Study on ultrasonic / hydraulic cavitation field for enhanced degradation of ceflor masonry in water

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Abstract. Based on ultrasonic cavitation, with low concentration of levofloxacin hydrochloride solution and cavitation product analysis, the degradation rules of levofloxacin hydrochloride were studied by ultrasonic, zero valent iron and zero valence iron (US / Fe0). The results showed that zero-valent iron promotes the degradation of levofloxacin hydrochloride solution by ultrasonic cavitation, and the degradation reaction fits the first-order reaction kinetic model, with a degradation rate constant of 6.3710-3min-1. Under the reaction conditions, the biodegradability of levofloxacin hydrochloride solution was significantly improved, and after 270min minutes of the reaction, the solution BOD5 / CODcr was increased from 0 to 0.421.

1. Introduction

Ultrasonic / hydraulic cavitation effect is the explosive growth of microbubbles (or gas cores) caused by the liquid evaporation caused by the local low pressure (below the saturated vapor pressure of the liquid at the corresponding temperature). Liquid is affected by the environment and the movement of gas molecules, and will inevitably dissolve into some gas, and the liquid will suspend some gas-phase microbubbles, called the "gas core". The radius of such microbubbles is generally 10-5~10-7m, which can not be observed by the naked eye. It can only be observed after the liquid is brought to the low pressure area and grows. When the pressure in the liquid falls below the air separation pressure, the gas dissolved in the liquid rapidly separates and produces a large number of bubbles; when the pressure continues to decrease below the saturated vapor pressure of the liquid at this temperature, the liquid itself, in addition to the bubbles formed in the liquid gas precipitation, generates a large number of bubbles. Since the gasification of the liquid and the release of the dissolved gas go into the bubble acting as the nucleus, the bubbles filled with air and steam form. When these bubbles flow into the high pressure area with the liquid, they are quickly collapse, the steam condenses quickly, and the fluid mass moves to the center of the cavity at high speed, producing a strong impact. As a result, the local pressure and temperature rise sharply, leading to the cavitation effect. This extreme environment will correspondingly produce a series of effects, such as mechanical effect (shock wave, microjet), thermal effect (local high temperature), light effect (sonoluminescence), activation effect (• OH radical generation in aqueous solution), etc. These effects will strengthen the water treatment process, and play an energy-saving and efficiency-increasing effect, which is very beneficial to the wastewater treatment.

Ultrasonic / hydraulic cavitation effect and zero-valent iron reduction can produce degradation of antibiotic wastewater, but the former has slow degradation speed, high energy consumption, and the treatment efficiency is not high. Although the latter can achieve good decolorization effect, the reaction must be carried out in a low pH environment to avoid forming a passivation layer on the surface of zero-valent iron. The extremely strong shock waves and microjet currents generated by the ultrasonic cavitation effect are used to remove the passivation layer formed on the zero-valent iron surface, increase the contact area of the system, promote the renewal of the reaction surface, strengthen the mass transfer process between the interfaces, and accelerate the chemical reaction. Therefore, it is of great significance to construct ultrasonic cavitation of antibiotic wastewater.

2. Experimental part

2.1 Experimental drugs, instruments and equipment

Main experimental drugs, see Table.1, and Table 2. for main instruments and equipment.

Tab 1. List of Major Drugs

Reagent name	Fineness	Place of production
Levofloxacin Hydrochloride Tablets	Tachnical pure	Shandong Lukang Pharmaceutical Group Saite Co., LTD
Sulfuric acid	AR	Beijing Beiyuan Fine Chemicals Co., Ltd
Sodium hydroxide	AR	Laiyang Kant Chemical Co., Ltd
Potassium dichromate	AR	Tianjin Guangcheng Chemical Reagent Co., Ltd
Mercuric sulfate	AR	Jiangyan City Global Reagent Factory
Silver sulfate	AR	Tianjin Yingda your chemical reagent factory
Potassium acid phthalate	AR	Shanghai reagent factory 3
Llithium hydroxide	AR	Tianjin Comio Chemical Reagent Co., Ltd
Zero price iron	AR	Tianjin Guangcheng Chemical Reagent Co., Ltd

Tab 2. Table of main equipements

Name of instrument and equipment	Model	Place of production
ultrasonic cell disruptor	JY92-IIN	Ningbo Xinzhi Biotechnology Biotechnology Co., Ltd
A UV-visible spectrophotometer	752 Type	Shanghai Spectroscopic Instrument Co., Ltd
Digital display pH meter	PHS-25	Shanghai Mike Instrument Co., Ltd
Quartz subboiling high purity water distillation machine	SYZ-550	Jiangsu Jintan Hongkai Instrument Factory
Digester	AL32	German quark AQUALYTIC
Electronic analytical balance	JA2003	Shanghai Jingke Instrument Factory
Magnetic stirring apparatus	CJJ78-1	Jiangsu Jintan Xiaoyang Electronic Instrument Factory
BOD5-based tester	BODTrak	Hash HACH, USA
Electric-heated thermostatic water bath	DZKW-S-4	Yuyao Yaxing Instrumentation Co., Ltd

2.2 Experimental process

Levofloxacin hydrochloride solution was prepared, and the pH value of dilute sulfuric acid or sodium hydroxide solution was used to adjust the solution. 50mL solution was placed in the self-made reactor, and a certain amount of reduced iron powder was taken by the analytical scale and added to the self-made reactor. Turn on the ultrasonic generator and time it. CODcr was measured after sampling and filtration at certain intervals. The ultrasonic cell grinder produces the ultrasonic wave in a pulse operation mode, namely working for 30s and resting for 15s for a cycle. When calculating the degradation time of ultrasonic production, only the working time of the ultrasonic wave is calculated. All the reagents added to the experiment were analytically pure. Under the same experimental conditions, the solution of levofloxacin hydrochloride was performed by magnetic agitation instead of ultrasound.

2.3 Analysis of the experimental results

2.3.1 *Promotion effect of zero-valent iron*

At 50mL of 20 mg/L initial concentration, ultrasound, Fe0 (4000 mg/L), and CODcr was sampled at certain intervals to obtain the degradation curve of levofloxacin hydrochloride in the three conditions (as shown in Table 3 and Figure 1).

Tab .3 The degradation of levofloxacin in different conditions

Degradation time/ min	Degradation rate/ %		
	US	Fe0	US-Fe0
0	0	0	0
30	20.08	13.44	19.69
60	27.29	29.74	37.61
90	35.44	33.81	40.33
120	48.48	34.69	50.11
150	56.63	36.27	64.47

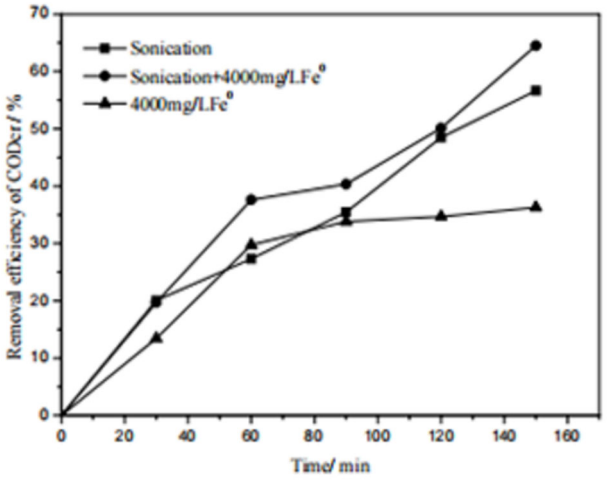

Figure.1 The degradation of levofloxacin in different conditions (the concentration of Fe0 : 0.2g, initial levofloxacin concentration: 20 mg/L, temperature: 20 °C, pH value: 5.86, ultrasound power: 400W)

As can be seen from the experimental results, zero iron and ultrasonic alone for levofloxacin hydrochloride solution has a certain degree of degradation, but ultrasonic degradation effect alone than zero iron alone degradation effect is significant, and with the extension of time, zero valence iron alone degradation increased slightly, this is because as the reaction, the layer on the surface of iron, hindered the degradation reaction. After combining ultrasonic wave and zero-valent iron, zero-valent iron promotes the degradation of levofloxacin hydrochloride solution by ultrasonic cavitation effect.

2.3.2 Dynamic study

The treatment of levofloxacin hydrochloride solution using US-Fe0, which was illustrated with the CODcr of levofloxacin hydrochloride solution, and it found that the CODcr of levofloxacin hydrochloride solution decreased with increasing reaction time. The degradation time is calculated by the logarithm (-lnc / c0), indicating that the degradation reaction of US-Fe0 combined for levofloxacin hydrochloride can be described by the first-order reaction. The reaction rate constant is 6.3710-3min-1, and the correlation coefficient is R=0.9821.

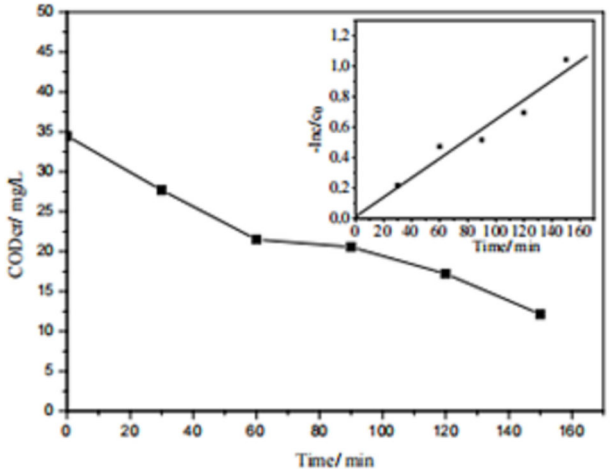

Figure 2. Changes in the values of CODcr of levofloxacin solution at different time during sonication. Insert shows sonodegradation kinetics of levofloxacin (the concentration of Fe0 :4000mg/L, initial levofloxacin concentration: 20 mg/L, temperature: 20°C, pH value: 5.86, ultrasound power: 400W)

2.3.3 Effects of ultrasonic power

The degradation of levofloxacin hydrochloride was performed at 50mL of 20℃, 4000mg / L and an initial pH of 100W, 200W, 300W, 300 W, 400W and 500W, respectively.

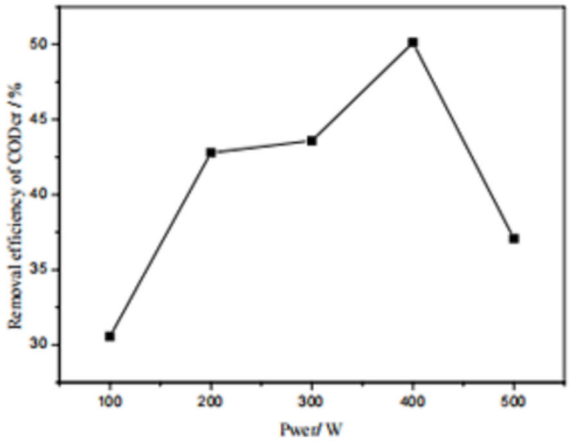

Figure.3 The removal efficiency of CODcr as a function of ultrasound power (the concentration of Fe0 : 4000mg/L, initial levofloxacin concentration: 20 mg/l, temperature: 20°C, pH value: 5.86, reaction time: 120 min).

Experimental results show that the ultrasound power is in the range of 100 W to 400 W, and the removal rate of levofloxacin solution CODcr is increased with the increasing ultrasound power. This is because with the increase of ultrasonic power, ultrasonic cavitation strengthening, produce more oxidation radicals, thus promote the degradation of levofloxacin, and with the increase of power solution of turbulence and perturbation more intense [84-85], promote the activation of zero-valent iron surface, accelerate the mass transfer rate of levofloxacin hydrochloride solution and its decomposition products, strengthen the degradation reaction at Fe / H2O heterogeneous interface, make the degradation rate of levofloxacin hydrochloride solution increased. However, when the ultrasonic power increases to 500W, the degradation rate is instead reduced, which is due to the excessive power and the shielding effect, and when the power is too large, the ultrasonic generator is heating seriously, and the requirements for the instrument are also relatively high.

3. Conclusion

The solution of zero-valent iron / ultrasonic degradation of levofloxacin hydrochloride is better than the solution of ultrasound iron alone, which promotes the degradation of levofloxacin hydrochloride by ultrasonic cavitation. In addition, the degradation effect of pH value, the highest CODcr degradation rate of levofloxacin hydrochloride is 400W; with the dosage of zero iron, the degradation rate of iron hydrochloride gradually increases with the dosage of iron powder, and the bioavailability of levofloxacin hydrochloride solution.

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