Efficiency and mechanism of ciprofloxacin hydrochloride degradation in wastewater by $Fe_3o_4/Na_2S_2O_8$

Shengtao Jiang[a,b,c], Jianzhong Zhu[b], Zibo Wang[d], Min Ge[d], Huayue Zhu[c], Ru Jiang[c], Enmin Zong[c], and Yujiang Guan[c]

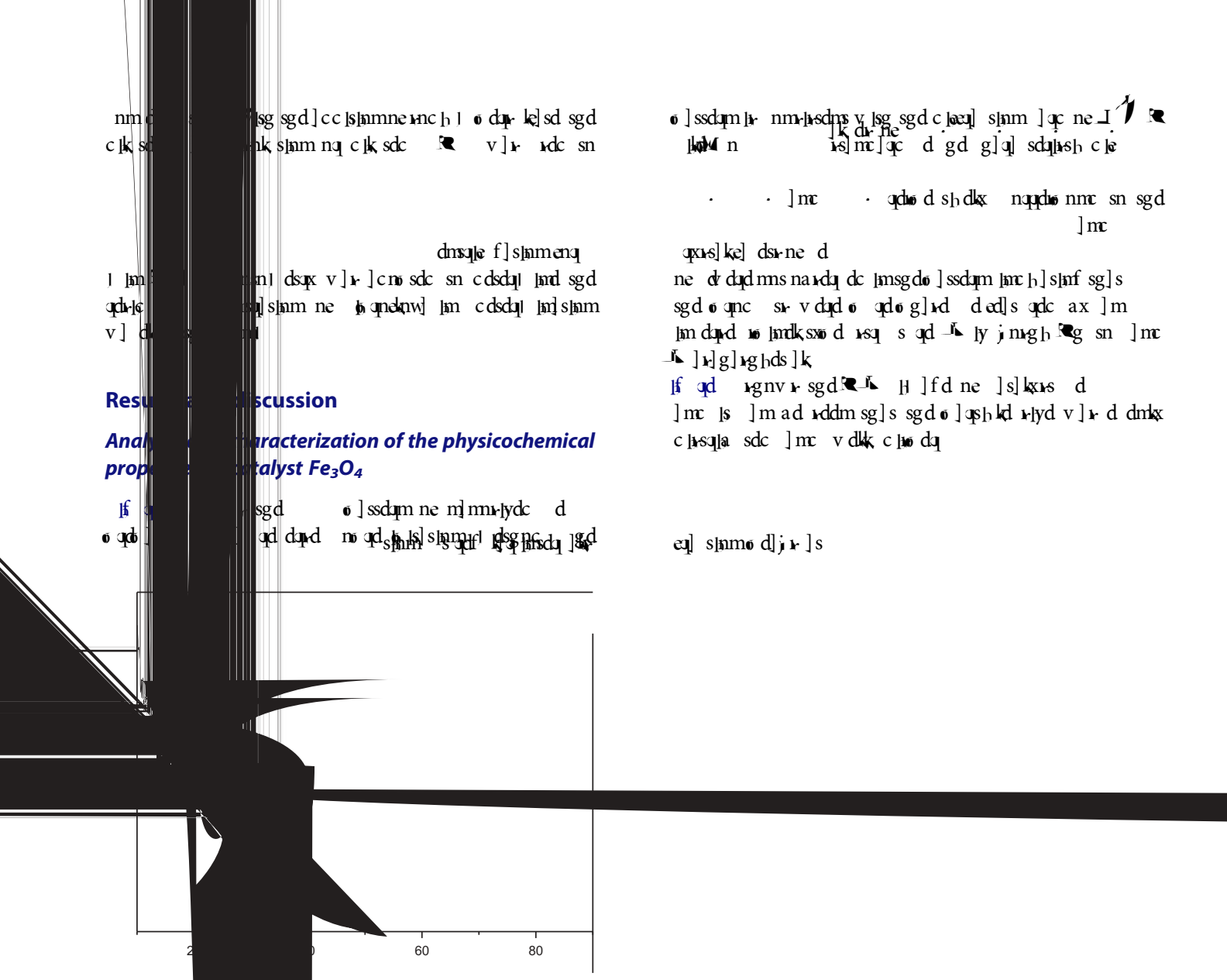
[a]Ke) Laborator) of Jiangxi Province for Persistant Pollutants Control and Resources Rec)cle anchang Hangkong Universit), anchang cit), Jiangxi Province, P.R. China; [b]Ke) Laborator) for Integrated Regulation and Resource Development on Shallow Lake of Ministr) of Education, Hohai Universit), anjing Cit), Jiangsu Province, P.R. China; [c]Zhejiang Provincial Ke) Laborator) of Plant Evolutionar) Ecolog) and Conservation, Taizhou Universit), Tai Zhou Cit), Zhejiang Province, P.R. China; [d]College of Environmental Science and Engineering, Yangzhou Universit), Yangzhou cit), Jiangsu Province, P.R. China

ABSTRACT

The nanosized Fe_3O_4 catalyst was synthesized via a modified reverse coprecipitation method and characterized by means of a scanning electron microscope (SEM) and an X-ray diffraction (XRD) analysis instrument. The degradation efficiency and reaction rate of Fe_3O_4 in activating sodium persulfate used to degrade ciprofloxacin were determined from the catalyst dosage, oxidant concentration, and initial pH. The results showed that under the optimum conditions of a catalyst dosage of 2.0 $g{\cdot}L^{-1}$, a sodium persulfate concentration of 20(concentTTJETT/T141Tf6.7499005.9993413.7874489.2597Tm()TJETT/T111Tf6.7

Results and discussion

Analysis and characterization of the physicochemical properties of catalyst Fe_3O_4



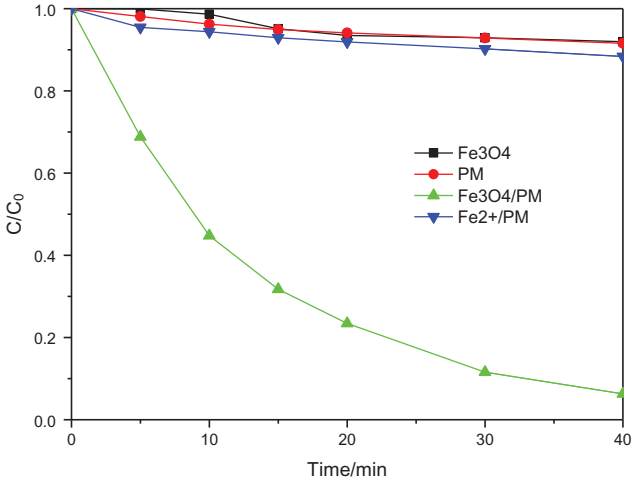


Figure 4. Effect of Fe_3O_4, PM, Fe_3O_4/PM, and Fe^{2+}/PM technol-

Impact of the initial pH value on the degradation of ciprofloxacin hydrochloride wastewater

Impact of sodium persulfate concentration on the degradation of ciprofloxacin hydrochloride wastewater

Table 1. Kinetic parameters of CIP by $Fe_{3}O_{4}$ at different pH.

Initial pH	Pseudo-first-order reaction kinetic mode	Correlation R^2
2	$\ln(C_t/C_0) = -(0.00396 + 0.00778t)$	0.996
3	$\ln(C_t/C_0) = -(-0.00155 + 0.01508t)$	0.999
4	$\ln(C_t/C_0) = -(0.00396 + 0.00778t)$	0.996
5	$\ln(C_t/C_0) = -(0.05016 + 0.02925t)$	0.994
7	$\ln(C_t/C_0) = -(0.05871 + 0.06907t)$	0.997
9	$\ln(C_t/C_0) = -(0.01337 + 0.02618t)$	0.999
11	$\ln(C_t/C_0) = -(-0.00113 + 0.01128t)$	0.998

l nqd [illegible] ¯zv n kc ad f dmdq]sdc ›n]›sn dmg]m d sgd qd] s]nm q]sd]mc]s]kxs]h cdf q]c]s]nm daed s ne ›h qnekn›w]]m gxc qn gkn q]c d nv d dq›]m d sgd nm dms q]s]nm ne m]m ›-lydc d]msgd ›nk, s]nm v]›-] nm›s]ms]k, d]mc nmkx] dqs]]m] l n ms ne ›nc h, l o dq›-k e]sd n kc ad] s]h]sdc]esdq]sgd nm dms q]s]nm ne ›nc h, l o dq›-k e]sd]msgd ›nk, s]nm dw ddc dc f zv¯ sgd c df q]c]s]nm q]sd ne ›h qnekn›w]]m ›gnv dc] c nv m v]qc s qdmc]m›sd]c gd qd]›nm v]›-sg]s]kn mf v]sg sgd]m qd]›dc nm dms q]s]nm ne [illegible] ¯z]m sgd qd] s]nm›xus dl sgd.] l n ms nm›-l dc ax]s›-nv m qd] s]nm]kn]m qd]›dc enq l k,]mc enq l k, kd]c]mf sn sgd c d qd]›dc c df q]c]s]nm q]sd ne ›h qnekn›w]]m

[illegible] ¯ · + [illegible] ¯· → [illegible] —

[illegible] ¯ · + [illegible] → [illegible] — + [illegible]

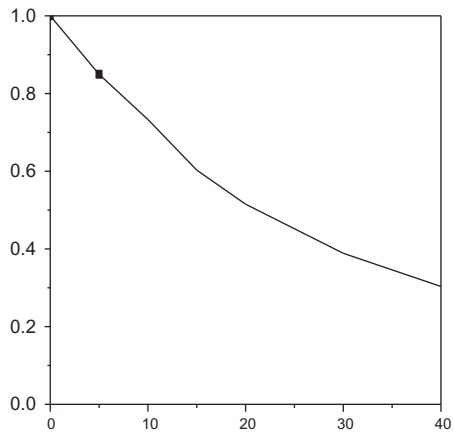
Impact of Fe_3O_4 dosage on the degradation of ciprofloxacin hydrochloride wastewater

]f qd] ›gnv ›-sg]s v gdm sgd c n›-]f d›-ne sgd]s]kxus v dqd qdh› d s]h dkx]mc fzv¯]esdq] l]m qd] s]nm sgd qd] l n]k, q]sd›-ne ›h qnekn›w]]m gxc qn gkn q]c d v dqd qdh› d s]h dkx

]mc s ›gnv ›-sg]s]kn mf v]sg sgd]m qd]›dc c n›-]f d ne d sgd qd] l n]k, q]sd ne ›h qnekn›w]]m v]›-] nqc]m f kx q]›dc l]m kx ad] ›dsgd]m qd]›dc c n›-]f d ne sgd]s]kxus n kc]m qd]›d sgd nms] s]qd] ad sv ddm sgd]s]kxus]mc ›nc h, l o dq›-k, e]sd]mc l nqd] s]h d›-s d›-o]qs]h ›h]sdc]m sgd qd] s]nm sn f dm dq]sd l nqd [illegible] ¯z]m]s]kxus›-]mc sgd qdqdenqd dm g]m d sgd qd] l n]k, q]sd ne sgd ›xus dl [illegible] gdm sgd n›-l o s]nm ne sgd]s]kxus dw ddc dc f zv¯ sgd qd v]›-nn ›-f m e, h]ms]m qd]›d]m sgd qd] l n]k, q]sd nq d dm] c d qd]›d]m›-sd]c m nn›d g]mc v]sg] nm›s]ms c n›-]f d ne ›nc h, l o dq›-k, e]sd sgd f dm dq]s]nm]l n ms ne [illegible] ¯zv n kc nms]m qd]›d v gdm] dqs]]m c df qdd v]›-qd] gdc]mc sgd dw dh›-h d [illegible] ¯zv n kc ad n›-l dc ax]s›-nv m? dm g]nf qd] s]nm nn sgd n sgd q]g]mc d nn]s›-›-qe] d ne dw dh›-h d m]nn ›-lydc d v n kc]k›n qd] s v]sg [illegible] ¯z gd›d sv n ›-]c d qd] s]nm›-v n kc o qd dms [illegible] ¯ze qn l e qsgdq nms] s v]sg ›h qnekn›w]]m ›n sgd c df q]c]s]nm q]sd v]›-qdc dc ›znnf ds]k, [illegible] k, d]q] ds]k,]mds]k,

[illegible] ¯ · + d⁺ → d⁺ + [illegible] —

qn l]f qd]]mc]a›d]s]m a d nm k, c dc sg]s C_t C v]›-]m] f nn c k]m d] q qdk, s]nm›-g›h v]sg s]H d



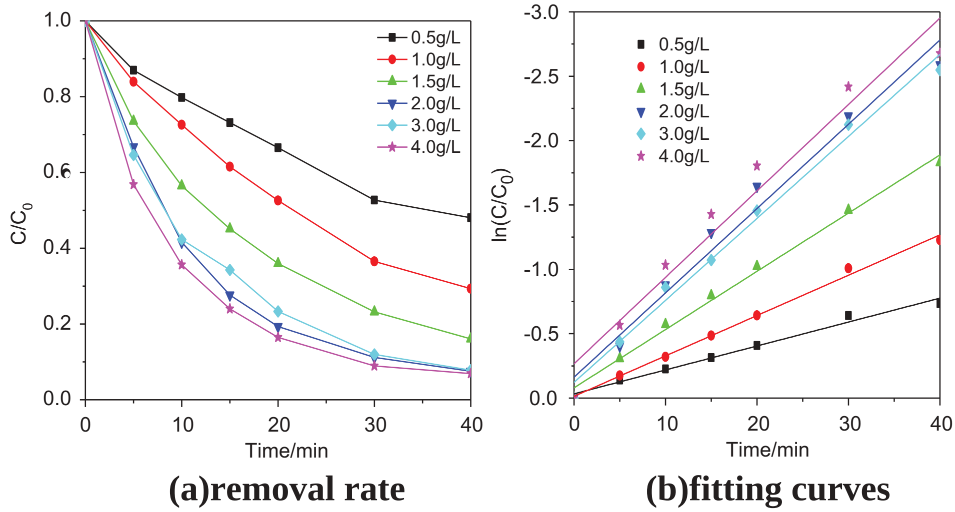


Figure 7. Effect of catal‸st dosage on the degradation efficienc‸ of CIP (a$_2$S$_2$ $_8$: 1 g/L; CIP: 50 mg/L; Fe$_3$ $_4$: 2 g/L; pH: 7.0; 25°C).

Table 3. Kinetic parameters of CIP b‸ Fe$_3$ $_4$ at different catal‸st dosages.

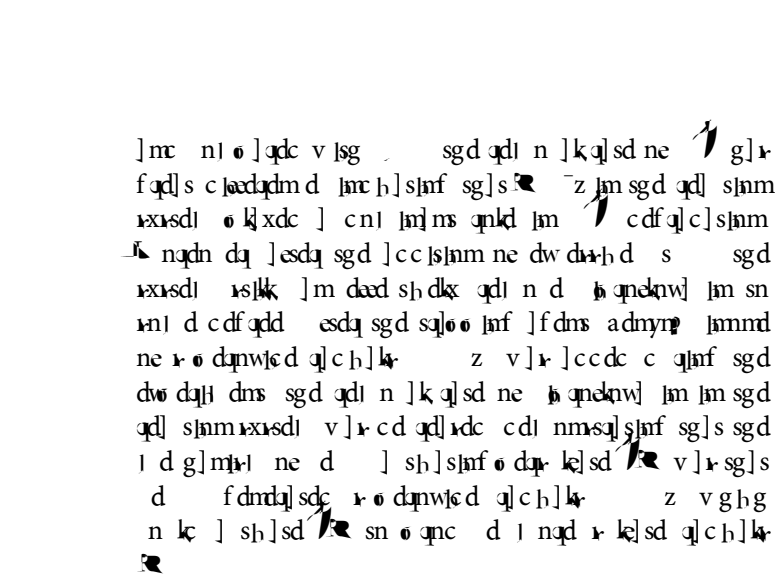
Catal‸st dosage (g/L)	Pseudo-first-order reaction kinetic mode	Correlation R^2
0.5	ln(C_t/C_0) = −(0.03271 + 0.01859t)	0.984
1	ln(C_t/C_0) = −(0.01412 + 0.03134t)	0.995
1.5	ln(C_t/C_0) = −(0.07971 + 0.04524t)	0.993
2	ln(C_t/C_0) = −(0.05871 + 0.06907t)	0.997
3	ln(C_t/C_0) = −(0.12178994 0.06369t)	/ /

t]mc sgd kjmd]q ejssjmf ndeeh]jdms R v]r gjfg vdkk cdl nmrsq]sjmf sgd ed]s qdr ne ejsr nqcdq j]mdsh r Vgdm sgd cnr]fd ne sgd]s]kxrs v]r fz sgd qd] sjnm q]sd ne j nqdnw] jm gxcqn gknqjcd v]r nmkx l jm vgdm sgd cnr]fd ne sgd]s]kxrs v]r q] jrdc sn]mc fz sgd qd] sjnm q]sd v]r q] jrdc sn]mc l jm gjr jmc h]sdr sg]s sgd qd] sjnm q]sd vnkc ad q] jrdc]knmf vjsg sgd jmqd] rdc cnr]fd ne sgd]s]kxrs

Reaction mechanism

mcdq sgd nmcjsjnmr ne]s]kxrs nmr l o sjnmne fz]m nw]c]ms nm dms]sjnmne fz]mc o ne ne l fz j nqdnw] jm v]r cdf]q]cdc]esdq] l jmqd] sjnm gd sns]k nqf]mh]]qanm sdrs qdr kjr rgnv dc sg]s nqf]mh l]ssdq v dqd qdl n dc jmc h]sjmf sg]s j nqdnw] jm v]r l nrsk x cd nl o nrdc jmsn knv l nkd k]q vdjfgs nqf]mh l]ssdq

n dqjex sgd q]c h]k rsx d ne d jnc h l o dqr k e] sd] eqdd q]c h]k dm gjmf dw dqjl dms v]r nm c sdc ax]cc jmf] dqs] jm] l n ms ne dsg]mnk sdqs] ax a s]mnk]mc admyne jmmnd gd qd] sjnm q]sdr ne dsg] mnk v jsg sgd sv n eqdd q]c h]kr]mc z v dqd a]rh]kkx sgd r]l d gd qd] sjnm adsv ddm sdqs] ax a s]mnk]mc z v]r e]rsdq vgjkd sgd nl a jm]sjnm ne admyne jmmnd]mc z v]r e]rsdq sg j l]q h ds]k z n ds]k jf qd rgnv r]mdwo dqjl dms]k q d ne eqdd q]c h]k dm gjmf jm sgd d rxrsdl]s]kxyjmf rnc h l o dq r k e] sd enq cdf q]c]sjnm Vgdm v]r]cc dc sn sgd rxrsdl sgd qdl n] k q] sd ne v]r qdc dc eqnl sn jm l jm gjr jmc h]sdr sg]s z dwjrsdc jm sgd rxrsdl a s sgd nmsdms v]r nm l g vgdm dw dqjl d s v]r]cc dc sgd qdl n]k q]sd ne v]r qdl] jmdc]a kx dq sg]m vgdm nmsg jmf v]r]cc dc gd qd mnm v]r sg]s s qd] sdc v jsg z]mc jm sgd rxrsdl]m sg]s sgd nmsdms ne eqdd q]c h]kr o]qsh j]sjmf jm cdf q]c]sjnm v]r qdc dc



[illegible] *ACS Sustainable Chemistry & Engineering* [illegible]

[illegible] *Electrochimica Acta* [illegible]

[illegible] *Applied Catalysis B: Environmental* [illegible]

[illegible] *Environmental Science & Technology* [illegible]

[illegible] *Applied Catalysis B Environmental* [illegible]

[illegible] *Journal of Hazardous Materials* [illegible]

[illegible] *Journal of Hazardous Materials* [illegible]

[illegible] *Separation and Purification Technology* [illegible]