Mechanical Engineering, Materials and Information Technology II

Edited by
B. Xu and H.Y. Li

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Preface

2014 2nd International Conference on Mechanical Engineering,Civil Engineering and Material Engineering(MECEM2014) mainly focusing its center on Mechanical Engineering,Civil Engineering and Material Engineering and information technology. The objective of the conference is to provide a forum for different researchers in different fields especially in Material field to exchange their different findings. The researchers are from different countries and in different professionals. The conference will bring all the researchers from all around the world together to share their new findings, thus to promote academic exchanging.

All the papers accepted had been passed the strict peer-review course before their publication by TTP. Here, we should show our sincere thanks to all authors for their high-quality papers and their careful presentations in the conference. At the same time, all reviewers should be thanked too for their careful work. In addition, all sponsors and all team members of TTP should be especially thanked too for their hard work and careful edition on MECEM2014.

It's the joint efforts of all different parts that they makes our conference be successful.

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Study on the Preparation Process of Photocatalysts by the Acidolysis of High Titanium Slag with Hydrochloric Acid

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Keywords: air-cooled titanium-bearing blast furnace slag; the hydrochloric acid; the acidolysis process; the photocatalytic activity; methyl orange

Abstract: The paper preliminary studied the photocatalytic efficiency of the filter residue of the acidolysis of high titanium slag (RAHTS) with hydrochloric acid, and explored the photocatalytic efficiency on the acid methyl orange solution under the mercury lamp irradiation. With RAHTS performing as a raw material to react with hydrochloric acid, and then the substance content, nature and catalytic efficiency of the filter residues were examined by X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR) and photocatalytic reaction apparatus. Through the experimental investigation, the photocatalytic degradation efficiency on the methyl orange of the filter residues increased with the acid-sludge ratio, reaction time, reaction temperature, and the concentration of hydrochloric acid. When the temperature was 100℃, the reaction time was 4 h, the concentration of the hydrochloric acid was 6 mol/L, the acid-sludge ratio was 1, the filter residues showed a best photocatalytic degradation efficiency. Under that experimental condition, the degradation rate was as high as 85.1%.

Introduction

Currently, the utilization of high titanium slag (HTS) is classified into two parts: partial and overall utilizations. The former uses HTS as raw material to refine titanium resources. Although the technique is valid with a low cost and high productivity, the difficulty in purifying products and the high pollution in extraction process should not be ignored [1-3]. The latter overall one is indeed to consider HTS as the whole used for ecological utilization with an aim of both integration and increment but without second-time waste and polluted. As illustrated by our recent works, our groups have reported that the whole of HTS as photocatalysts, and some effect has been obtained with a lot of research [4-11]. Use titanium-bearing blast furnace slag TiO_2 as photocatalytic material instead of pure, which can make full use of our country's existing solid waste, and promote the reuse of energy. Furthermore, it not only reduces the cost of photocatalytic materials, but finds reasonable utilizations for China's accumulation of a large number of HTS. Thus, it achieves the purpose of treating waste by the waste.

It is well known that the photocatalytic activity of photocatalyst strongly depends on the preparing methods and post-treatment conditions, since they have a decisive influence on the chemical and physical properties of photocatalyst. In this work, for the better photocatalytic

efficiency under the condition of mercury lamps, it studied the preparation process of photocatalysts by the acidolysis of HTS with the photocatalytic effect of filter residue as indicators, and controlled variables to come up with the optimal photocatalytic effect and conditions of acidolysis.

1. Experimental procedure

1.1. Materials

HTS from Panzhihua Iron and Steel Corporation was used in this study. The composition of HTS is shown in Table 1. In the preparation of HTS powder, pretreat 200 g HTS with artificial sampling. HTS were broken into pieces; the resulting shatters were then crushed finely by mortar until the uniform particles were obtained; subsequently, the particles were milled in the high-energy ball mill for 48 h; after pulverizing, all of powders were screened with 200 mesh sieve, and unqualified powders were milled again. The resulting samples were detected by laser particle sizer.

Table 1 The composition of HTS (wt %)

TiO_2	SiO_2	Al_2O_3	P_2O_5	∑Ca	∑Mg	∑Fe	∑S	∑Mn	∑V
19.23	24.74	13.64	0.016	17.8	3.72	1.78	0.47	0.399	0.137

1.2. Experimental procedure and analytical methods

First of all, the 50 ml conical flask was placed in the water bath, and then fixed by clamps. Temperature probe was put into the water bath injected the right amount of water. Measure a certain volume, mass and concentration of hydrochloric acid, which were added into the conical flask. When the temperature of the thermostat water bath rose to the set value, add the HTS into the conical flask at a certain acid-sludge ratio. After a certain reaction time, the resulting products were washed with water and dried through filtration in vacuum. According to the different experimental conditions, which included the reaction temperature, the reaction time, the acid-sludge ratio, the concentration of hydrochloric acid, the optimum reaction conditions were determined with the testing of the phase.

Photocatalytic irradiations were carried out in a recirculating reactor equipped with a quartz immersion well, where a 500 W medium-pressure mercury lamp was placed (emitting mainly in the range of 300-580 nm). The crystal structure identification of RAHTS obtained by using Philips X'pert X-ray diffractormeter with Cu Kα radiation and Fourier transform infrared spectroscopy. UV-vis spectra were obtained by employing a UV-2550 spectrophotometer.

2. Results and discussion

2.1. Phase analysis

The XRD and FTIR patterns of RAHTS catalysts are shown in Fig 1 and Fig 2, respectively. The diffraction pattern reveals that RAHTS catalysts are identified to be a mixture of perovskite and diopside [12]. Maximum deviation of the observed peak value corresponding to 33.11° denotes the formation of perovskite. From Fig 2, it is believed that the broad peaks at 3421 cm^{-1} and 1637 cm^{-1} correspond to the surface adsorbed water and hydroxyl groups. This gives us the indication of the presence of free hydroxyl groups of the prepared samples. In the photocatalytic reaction, the more surface hydroxyl groups of the materials, the more conducive to produce more hydroxyl radicals and improve the photocatalytic activity. Another peak near 462 cm^{-1} could attribute to the typical Ti-O-Ti vibration [13]. The peak at 1093 cm^{-1} corresponds to silicate in diopside [13]. The result is just consistent with XRD analysis result.

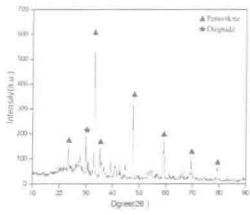


Fig 1 XRD patterns of RAHTS catalysts

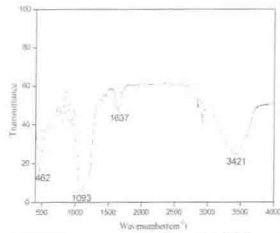
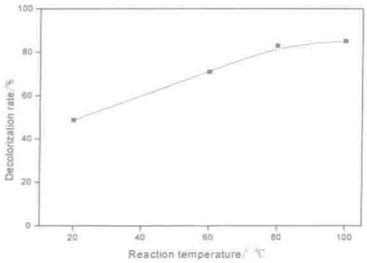


Fig 2 FTIR patterns of RAHTS catalysts

2.2. Effect of the reaction temperature on the acidolysis

Fig 3 shows that the temperature has a tremendous impact on the reaction of the process of the acidolysis. As the temperature rises, the decolorization rate is enhanced gradually, which indicates the photocatalytic efficiency of the RAHTS is strengthened till the temperature reaches 100℃. But when the temperature is higher than 100℃, it changes little. The main reasons for this phenomenon were that the leaching rate of $TiCl_4$ in the high titanium slag rose firstly and then declined with temperature increasing. However, when the reaction temperature reached 100℃, there appeared a large number of precipitation because of the reduction of the Ti^{4+} caused by the hydrolyzation of $TiCl_4$. So it can be concluded that the acidolysis of HTS worked best when the reaction temperature was 100℃.



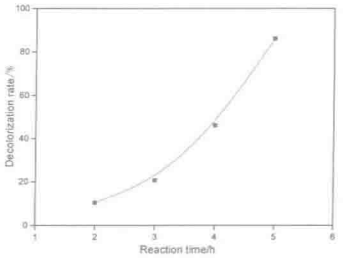


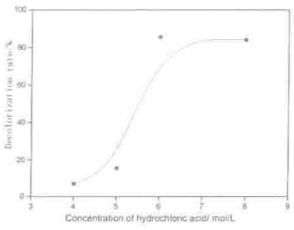
Fig 3 Effect of the reaction temperature on the acidolysis Fig 4 Effect of the reaction time on the acidolysis

2.3. Effect of the reaction time on the acidolysis

It is evident from the Fig 4 that the decolorization rate of the solution is gradually enhanced with reaction time increasing. Moreover, the effect of the decolorization is strongly abvious when the reaction time is 4 h. This fact could be attributed to the concentration of hydrochloric acid. At the beginning of the reaction, the generation rate of the $TiCl_4$ was faster than its rate of hydrolysis under the high concentrations of acid solution, causing the leaching rate increased gradually. With increasing the reaction time, the hydrolysis of $TiCl_4$ dominated the overall reaction with the low concentration of the acid, resulting in the decrease of Ti^{4+} in the solution. After 4 h, the leaching rate of TiO_2 had been low and gradually became balanced. Therefore, the optimal reaction time was 4 h.

2.4. Effect of the concentration of hydrochloric acid on the acidolysis

The decolorization rate under the different the concentration of hydrochloric acid are illustrated in Fig 5. Along with the increase of the concentration, the decolorization rate increases step by step. But it can be seen that the acidolysis of HTS does not change significantly when the concentration of acid solution is 6 mol/L, mostly because the high concentration solution would inhibit the hydrolysis of Ti^{4+} though, it would go against the separation of components of other impurities. On the contrary, when the concentration was lower than 6 mol/L, the reaction with the hydrochloric acid was imbalance and inadequate. Thus, it was obvious the concentration of 6 mol/L was most appropriate in the pretreatment of the acidolysis.



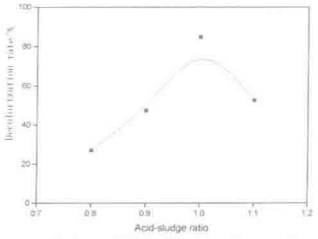


Fig 5 Effect of the concentration of hydrochloric acid on the acidolysis

Fig 6 Effect of the acid-sludge ratio on the acidolysis

2.5. Effect of the acid-sludge ratio on the acidolysis

From the Fig 6, it can be seen that the acid-sludge ratio has a great impact on the reaction. When the acid-sludge ratio falls below 1.0, the decolorization rate rises gradually. In contrast, the rate comes down under the conditions of the higher acid-sludge ratio (>1.0). In theory, it can be calculated that 100 g HTS are leached by 110 g hydrochloric acid, assuming that CaO, MgO, Al_2O_3 and other oxides could react with hydrochloric acid completely. In other words, the theoretical acid-sludge ratio is 1.1. However, the normal ratio was lower than that actually due to the inadequate reaction. In addition, if the acid-sludge ratio was too small, it would strongly result in the incomplete reaction. As is shown in the figure, the best results would be obtained with the acid-sludge ratio of 1.0.

3. Conclusions

The diffraction pattern reveals the formation of perovskite in RAHTS catalysts. Maximum deviation of the observed peak value corresponding to 33.11° denotes the formation of perovskite.

According to the different experimental conditions, the optimum reaction conditions can be determined. And with the increase of the concentration of hydrochloric acid and the acid-sludge ratio, the decolorization rate of methyl orange increases obviously and thereafter (> 6 mol/L or the acid-sludge ratio > 1.0) it decreases slightly. With increasing the reaction temperature and reaction time, the decolorization rate of methyl orange increased obviously. Overall, when the reaction time is 4 h, the reaction temperature is 100℃, the concentration of hydrochloric is 6 mol/L, the acid-sludge ratio is 1.0, the pretreatment of the acidolysis has best effect.

Acknowledgements

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Preparation of acrylated epoxidized soybean oil with excellent properties

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Keywords: Epoxidized soybean oil; Acrylated epoxidized soybean oil; UV curing; Low viscosity

Abstract. In this paper, a kind of abundant and environment-friendly material—epoxidized soybean oil (ESO) was chosen to be esterified with acrylic acid to produce acrylated epoxidized soybean oil (AESO). By studying the influence of various factors including feed rate, reaction temperature, feed ratio, catalyst and inhibitor on the reaction, we got the optimal synthesis conditions: feed ratio is 1.25:1; reaction temperature is 120°C; feeding time is about 2.5h;the dosage of the inhibitor(TBC) is 0.15 % and the catalyst (Triphenylphosphine oxide) is 1.5 %. The AESO we prepared has low viscosity, low skin irritation, excellent pigment wetting characteristics and so on. It can also be widely used in the manufacture of coating, printing ink, paint, etc.

Introduction

In recent years, due to the shortage of energy, people's awareness of environmental protection is continuously enhancing. At the same time, preparation of new materials using natural renewable resources becomes a research hotspot in the field of materials in the world. Among them, vegetable oil has drawn greater attention in the coatings industry recently. Especially soybean oil, because its price is relatively stable, it is a good choice whether from the strategy of sustainable development, or from the economic cost considerations. American Soybean Association annual set aside tens of millions of dollars earmarked to fund the comprehensive utilization of soybean oil [1]. Because of its biodegradability and low cost, AESO will get more extensive application in the fields of UV-curing coatings, biodegradable foam and composite materials [2]. Therefore, light-colored and low viscosity AESO suitable for practical application will be the focus of future research and development [3].
Acrylic acid as the ring-opening reagent to be esterified with ESO, then got AESO. It has low viscosity, low skin irritation, excellent pigment wetting characteristics and so on. Because of its molecular chain is aliphatic structure, it can significantly improve the UV coating flexibility and adhesion [4-5]. AESO cured film also has a slow rate of assimilation, strong adhesion, low hardness, good thermal stability and other characteristics. These advantages make the AESO can make up for the disadvantages of high viscosity biphenyl-A type epoxy acrylate, which needs large amount of reactive diluents and possesses poor curing film flexibility. Research on AESO coatings is very active at china and abroad, American company UCB has started commercial production, such as Ebecryl860 [8-10]. The purpose of this paper will study the process conditions of synthesizing AESO,while exploring the optimum technological conditions for preparation of light color AESO.