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TREATMENT OF WASTEWATER CONTAINING PRINTING DYES: SUMMARY AND PERSPECTIVES

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Introduction

Synthetic dyes and pigments released into the environment in the form of industrial effluents causes severe ecological problems. These substances are utilized in industries such as textile, plastic, leather, paint, cosmetics, printing, and paper.
Around 10 000 types of synthetic and natural dyes are produced every year all over the world which is roughly weighed in between 7×105–1×106 tons and a significant amount of dyes is wasted during manufacturing and application processes .
Large amount of chemicals and dyestuffs are remaining unused during textile dying and printing process and is discharged as excess waste effluent into the environment.
This kind of wastewater is intensively coloured with varying degrees of chemical oxygen demand.
Neither simple chemical nor biological treatment alone has proved adequate in decolourization and sufficient depletion of organic matter.
Treatment of this king of effluents is challenging from engineering aspect.

Biological and physical-chemical processes

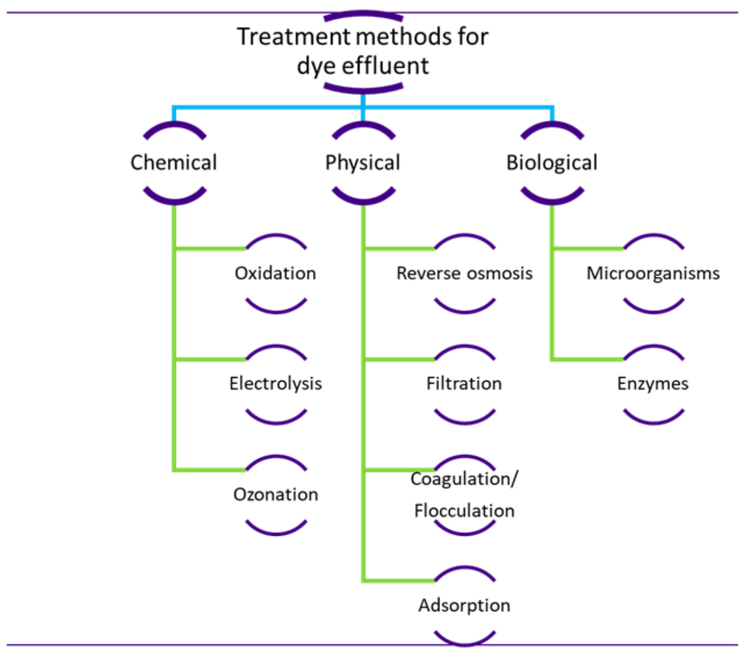

Figure 1. *Treatment methods for the removal of dyes from wastewater effluent*

Different treatment methods are used to remove dyes from wastewater (Fig. 1).
Regarding biological process, activated sludge plays an essential role in decolourization and degradation of dyes to inorganic products. Treatment efficiency of activated sludge depends on the characteristics of the microorganisms involved in biological community.
Specialized cultures are necessary for decolourization of dyes. In recent years, with the development of molecular biological techniques, high-throughput sequencing technology, which overcomes the limitation of conventional techniques, is developed, become the most popular method for the evaluation of microbial community.
Reverse osmosis process, are one of physical processes, that has been widely applied in printing and dyeing wastewater treatment as it can effectively barrier various organic/inorganic contaminants and also biological constituents. After being treated, a large proportion of influent stream can be reused directly in printing and dyeing process, while the residual reverse osmosis concentrate (ROC) of printing and dyeing wastewater, which is characterized by recalcitrant organics, high hardness and high salinity, cannot be directly discharged and still remains serious environmental risks. On the other hand, the physical and chemical treatments such as coagulation, membrane distillation and adsorption will eventually cause secondary pollution and most of them come with a high waste disposal cost.
The adsorption process is one of the potential and efficient methods among all the possible techniques for coloured effluent treatment due to its low initial investment, design simplicity and availability of low-cost adsorbents. Low-cost and readily available natural bio-adsorbents are commonly applied for the elimination of several kinds of pollutants from printing and dying wastewater.
Electrocatalytic technology has also been used for the treatment of pollutants that are more toxic and difficult to handle. There are several advantages of the electrocatalytic technology, such as simple equipment, easy operation, high removal efficiency, and little sludge generation.
Among many kinds of electrocatalytic materials, titanium dioxide (TiO2) is relatively cheap.
Development of alternate methods that can degrade toxic organic compounds brought up ozone (O3) that becoming a versatile and environmentally sound oxidation agent.
Ozonation of water is a well-known technology and the strong oxidative properties of O3 have the ability to effectively oxidize many organic compounds. Due to its high electrochemical potential (2.08 V), O3 is the strongest oxidant available and applicable as compared to H2O2 (1.78 V) and can react with several classes of compounds through direct or indirect reaction.

Photochemical processes

Printing dyes wastewater contains significant amount of dye, therefore, the energy of light may be absorbed by organic molecule. As a result, the light penetration is limited to a thin layer. In order to prevent this many techniques, which use natural or artificial radiation, are widely used in treatment processes in order to provide cleaner water (Figure 2).

UV/H2O2 process: During the last decade, some researchers have reported the successful applications of the UV/H2O2 process of coloured wastewater treatment. Namely, when using hydrogen peroxide as oxidating agens under UV radiation, hydrogen peroxide is directly photolyzed in to two hydroxyl radicals. During th is process, ultraviolet radiation is used to cleave the O-O bond in molecule of hydrogen peroxide. Process of its photolysis is described by reactions (1-6).

Photocatalytic degradation: Photocatalysis is the process in which photoactivation of semiconductors is initiated by irradiation, with electron -hole pairs appearing as a result of band gap excitation. Positive holes generated by light can react with electron donors and generate hydroxile radical. Organic compounds which include dyes, can undergo oxidative degradation through their reactions with valence bond holes, hydroxyl and peroxide radicals as well as reductive cleavage through their reactions with electrons.

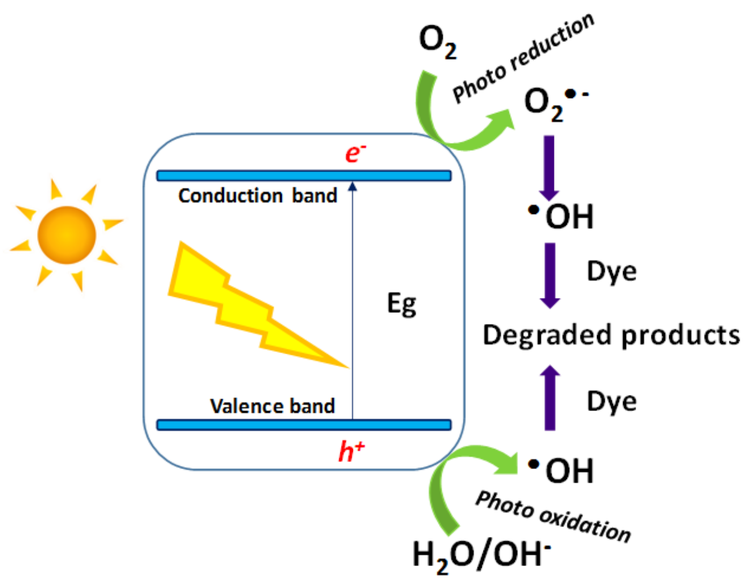

Figure 2. *Photocatalytic mechanism*

Photo-Fenton process: The photo-Fenton (or photo-assisted Fenton) process involves the use of solar radiation or an artificial radiation source, which increases the rate of contaminant degradation by stimulating the reduction of ferric ions (Fe^{3+}) to ferric ions (Fe^{2+}). This process shows high efficiency of oxidation of organic pollutants and inactivation of microorganisms in wastewater . The photo-Fenton process is a combination of iron ions, hydrogen peroxide and solar and UV-VIS radiation (λ <600 nm), which leads to higher production of hydroxyl radicals through the following reactions: reduction of Fe^{3+} to Fe^{2+}(7) and photolysis of hydrogen peroxide at smaller wavelengths (8).

$$H_2O_2 + h\nu \rightarrow 2HO\cdot \quad (1)$$

$$H_2O_2 + HO\cdot \rightarrow HO_2^{\cdot} + H_2O \quad (2)$$

$$H_2O_2 + HO_2^{\cdot} \rightarrow HO\cdot + H_2O + O_2 \quad (3)$$

$$2HO\cdot \rightarrow H_2O_2 \quad (4)$$

$$2HO_2^{\cdot} \rightarrow H_2O_2 + O_2 \quad (5)$$

$$HO\cdot + HO_2^{\cdot} \rightarrow H_2O + O_2 \quad (6)$$

$$Fe(OH)^{2+} + h\nu \rightarrow Fe^{2+} + HO^{\cdot} \quad (7)$$

$$H_2O_2 + h\nu \rightarrow 2HO^{\cdot} \quad (8)$$

Conclusion

No technique fully capable of satisfactory treatment exists since the nature of effluents from dying and printing industries contains complex compounds.
Various processes different in nature were applied in research for treating this kind of effluents. High efficiencies od effluent decolourization is achieved, but main problem that remains is mineralization degree of the remaining effluents.
Many scientific researches are focused on biological treatments, while some of them had attended to chemical or physical treatments.
For further improvement, a combination of several treatments known as hybrid processes is becoming a practice to gain the most efficient quality in the most economical way.

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