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THE IMPORTANT ROLE OF AG AND CU ON ENHANCING DECHLORINATION OF 2,4-DICHLOROPHENOL BY AG/CU/FE NANOPARTICLES: PERFORMANCE STUDY

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ABSTRACT

In this paper, polyvinylpyrrolidone-stabilized Ag/Cu/Fe polymetallic composites were successfully prepared by liquid-phase reduction method and characterized by X-ray diffraction (XRD), transmission electron microscopy (TEM) and Vibration magnetometer (VSM) detection means that the crystal structure of the material, surface morphology, Magnetic properties and group changes. The catalytic degradation of chlorinated phenolic organic pollutants, such as 2,4-dichlorophenol in water was studied initially discussed the Ag/Cu/Fe NPs removal of 2,4-dichlorophenol catalytic reduction mechanism and kinetic model. The results show that PVP has good stability to Ag/Cu/Fe NPs. The particle size of Ag/Cu/Fe modified by PVP is small, and it is uniformly dispersed in alcohol aqueous solution and cannot be easily agglomerated. Fast and efficient separation, with excellent recycling performance, PVP stabilized Ag/Cu/Fe NPs for 2,4-dichlorophenol catalytic degradation has a good effect. The degradation of 2,4-dichlorophenol by Ag/Cu/Fe NPs accords with quasi-first-order kinetic model.

KEY WORD : Cu/Fe, Catalytic degradation, 2,4-dichlorophenol, Reduction.

INTRODUCTION

Phenolic compounds are currently the main pollutants in groundwater. They enter the environment through many ways, seriously polluting the atmosphere, soil and water resources, and endangering human health. They are highly toxic, fast migration, stable in nature, and are persistent pollutants that are difficult to biodegrade by Ji and Yu (2015). The development of nanotechnology has brought a new dawn to the treatment of these pollutants, and the method of zero-valent iron metal to treat organic pollutants in the environment has gradually become an active development area by Park and Kim (2017). Compared with traditional methods of removing pollutants, zero-valent iron particles have small particle size, large specific surface area, active chemical properties, and rapid reaction, showing great prospects for being used as catalysts (Hong *et al*., 2005). However, due to the small particle size of zero-valent iron, the agglomeration between particles is serious, and the chemical properties are active. It is very easy to react with water or oxygen in the air in the environment, and form iron oxides and hydroxides on the surface of zero-valent iron. The thin passivation layer in the morphology reduces its catalytic performance, incomplete degradation of certain pollutants, and produces substances that are more harmful to the environment and more difficult to degrade, which brings a lot of inconvenience to practical applications (Ren *et al.*, 2007). Studies have found that adding certain transition metals, such as palladium (Pd), silver (Ag), copper (Cu), gold (Au), etc., to the reaction system, forming a bimetallic system with zero-valent iron can effectively increase the zero-valent iron Catalytic performance, and extend the service life of metallic iron. Compared with Pd/Fe, Au/Fe and other bimetallic materials, Fe/Cu bimetallic materials have lower activity, but their activity is enough to play a role in groundwater

remediation, avoiding the excessive activity of iron due to too high activity. Disadvantages of fast consumption. In terms of price, copper has more advantages than metals such as palladium, gold, and nickel (Ji *et al.,* 2015). Therefore, it is of great significance to study the application of Fe/Cu bimetal and Ag/Cu/Fe in the fields of sewage treatment and environmental pollution remediation.

In this paper, a liquid phase reduction method was used to prepare zero-valent iron-copper-silver nanoparticles with stable and uniform dispersion of poly vinylpyrrolidone and a small particle size, and the representative 2,4-dichlorophenol organic matter of phenols was selected as the target pollution. The effects of Ag/Cu/Fe on its catalytic degradation, reusability and kinetic thermodynamic analysis were systematically investigated.

MATERIALS AND METHODS

Chemicals and instruments

Acetonitrile was purchased from Shanghai Jing Purification Technology Co. Ltd., chromatographically pure , Without any purification treatment before use. All other chemicals used in this study were of analytical grade and were used without further purification.The main instruments include High performance liquid chromatograph (Agilent1260, C_{18})X-ray diffractometer (XRD) (D_8-Focus)) and Transmission Electron Microscope (TEM) (CM12/STEM).

Synthesis of Ag/Cu/Fe NPs

The preparation of iron-copper bimetal is similar to the preparation of zero-valent iron. Under the conditions of continuous stirring and continuous N_2, 0.3M $NaBH_4$ is dropped into 0.1M $FeSO_4 \bullet 7H_2O$ and $CuSO_4 \bullet 5H_2O$ alcohol water mixture. In the solution, after reacting for 30 minutes, the color of the solution changes from light blue to brown, brown and black, and then to black, to obtain Fe/Cu bimetallic particles. The reaction equation is expressed as Vitors and Skive (2008).

$$Fe^{2+} + 2BH_4^- + 6H_2O \rightarrow Fe^o + 2B(OH)_3 + H_2\uparrow \quad .. (1)$$

$$Cu^{2+} + 2BH_4^- + 6H_2O \rightarrow Cu^o + 2B(OH)_3 + H_2\uparrow \quad .. (2)$$

Drop a quantitative $AgNO_3$ solution into the above solution. It is found that golden yellow substance is produced in the solution. Continue stirring for 30 minutes and stop after the complete reaction. A black Ag/Cu/Fe solid-liquid mixture is obtained. The reaction formula is expressed as£°

$$Ag^+ + 2BH_4^- + 6H_2O \rightarrow Ag^o + 2B(OH)_3 + H_2\uparrow \quad .. (3)$$

$$Fe^o + Ag^+ + Ag^o + Fe^{2+} \quad .. (4)$$

The synthesized Fe/Cu and Ag/Cu/Fe nanoparticles are quickly suction filtered and washed with deoxidized absolute ethanol and deionized water for 2 to 3 times to remove excess SO_4^{2-}, NO_3^- and other impurity ions. And then dispersed in deoxygenated deionized water, sealed and put into the glove box for later use.

Degradation experiment of 2,4-DCP

The degradation experiment was carried out in a 20 ml ampoule bottle. Add 10 mg•L-1 of 2,4-DCP solution to a 20ml ampoule, adjust the pH to near neutral, add Fe/Cu particle suspension quantitatively, seal it and put it in a water bath constant temperature shaker to 200r/min. It oscillates rapidly at a speed of min-1, and samples are taken regularly with a syringe. Separate the material magnetically, and study the recycling performance of Ag/Cu/Fe NPs for 3 times, The reaction solution is filtered through a 0.22 μm microporous nylon filter membrane and then analyzed and tested by high performance liquid chromatography.

RESULTS AND DISCUSSION

Material characterization

From the XRD pattern of Fe/Cu, it can be seen that the sharp diffraction peak at 44.7° is the characteristic peak of α-Fe crystal phase, and the diffraction peaks at 2ε values of 50.4° and 74.1° are the characteristic peaks of zero-valent copper. Corresponding to the (200) and (220) crystal planes of cubic copper crystals (JCPDS no.85-1410); no Ag diffraction peak is found at 38.06° in the figure, which may be due to the low silver content (0.2%). It was detected (Fu *et al.,* 2015); no other impurity peaks were found in the figure, indicating that the synthesized Cu/Fe and Ag/Cu/Fe particles have better crystallinity, higher purity, and no oxidation (Luo *et al.,* 2012). The presence of PVP molecules It may inhibit the oxidation of zero-valent metals. The interactions between the CN bond and C=O double bond in the PVP molecule and Fe, Cu/Fe and Ag/Cu/Fe particles play a good protective role (Vitors *et al*., 2008).

It can be seen from Figure 1(c)(d)(e) that Fe-PVP

is composed of spherical particles with a particle size of about 20 nm-40 nm. The particles are attracted to each other by van der Waals and magnetic forces between molecules, forming dendrites (Jafari *et al.,* 2010). The particle size of Cu/Fe-PVP and Ag/Cu/Fe nanoparticles are both 10nm¡«20nm. Compared with the transmission electron microscope image of zero-valent iron, Cu/Fe-PVP and Ag/Cu doped with copper and silver / Fe-PVP particles have a smaller particle size and surface morphology, probably because Cu and Ag have lower surface energy, the introduction of copper and silver atoms reduces the agglomeration between particles and enhances the nanoparticle's water Disperse (Luo *et al.,* 2012).

The magnetic properties of stabilized zero-valent iron and Cu/Fe-PVP and Ag/Cu/Fe nanoparticles were tested at 300K using a vibrating sample magnetometer (VSM, PPMS-9T). It can be seen from Figure 1(b) that the saturation magnetization MS of Fe-PVP, Cu/Fe-PVP and Ag/Cu/Fe-PVP are 42.9 emu/g, 45.7emu/g, and 46.9 emu/g, the coercivity Hc is 188.4Oe, 209.7Oe and 225.9Oe, which are consistent with reports in the literature. Therefore, Fe-PVP, Cu/Fe-PVP and Ag/Cu/Fe-PVP all exhibit strong soft magnetic properties, and the recycling of magnetic research materials has broad application prospects.

The influence of PVP content and copper loading on the degradation of 2,4-DCP

Due to the huge specific surface area and super high reactivity, Fe/Cu is easily oxidized when exposed to air. At the same time, due to the magnetic properties and strong agglomeration of Fe, the practical application of zero-valent metals is greatly restricted [20]. Studies have shown that some organic high molecular polymers such as chitosan, CMC, PEG and PVP can often be used as dispersants for nanomaterials to improve the dispersion of nanoparticles by changing the ion surface charge distribution and the great steric effect of the polymer. PVP is a low-cost, water-soluble non-ionic polymer with both C=O, C-N and CH2 functional groups. It has been widely used for the stabilization of nanoparticles by Zhu, B.W and Lim, (2007). In this study, the polymer PVP was used as a stabilizer for the synthesis of nanoparticles, and the effect of Fe/Cu composite materials (Cu/Fe-PVP) stabilized by PVP in different proportions on the catalytic reduction effect of 2,4-DCP was investigated. The results are shown in the figure. As shown in 2(a). It can be seen from the figure that when the mass of PVP increases from 0g to 0.3g, the degradation rate of 2,4-DCP corresponding to Cu/Fe-PVP increases from 71.6% to 75.4%. The presence of PVP enhances Fe/ The dispersion of Cu particles in water improves the degradation efficiency of 2,4-DCP; if the amount of PVP is increased to 0.5g and 0.8g, the degradation efficiency of 2,4-DCP decreases to 66.2% and 61.8. %. As a water-soluble polymer, PVP has a long molecular chain. There is a strong intermolecular interaction between the CN bond and C=O double bond in the molecule and the

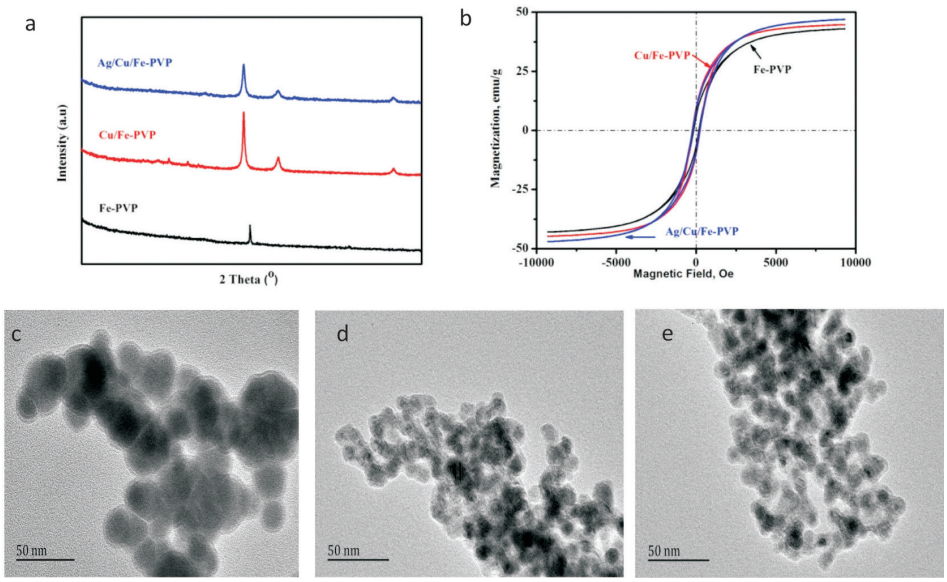

Fig. 1(a). The XRD patterns of Fe-PVP¡¢Cu/Fe-PVP and Ag/Cu/Fe-PVP (b) Magnetic hysteresis loops of Fe-PVP¡¢Cu/Fe-PVP and Ag/Cu/Fe-PVP. TEM image of (c) Fe-PVP (d) Cu/Fe-PVP (e)Ag/Cu/Fe-PVP

nanoparticle, which can produce relatively high molecular weight in the alcohol-water medium. The large steric hindrance effect, and at the same time the negative charge of the amide group in the PVP molecule improves the electrostatic repulsion between the nanoparticles, so as to achieve the effect of stability and dispersion (Wang *et al.*, 2008). Too much PVP easily forms bridging flocculation between the nanoparticles, which is not conducive to their good dispersion and reduces the catalytic activity of the nanoparticles (Jafari *et al.*, 2010). Therefore, the optimal PVP stabilization amount of Cu/Fe-PVP particles is 0.3g. At this time, the catalytic performance of the nanoparticles is the best, and the removal efficiency of 2,4-DCP is also the highest.

Prepare Cu/Fe-PVP nanoparticles with different copper content (0%, 5%, 10%, 50%, 75% and 100%, w%), and investigate the catalytic performance of different materials and the degradation effect on 2,4-DCP. The dosage of Cu/Fe-PVP is 2.0g.L^{-1}, the concentration of 2,4-DCP solution is 10mg.L^{-1}, the initial pH value of the solution is close to neutral, and the result is shown in Figure 2(b). It can be seen from the figure that in the range of 0~50%, with the increase of copper content, the reactivity of Cu/Fe-PVP and the degradation efficiency of 2,4-DCP both increase. When the copper content is 50%, the bimetallic catalyst has the strongest reaction activity, and the removal rate of 2,4-DCP can reach 75.4% when the reaction is 300min at room temperature, and only 38.8% of 2,4-DCP can be Fe-PVP Catalytic reduction; as the copper content continues to increase, the reaction activity of Cu/Fe-PVP decreases. This may be because the surface of the zero-valent iron is loaded with an appropriate amount of copper, which can increase the active sites on the surface of the catalyst, promote the corrosion of the zero-valent iron, and accelerate the dechlorination reaction (Fu *et al.*, 2015); but too many copper atoms cover the zero-valent iron On the surface, the effective active sites for reaction with pollutants are reduced, resulting in a decrease in reaction activity (D.Q. and Lu (2011)). From Figure 2(c) and Figure 2(d), it is not difficult to find that the introduction of copper has significantly enhanced the catalytic performance of zero-valent iron. Compared with Fe-PVP and physical hybrid Cu/Fe-PVP, Cu/Fe-PVP exhibits better catalytic activity, and the reaction rate constants for 2,4-DCP are 0.01504 min^{-1}, 0.01401 min^{-1} and 0.01244 min^{-1}, respectively, because Cu/Fe-PVP is from Faster electrochemical corrosion and electron transfer occurred between iron metal and copper metal, while the electron transfer between physically mixed Cu/Fe-PVP was inhibited, showing a lower

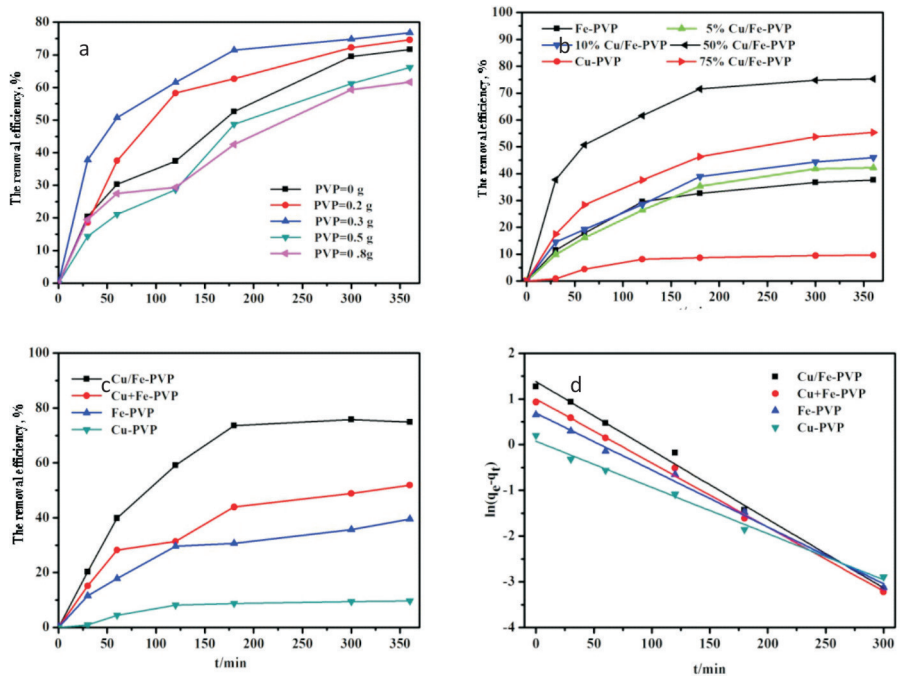

Fig. 2. Effect of (a) PVP concent (b) Cu concent (c) compare of 50%Cu/Fe-PVP and physical mixture of 50%Cu/Fe-PVP (d)50%Cu/Fe-PVP and physical mixture of 50%Cu/Fe-PVP on 2,4-DCP degradation with the fitted pseudo-first-order kinetics

reactivity (Zheng *et al.,* 2009).

The effect of Ag loading on the dechlorination of 2,4-dichlorophenol

Choose 50% copper loading Cu/Fe-PVP nanoparticles, and prepare different silver loading (0.5%, 1%, 2%, 5%) ternary Ag/Cu/Fe-PVP composite materials by reducing $AgNO_3$ solution. Study its catalytic degradation effect on 2,4-DCP, the results are shown in Fig.3. It can be seen from the figure that as the silver loading increases from 0% to 2%, the degradation efficiency of Ag/Cu/Fe-PVP on 2,4-DCP increases significantly, from 75.4% to 81.9% . As an excellent hydrogenolysis catalyst, Ag effectively reduces the agglomeration between nanoparticles, increases the number of active sites, promotes the electron transport and electrochemical corrosion between Fe and Cu, and promotes the effect of nanoparticles on 2,4. The degradation efficiency of DCP (Yang, *et al.,* 2015). Continue to increase the silver loading of Ag/Cu/Fe nanoparticles to 5%, but the degradation efficiency of 2,4-DCP has decreased slightly, to 73.6%. Due to the existence of excessive Ag, the reaction produces excessive H_2, which occupies. The active sites used for the reaction hinder the effective contact of the catalyst with the target pollutants, thereby reducing the catalytic efficiency (Kone *et al.,* 2011). Therefore, this study chose the optimal 2% silver loading Ag/Cu/Fe nanoparticles as the experimental catalyst to study its catalytic degradation effect on 2,4-DCP.

The influence of pH on the dechlorination of 2,4-dichlorophenol

Solution pH is one of the important factors affecting

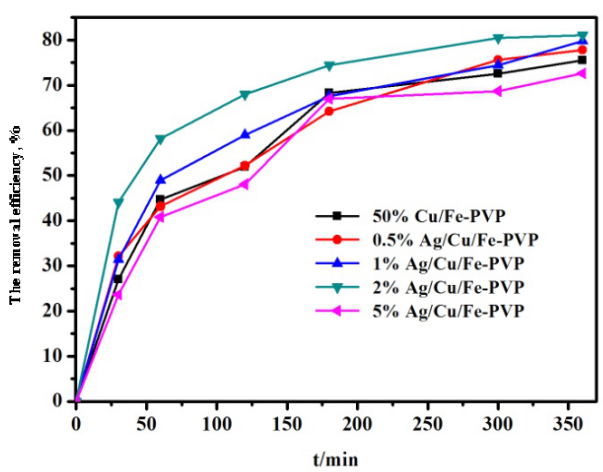

Fig. 3. Effect of Ag concent on 2,4-DCP degradation with silver-copper-iron nanoparticles

the degradation of 2,4-DCP by Ag/Cu/Fe-PVP nanoparticles. In this experiment, 0.1 mol•l^{-1} hydrochloric acid and 0.1 mol•l-1 sodium hydroxide solution were used to adjust the initial pH value of the reaction solution, and the Ag/Cu/Fe- The catalytic effect of PVP particles on 2,4-DCP. As shown in Figure 4(a), the initial pH of the solution has a significant impact on the degradation effect. The acidic environment is conducive to the dechlorination of 2,4-DCP, and the alkaline conditions are not conducive to the progress of the degradation reaction. When the pH value is 3.0, after 360 minutes of reaction, the removal rate of 2,4-DCP in the solution is 87.1%, which is 21.8% higher than the pH value of 9.00 under the same conditions. The presence of a large amount of H^+ in the low pH solution accelerates the corrosion of zero-valent iron, and can maintain a fresh iron surface on the catalyst surface, providing a large number of active sites required for the dechlorination reaction (Joshi *et al.,* 2015). With the continuous progress of the 2,4-DCP degradation reaction, the pH value gradually increased, and a large amount of OH- in the solution and the Fe^{2+} produced after the reaction formed iron hydroxide precipitates and deposited on the surface of the nanomaterials, reducing the 2,4-DCP Effective contact with active sites on the catalyst surface, thereby reducing the degradation efficiency of 2,4-DCP (Hong *et al.,* 2005). This process can be represented by equations (7) and (8).

$$Fe^o + R - Cl + H^+ \rightarrow Fe^{2+} + R - H + Cl^- \quad .. (7)$$

$$2Fe^{2+} + H_2O + R - Cl \rightarrow 2Fe^{3+} + R - H + Cl- + OH^- \quad .. (8)$$

Figure 4(b) describes the pH change during the degradation of 2,4-DCP by Ag/Cu/Fe-PVP nanoparticles. It can be seen in the figure that when the initial pH of the solution is 3.0 and 5.0, the reaction. The pH value of the solution has increased significantly. When the pH value is close to neutral alkalinity, the pH value changes very little and basically remains in a stable state. This may be due to the existence of $Fe^0/Fe^{2+}/Fe^{3+}$, which may consume part of the OH- (Bankar *et al.,* 2010). So that the OH- concentration of the solution is reduced, and the pH value remains constant.

Kinetic/thermodynamic analysis of the catalytic degradation of 2,4-DCP

Catalytic kinetics is one of the important indicators

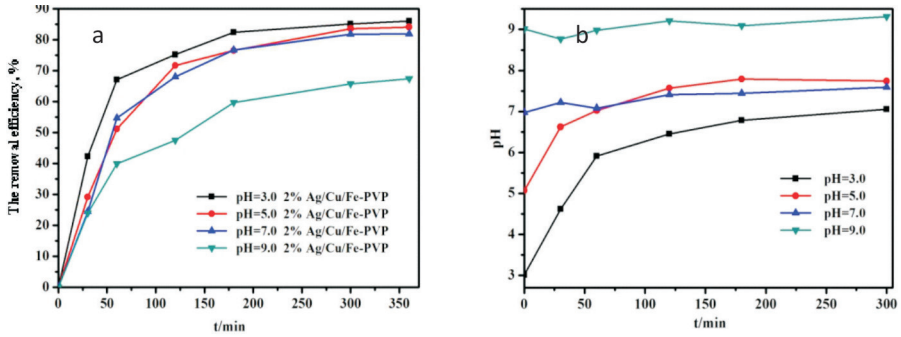

Fig 4. (a) Effect of pH on 2,4-DCP degradation by PVP modified Ag/Cu/Fe polymental nanoparticles (b)pH change curve during degradation reaction

reflecting the catalytic efficiency of a catalyst, and it determines the potential application value of the catalyst to a large extent. The reaction of removing 2,4-DCP by zero-valent metal is a heterogeneous reaction that occurs at the interface. A pseudo-first-order kinetic model can be used to fit the relevant data. The expression of the pseudo-first-order model is as follows (Thi *et al.,* 2011):

$$\ln (q_e - q_t) = -kt \qquad .. (9)$$

Among them, qe and qt are respectively the removal amount of 2,4-DCP at equilibrium and time t ($mg.g^{-1}$), and k is the apparent rate constant of the quasi-first order kinetic model.

Figure 6(a) shows the linear fitting curve of the quasi-first order kinetics for the catalytic degradation of 2,4-DCP by different materials. The experimental results show that at 298K, the apparent rate constants of Fe-PVP, Cu/Fe-PVP, Ag/Cu/Fe-PVP degrading 2,4-DCP are: 0.01065min^{-1}, 0.01504 min^{-1}, 0.01625, respectively min^{-1}. It shows that copper doping improves the catalytic activity of zero-valent iron particles. Compared with Cu/Fe-PVP particles, Ag/Cu/Fe nanoparticles doped with a small amount of silver have higher reactivity and catalytic performance. .

Figure 6(b)(c)(d) shows the change curve and reaction standard of the 2,4-DCP degradation rate of Fe-PVP, Cu/Fe-PVP and Ag/Cu/Fe-PVP at different temperatures. The first-order kinetic fitting curve, as shown in the figure, as the reaction temperature increases from 298K, 308K to 318K, the reaction rate constant of Ag/Cu/Fe-PVP to remove 2,4-DCP from 0.01625 min^{-1}, 0.02149 min^{-1} significantly increased to 0.02377 min^{-1}, compared to 0.01504 min^{-1}, 0.01940 min^{-1}, 0.02080min^{-1} of Cu/Fe-PVP and 0.01065 min^{-1}, 0.01521 min^{-1}, 0.01718 min^{-1} of Fe-PVP has been increased, indicating that high temperature is beneficial to the catalytic dechlorination of 2,4-DCP, and increasing the temperature is beneficial to reduce the reaction energy barrier, increase the number of active molecules and the free movement of molecules, and accelerate 2,4-DCP and The transport of free electrons between nanoparticles promotes the removal of pollutants (Tha *et al.,* 2011).

To a certain extent, temperature affects the rate constant of the degradation reaction. This process can be expressed by the Arrhennius formula :

$$k = Ae^{(-E_a/RT)} \qquad .. (10)$$

E_a is the apparent activation energy ($kJ{\cdot}mol^{-1}$), A is the pre-factor, R is the gas constant 8.314 ($J{\cdot}mol^{-1}{\cdot}K^{-1}$), T is the reaction temperature (K^{-1}), and k is the reaction Rate constant (min^{-1}).

After taking the logarithm of Equation 10, we get:

$$\ln k = \ln A - \frac{E_a}{RT} \qquad .. (11)$$

Using lnk to plot 1/T linearly, the slope of the straight line is -Ea/R according to Equation 11, and the fitting equation is obtained:

$$\ln k = 1.1604 - 1750.4/T \qquad .. (12)$$

$$\ln k = 1.0024 - 1545.3/T \qquad (13)$$

$$\ln k = 0.93181 - 1512.3/T \qquad (14)$$

Equations (12), (13) and (14) are the linear fitting curves of lnk vs. 1/T for the degradation of 2,4-DCP by Fe-PVP, Cu/Fe-PVP and Ag/Cu/Fe-PVP at different temperatures. From the formula, it can be estimated that the activation energy of the catalytic removal of 2,4-DCP by Ag/Cu/Fe nanoparticles is 12.57 $kJ{\cdot}mol^{-1}$, which is lower than the 14.55 kJ·of Fe-PVP and Cu/Fe-PVP. mol^{-1} and 12.84 $kJ{\cdot}mol^{-1}$, the activation energy is lower than the reported 1.23$kJ{\cdot}mol^{-1}$ (13.8$kJ{\cdot}mol^{-1}$) of the Fe/Pd bimetallic

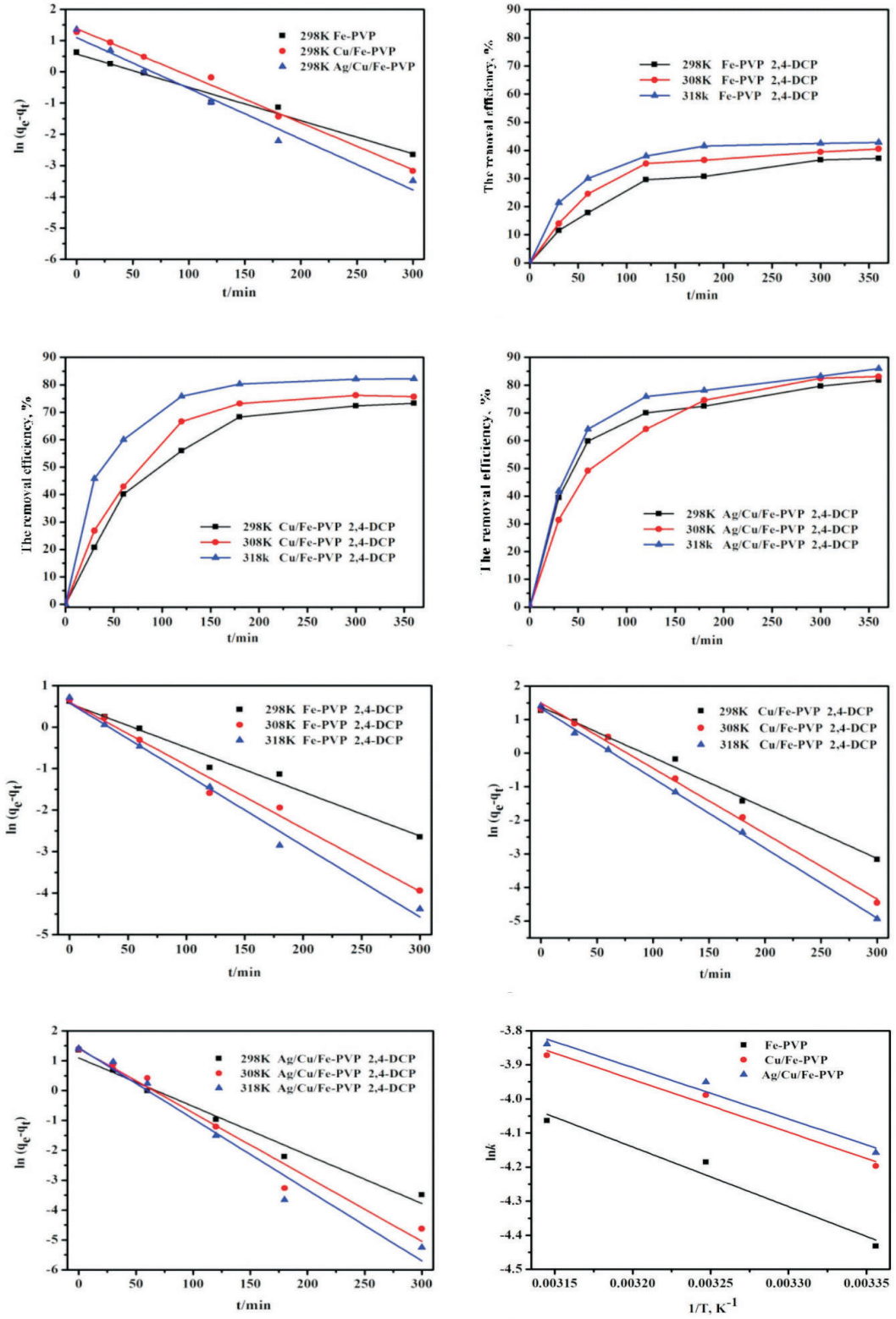

Fig. 6. (a) pseudo-first -order fitting curve for 2,4-DCP degradation by PVP modified Fe0Cu/Fe and Ag/Cu/Fe nanoparticles. The change of degradation rate of 2,4-DCP in (b) Fe-PVP (c) Cu/Fe-PVP (d) Ag/Cu/Fe-PVP. pseudo-first-order fitting curve for 2,4-DCP degradation of (e)Fe-PVP (f)Cu/Fe-PVP (g)Ag/Cu/Fe-PVP at different temperatures. (h)ln*k*~1/T curve of 2,4-DCP degradation with Fe-PVP 0Cu/Fe-PVP and Ag/Cu/Fe-PVP nanoparticles.

system (Fang *et al.,* 2018). The smaller activation energy enables more molecules in the system to be converted into activated molecules under the same conditions. The more the number of activated molecules, the stronger the effective collision between molecules, the faster the intermolecular reaction speed, and the faster the effective contact between the catalyst and the pollutant molecules. The catalyst has a better effect on the removal of pollutant molecules (Si Luo *et al.,* 2010). This also further proves that the introduction of silver metal and copper metal effectively improves the catalytic activity of zero-valent iron particles.

Recyclability

From the perspective of the use cost of the catalyst, the ideal catalyst not only requires good catalytic performance, but also needs to exhibit excellent repeated use performance. Because Cu/Fe bimetal has strong magnetic properties, it is necessary to study its reusability through magnetic separation. The experiment uses the Ag/Cu/Fe-PVP composite material with a silver loading of 2% as the catalyst. The Ag/Cu/Fe-PVP is studied by magnetic separation of the nanoparticles in the solution after the reaction, and 4 consecutive repeated reactions. The recyclable performance of the particles is shown in Figure 7. It can be found from the figure that the removal rate of 2,4-DCP by Ag/Cu/Fe nanoparticles is 81.9% in the first cycle. As the degradation reaction progresses, NZVI will be gradually consumed and lost, and the reaction activity of the Ag/Cu/Fe-PVP catalyst will also decrease with the consumption of NZVI. After another 3 cycles, the 2,4-DCP will be removed. The rate is still more than 80.1%, therefore, Ag/Cu/Fe-PVP material is one of the economical and effective catalysts with good reusability (Sun *et al.,* 2007).

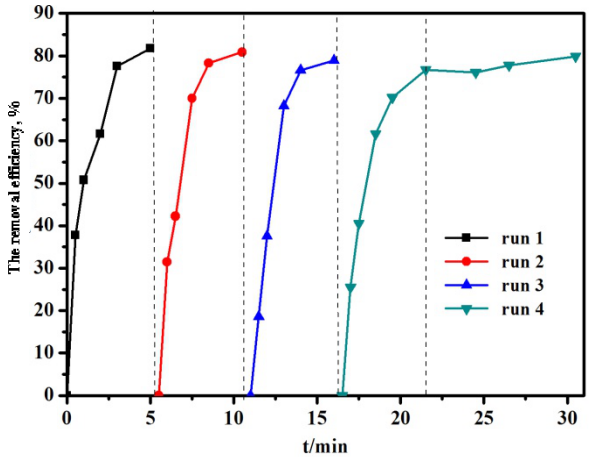

Fig. 7. Recyclability of the PVP modified iron-copper-silver polymental particles

CONCLUSION

In this paper, the liquid phase reduction method was used to successfully obtain Ag/Cu/Fe nanoparticles modified by PVP. The degradation performance, magnetic properties and recycling performance of the Ag/Cu/Fe-PVP nanoparticles were found to be uniformly synthesized. Dispersed in the reaction solution, it can be effectively separated by magnetism before and after the reaction, which has broad prospects for development. Degradation experiments show that Ag/Cu/Fe-PVP can quickly and efficiently remove chlorinated organic pollutants represented by 2,4-DCP, solution pH, temperature, silver loading rate of nanomaterials, etc. have certain effects on the degradation and dechlorination of 2,4-DCP. The degradation reaction is inhibited; the catalytic degradation of 2,4-DCP by Ag/Cu/Fe nanoparticles conforms to the quasi-first-order kinetic model. Temperature has a significant effect on the reaction rate. Increasing the temperature reduces the activation energy of the reaction. It is beneficial to the degradation and removal of 2,4-DCP, lowering the temperature, reducing the number of activated molecules, and reducing the degradation rate of 2,4-DCP. Research on the reusability of the catalyst found that after four consecutive cycles, the degradation rate data of Ag/Cu/Fe-PVP to 2,4-DCP remained basically stable, exceeding 80.1%, indicating that the Ag/Cu prepared in this study/Fe-PVP particles have good catalytic degradation performance and recycling performance, which is a relatively economical and effective catalyst.

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