



The kinetic of dyes degradation resulted from food industry in wastewater using high frequency of ultrasound



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ABSTRACT

The ultrasound techniques have employed to study the effect of high frequency on the degradation of methyl orange dye, MOD, from a model of industrial wastewater. Three different initial concentrations of methyl orange (10, 30 and 50 ppm), with three different power supply's to ultrasound device voltages (15, 20 and 25 V), and two different liquid volumes (15 and 20 ml) were investigated here on the effect of MOD degradation. Results show that as the concentration of azo dyes increases, the degradation increases. It was also found that as the liquid volume increases, the ability to degraded azo dyes decreases. The best condition achieved for degradation of azo dyes obtained at 50 ppm, 15 ml, and 25 V. The degradation data results are best fitted with a first order kinetic degradation model. The degradation rate constant was calculated by best fitting and found to be equal to an average value for 25 and 20 V to 0.0114 min^{-1} .

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1. Introduction

Azo dyes are synthetic colors that contain an azo group, $-\text{N}=\text{N}-$, as part of the structure. Azo groups do not occur naturally. Most azo dyes contain only one azo group, but some contain two (disazo) three (trisazo) or more.

Azo dyes account for approximately 60–70% of all dyes used in food and textile manufacture. In theory, azo dyes can supply a complete rainbow of colors [1].

More than half the commercial dyes belong to this class. Depending on other chemical features, these dyes fall into several categories defined by the fibers for which they have an affinity or by the methods by which they are applied [2].

Azo dyes are commonly used in several industries including textile, dyeing, printing and cosmetic industries. Due to their complex structure they are highly persistent in natural environments, which may lead to the acute toxicity of the ecosystem.

Most commonly used dyes for dyeing of cotton are fiber reactive azo dyes, direct dyes, sulfur and vat dyes. Fiber reactive dyes are rapidly replacing direct dyes and are usually the principle dyes used for coloring cotton. Different dye classes require specific dyeing procedures, however a common factor is that water is required

for all forms of dyeing, either as a solvent or transport medium and therefore effluent is generated by all dyeing processes [3].

The acute toxicity of azo dyes, as defined by the (European Union) EU criteria for classification of dangerous substances, is rather low. Direct toxic levels of azo dyes will never be reached by consuming azo dye colored food. The majority of azo dyes (food and textile) have LD50 (lethal dose) values between 250 and 2000 mg/kg body weight, indicating that for a lethal dose many grams of azo dyes have to be consumed in a single dose. As azo dyes are highly water soluble, they do not accumulate in the body.

The application of ultrasonic technology has received wide attention by the world in wastewater treatment and the environmental remediation areas. The use of ultrasound technology is shown to be very promising for the degradation of persistent organic compounds in wastewater as it is proven to be an effective method for degrading organic effluent into less toxic compounds. The advantages of this technology include potential chemical-free and simultaneous oxidation, thermolysis, shear degradation, enhanced mass-transfer processes together, etc. [4]. Overall, sonochemical oxidation uses ultrasound to produce cavitations phenomena, which is defined as the phenomena of the formation, growth and subsequent collapse of micro-bubbles, releasing large magnitude of energy, and induces localized extreme conditions [5]. The sonochemical destruction of pollutants in aqueous phase generally involves several reaction pathways such as pyrolysis

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inside the bubble and hydroxyl radical-mediated reactions at the bubble–liquid interface and/or in the liquid bulk [6].

Dyes' house effluents contain large amounts of dyes. Unbound reactive dyes undergo hydrolysis due to elevated temperature and pH values during the dyeing processes. The strong color of discharged dyes even at very small concentrations has a huge impact on the aquatic environment caused by its turbidity and high pollution strength. Additionally, toxic degradation products can be formed [7].

Azo dyes, which constitute the largest group of color and used in industry, leave municipal wastewater plants highly diluted but nearly unchanged because they resist aerobic and short-term anaerobic treatment, only small amounts can be precipitated or adsorbed, while under anaerobic condition azo dyes are cleaved by microorganisms, forming potentially carcinogenic aromatic amines [8].

Over the last few years there have been a lot of reports using different advanced-oxidation processes, and their combinations, for destroying either partial or full varieties of textile dyes, especially azo dyes, with the aim of providing non-toxic and stable end-products. In recent years, considerable interest has been shown in the application of ultrasound for the destruction of textile dyes. Sonochemical reactions are induced upon high-intensity acoustic irradiation of liquids at frequencies that produce cavitation (typically in the range 20–1000 kHz). Cavitation is a phenomenon of micro-bubbles formation, and their growth and implosion in the irradiated liquid. The extreme temperature and pressure released during the adiabatic bubble collapse causes the fragmentation of those gas molecules trapped in the micro bubbles into radical species. These radical species can either recombine or react with other gaseous molecules within the cavity or in the surrounding liquid, after their migration.

Ultrasound was discovered in 1880 an important turning point in the world for its many uses and its importance in solving many of the problems faced by the industrial progress as technological problems on the one hand and the impact of industrial progress on the environment, on the other hand Azo dyes is one of the products that have many uses in industry and in the laboratory uses specifically went the attention of scientists and researchers on these azo dyes, research work and studies them as advantage and its disadvantage.

Perrier Curie was found ultrasound technology and it is defined as the sound of energy at frequencies between (20 kHz) and (10 kHz) above the audible range for humans [9].

In 2002, Chinese science bulletin studied the decomposed characteristic of azo dyes by ionization with ultrasonic enhancement. The conclusion derived from this investigation may be summarized as follows: The decoloration rate of arsenazo solutions during sonozone treatment is more rapid than the rate obtained with ozone alone because the complicated constitution has been destroyed by the O_3 free radical from ozone decomposition [10].

The photo degradation of dimethyl methyl phosphonate in the presence of low frequency ultrasound (20 kHz) in a batch reactor was studied by Chen et al. They studied the influence of low frequency and nonvolatile product for photo catalytic degradation. They found that the low frequency of ultrasonic irradiation increases the rate of dimethyl methyl phosphonate photo catalytic oxidation [11].

In Zhang et al. studied the declorization of the dye using ultrasound and ultrasound enhanced ozonation. In general declorization of wastewater is one of the significant problems facing industries that discharge wastewater containing a diversity of dyes. The study generates at a low frequency of ultrasound (20 kHz) and the reaction rate due to mass transfer, pH, temperature, dye concentration, and ozone concentration is effected in the dye degradation rate [12].

In 2005 there were many researches that were discussed this topic such as Maleki et al. [13] studied the ultrasound degradation of phenol and determination of the oxidation by product toxicity. Phenol is a potential hazard to human health and the environment. They studied the sonochemical degradation of phenol in aqueous solution by using (35 kHz) frequency and initial concentration of phenol varying from one to 100 ppm. The effect of parameter such as ph and initial phenol concentration in sonochemical, pH value, and phenol concentration, but the rates of phenol degradation had always been quite low.

Matouq and Al-Anber [14] studied the removing or recovering of ammonia from industrial wastewater. The ammonia cannot be removed easily from the stripper of the Jordan Refinery Company, which has a high ammonia concentration, and it is a crucial problem at the refinery. High frequency of ultrasound device was used with (2.4 and 1.7 kHz), three different concentrations (5, 15 and 25 vol), and three volumes (80, 100, 110 ml) of the solution was poured in the reactor, they found that the best condition to remove ammonia from waste water is at .005 concentration and .0165 m liquid height of solution in reactor (2007).

Applying the oxidative process of enzymatic treatment with laccases and ultrasound treatment was published by bio resource technology journal in (2008) [15]. They found the Laccase treatment degraded both Acid Orange and Direct Blue dyes within 1–5 h but failed in the case of reactive dyes, whereas ultrasound degraded all the dyes investigated (3–15 h). When applied as multi-stage combinations the treatments showed synergistic effects for dye degradation compared with individual treatment.

In 2011 environmental earth sciences journal [16] published a study about the azo dyes decolourization by combining ultrasonication and microbial removal and the result In this study, the decolourization of Reactive Red 2 (RR2), Reactive Blue 4 (RR4) and Basic Yellow 2 (BY2) were studied in the first step by continuous ultrasonic irradiation at 20 kHz and in the second step by microbial. The maximum decolourizations were found at 97%, 89% and 46% for RR2, RB4 and BY2, respectively by an ultrasonic/microbial combined method.

The main aims of this work are to investigate the decomposition of azo dye by oxidation process such as ultrasound technique, more specific is to investigate the effects of the main parameter influence of the degradation amount such as (level, voltage, initial concentration of the dye). This study will be the newly investigated process at high frequency of 1.4 MHz.

2. Materials and methods

Methyl orange dye ($C_{14}H_{14}N_3NaSO_3$) with a chemical structure as shown in Fig. 1 obtained from (Hopkin & Willims LTD, with molecular weight = (2.8–4.6)g/mol), distillate water.

2.1. Experimental setup

The experimental Apparatus is demonstrated in Fig. 2, which consists of a cylindrical vessel with 44 mm inside diameter, and 270 mm height. Cover attached to the cylindrical vessel at the

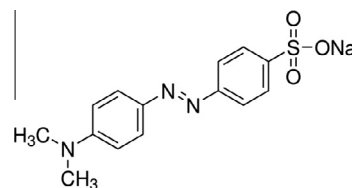


Fig. 1. Methylorangestructure.

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