Experimental Research on Removal of UV$_{254}$ by PFS in Pi River water with low turbidity

Ru-sheng Jia*, Yu-lan Gao

Architecture and Civil engineering College, West Anhui University, Anhui 237012, China

Abstract. Through beaker test, it was analyzed the effect on the removal of turbidity, chroma and UV$_{254}$ in Pi River water with low turbidity by poly-ferric sulfate (PFS). The results showed that it has good effect on removing turbidity and chroma by adding PFS, but it was normal to UV$_{254}$, not exceed 50%, with the increase of PFS dosage, the turbidity and chroma removal trend is similar to that of UV$_{254}$. For turbidity removal, the optimal dosage of PFS was 70 mg/L, and for UV$_{254}$ removal, the optimal pH value range is not neutral, and it is speculated that PFS mainly neutralizes pollutants during coagulation in Pi River water.

1 Introduction

The Pi River main canal is a national strategic high quality water source and also an important drinking water source in Lu’an and Hefei, which is related to the drinking water safety of more than 5 million people in the two cities[1]. However, with the acceleration of urbanization construction and the rise of the central economy, in recent years the water quality has shown slow downward trend.

At present, most of the water supply plants in Pi River basin generally use PAC as coagulant. The enhanced coagulation technology is used to treat the Pi River water, which has good removal effect on turbidity and chroma, but it will lead to increased aluminum content in water, the body's excessive intake of aluminum may cause severe calcium deficiency, and the body's high residual aluminum may cause Parkinson's disease, Alzheimer's disease, hair loss and other diseases[2]. Polymeric ferric sulfate (PFS) is widely used in the field of water treatment due to its advantages of short coagulation reaction time, low price, wide range of pH application, less residual iron ions and good dehydration performance of hydrolysate[3]. Therefore, it is discussed the effect of coagulation treatment by the PFS coagulant for the Pi river water, which are used turbidity, chroma, UV$_{254}$ as the main measurement indicators. It is provided a feasible way for Pi River Basin water production enterprises to cope with the continuous improvement of water quality, and lay a foundation for the study of coagulation mechanism of PFS.

2 Methods

The raw water is taken from the Jiefang south road bridge intake, the water quality as shown in Table 1.

| temperate (°C) | pH  | turbidity (NTU) | chroma | UV$_{254}$ (cm$^{-1}$) |
|---------------|-----|----------------|--------|-----------------------|
| 20~28.9       | 6.9~7.6 | 3~10           | 3.1~20 | 0.048~0.076           |

Instruments: 2100P turbidimeter, HACH company; WGZ-200 colorimeter, Shanghai Xinxin Instrument Co., Ltd.; T6 new century UV spectrophotometer, Beijing Puxi General Instrument Co., Ltd.; MY3000-6F intelligent coagulation test mixer, Wuhan Meiyu Instrument Co., Ltd.; portable pH meter, Taizhou Zhengda science and education equipment factory; FA2204N electronic balance, Shanghai Qinghai Instrument Co., Ltd.

Reagents: poly-ferric sulfate chloride (PFS) performance in Table 2. Other reagents are analytical pure.

It is process used PFS as coagulant, and simulated hydraulic condition. The procedure for coagulation sedimentation test is shown in Table 3.

The superabundant is determined by 2100P turbidimeter. UV$_{254}$ in the water sample is measured by spectrophotometry. The chromaticity was measured by WGE-200 desktop colorimeter. pH value is determined by portable pH meter determination.

Table 1. Raw water quality in Pi river water.
Table 2. Performance parameters of poly-ferric sulfate and poly-aluminum chloride.

| Project       | poly-ferric sulfate  |
|---------------|-----------------------|
| Place of origin | Tianjin dingshengxin Chemical Co., Ltd. |
| Character     | solid                |
| pH            | /                    |
| Iron content/% | 18.5%                |
| Alumina/%     | /                    |
| Salt degree/% | 9.0~14               |
| Pb            | 2.0~3.0              |
| Arsenic       | 0.0008               |
| Lead          | 0.0015               |
| Insoluble matter | 0.5                 |

Table 3. Coagulation test procedures.

| Segment number | speed (r.min⁻¹) | time (s) | dosing conditions |
|----------------|-----------------|----------|-------------------|
| 1              | 400             | 30       | dosing            |
| 2              | 150             | 600      | no dosing         |
| 3              | 80              | 600      | no dosing         |
| 4              | 0               | 1800     | no dosing         |

3. Results and discussion

3.1 Effect of PFS on turbidity reduction, decolorization and organic matter removal

The dosage of PFS is 40-90mg/L, and the effect on the treatment effect is examined as shown in Figure 1.

Figure 1 Effect of PFS dosage on flocculation

It can be seen from Figure 1 that with the increase of PFS dosage, the removal rate of turbidity, chroma and UV254 in Pi River water increases. When the dosage of PFS increases from 30 mg/L to 70 mg/L, the turbidity removal rate increases slowly from 81.88% to 88.05%, the color removal rate increases from 47.86% to 73.54%, and the UV254 removal rate increases from 4.29% to 34.29%. When the dosage was increased to 80 mg/L, turbidity, UV254 removal rates decreased slowly, color removal rate increase, it is because the PFS electric neutralization, which is conducive to the formation and growth of flocs; when the dosage of PFS is small, which can not effectively adsorb more particles in Pi River water. With the increase of PFS dosage, the adsorption sites gradually increase, so the flocculation efficiency gradually increased. In conclusion, when the dosage of PFS is 70 mg/L, the flocculation effect is the best.

3.2 Effect of different raw water turbidity on turbidity reduction, decoloration and organic matter removal

The PFS dosage was 70 mg/L, raw water pH 7.4 and the results are shown in Table 4.

Table 4. Effect of raw water turbidity by adding PFS on coagulation effect

| Raw water turbidity (NTU) | Raw water chroma (cm⁻¹) | Raw water UV254 (cm⁻¹) |
|--------------------------|-------------------------|------------------------|
| 4.99                     | 13.6                    | 0.052                  |
| 7.81                     | 17.3                    | 0.074                  |

| Turbidity of supernatant (NTU) | Chroma of supernatant (cm⁻¹) | UV254 of supernatant (cm⁻¹) |
|--------------------------------|-------------------------------|-----------------------------|
| 1.94                           | 7.2                           | 0.042                       |
| 1.56                           | 7.2                           | 0.043                       |

| Turbidity removal (%) | Chroma removal (%) | UV254 removal (%) |
|-----------------------|--------------------|-------------------|
It can be seen from Table 4 that the raw water turbidity has impact on the coagulation treatment effect. For the coagulant PFS, when turbidity is less than 10 NTU, with raw water turbidity increase, turbidity, chroma and UV$_{254}$ are increased, increased from 61.12% to 80.03%, from 47.06% to 58.38%, and from 19.23% to 41.89% respectively, the removal rate of turbidity and chroma is high, but UV$_{254}$ removal rate is general, which is because that the adjustment of pH is the key to the removal of NOM. When the pH is low, the humus in the water is a kind of humic acid colloid with negative charge which is easy to react with coagulant; when the pH is high, it is transformed into humic acid salt, which increases the ionic property and solubility, so it is difficult to remove$^{[6,15]}$. A large number of surface water treatment studies show that the optimal pH range of ferric salt coagulant is low, generally between 4.5 and 6.0$^{[6-10]}$.

### 3.3 Structural characterization of PFS

The SEM of PFS is shown in Figure. 2

![Figure 2](image)

**Figure 2** structural morphology of PFS

It can be seen from Fig. 2 that PFS is a kind of cloud with branches and interlacing. The surface porosity of PFS is relatively small and smooth, the surface area between molecular particles is small, and the adsorption capacity and bridging net catching capacity are limited. So it is speculated that PFS mainly neutralizes pollutants during coagulation.

### 4 Conclusions

For turbidity removal, the optimal dosage of PFS is 70 mg/L, for UV$_{254}$ removal, the optimal pH value range is not neutral.

It has good effect on removing turbidity and chroma by adding PFS, but it is normal to UV$_{254}$, the removal rate is not exceed 50%. When the dosage of PFS increases from 30 mg/L to 70 mg/L, the removal trend of the turbidity and chroma is similar to that of UV$_{254}$, more than 70 mg/L, turbidity, UV$_{254}$ removal rates decreased slowly, color removal rate increase.

Raw water turbidity has impact on the coagulation treatment effect, when turbidity is less than 10 NTU, with raw water turbidity increase, turbidity, chroma and UV$_{254}$ are increased, and UV$_{254}$ removal rate is general. PFS mainly neutralizes pollutants during coagulation by SEM.

In summary, it can be seen that PFS is an effective inorganic polymer coagulant and it is provided a scientific reference basis for a water plant to deal with low turbidity, high natural organic matter raw water.

### Acknowledgement

This research was funded by university natural science research project in Anhui. No. KJ2019A0621.

### References

1. Zhang Changjun. Some thoughts on water quality safety of Pi River main canal [J]. Water conservancy science and technology and economy, 2014, 20(10): 15-16 (in Chinese).
2. Xu Hui, Jiao Ruyuan, Xiao Feng, et al. Relative importance of hydrolyzed Al species (Ala, Alb, Alc) on residual Al and effects of nano-particles (Fe-surface modified TiO$_2$ and Al$_2$O$_3$) on coagulation process. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 2014, 446: 139-150.
3. Zhang Xiaoshan. Research on Synthesis and Phosphorus Removal Effect of Composite Flocculant PFS-PDMDAAC [J]. Guangdong chemical engineering, 2017, 44(14): 55-56 (in Chinese).
4. Tipping E., Reddy M. M., Hurley M. A Modelling electrostatic and heterogeneity effects on proton dissociation from humic substances. Environ. Sci. Technol., 1990, 24: 1700-1705.
5. Julien F., Gierroux B., Mazet M. Comparison of organic compounds removal by coagulation-floculation on by adsorption onto performed hydroxide flocs [J]. Water Res., 1994, 28:2567-2574.
6. Yan M. Q., Wang D. S., Qu J. H.. Enhanced coagulation for high alkalinity and micropolluted water: The third way through coagulant optimization [J]. Water Res. 2008.42(8-9):2278-2286.

7. Shin J. Y., Spinette R. F., O'Melia C. R.. Stoichiometry of coagulation revisited [J]. Environ. Sci. Technol. 2008, 42(7): 2582-2589.

8. Bond T., Goslan E. H., Parsons S. A., et al. Disinfection byproduct formation of natural organic matter surrogates and treatment by coagulation, MI EX and nanofiltration [J]. Water Res., 2010, 44(5): 1645-1653.

9. Abbaszadegan M., Mayer B. K., Ryu H., et al. Efficiency of removal of CCL viruses under enhanced coagulation conditions [J]. Environ. Sci. Technol. 2007, 41(3): 971-977.

10. Park S., Yoon T.. Effects of iron species and inert minerals on coagulation and direct filtration for humic acid removal [J]. Desalination, 2009, 239(1-3): 146-158.