Potassium Ferrate(VI)의 합성과 처리

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Synthesis and Application of Potassium Ferrate(VI)

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1. Introduction

Industrialization have resulted in the introduction of pollutants to the environment. The environmental pollution therefore has an impact on the water resources, which ultimately causes health hazards for the population. This leads to the development of environmentally safe and economically competitive technologies for purifying water. A wide range of coagulants and oxidants/disinfectants can be used for water and wastewater treatment. The most common coagulants used include ferric sulphate, aluminium sulphate, and ferric chloride, and the oxidants/disinfectants used are chlorine, sodium hypochlorite, chlorine dioxide, and ozone.

Ferrate(VI) is an environmental friendly treatment chemical, which has properties such as high stability, oxidizing power, selectivity, and a non-toxic by-product. The iron(VI) derivative, potassium ferrate (VI) (K_2FeO_4) can perform superiorly in degrading various synthetic and natural organic pollutants. This paper demonstrates the potential of using potassium ferrate(VI) for organic compounds. We have compared the power of potassium ferrate(VI) with those of potassium permanganate ($KMnO_4$) and potassium chromate (K_2CrO_4).

2. Experimental

Preparation of potassium ferrate. The oxidation of ferric ion concentrated hypochlorite (NaClO) in strong basic solution (NaOH) can produce Fe(VI) ion which is currently the best method for laboratory scale production of Fe(VI). Then the solution containing soluble Fe(VI) ion is treated by adding excess amount of potassium hydroxide (KOH) in order to obtain potassium Fe(VI) salt, K_2FeO_4. The precipitation of potassium Fe(VI) is possible due to its relative low solubility compared to that of sodium Fe(VI) in strong basic solution.

$2Fe(OH)_3+3NaClO+4NaOH \rightarrow 2Na_2FeO_4+3NaCl+5H_2O$
$2NaFeO_4+2KOH \rightarrow K_2FeO_4\downarrow+2NaOH$

Oxidation of ethanol. 2 g of K_2FeO_4 (10 mmol) were added to 5 mmol of an ethanol in 50 mL of *n*-pentane. The solution was stirred at room temperature, and the reaction was monitored by GC.

Comparison of with conventional oxidants. We have compared the power of potassium ferrate(VI) with those of potassium permanganate ($KMnO_4$) and potassium chromate (K_2CrO_4). To allow a direct comparison of the results, all the reactions were run in cyclohexane (30 mL) at room temperature using 2 mmol of benzyl alcohol , 5 mmol of oxidants (K_2FeO_4, K_2CrO_4, $KMnO_4$). The solution stirred for 3h at room temperature, and the solution was analyzed by GC.

3. Results

Analysis of potassium ferrate. Fig 2. shows two potassium ferrate(VI) specific IR peaks at wave numbers of 324 and 800 cm^{-1}

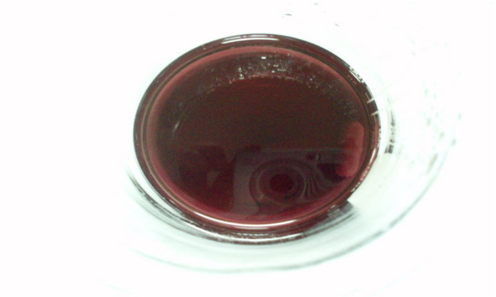

Fig 1. Potassium ferrate(VI) solution

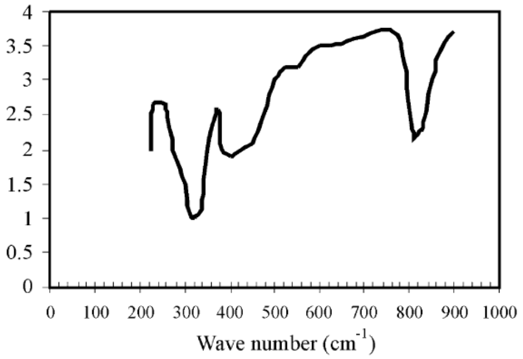

Fig 2. IR Spectrum of potassium ferrate(VI)

Oxidation of ethanol.

run	Ethanol GC yield(%)			
	0.5h	1h	2h	4h
1	32	64	73	81
2	28	63	73	80
3	32	64	72	82
4	33	62	75	80

Table 1. Oxidation of Ethanol by Potassium Ferrate in *n*-pentane

Comparison with conventional oxidants.

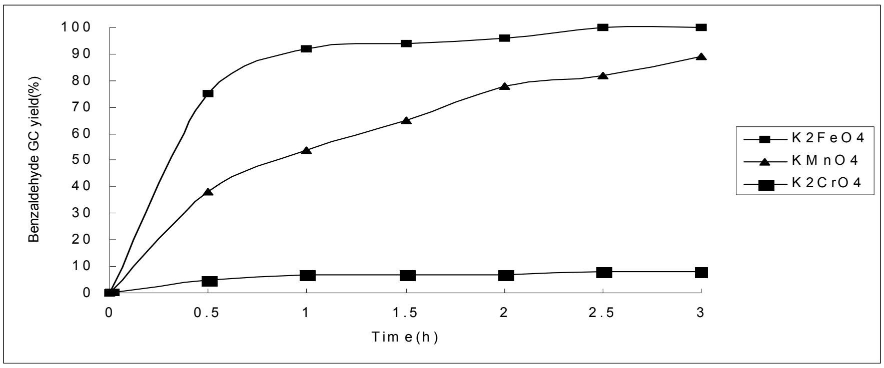

Fig 3. Comparison with conventional oxidants in Cyclohexane

4. Conclusions

Potassium Fe(VI) can be obtained by this method with subsequent re-crystallization from 3M KOH. Although this method provides an easy and efficient synthetic route to potassium Fe(VI), there have been points on a few disadvantages. First, the use of highly concentrated hypochlorite solution generates poisonous and dangerous chlorine gas, In addition, there remains a waste disposal problem of a concentrated chlorine-containing solution. Second, this method requires highly pure reagents because the generated Fe(VI) ion can be easily decomposed to ferric oxide in the presence of even small amounts of impurities(such as, transition metals) in NaOH and KOH reagents (near saturated NaOH and KOH solution are used in this method)

Aqueous solution of ferrate ion has a characteristic red–violet colour. spectroscopy methods for the characterization of ferrate(VI), the infrared (IR) spectroscopy has attracted more attention as it can be used to determine the potassium ferrate either quantitatively or qualitatively. Fig. 2 shows two ferrate specific IR peaks at wave numbers of 324 and 800 cm^{-1}

The oxidation of ethanolmediated by ferrate (FeO_4^{2-}) is discussed. Ferrate is an effective oxidant for the activation of the C-H and O-H bonds of ethanol.

The performance of potassium ferrate(VI) was compared with conventional coagulants. High-valent transition metal oxides such as manganese dioxide (MnO_2), potassium permanganate ($KMnO_4$), potassium chromate (K_2CrO_4) are frequently used for oxidation of organic contaminants in water treatment. However, in addition to their lack in selectivity and difficulty in controlling the conditions, these reagents are corrosive and violently toxic to human beings and to the environment.

In view of ever compelling environmental constraints, it is unacceptable for industrial wastes to contain such highly toxic transition metal complexes.

Ferrate(FeO_4^{2-}), derived from mineral salts such as the potassium (K_2FeO_4) can mediate oxidation of a wide variety of organic compounds with excellent selectivity.

5. References

[1] Takehiro Ohta, Takashi Kamachi, Yoshihito Shiota, and Kazunari Yoshizawa. A Theoretical Study of Alcohol Oxidation by Ferrate. J. Org. Chem. 2001;66: 4122-4131.

[2] Lionel Delaude and Pierre Laszlo. A Novel Oxidizing Reagent Based on Potassium Ferrate(VI). J. Org. Chem. 1996;61:6360-6370.

[3] C. Li a, X.Z. Li a, N. Graham. A study of the preparation and reactivity of potassium ferrate. Chemosphere 2005;61:537–543.

[4] Virender K. Sharma. Potassium ferrate(VI): an environmentally friendly oxidant. Advances in Environmental Research 2002;6:143-156.

[5] Jia-Qian Jianga, Alex Panagoulopoulos, Mike Bauer, Pete Pearce. The application of potassium ferrate for sewage treatment. Journal of Environmental Management 2006;79:215–220.

[6] Lionel Delaude and Pierre Laszlo. A Novel Oxidizing Reagent Based on Potassium Ferrate(VI). J. Org. Chem. 1996;61:6360-6370