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Research on Adsorption Material for Organic Solvent Floating on the Water

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Abstract: Based on short of effective disposal measure for organic solvent leakage, this paper developed a kind of styrene-divinybenzene copolymer that can absorb massive organic solvent such as benzene on the water, and it contains a great deal of benzene ring, has good hydrophobic and lipophilic property, what's more, it has lower density than water and thus floating on the water before and after adsorption, easily separating from water, so it is a kind of perfect adsorption material of organic solvent like benzene at leakage case on the river. Besides, this paper discussed synthesis temperature, feeding proportion and water containing, obtaining optimal synthesis conditions, so max. adsorption amount for benzene on the water can be reached 25mg/l at this optimal conditions.

1 Preface

Benzene is a kind of dangerous chemical having flammability, explosion of its vapour, heating dilatancy, fluidity and toxicity. In the process of production, storage, transportation and use, accidents such as fire, explosion or toxicity easily happen if leakage occurs, which leads to big property loss, personal injury and death. When leakage occurs on the river, and if we don't take action against this leakage, such pollution may bring about a time of impact on water environment. At present, we still have not seen a palatable solution to the problem so far, so it is necessary to develop a kind of material that can absorb a mass of liquid benzene[1,2]. The following three performances for such material can be reached, firstly, it must absorb a mass of liquid benzene; secondly, it must be highly hydrophobic, otherwise, the material that absorbs benzene can mix with water and they can not be separated effectively; thirdly, the material must be easily separated from water, which makes simpler of the follow-up treatment step.

Styrene-divinybenzene copolymer is a type of material to fit the above requirements, it structure as shown in fig.1. First of all, from the structure view, copolymers with porous structure, especially with massive benzene ring, have noticeable effect to benzene adsorption; secondly, such type of copolymer has excellent hydrophobicity; furthermore, this material has a lower density than water, floating on the surface of water before and after the adsorption, very suitable for adsorption benzene on the water. As a result, we took a study on this material, investigating various factors including synthesis conditions, adsorption law of benzene etc., conducting a series of adsorption experiments for benzene on the water.

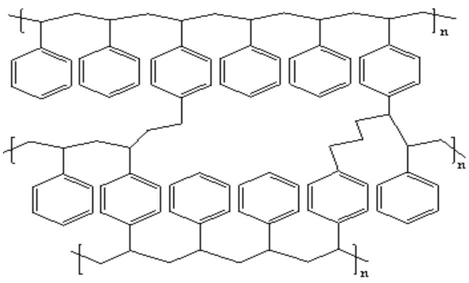

Fig. 1 Structure profile of styrene-divinybenzene copolymer

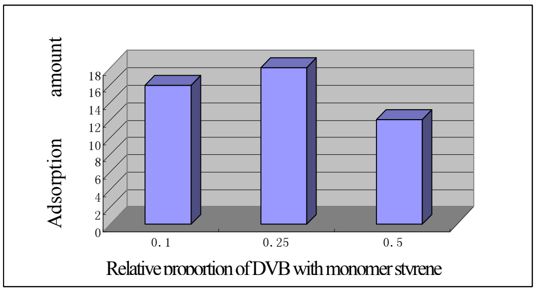

Fig. 2 Effect of relative proportion of DVB with monomer styrene on adsorption amount

2 Investigation on synthesis method and optimal synthesis conditions

2.1 Synthesis method

The following is the synthesis method of three steps for this copolymer:

1. Styrene and divinybenzene as monomer, azobisisobutyronitrile as initiator and diethylene oxide as solvent and template agent in fixed proportion, are stirred at room temperature for a certain time to make intensive mixing;

2. All the above reactants are put into reaction still and reacted within a specified time at a certain temperature;

3. Crude product can be got from the reaction still, and final product is obtained after dried at room temperature in a vacuum.

2.2 Investigation on the optimal synthesis condition

In this experiment, evaluation standard of material performance is the benzene adsorption amount of this material. Use the following way to measure the amount and rate of benzene adsorption: The conical flask with the plug as the container, is filled a certain amount of adsorption material, then added a measured amount of liquid benzene in batches, the complete adsorption was observed each time, if liquid benzene adsorption reaches equilibrium within the material in container, the material cannot absorb additional liquid benzene, and record total amount of adding liquid benzene.

To get the optimal synthesis condition, we also discussed synthesis temperature, feeding proportion and adding of water, effects on the material adsorption performance.

2.2.1 Effect of feeding proportion

A certain amount of divnylbenzene (DVB) was prepared through mixing with monomer styrene (st) of 0g, 0.2g, 0.5g and 1g respectively, using a few azodiisobutyronitrile (AIBN) as initiator, 30ml diethylene oxide (THF) as solvent and template agent, in the condition of stirring 5h for complete mixing at room temperature and puting into the teflon reaction still, then placing the reaction still in oven at 120℃ for 48h. After that, taking the reaction still out and drying 48h at room temperature in a vacuum, final products marked with DVB-0St-120, DVB-0.1St-120, DVB-0.25St-120, DVB-0.5St-120 were obtained respectively.

Benzene adsorption experiments under different feeding proportion were carried out and the results is shown in fig.2, it is found that the biggest adsorption amount of material to liquid benzene is DVB-0.25St-120, showing its stronger adsorption performance to liquid benzene within a suitable condition, but its adsorption performance will reduce if styrene monomer is added excessively, so a suitable feeding amount of styrene is about 20%.

2.2.2 Effect of water amount

A certain amount of DVB was prepared through mixing with monomer styrene of 0.5g, using a few AIBN as initiator, 30ml THF as solvent, 0g, 0.25g, 0.5g and 1g water as template agent respectively, in the condition of stirring 5h for complete mixing at room temperature and puting into the teflon reaction still, then placing the reaction still in oven at 120°C for 48h. After that, taking the reaction still out and drying 48h at room temperature in a vacuum, final products marked with DVB-0.25St-120, DVB-0.25St-0.25 H_2O -120, DVB-0.25St-0.5 H_2O -120, DVB-0.25St- H_2O -120.

Benzene adsorption experiments under different water amount were carried out and it is found that the adsorption performance of material to liquid benzene will reduce due to water existing in material. The same DVB mixing with 0.25g styrene without water existing is mixed and reacted, dried 48h at room temperature in air, then final product marked with DVB-0.25St-air is got, the same adsorption experiments were conducted for DVB-0.25St-120, DVB-0.25St- H_2O -120 and DVB-0.25St-air, the results is shown in fig.3, showing the vacuum drying treatment is needed for this material.

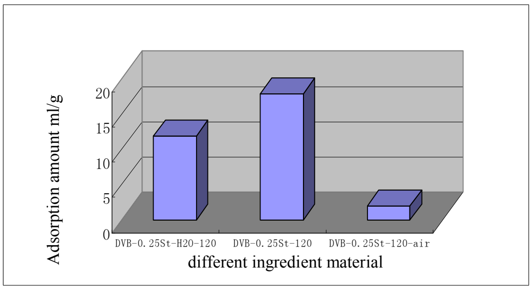

Figure 3 Effect of different ingredient material on adsorption amount

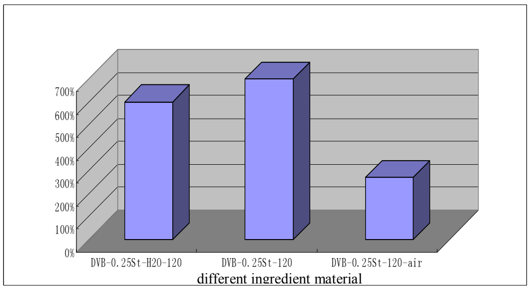

Figure 4 Swelling rate for different ingredient material

2.2.3 Effect of synthesis temperature

A certain amount of DVB was prepared through mixing with monomer styrene of 0.5g, using a few AIBN as initiator, 30ml THF as solvent and template agent, in the condition of stirring 5h for complete mixing at room temperature and puting into the teflon reaction still, then placing the reaction still in oven at 80°C, 120°C and 160°C for 48h. After that, taking the reaction still out and drying 48h at room temperature in a vacuum, final products marked with DVB-0.25St-80, DVB-0.25St-120, DVB-0.25St-160.

Benzene adsorption experiments under different synthesis temperature were carried out and the results is shown that there is few influence for material adsorption performance within 80~160°C, that is, such material can be synthesized at wider temperature range.

In summary, the optimal synthesis condition is that for DVB-0.25St-120, under this condition, benzene adsorption amount, synthesis condition and its cost is the best.

2.2.4 Swelling rate of materials

Select three materials marked DVB-0.25 St-120 , DVB-0.25 St- H_2O-120 , DVB-0.25 St-120-air to conduct the swelling experiments, shown in fig.4.

Corresponding to adsorption amount result of fig.2, the bigger the swelling rate of the material, the bigger the adsorption amount of the material, and the material also gives bigger adsorption amount and swelling rate under a vacuum drying, indicating that drying in a vacuum can be helpful to remove the template agent from the material, raising its swelling performance and hence having higher adsorption amount to liquid benzene.

3 Adsorption test of benzene on the water

In a core hopper, add 5ml water and 0.2g adsorption material, then add different volume benzene accurately respectively, adsorption process will finish in several minutes, taking suction from the benzene-water system. Extract phase is used to test benzene amount by gas chromatograph, cyclohexane as internal standard substance. The results is shown in table 1 and fig.5

Table 1 Adsorption amount of the material for different benzene volume

Benzene volume/mL	Amount of cyclohexane as internal standard /g	Benzene amount /%	Residual benzene in water /%
1	2.007	0	0
2	2.007	0	0
3	2.018	0.3	0.2
4	2.493	19.0	16.6
5	2.022	43.0	37.4

From table 1, the material can absorb massive benzene in water, max. adsorption amount reaches 25ml/g, furthermore, the material after absorbing benzene can float on the water and easily separate from the water phase.

Finally the material struction is tested by Transmission Electron Microscope (TEM), as shown in fig.6, showing the structure of the material is porous.

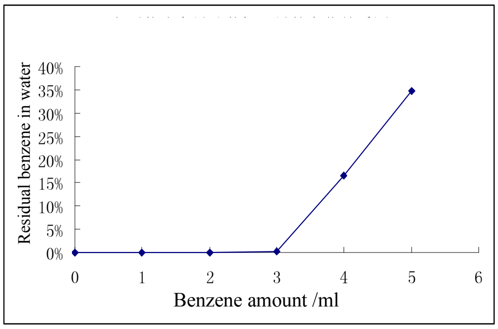

Figure 5 Relation between benzene amount in system and residual amount in water (0.2g benzene adsorption material in the system)

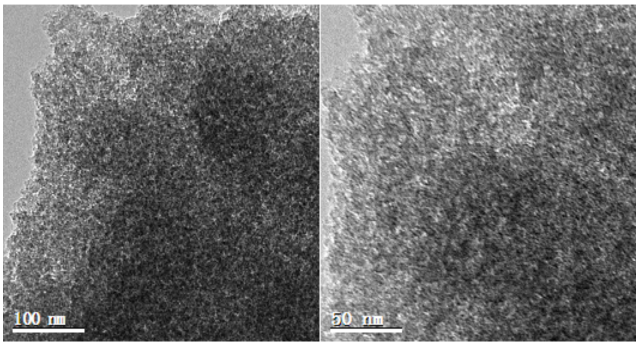

Figure 6 TEM of the material

4 Summary

In this paper, styrene-divinybenzene copolymer is synthesized, and it is porous, having massive benzene ring, high hydrophobicity and easy separating from the water phase, furthermore, the density of this material is less than that of water, it can float on the surface of water and is a kind of ideal material to absorb benzene. Such material can be shaped and directly use to absorb benzene leaked on the river at the emergency case in the future.

Acknowledgement

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