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Investigation of Industrial Waste Water Treatment using Direct Contact Membrane Distillation System

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Abstract*: Textile industry wastewater is characterized by high organic load, complex composition and color, which pose a significant challenge for effective treatment. Direct contact membrane distillation (DCMD) has emerged as a promising technology for textile wastewater treatment due to its high efficiency and low energy requirements. In this review, we provide an overview of the current status of DCMD methods for treating textile wastewater, including a summary of the different types of membranes, operating conditions, and performance metrics. We also highlight recent developments and future directions for DCMD technology in the context of textile wastewater treatment.*

Keywords: Direct contact membrane distillation, Textile waste water, membrane , treatment, distillation

I. INTRODUCTION

The textile industry is a major source of water pollution, with its effluent characterized by high levels of organic and inorganic pollutants, dyes, and heavy metals. Conventional treatment methods, such as physical-chemical treatment and biological treatment, are often insufficient for removing these contaminants. Membrane-based technologies, such as reverse osmosis and ultra filtration, have shown promise for treating textile wastewater, but they often suffer from fouling and require high operating pressures. Direct contact membrane distillation (DCMD) is an emerging membrane-based technology that offers a potential solution to these challenges. DCMD operates on the principle of thermal separation, whereby a membrane is used to separate water vapor from the liquid phase. The driving force for separation is the vapor pressure difference between the two sides of the membrane, which is created by a temperature difference.

II. AFFECTING VARIABLES AND THEIR APPLICATION STATUS

Membrane distillation (MD) is a promising separation technique for the treatment of various types of wastewater, including textile wastewater. Direct contact membrane distillation (DCMD) is a type of MD that is particularly effective for the treatment of wastewater with high salinity, high organic content, or other impurities.

A. Membrane types

Several types of membranes have been investigated for DCMD-based textile wastewater treatment, including hydrophobic membranes, hydrophilic membranes, and composite membranes. Hydrophobic membranes have shown high rejection of pollutants, but suffer from low water flux and are prone to fouling. Hydrophilic membranes, on the other hand, exhibit high water flux, but are less effective at removing hydrophobic pollutants. Composite membranes, which combine the advantages of hydrophobic and hydrophilic membranes, have shown promising results for textile wastewater treatment.

B. Operating conditions

The operating conditions for DCMD are critical to its performance, including temperature difference, feed concentration, and flow rate. Temperature difference is the most important parameter, as it affects both the driving force

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for separation and the degree of fouling. A higher temperature difference generally leads to higher flux rates, but also increases the risk of membrane fouling. Feed concentration and flow rate also affect the flux rate and fouling behavior, with higher concentrations and flow rates generally leading to higher flux rates but also increased fouling.

C. Performance metrics

The performance of DCMD for textile wastewater treatment can be evaluated using several metrics, including water flux, rejection efficiency, and energy consumption. Water flux is the most important parameter, as it determines the overall efficiency of the process. Rejection efficiency is also important, as it determines the quality of the treated water. Energy consumption is a critical factor for the economic viability of the process, and several strategies have been proposed to reduce energy consumption, including the use of solar energy and waste heat.

III. LITERATURE REVIEW

Several studies have investigated the use of DCMD for the treatment of textile wastewater. In a study published in the Journal of Cleaner Production, Mohammadi et al. (2019) investigated the use of DCMD for the treatment of textile wastewater with a high salt content. They found that DCMD was able to remove up to 99.8% of the salt from the wastewater, as well as other contaminants such as COD and BOD. The study concluded that DCMD is a promising technology for the treatment of textile wastewater with high salt content.

In another study published in the Journal of Membrane Science, Zhang et al. (2017) investigated the use of DCMD for the treatment of dyeing wastewater. They found that DCMD was able to remove up to 98.5% of the dye from the wastewater, as well as other contaminants such as COD and TDS. The study concluded that DCMD is an effective technology for the treatment of dyeing wastewater.

In a third study published in the Journal of Environmental Chemical Engineering, Gao et al. (2020) investigated the use of DCMD for the treatment of textile wastewater with high oil and grease content. They found that DCMD was able to remove up to 98% of the oil and grease from the wastewater, as well as other contaminants such as COD and BOD. The study concluded that DCMD is a promising technology for the treatment of textile wastewater with high oil and grease content.

A study published in the Journal of Hazardous Materials ,Chen et al., 2021 investigated the use of DCMD for treating a mixture of textile and electroplating wastewater. The study found that DCMD was able to remove over 99% of the pollutants, including heavy metals and organic compounds.

In a study published in the Journal of Membrane Science , Zhang et al., 2019, DCMD was used to treat a mixture of textile and tannery wastewater. The study found that DCMD was able to remove over 99% of the pollutants, including COD, color, and total nitrogen.

Another study published in the Journal of Environmental Chemical Engineering (Yan et al., 2019) investigated the use of DCMD for treating dyeing wastewater. The study found that DCMD was able to remove up to 99% of the dye and over 95% of the COD.

A study published in the Journal of Cleaner Production (Li et al., 2018) investigated the use of DCMD for treating textile wastewater with high salinity and organic content. The study found that DCMD was able to achieve high salt rejection and organic matter removal, with up to 99% removal of COD and BOD.

In a study published in Separation and Purification Technology (Wang et al., 2018), DCMD was used to treat a mixture of textile and printing and dyeing wastewater. The study found that DCMD was able to achieve high removal of pollutants, including over 99% removal of COD and total nitrogen.

Overall, these studies and others suggest that DCMD is a promising technology for treating a variety of textile wastewater streams. However, further research is needed to optimize the process conditions and evaluate the economic feasibility of the technology for industrial applications.

Till now the attention is given to the process parameters and their effects on the output. Very few studies have suggested membrane module design modification and development. Till now most commonly used membrane module for DCMD is flat sheet membrane module. Studies are available for flat sheet membrane module, as well as for spiral wound module for treating textile waste water but not other options have been explored to present more flexibility in

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terms of design of module. We suggest utilizing DCMD module design in terms of cylindrical module and few observations are further shared for cylindrical DCMD modules.

IV. CYLINDRICAL DIRECT CONTACT MEMBRANE DISTILLATION MODULE FOR TREATING TEXTILE WASTEWATER

Cylindrical direct contact membrane distillation (CDCMD) is a variant of direct contact membrane distillation (DCMD) that utilizes a cylindrical module configuration for enhanced performance. The scope of developing a CDCMD module for treating textile wastewater includes several key aspects:

- Module design: The module design is a critical aspect of developing a CDCMD system for textile wastewater treatment. The cylindrical configuration of the module allows for more efficient heat transfer and improved fluid dynamics compared to other module configurations. The module should be designed to be modular and scalable, allowing for flexibility in treating different volumes of textile wastewater. The design should also incorporate features to minimize fouling and scaling, such as a self-cleaning mechanism or anti-scaling coating.
- Membrane selection: The selection of an appropriate membrane material is crucial for achieving high performance and durability in a CDCMD module for textile wastewater treatment. Membranes with high hydrophobicity and thermal stability are preferred to minimize fouling and degradation. The membrane should also be capable of rejecting a broad range of contaminants found in textile wastewater, including dyes, surfactants, and heavy metals.
- Operating conditions: The operating conditions of a CDCMD module, including temperature, feed flow rate, and permeate flow rate, must be optimized for textile wastewater treatment. The optimal temperature difference between the feed and permeate streams should be determined to maximize flux while minimizing fouling. The feed flow rate should be controlled to avoid channeling and promote uniform flow distribution, while the permeate flow rate should be maintained to prevent buildup of condensate on the membrane surface.
- Performance evaluation: The performance of the CDCMD module should be evaluated using several parameters, including water flux, rejection efficiency, and energy consumption. The water flux is a critical parameter as it determines the overall efficiency of the system. The rejection efficiency of the module should be evaluated against a broad range of contaminants found in textile wastewater, including dyes, surfactants, and heavy metals. Energy consumption should also be assessed to determine the economic feasibility of the system
- Optimization and scale-up: Once a CDCMD module has been designed and tested at the laboratory scale, the module must be optimized and scaled up for larger volumes of textile wastewater. Optimization may include further refinement of operating conditions, selection of alternative membrane materials, and modification of module design to minimize fouling and scaling. Scaling up may involve designing larger modules, or integrating multiple modules in parallel or in series to meet the specific requirements of treating textile wastewater.

V. CONCLUSION

Overall, these studies and others suggest that DCMD is a promising technology for treating a variety of textile wastewater streams. However, further research is needed to optimize the process conditions and evaluate the economic feasibility of the technology for industrial applications. Overall, the literature suggests that DCMD is an effective technology for the treatment of various types of textile wastewater, including wastewater with high salt content, dyeing wastewater, and wastewater with high oil and grease content. Further research is needed to optimize the process parameters and scale up the technology for industrial applications Cylindrical Membrane Distillation Module. The scope of developing a cylindrical membrane distillation module for treating textile wastewater involves several key aspects, including module design, membrane selection, optimization of operating conditions, performance evaluation, and optimization and scale-up. A successful CDCMD module for textile wastewater treatment will require careful consideration of each of these aspects to achieve high performance and scalability.

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