富里酸(FA)对MC-LR的光敏降解作用及相关环境条件研究

Photosensitized degradation of MC-LR by fulvic acid (FA) and its related environmental conditions

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Abstract

Cyanobacteria bloom frequently occurs in freshwater ponds, and microcystins (MCs) can cause direct harm to farmed animals. Photodegradation is an effective way to reduce MCs-caused harm in natural waters. Fulvic acid (FA) is a widely existing photosensitizer in ponds. Effects of different concentrations of FA on the photosensitized degradation of MC-LR and its related environment conditions were investigated under simulated solar light. The results showed that the direct photolysis of MC-LR occurred in deionized water. Different concentrations (2.5, 5, 7.5 and 10 mg L^{-1}) of FA promoted the photolysis of MC-LR, of which 7.5 mg L^{-1}FA had the best photosensitized degradation effect. The degradation rate reached 52.65% after 180 min. The photosensitive degradation of MC-LR by FA conformed to the second-order reaction kinetics, and the photosensitive degradation products are the same as the direct photolysis products in deionized water. Under different pH values and light intensities, the photosensitive degradation effects of FA on MC-LR were pH6>pH7>pH8>pH9 and 350 W>500 W>200 W, respectively. The results showed that both pH value and light intensity affected the photosensitized degradation of FA on MC-LR.

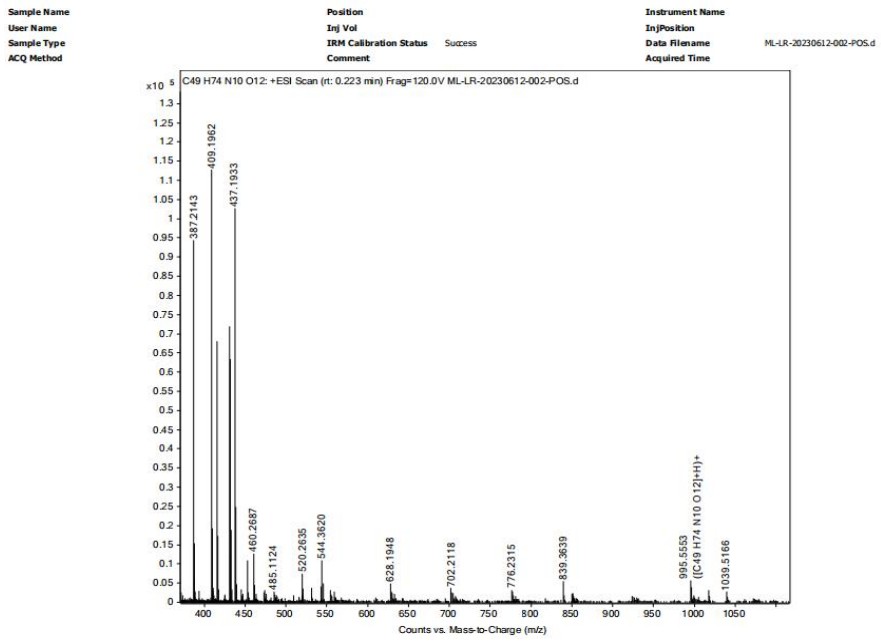
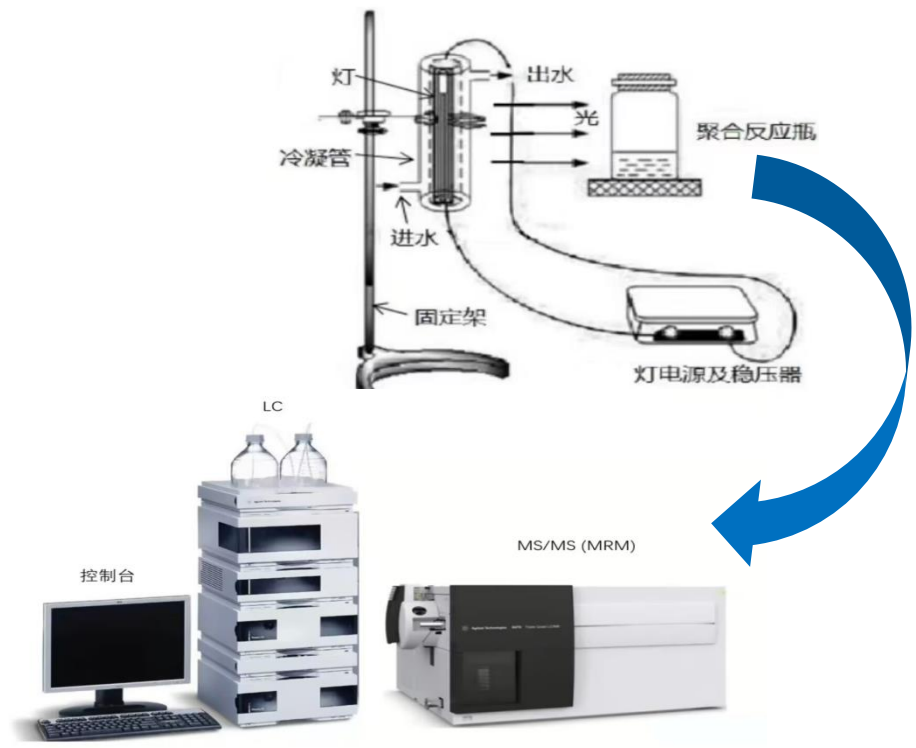


Fig.1 Mass spectrum of MC-LR

Methodology



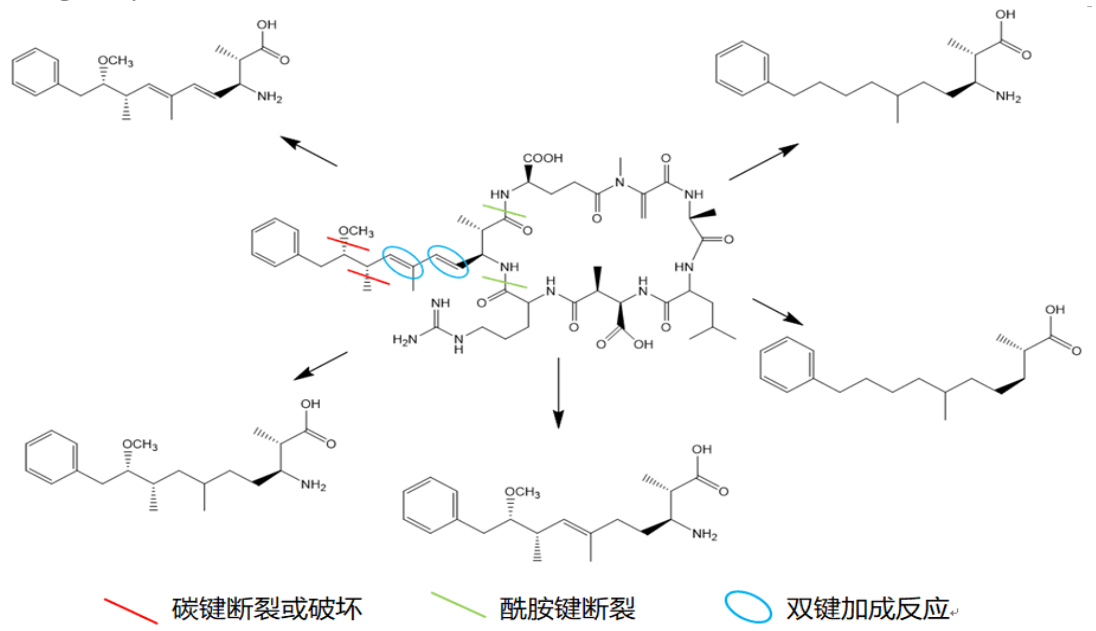


Fig.2 Photolysis products of MC-LR in different concentrations of FA solution

在7.5 mg L^{-1}FA溶液中，MC-LR光降解产物的m/z值为277.2156、292.2267、332.2190、334.2349、336.2518，去离子水中m/z值为277.2159，292.2267，332.2192，334.2350，336.2517。FA溶液中MC-LR的降解产物与去离子水中的基本相同。根据不同产物的（M+H）$^{+}$m/z 数据推断产物结构及可能的降解途径见图2，以上大部分产物中Adda的共轭碳双键均被破坏，FA溶液中及去离子水中MC-LR的光解途径主要通过Adda基团的共轭双键断裂以及酰胺键的断裂实现的。

Results

Tab.1 Kinetic equations and parameters of photodegradation of MC-LR in FA solutions with different concentrations

FA浓度 (mg L^{-1})	一级动力学拟合 方程	k_1/min^{-1}	R^2	二级动力学拟合 方程	k_2/min^{-1}	R^2
FA=2.5	$\ln(C_0/C)=0.00196t$	0.00196	0.7335	$1/C-1/C_0=0.00245t$	0.00245	0.7765
FA=5	$\ln(C_0/C)=0.00259t$	0.00259	0.9293	$1/C-1/C_0=0.00290t$	0.00290	0.9703
FA=7.5	$\ln(C_0/C)=0.00263t$	0.00263	0.8734	$1/C-1/C_0=0.00293t$	0.00293	0.9821
FA=10	$\ln(C_0/C)=0.00179t$	0.00179	0.9890	$1/C-1/C_0=0.00227t$	0.00227	0.9895
去离子水	$\ln(C_0/C)=0.00155t$	0.00155	0.9269	$1/C-1/C_0=0.00188t$	0.00188	0.9336

Tab.2 Apparent rate constant and light shielding coefficient of MC-LR in FA solutions with different concentrations

FA浓度(mg L^{-1})	$kobs_{(FA)}$	S_λ	$kobs_{(no-FA)}$ S_λ	k_{FA}
FA=2.5	0.00245	0.611	0.0011	0.00135
FA=5	0.00290	0.542	0.0010	0.00190
FA=7.5	0.00293	0.489	0.0009	0.00203
FA=10	0.00227	0.442	0.0008	0.00147

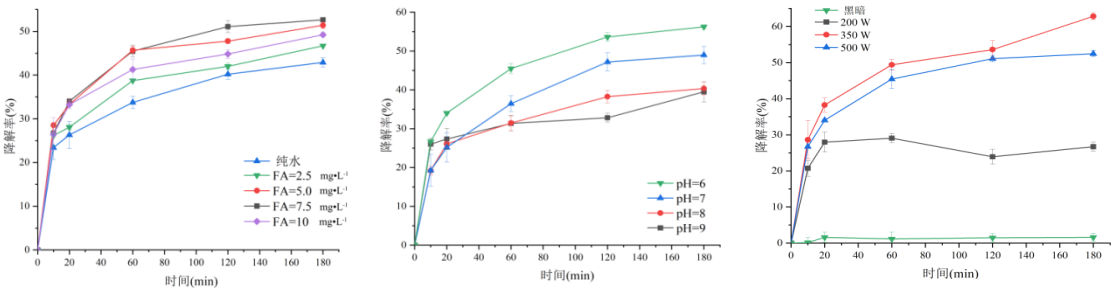


Fig.3 Photodegradation experiments of FA solutions with different concentrations and under different conditions

References

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