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Research on characterization and modeling for ultraviolet degradation of imidacloprid based on absorbance change

Xiaoyan Wang[a,b], Rendong Ji[a,b,*], Yulin Zhang[a,b], Yudong Yang[a,b], Chengfang Fu[a,b], Dingli Yang[a,b]

[a] Faculty of Electronic Information Engineering, Huaiyin Institute of Technology, Huaian 223003, China
[b] Jiangsu Laboratory of Lake Environment Remote Sensing Technologies, Huaiyin Institute of Technology, Huaian 223003, China

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ABSTRACT

Absorption spectrum of imidacloprid was measured using spectrophotometer and the most intensive characteristic peak (269 nm) was found. The function relationship between imidacloprid concentration and absorbance was obtained with a good linear relationship($R > 0.99$). The hardware platform for pesticide degradation was designed and built based on ultraviolet light technology, and imidacloprid degradation experiments were conducted based on the platform. It was proposed to describe degradation effect using absorbance change, and prediction model of pesticide residues degradation was obtained according to the relationship between degradation time and absorbance. The results showed that it was feasible to characterize ultraviolet degradation effect according to absorbance change, degradation rate was 4.71% after ultraviolet irradiation for 1 minute, and it was 98.43% after 10 minutes.

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1. Introduction

Imidacloprid is a kind of insecticide, which is widely used in agricultural production [1,2]. Pesticide residues will bring potential risk to consumers, and the research methods of pesticide residues have been reported in the literature. For example, P. Karthik conducted a study on imidacloprid residue dynamics in okra under open field conditions [3], Huanan Guan carried out experimental study on dynamics and degradation method of imidacloprid residues in soyabean fields [4], Ji Rendong studied fluorescence spectral method to detect the Imidacloprid residues of apple juice [5], Bahareh Jamshidi implemented the detection of pesticide residues in agricultural product based on Vis/NIR spectroscopic technology [6]. On the other hand, the degradation of pesticide residues is also an important research field. At present, the main degradation technology includes physical method, chemical method and biological method. The physical method mainly contains ultrasonic wave and ionization irradiation [7–9]. Chemical method is one of the most studied degradation technologies, which includes photochemical degradation, chemical oxidation, photocatalysis method and so on [10–12]. Microorganism including bacteria, fungi and actinomycetes are used to degrade pesticide residues in biological method [13,14]. The principle of ultraviolet irradiation degradation of pesticide residues is consistent with the photochemical degradation [15], ultraviolet irradiation can break the double bond of pesticide and destroy the combination of organic carbon that constitute the pesticide, and then, organic matter will be decomposed into small molecular substances.

* Corresponding author.
E-mail address: jrd7933@163.com (R. Ji).

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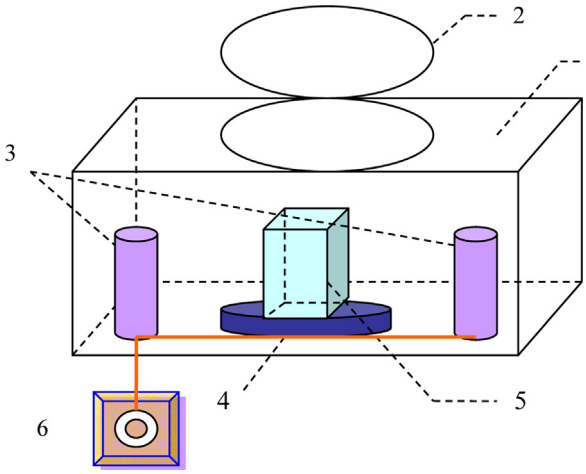

Fig. 1. Structure of ultraviolet irradiation experiment.

The degradation of imidacloprid residue using ultraviolet light was proposed in this paper, degradation effect was characterized through the change of absorbance, and the relationship between degradation time and degradation rate was derived at last. Research results have some reference value on the selection of detection and degradation technology of pesticide residues.

2. Experiments

2.1. Materials

Imidacloprid purchased from Shanghai pesticide research institute (Shanghai, China) was selected as experiment sample.

2.2. Experimental apparatus

UV3600 ultraviolet visible spectrophotometer (Shimadzu, Japan) was used to measure the absorption spectrum of imidacloprid pesticide sample. The equipment structure of ultraviolet irradiation degradation was shown in Fig. 1, which contained 6 parts. The numerical label 1 represented closed system, 2 represented switching device of closed system, 3 was ultraviolet light source module, 4 was module support, 5 was sample pool and 6 was the time control switch of power supply, which can control the irradiation time of ultraviolet irradiation.

Low-voltage and high intensity ultraviolet lamp of quartz type was selected as the ultraviolet light source, and its light transmittance was greater than 90%. The lamp was controlled by a electronic ballast with variable power output, the emission wavelength was set to be 253.7 nm, the power was set as 3W, the tube voltage was 9.5 ~ 13 V, and the pipe flow was 300 mA. Ultraviolet lamp was connected to 220 V alternating current through a capacitor (4.7F/400 V), and ultraviolet irradiation time was controlled by the time control switch. The closed system also contained a cavity and a bracket to place the sample pool.

2.3. Procedures

First, a right amount of imidacloprid pesticide was measured using electronic balance which was then configured as standard pesticide solution of different concentrations, and the solution with different concentrations was placed in the cuvette and its absorption spectrum was detected by using UV3600, respectively.

And then, 3 ml imidacloprid solution was placed in the sample pool of ultraviolet degradation device using cuvette, the absorption spectrum of pesticide was recorded by using UV3600 after the solution was irradiated under ultraviolet light for different time. And the relationship between illumination time and characteristic peak absorbance of the pesticide was deduced at last.

3. Results and analysis

3.1. The absorption spectrum of imidacloprid

The absorption spectrum of imidacloprid solution detected by UV3600 was shown in Fig. 2, and it showed that the spectrum range was from 220 nm to 700 nm. In Fig. 2, four curves represented corresponding absorbance spectrum of four dif-

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