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Utilizing Advanced Oxidation Processes and Nanofiltration to Decrease the Color and Chemical Oxygen Demand in Waste Soy Sauce

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Introduction

The rapid industrialization of food production has significantly impacted both the quality and quantity of wastewater generated by various sectors. One such sector that has raised environmental concerns due to its wastewater effluents is the food industry, particularly the soy sauce production industry. Soy sauce is a staple condiment in many Asian cuisines and its production involves complex fermentation processes, often leading to wastewater that is highly colored, chemically complex and laden with organic pollutants. Waste soy sauce, the by-product of soy sauce manufacturing, is known for its high Chemical Oxygen Demand (COD), high levels of organic compounds and strong coloration, all of which contribute to environmental pollution if not managed properly To address the challenges of treating waste soy sauce effluents, there is a growing interest in utilizing advanced water treatment technologies, specifically Advanced Oxidation Processes (AOPs) and NanoFiltration (NF), to improve wastewater quality. AOPs, which include processes like ozonation, UltraViolet (UV) light treatment and Fenton's reagent, are highly effective in breaking down complex organic pollutants, reducing COD and decolorizing wastewater. On the other hand, nanofiltration is a membrane-based separation process that is capable of removing dissolved salts, organic molecules and particulate matter from water, making it a valuable technology in the context of wastewater treatment [1].

Soy sauce is traditionally made by fermenting soybeans, wheat, salt and water, with the help of microorganisms such as molds, yeasts and bacteria. The fermentation process takes several months, during which complex biochemical reactions occur, resulting in the formation of various aromatic compounds, amino acids, peptides and sugars. These byproducts contribute to the rich flavor profile of soy sauce but also present challenges when it comes to wastewater treatment. In large-scale production, the wastewater generated contains not only organic matter but also a range of other contaminants such as phenolic compounds, salts and small peptides, which contribute to the high COD and intense coloration of the effluent. The COD of the wastewater is an important indicator of water quality, reflecting the amount of oxygen required to chemically oxidize the organic pollutants present. The color of the wastewater is caused primarily by the presence of melanoidins and other dark-colored compounds formed during fermentation, making it difficult to treat using conventional methods such as activated sludge or biological filtration [2].

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Description

Soy sauce is traditionally made by fermenting soybeans, wheat, salt and water, with the help of microorganisms such as molds, yeasts and bacteria. The fermentation process takes several months, during which complex biochemical reactions occur, resulting in the formation of various aromatic compounds, amino acids, peptides and sugars. These byproducts contribute to the rich flavor profile of soy sauce but also present challenges when it comes to wastewater treatment. In large-scale production, the wastewater generated contains not only organic matter but also a range of other contaminants such as phenolic compounds, salts and small peptides, which contribute to the high COD and intense coloration of the effluent. The COD of the wastewater is an important indicator of water quality, reflecting the amount of oxygen required to chemically oxidize the organic pollutants present. The color of the wastewater is caused primarily by the presence of melanoidins and other dark-colored compounds formed during fermentation, making it difficult to treat using conventional methods such as activated sludge or biological filtration [3].

AOPs represent a class of water treatment techniques that involve the generation of highly reactive hydroxyl radicals (•OH) to degrade organic contaminants in water. These processes are recognized for their high efficiency in oxidizing a wide range of organic pollutants, including those that are resistant to conventional biological treatment methods. The principle behind AOPs is the generation of hydroxyl radicals, which are extremely reactive and can break down complex organic molecules into smaller, more biodegradable compounds. NanoFiltration (NF) is a membrane filtration technology that operates between Reverse Osmosis (RO) and Ultra Filtration (UF) in terms of pore size and separation capabilities. NF membranes typically have pore sizes ranging from 1 to 10 nanometers, which allows them to selectively remove particles, organic molecules and certain salts from water while retaining larger molecules such as proteins and sugars [4].

In the context of soy sauce wastewater, NF has several advantages. It can effectively remove high-molecular-weight organic compounds, salts and other contaminants that contribute to the COD of the effluent. Additionally, NF membranes are capable of significantly reducing the color in the wastewater by separating the color-causing compounds from the treated water. NF can be used in combination with AOPs to further improve the water quality and provide a more comprehensive treatment solution [5].

Conclusion

The treatment of waste soy sauce effluent remains a significant environmental challenge, particularly due to its high COD, complex organic content and intense coloration. Advanced Oxidation Processes (AOPs) and NanoFiltration (NF) offer complementary solutions to address these issues. AOPs provide an efficient method for breaking down complex organic molecules and reducing COD, while NF offers selective separation of contaminants, further improving water quality and reducing color intensity. The combination of AOPs and NF represents a synergistic approach that enhances the effectiveness of individual technologies, reduces operational costs and promotes sustainability in wastewater management. This integrated

treatment method not only improves the quality of the treated water but also reduces the ecological impact of soy sauce production, contributing to more sustainable practices in the food industry.

Further research and development in this area, including optimization of operational parameters and membrane fouling control, will be crucial to maximizing the potential of these technologies for large-scale applications. As industries continue to prioritize environmental sustainability, integrating AOPs and NF into wastewater treatment systems could become a key strategy in reducing the environmental footprint of food production processes like soy sauce manufacturing. By adopting these advanced technologies, the food industry can take significant strides toward cleaner, more sustainable water management and a greener future for global food production.

Acknowledgement

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Conflict of Interest

None.

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