Nano silver oxide-modified activated carbon as a novel catalyst for efficient removal of bacteria and micropollutants in aquatic environment

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2. Materials and methods

Text S1

Silver nitrate ($AgNO_3$, ≥99%), hydrogen peroxide (30%), Nitric acid, hydrochloric acid and sodium hydroxide were purchased from Guangzhou Reagent Factory and all reagents were analytical grade. Tetracycline (TC), tertbutyl alcohol (TBA), p-benzoquinone (BQ), 5, 5-dimethyl-1-pyrroline N-oxide (DMPO) and catalase were received from Shanghai Aladdin Reagent Factory. Guangdong Huankai Microbial Technology Co., Ltd. provided Luria-Bertani (LB) broth, agar powder and *Escherichia coli (E. coli)*. Porous activated carbon (AC, 770 m^2/g of surface area, 0.1 mm of average diameter) used in this study was obtained from Hongsen Activated Carbon Co., Ltd.

Text S2

The purchased *E. coli* strain is dry powder in a bottle. The rejuvenation process of *E. coli* is as follows: the bottle was injected with 1 mL LB culture medium by a pipette gun and then shaken in a super clean console. After the dry powder was completely hydrated, it was transferred into the test tube, into which 5 mL LB culture medium was added. Then the solution was inoculated on LB agar solid medium, which was put into a constant temperature incubator at 37 ^oC for 24 h until colonies grow.

The amplification and culture methods of *E. coli* are as follows: A colony of bacteria from the above rejuvenating medium was taken with an inoculation ring and inoculated in 100 mL liquid medium. Then the liquid medium was shaken in a

constant temperature shaker at 37 °C for 24 h to obtain a bacterial solution with a concentration of 10^{11} CFU/mL.

Plate counting method was adopted for the analysis and identification of *E. coli*: After sample was diluted to different concentrations, 0.1 mL diluent was taken and coated evenly on LB agar medium. Then the agar medium was put in an incubator at 37 °C for 24 h and the number of colonies on it was counted. The bacterial concentration can be calculated by the following formula:

Bacterial concentration (CFU/mL) = colony forming units × 10 × dilution times

Three parallel plates were made for each diluted sample, and the average value was used.

Text S3

To identify effects of various reactive oxide species (ROS) during the reaction process, t-butyl alcohol (TBA) as a scavenger of hydroxyl radical ($OH^{\bullet}$) was applied to scavenge the role of generated $OH^{\bullet}$ in reaction [1]. In detail, TBA was injected into the mixed solution of 100 mL H_2O, 0.1 g nAg_2O/AC, 0.1 mg TC and 1 mL *E. coli* (10^8 CFU/mL). After adjusting solution pH value to about 7.0, 32 μL H_2O_2 (30%) was added into the mixture solution and then the reactor was shaken at 30°C and 90 rpm to start reaction. When the reaction for 5 min (or 1, 3, 10 min), 1 mL sample was immediately collected to detect *E. coli* and TC concentration by the above method and removal efficiency was calculated to evaluate the effect of $OH^{\bullet}$. In addition, *p*-benzoquinone (BQ) and catalase as scavenger for superoxide radicals ($O_2^{\bullet-}$) and hydrogen peroxide (H_2O_2) were also introduced into nAg_2O/AC heterogeneous

Fenton system, respectively, investigating their contribution in the process of removing pollutants [1].

The generated $OH^{\bullet}$ was quantitatively measured through terephthalic acid (TA) capturing method [2], herein non-fluorescent TA can react with $OH^{\bullet}$ to produce strong fluorescent hydroxyterephthalic acid (HTA). The concentration of HTA can be expressed by intensity of fluorescence signal detected by fluorescence spectrometer and represented the quantity of $OH^{\bullet}$ in solution. Briefly, 0.1 g nAg_2O/AC and 60 mg TA were mixed into 100 mL of deionized water. Next, 32 μL H_2O_2 (30%) was injected and mixed to start the reaction. After reaction for 5 min, samples were taken out and detected by fluorescence spectrometer (excitation wavelength: 436 nm). Similarly, the control experiments including nAg_2O/AC or H_2O_2 alone system were also carried out, respectively.

3. Results and discussion

Table S1 Elemental composition of AC, nAg_2O and nAg_2O/AC before and after reaction.

Sample	Elemental (wt%)		
	C	O	Ag
AC	87.6	12.4	ND
nAg_2O	ND	12.1	87.9
nAg_2O/AC	85.2	12.8	1.5
nAg_2O/AC*	85.9	12.7	1.4

ND: not detected; nAg_2O/AC*: nAg_2O/AC after reaction.

85 **Table S2** Kinetic analysis of *E. coli* inactivation experiments

Sample	Inactivation efficiency (log)	Time (min)	Rate constant (min-1)	R2
$nAg_2O/AC+H_2O_2$	6.0	10	0.550	0.96
$nAg_2O+H_2O_2$	1.8	15	0.026	0.98
$AC+H_2O_2$	0.9	15	0.008	0.99
nAg_2O/AC	1.2	15	0.019	0.99
H_2O_2	0.9	15	0.008	0.98

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87 **Table S3** Kinetic analysis of TC removal experiments

Sample	Removal efficiency	Time (min)	Rate constant (min-1)	R2
$nAg_2O/AC+H_2O_2$	98%	5	0.80	0.94
$nAg_2O+H_2O_2$	15%	10	0.04	0.93
$AC+H_2O_2$	7%	10	0.02	0.96
nAg_2O/AC	24%	10	0.07	0.98
H_2O_2	7%	10	0.02	0.97

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89 **Table S4** The summary of *E. coli* inactivation with different Fenton like catalyst

Catalyst	Bacteria	Inactivation efficiency (log)	Rate constant (min^{-1})	References
nAg_2O/AC	*E. coli*	6.0	0.550	present work
Fe_2O_3/CNT	*E. coli*	4.5	0.242	[3]
MgO/CNT	*E. coli*	3.4	0.182	[4]
Co_2O_3/AC	*E. coli*	5.0	0.391	[5]
Mn_2O_3/AC	*E. coli*	3.5	0.228	[6]

AgNP/CNT	*E. coli*	4.0	—	7

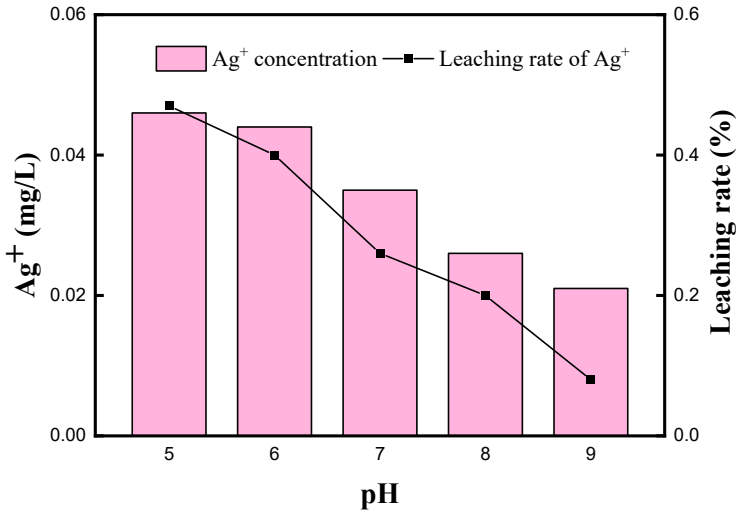

Fig. S1. Leaching concentration and leaching rate of Ag+ at different pH.

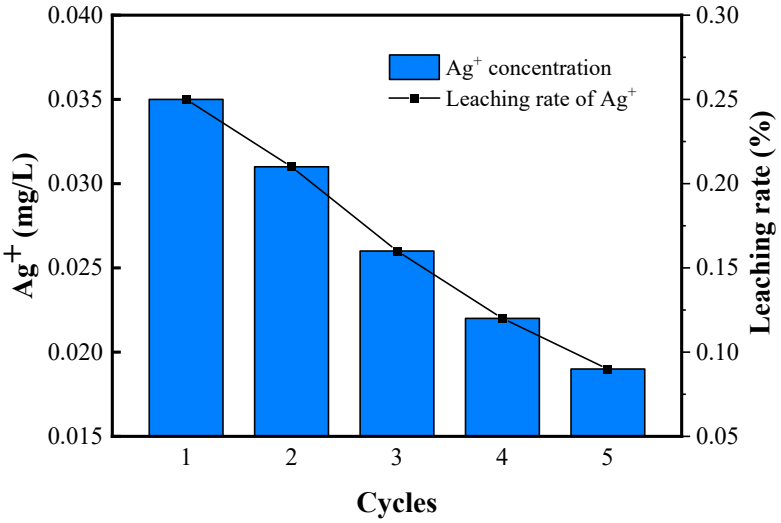

Fig. S2. Leaching concentration and leaching rate of Ag+ In the cyclic test.

References

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