

The Main Factors Affecting the Migration of Polyacrylamide in Soils

Zheng Chen^{1, a}, Zhou Fangyi^{2, b} and Jing Guolin^{1, c}

¹College of Chemistry & Chemical Engineering, Northeast Petroleum University
Daqing, China

²Nanchang University, School of Resources Environmental and Chemical Engineering,
Nanchang, China

^ajglxueshu@yeah.net, ^bfangyi_zhou@163.com, ^cjglxueshu@yeah.net

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Abstract. With the population and application of polyacrylamide (PAM) in China's tertiary oil, how to deal with residual PAM in soil has become the focus of attention. In this paper, the main factors affecting the migration of PAM in soil were reviewed, and the effects of various influencing factors on the migration of PAM and the mechanism of various degradation reactions were discussed. Which provided important reference and basis for studying the movement and transfer of PAM in soil.

Introduction

Polyacrylamide (PAM), the formula for C_3H_5NO . Is acrylamide homopolymer or copolymer with other monomer content of more than 50% of the linear water-soluble polymer chemicals in general. PAM has a special physical and chemical properties, due to the characteristics of molecular structure. As the unit structure containing amide group, easy to form hydrogen bonds, is an important water-soluble polymer. Polyacrylamide colorless, light yellow viscous colloid, non-corrosive, the temperature is more than 120 °C easy to decompose, flocculation, bonding, thickening and so on. Polyacrylamide itself is non-toxic, but its natural degradation occurs under slow conditions, the formation of polyacrylamide monomer, can cause neurological poisoning. Therefore, the study of polyacrylamide in soil migration and transformation of environmental governance is of great significance.

Polyacrylamide in the field of water treatment has a wide range of applications, raw water treatment, sewage treatment, at home and abroad is still the largest water treatment field of water treatment agent^[1]. PAM can not only be used as flocculant in wastewater treatment, but also can be used for ore and mineral separation, sealing mining pipeline and other purposes. With the popularization of ASP flooding technology, PAM has a very huge application prospect^[2]. PAM is one of the main substances of polymer flooding in tertiary oil recovery technology. At the end of last century, polyacrylamide was injected into the bottom of water injection well by water-soluble polymer to improve oil recovery^[3].

In Daqing oil field development and exploitation, the important component in the large-scale oil displacement agent is polyacrylamide (PAM), the water injection of tertiary oil recovery, by adding high molecular weight linear polyacrylamide to increase its viscosity. In the transportation of crude oil or other fluids, adding a small amount of PAM in the fluid can reduce the resistance^[4]. Extensive use of the important components in the oil displacement agent is polyacrylamide. However, polyacrylamide to improve oil recovery, but also for the ground caused some damage to the project^[5]. The ultimate destination of the excess polyacrylamide in the process of production, transport, use and disposal is the soil. Soil is an important home for human survival, and Daqing oil-based emerging industrial city, the petrochemical industry, the problem of soil pollution is growing. To master the law of PAM soil migration can better control the soil, and ultimately to improve and control the purpose of the soil. Therefore, it is of great significance to study the migration of polyacrylamide in soil and to protect soil ecological environment. It is important to know the pathway and migration law of PAM into the soil of oil field, which can provide the important basis for controlling the contaminated soil and have high application value. In this paper, the effects of three factors on soil migration are discussed: soil type, dissolved salt and soil type.

The Main Factors Affecting the Migration of Polyacrylamide in Soil

The process of polyacrylamide migration in soil environment is quite complex. The whole process can be systematically divided into: PAM into the surface soil, PAM in the soil system between the various phases of the exchange process, PAM in the soil transformation process, PAM in the soil system accumulation process. There are many influencing factors affecting polyacrylamide^[6].

After the PAM enters the soil environment, its migration path is realized by a plurality of processes together, involves various characteristics of PAM, the content of clay in the soil component, the content of organic matter and the porosity of the soil, but the groundwater level below the soil depth, flow, velocity, and soil environmental conditions and many other factors, this adsorption and migration process is very complex. There are many influencing factors affecting polyacrylamide. The main factors affecting the migration of PAM are discussed in the following three aspects.

Effects of soil types on PAM migration. The influence of soil on PAM migration is mainly reflected in the differences of soil texture. The relative proportions of different grain sizes in soil are called the soil texture of soil minerals. Into the interception of environmental pollutants migration and transformation of soil is directly related to soil texture. This is mainly because the adsorption of PAM on soil is confined to the outer surface of the adsorbate, so the size and thickness of soil aggregates can be affecting the amount of PAM adsorption. On the one hand, because the polyacrylamide solution has good dispersibility and the solution is easily captured and adsorbed by the soil colloids, the polyacrylamide molecules easily reach the soil surface and easily adhere to the soil surface; On the other hand, the properties of the soil, the general porous medium adsorption rate depends on the particle outside the diffusion rate and void diffusion rate^[7].

Zhang Xuejia^[8] and other experiments through the indoor soil column to study the number of different units of polyacrylamide and ASP flooding polyacrylamide in the black soil, loess, saline soil in the natural migration behavior, the experimental results show that: quantity of water phase at the same time, under the experimental conditions at the same time, under the experimental conditions water quantity of 110ml PAM, The migration depth of black soil, loess and saline soil was 4 cm, 5 cm and 4 cm, the migration depth was in the order of loess > black soil > saline soil. This is mainly because the saline alkaline soil particles the smallest, bulk density, PAM downward migration is very difficult, under the same conditions, The infiltration time of saline - alkali soil is far greater than that of black soil and loess, and the surface soil can have enough time to absorb PAM.

Effects of dissolved salts on PAM migration. The pH of the soil is generally between 5.0 and 9.0 under normal conditions, the surface of the soil particles is negatively charged, and the surface of the water-soluble anion PAM is also negatively charged. It is shown that the adsorption process is controlled by the electrostatic repulsive force interaction between the soil surface and the polymer surface. The existence of salt electrolyte reduces the repulsive force between PAM and clay mineral surface, and reduces the radius of self-rotation of PAM molecule, thus greatly increasing the adsorption capacity of PAM. According to the basic theory of colloidal chemistry, in order to reduce the electrostatic repulsion of the two particles in aqueous solution, the higher the valence, the more effective. Na^+ , K^+ and Ca^{2+} are the main cations in soil solution. At the same concentration, the divalent cations are more stable than monovalent cations Adsorption of PAM effect better.

Liu Xiao^[9] and other selected by 11 kinds of standard minerals, the size of these minerals crushed to the scope of screening to $50\mu\text{m} \sim 154\mu\text{m}$. A static adsorption experiment was carried out by using 1.0000g mineral and 1:10 solution of polyacrylamide with distilled water at a concentration of $1000\mu\text{g}/\text{ml}$, experiments show that the order of adsorption is gypsum > montmorillonite > kaolinite > chlorite > dolomite > calcite > plagioclase > microcline > quartz. This is because the gypsum in the Ca^{2+} content of polyacrylamide anionic polar groups have a greater attraction, so the largest amount of adsorption in gypsum. Because montmorillonite not only contains divalent ions, the crystal layer is easy to expand, the polymer has a greater attraction, polymer molecules can enter the crystal layer, so its adsorption capacity is also large. The biotite, muscovite and other small surface area, the adsorption mainly by the divalent cations attractiveness. For calcite, dolomite, because it contains Ca^{2+} , but also a strong

adsorption of polymers. Dolomite is relatively easy to precipitate cations, the adsorption is greater than calcite. The less divalent ions in quartz, the smaller the specific surface area, so the weakest adsorption capacity.

Zhu Yanrong^[10] and other amide-brominated cadmium iodide - starch colorimetric spectrophotometric determination of 0 ~ 50mg low concentration range of polyacrylamide in kaolin and montmorillonite adsorption isotherm, The results showed that the adsorption capacity of PAM on clay minerals was greatly enhanced by electrolytes. In Na^+ medium, the adsorption capacities of PAM on two kinds of clay minerals were not very different. In the Ca^{2+} medium, montmorillonite suspended particles produced splitting, in the same concentration, divalent cations than a cation adsorption PAM better effect. This is mainly due to the Na^+ medium, kaolinite and montmorillonite structure stability, the composition did not change much, for the PAM adsorption surface area almost did not change too much; When the cation is Ca^{2+} , the montmorillonite begins to divide, and the number of the units forming each structure begins to decrease, and many new external surfaces are available for PAM adsorption. The composition of kaolin remains the same as in Na^+ . Therefore, in Ca^{2+} , the adsorption of PAM on montmorillonite is much larger than that on kaolinite.

Effects of organic matter on PAM migration. Soil organic matter is a general term for various carbon-containing organic matter in the soil, generally only 1% to 10% of the total solids, the vast majority in the soil surface, It is an important indicator of soil composition and soil formation, and will have a great impact on soil properties. Because the saturation adsorption degree of PAM is related to soil texture and agglomeration, PAM has enough adsorption space to decrease the amount of organic matter destroyed aggregates, and the adsorption capacity of PAM is increased.

Zhu Linyong^[11] and other used amine and phenolic impurities to simulate the organic impurities on the stability of aqueous solution of acrylamide, the results show: Compared with the blank sample under the same conditions, it can be found that triethylamine can promote the decomposition of aqueous solution of acrylic acid at room temperature, so that the solution viscosity is greatly reduced. This is because triethylamine is a kind of active electron donor, prone to and redox reaction of peroxide, the peroxide decomposition at room temperature, the formation of active free radicals to accelerate the polymer oxidative degradation reaction, and thus So that the solution concentration decreased. The content of only 1.0ppm of p-xylene at room temperature, it will lead to degradation of aqueous acrylic acid solution, the solution viscosity decreased, with the increase of the concentration of p-xylene, the degradation rate was accelerated. This is mainly because phenolic compounds often act as antioxidants and improve molecular stability through chain blocking. P-xylene acts as a chain blocking agent by radical deactivation, and in addition, it has a strong reducing action to promote the decomposition of peroxides, and thus also for the redox system of polymerization.

The negative effects of soil organic matter on PAM adsorption are also related to the texture of the soil itself. Wang Hui^[12] and other through indoor artificial rainfall simulation experiment, analyzed the PAM on heavy soil and sand loess slope soil nutrient migration process, The results showed that, compared with the control group, the infiltration rate of PAM in sandy loess soil decreased, the surface runoff increased significantly, the runoff coefficient increased about 113%. PAM increased the runoff phosphorus and runoff loss by 55% and 100% and increased by 4.8 and 1.4 times, on runoff phosphorus and runoff potassium losses in sandy loess sloping land.

Conclusions

It can be seen from the above summary that soil types, dissolved salts and organic matter have an important effect on the migration of PAM in soil. The soil type is mainly due to different size of the adsorption effect caused by different, which have a certain impact on the migration of PAM; The dissolution of salts is mainly due to the different valence of ions, leading to different cation adsorption of PAM different effects; Organic matter in the room temperature will produce free radicals, which lead to redox reactions, accelerate the degradation rate of PAM. The above three aspects can be applied to

the PAM migration, which can be used in the experiment of polyacrylamide degradation in tertiary oil recovery, so as to achieve better treatment and protection of soil.

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