Adsorption of Ultra-High Crosslinked Resin on Waste Water from Benzoic Acid and Sorbic Acid

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Abstract

Aiming at the simulated production wastewater of benzoic acid and sorbic acid, the adsorption and desorption resource recovery system of ultra-high crosslinked resin ZH-01 was designed and developed, and the influence of ZH-01 on the removal of benzoic acid and sorbic acid production wastewater was studied. The results showed that the removal rates of benzoic acid and sorbic acid were 94.74% and 94.9%, respectively, and the removal rate of CODcr was as high as 91.2%. In addition, the adsorption properties of ZH-01 on benzoic acid and sorbic acid were investigated. When sodium hydroxide was used for resin desorption, the effects of temperature, desorption agent ratio and desorption velocity on resin desorption were investigated. Benzoic acid and sorbic acid were recovered to the maximum extent, and the recycling of benzoic acid and sorbic acid in waste water was realized.

Keywords Ultra high crosslinked resin ZH-01; Simulated production wastewater with benzoic acid and sorbic acid; Resource recovery.

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1. Introduction

Benzoic acid and sorbic acid, is acknowledged as the toxicity and the lowest in the world's most widely used food preservatives [1-3], which primarily by inhibiting the growth of microorganisms which have the effect of antiseptic, also is widely used in the pharmaceutical and dye. Emission levels of benzoic acid and sorbic acid wastewater will produce serious pollution to the environment, at the same time produce certain harm to the health of human beings, not only more biological produce certain effect of environments [4-6]. Therefore, reasonable and efficient with benzoic acid and sorbic acid wastewater treatment in the wastewater treatment is particularly important and urgent. In this study, the optimal resin adsorption conditions of benzoic acid and sorbic acid wastewater were optimized [7-9] to systematically study the adsorption conditions and influencing factors of ultra-high crosslinked resin on benzoic acid and sorbic acid. According to the optimal adsorption conditions, the adsorption effects of ultra-high crosslinked resin on benzoic acid and sorbic acid were determined. At the same time, the optimal resin desorption conditions were studied.

2. Experiment

2.1 Pretreatment of resin

It was placed in a beaker for ultra-high crosslinked resin of ZH-01, and it was soaked with anhydrous ethanol, and was extracted with soxhlet extractor for 7 ~ 8h. Then it was vacuum dried at 333K for 4h, and was followed by leaching resin with 4%HCl and 4%NaOH for 3h, respectively.

2.2 Selection of measurement wavelength

Accurately according to benzoic acid and sorbic acid 0.2000 g each ,it was prepared for 200.0mg• L^{-1} solution in a volumetric flask with a constant volume of 1000mL, and the maximum absorption wavelength was determined.

2.3 Standard curve drawing

Benzoic acid and sorbic acid solutions with concentrations of 200.0 mg• L^{-1}, 400.0mg• L^{-1}, 600.0 mg• L^{-1}, 800.0 mg• L^{-1} and 1000.0 mg• L^{-1} were prepared, respectively, for 100.0mL. The absorbance is then measured at wavelength lambda 225nm and 255nm to produce the standard curve for benzoic acid and sorbic acid solutions [14].

2.4 CODcr determination

According to the national standard $K_2Cr_2O_7$ method, the CODcr of all adsorbed and desorbed solutions was determined [15].

2.5 Dynamic adsorption of resin

At room temperature, benzoic acid and sorbic acid solutions were passed through the adsorption column containing 5.00mL ZH-01 resin at a certain flow rate to measure the concentration of benzoic acid and sorbic acid of each grade in the effluent. The dynamic adsorption curves of benzoic acid and sorbic acid were made respectively, and the optimal adsorption process conditions were determined.

2.6 Resin desorption conditions

The desorption conditions of adsorbed saturated resins were tested under the conditions of different proportion of ingredients, different temperature and different flow rate, so as to determine the best process conditions for desorption.

3. Results and discussion

3.1 Maximum absorption wavelength

The maximum ultraviolet absorption wavelength of benzoic acid and sorbic acid was determined by 1.2 method, as shown in Fig. 1-2.
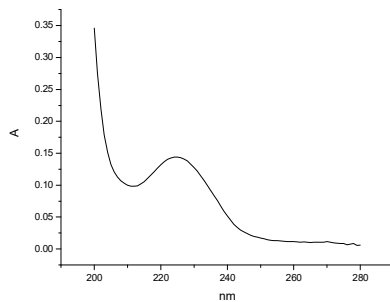

Fig.1 Ultraviolet absorption curve of benzoic acid
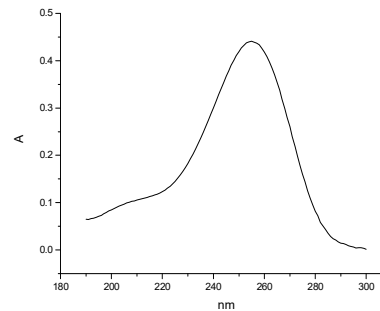
Fig. 2 Ultraviolet absorption curve of sorbic acid

3.2 Standard curve drawing

The standard curve of benzoic acid and sorbic acid solution was determined by 1.3 method, and the corresponding standard curve was drawn, as shown in Fig. 3-4. The curve was fitted by the least square method, and the standard curve equation was obtained. The standard curve equation of benzoic acid is $y=0.0671x+0.0087$, $R^2=0.9998$. The standard curve equation of sorbic acid was $y=0.2148x+0.0072$, $R^2=1.0000$.
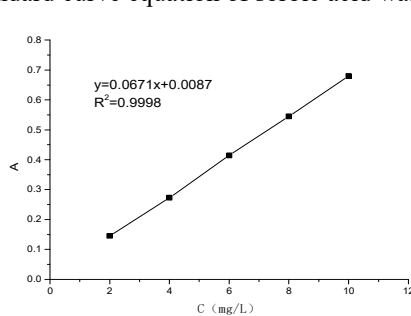

Fig.3 Linear relationship between benzoic acid concentration and absorbance
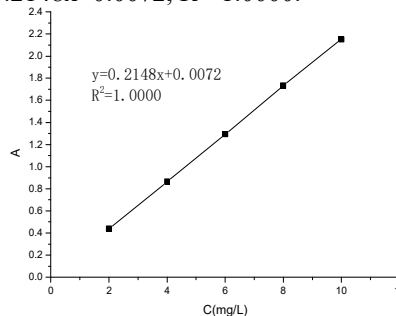
Fig.4 Linear relationship between sorbic acid concentration and absorbance

3.3 Influence of flow rate on dynamic adsorption of resin

The dynamic adsorption experiments were carried out at the flow rates of 2BV/h, 4BV/h and 6BV/h according to the 1.5 method. The dynamic adsorption curves of benzoic acid and sorbic acid at different flow rates were determined by UV. See Fig.5-6 for their dynamic adsorption curves. It can be seen from Fig. 5-6 that the adsorption capacity of the resin will increase with the slow adsorption flow rate of waste water, and the treated waste water will also increase. This is because the benzoic acid and sorbic acid molecules can fully conduct membrane diffusion and particle diffusion with the resin bed as the flow rate of waste water slows down. In addition, the above dynamic adsorption data were also tested for CODcr by 1.4 method, and the dynamic adsorption curve was shown in Fig. 7. As can be seen from Fig. 7, with the difference of adsorption velocity, CODcr in wastewater also presents a certain degree of change. Therefore, a moderate adsorption flow rate of 4BV/h was selected based on the above conditions.
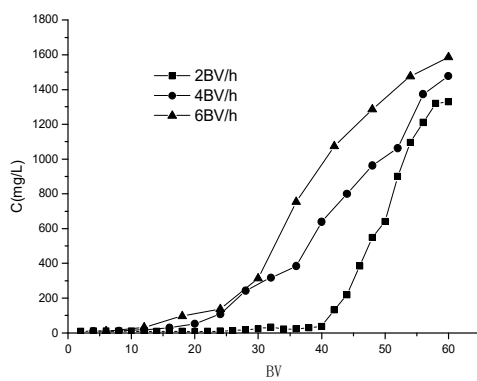
Fig. 5 Dynamic adsorption curve of benzoic acid
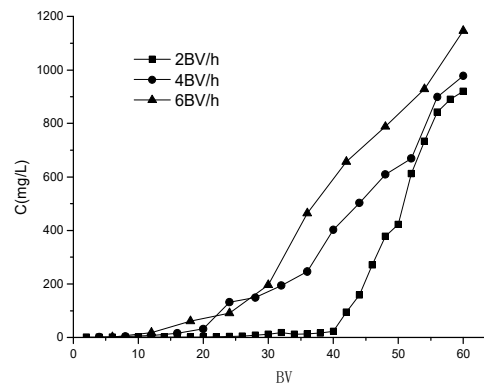at different flow rates

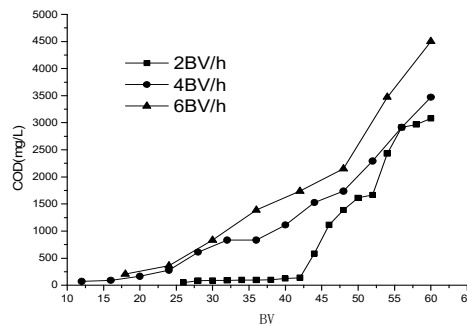Fig. 6 Dynamic adsorption curve of sorbic acid
at different flow rates

Fig.7 CODcr change curves at different flow rates

3.4 Determine the wastewater treatment capacity

The temperature is 25℃, the velocity of 4 BV/h solution through attached under the condition of constant temperature circulating water jacketed adsorption column, from top to bottom to make it through the adsorption resin layer, to stop the adsorption initial concentration 5%. The dynamic adsorption curve of the resin was shown in Fig. 8. According to figure 8, when the wastewater treatment capacity of resin reaches about 10BV, the adsorption rate of benzoic acid and sorbic acid can reach 94.74% and 94.9% respectively. Meanwhile, the removal rate of CODcr reached 93.2%. Therefore, we can conclude that the better treatment capacity of ZH-01 resin for wastewater containing benzoic acid and sorbic acid is 10BV.
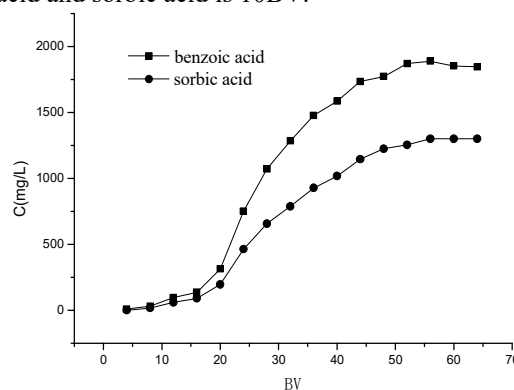

Fig. 8 Dynamic adsorption curves of ZH-01 resin for benzoic acid and sorbic acid

3.5 Influence of desorption agent flow rate on resin desorption

Under the condition of 45℃, with 8% NaOH as stripping agent, respectively by BV/h 1, 2, BV/h, 3 BV/h of stripping experiment was carried out on the resin flow velocity, and the stripping curve as shown in Fig. 9, as shown in figure 10 and figure 11. As can be seen from Fig. 9 -10, the desorption velocity is the best at 2BV/h, and as can be seen from fig.11, the removal rate of CODcr is also the highest at 2BV/h. Therefore, taking the above factors into consideration, the 2BV/h velocity is adopted for desorption.
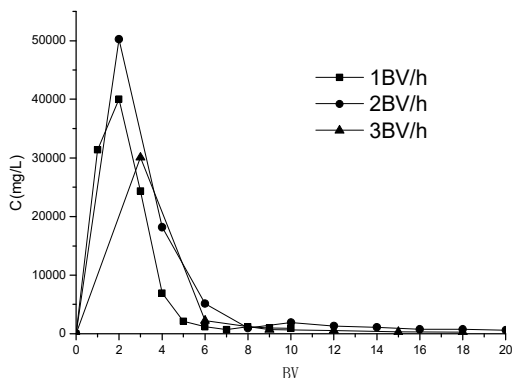
Fig.9 Desorption curve of benzoic acid
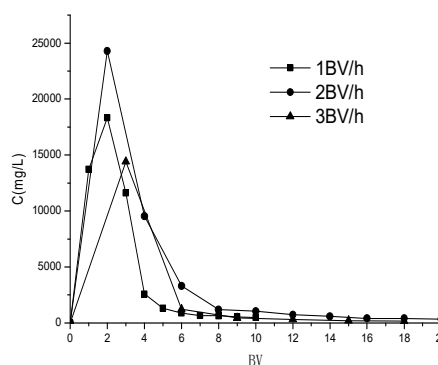at different flow rates

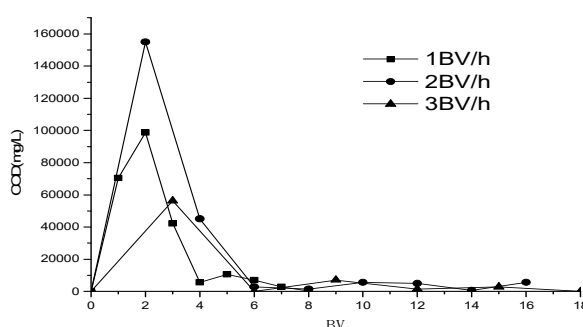Fig. 10 Desorption curves of sorbic acid
at different flow rates

Fig.11 Changes of CODcr at different flow rates

3.6 Influence of desorption temperature on dynamic desorption of resin

With 1 BV/h stripping velocity, with 8% NaOH solution as resin stripping agent, in 30℃,45℃ and 60℃ under three different temperature dynamic stripping experiment, stripping curve as shown in Fig. 12-14. Fig. 12-14 showed that rise in the temperature of the stripping become more concentrated, and useful ZH-01 resin regeneration performance is good. This is because the stripping process is an endothermic process, to improve the temperature of the stripping, can make stripping agent molecules of the resin micro channel, increased resin pore benzoic acid and sorbic acid molecules and stripping agent molecules collide, is advantageous to the reaction, so you can choose the best temperature of 60℃ as stripping.
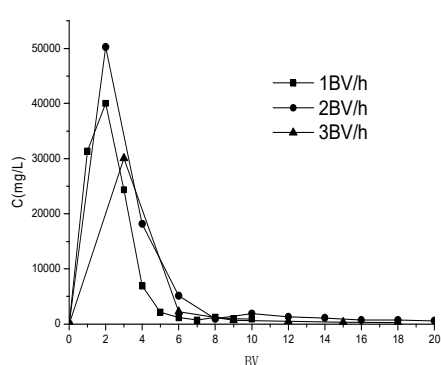

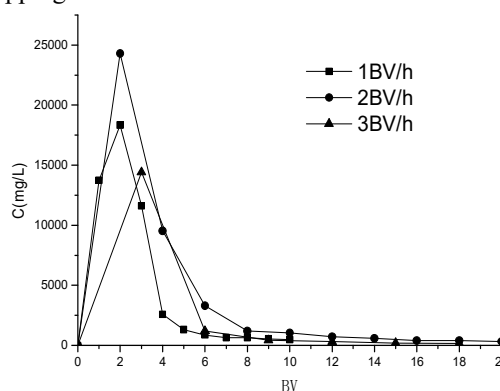Fig. 12 Desorption curves of benzoic acid
at different temperatures

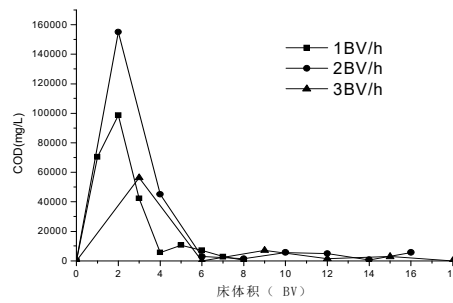Fig. 13 Desorption curves of sorbic acid
at different temperatures

Fig. 14 Changes of COD at different temperatures

3.7 Influence of the ratio of desorption agent on the resin desorption performance

This experiment chooses dilute NaOH solution stripping was studied for the resin, the flow rate of 1 BV/h, under the condition of temperature 45 °C, respectively by 2% NaOH solution and 4% NaOH solution and 8% NaOH solution as stripping agent, ZH-01 resin for adsorption of benzoic acid and sorbic acid solution has been saturated with useful ZH- 01 resin stripping experiments, stripping curve as shown in Fig.15 - 17. It can be seen from Fig.15 and Fig. 17 that 8% NaOH solution as a desorption agent has a good desorption effect on benzoic acid and sorbic acid.
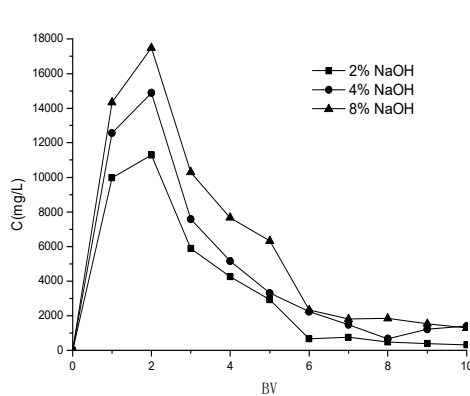

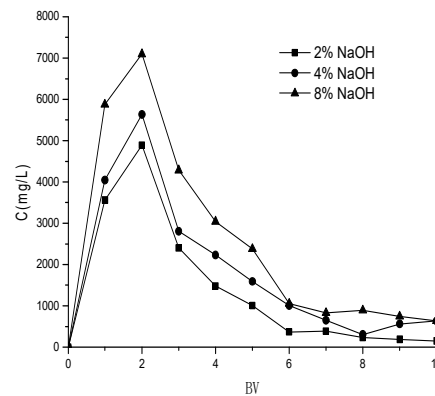Fig.15 Desorption curve of p-benzoic acid with different desorption ratios

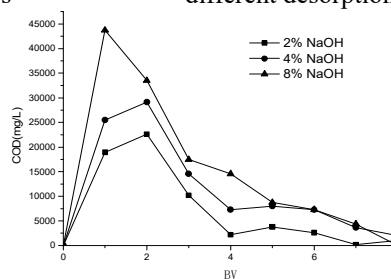Fig. 16 Desorption curves of sorbic acid with different desorption ratios

Fig..17 Change curve of CODcr with different proportion of desorption agent

4. Conclusion

The CODcr of the original water sample containing benzoic acid and sorbic acid was 19115mg/L, the average adsorption rate was 94.05% when the water sample was treated with ZH-01 resin to reach 10BV, and the CODcr of the outflow water sample was reduced to 1684mg/L, so the removal rate of CODcr reached 91.2%. When NaOH is used as resin desorption agent, the final average desorption rate can reach 95.3%. ZH-01 resin not only has good adsorption and desorption performance, but also can get high concentration of benzoic acid and sorbic acid, which has achieved the purpose of separation and recovery, and the recovery and utilization of resources. Processing conditions are as follows: Absorption: the amount of waste water processing 10 BV/batch, and waste water flow rate is 4.0 BV/h, the temperature is 25℃. Stripping: stripping agent and the use of 8% NaOH solution, velocity of flow control in 2.0 BV/h, the temperature at 45℃, optimization of adsorbent in about 10 ml volume. Through the above simulation experiment, we can apply it to the treatment of benzoic acid and sorbic acid production waste water, and at the same time recover high concentration of benzoic acid and sorbic acid, so as to realize the recycling of resources, and provide sufficient theoretical basis for enterprises.

Acknowledgement

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