

## CHAPTER V

### CONCLUSION and SUGGESTION

#### 5.1 Conclusion

The present study on synthesis of styrenic imbibor beads has reached its basic goals in providing fundamental information on the influencing factors that affect the general appearance of the imbibor beads and its absorption in solvents.

The imbibor bead synthesized in this study can be used to absorb various industrial solvents, such as toluene, xylene, benzene, chloroform, etc., which are widely used in plastics, coatings and fiber industries. Therefore, this method presents another way to cope with pollution problems in various water resources. In fact, the principle factors which govern the absorption ability of these polymer beads are its internal structure, pore volume and surface area. The findings can be concluded as follows:-

5.1.1 From the first polymerization batch, the yield of the polymer beads is about 47%. The average size of the synthetic polystyrene bead is around 2.5-3.0 mm.

5.1.2 Divinylbenzene was used as the crosslinking agent in the synthesis of the polystyrene imbibor bead. The crosslinking agent helps stabilize and maintain

the dimension of the imbiber bead during absorption and desorption of solvent. However, the large amount of the crosslinking agent made the bead rather rigid and then decreased its absorption property. The most appropriate amount of divinylbenzene in this study is about 0.3%

5.1.3 The length of time during seeded suspension polymerization influences the absorption property of the synthetic beads. The imbiber beads which were seeded polymerization too long would deform after excessive swelling due to too great crosslinking that rendering the beads hard and brittle. The most appropriate time for the seeded suspension polymerization in this study is about 12 hr.

5.1.4 The time and temperature during suspension polymerization also affect the absorption ability of the synthetic beads. The polystyrene beads synthesized under the high polymerization temperature for a short time would become rather soft and consequently absorbed more styrene monomer in the stepwise swelling. The fully swollen polystyrene beads would then become larger in size through further polymerizations. Therefore, polystyrene beads which were polymerized under the condition of  $70^{\circ}\text{C} - 4 \text{ hr.} + 90^{\circ}\text{C} - 2 \text{ hr.}$  rendered the higher swelling ratio and larger size compared with those polymerized through the condition of  $70^{\circ}\text{C} - 2 \text{ hr.} + 90^{\circ}\text{C} - 4 \text{ hr.}$

5.1.5 The most appropriate suspending agent for the synthesis of the polystyrene beads in this study is



the mixture of HPMC + HEC which gives the larger beads compared with that using only HPMC.

5.1.6 The most appropriate monomer phase volume fraction in this study is about 0.1.

5.1.7 The most appropriate condition for the synthesis of the polystyrene imbiber beads crosslinked with divinylbenzene, by far, could be as follows:

Composition:

Water phase	: suspending agent	HPMC	0.4%
		HEC	0.076%
		sodium bicarbonate	2%
		(based on the resin)	
Monomer phase:	styrene monomer		99.4%
	benzoyl peroxide		0.3%
	divinylbenzene		0.3%
Monomer phase volume fraction			0.1
Time-temperature schedule		70°C-4 hr.+ 90°C-2 hr.	
Agitation rate			220 rpm.

5.1.8 The imbiber beads synthesized were of very little porosity. The porosity and surface area of the beads can be improved by using the much bulkier monomers and manipulating the more appropriate conditions.

5.1.9 The solubility parameter of the polystyrene beads was approximated to be in the range of  $\delta = 8.6 - 9.6$  [cal/cm<sup>3</sup>]<sup>1/2</sup>. The highest swelling ratio in chloroform is 13.17.

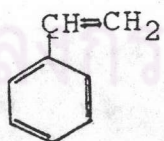
5.1.10 The density of the polystyrene synthetic beads is in the range of 1.05 g/cm<sup>3</sup>. This figure is

slightly higher than that of oil and some organic and industrial solvents.

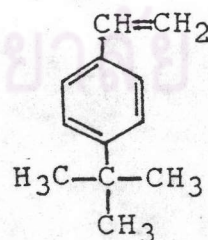
## 5.2 Future Work

The synthetic beads of polystyrene crosslinked with divinylbenzene in this study was characterized to be slightly porous. Therefore, the absorption ability of the beads was too little for some solvents such as benzene, toluene, xylene and chloroform, etc. To improve the porous structure of the bead and its absorption ability, future work should be carried out as follows.

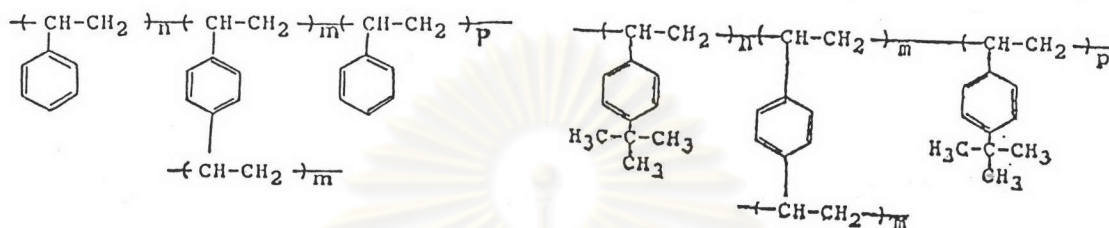
5.2.1 Change the monomer from styrene to tert-butylstyrene. According to the structure of both chemicals given below, tert-butylstyrene monomer is much bulkier and the divinylbenzene crosslinked polystyrene beads should be of higher porosity because the tert-butylstyrene group would separate the polymer backbones further which introduce less compact structure with more spaces in the bead. Therefore the higher the porosity, the more the solvent absorption ability of the beads.



styrene



tert-butylstyrene



Polystyrene crosslinked  
with divinylbenzene

Poly (t-butylstyrene) crosslinked  
with divinylbenzene

5.2.2 The density of the divinylbenzene crosslinked polystyrene bead is directly controlled by all the factors involved especially porosity. The desired density of the imbibed bead depends, to a greater extent, on the particular application.

5.2.3 Another way to increase the pore volume inside the polymer bead may be as follows:

5.2.3.1 Using other suspending agents which can produce a large amount of bubbles during polymerization.

5.2.3.2 Adding diluents such as di-2-ethyl hexylphthalate, into the monomer solution before the polymerization. During the formation of the polymer bead,



the diluent will gradually evaporate out of the bead leaving a large amount of pores inside.

5.2.3.3 Keeping the temperature during extraction of the excess monomer below  $100^{\circ}\text{C}$  to prevent the self-initiated polymerization of the remaining styrene monomer in the beads.

5.2.3.4 To produce a floating type imbiber bead, one should be able to monitor the crosslinking density, pore size as well as the density of the beads, the properties of which depending on the required application range such as the use in certain types of oil. Therefore, the technique of seeded suspension polymerization of the imbiber beads can be regarded as a tailor-made procedure for each individual purpose in the function of imbiber material over a wide range of industrial solvents.

ศูนย์วิทยทรัพยากร  
จุฬาลงกรณ์มหาวิทยาลัย