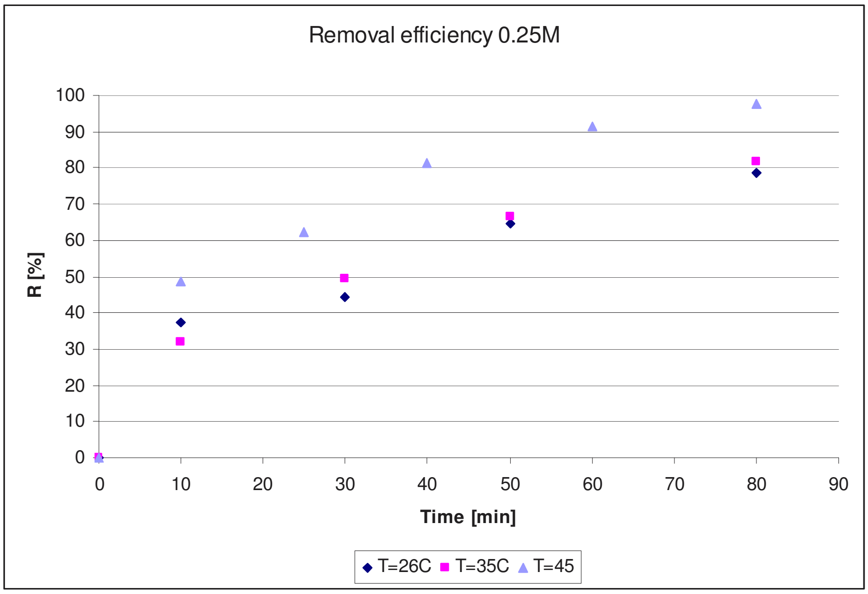

Fig. 3. Ammonia removal efficiency (R%) as a function of time (T) at different feed temperature and constant ammonia concentration at 0.25 M

In Figure 3 the ammonia removal efficiency is plotted as a function of time for different feed temperatures ranging from 26 to 45°C. Higher feed temperatures resulted in higher ammonia removal efficiency.

Conclusions

A commercially available hollow fiber module was tested in order to present its usability for ammonia removal process from its aqueous solution.

The results of experiments leads us to formulate following conclusions:

- The hollow fiber membrane module present that process considerably works effectively at ambient temperatures, that is to say, the increase of feed temperature solution reduce time needed for removing ammonia from its aqueous solution.
- The higher the initial feed concentration seems to favor the ammonia removal efficiency.
- The resulting ammonia salt solution could have a high market value being sufficiently concentrated.

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ZASTOSOWANIE MIKROFILTRACYJNEGO MODUŁU MEMBRANOWEGO DO PROCESU USUWANIA AMONIAKU

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Abstrakt: Przetestowano możliwość usuwania amoniaku z jego wodnych roztworów za pomocą hydrofobowego, mikrofiltracyjnego (MF) modułu membranowego wyposażonego w membrany kapilarne. Określono wpływ temperatury oraz początkowego stężenia amoniaku na szybkość jego usuwania z wodnego roztworu. W obu analizowanych przypadkach amoniak został zaabsorbowany w mocnym kwasie nieorganicznym.

Słowa kluczowe: usuwanie amoniaku, kontaktory membranowe, membrany hydrofobowe