

The measurement of n-hexane solubility and diffusivity in Acrylonitrile-butadiene-styrene (ABS) and poly styrene-co-acrylonitrile (SAN) via our designed chamber

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Abstract

In this work, a batch chamber was designed to measure the solubility of (n-hexane) in the acrylonitrile-butadiene-styrene (ABS) and poly styrene-co-acrylonitrile (SAN) at different temperatures and pressures. The designed high pressure chamber consisted of the self-sealing cell equipped to the pressure controller. The polymer samples were saturated by n-hexane in high pressure and the solubility and diffusivity of n-hexane in samples were measured by the same apparatus. The effect of different foaming conditions on the solubility of n-hexane in the samples was examined. The results show that the solubility and diffusivity was increased by saturation pressure increment. As well, the diffusivity of n-hexane was increased by increasing of the temperature.

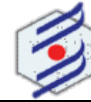
Keywords: ABS, SAN, Solubility, Diffusivity, n-hexane, bath Chamber.

Introduction

The final properties of polymeric foams in batch systems are affected by the type and amount of the dissolved blowing agent, as well as by the foaming parameters such as, saturation pressure and temperature [1,2]. These parameters were influenced by temperature and pressure. The solubility of different blowing agents in molten polymers were considered by several authors [3,4]. In this study, we used the acrylonitrile-butadiene-styrene (ABS) and poly styrene-co-acrylonitrile (SAN) for solubility experiment. As well as the solubility and diffusivity of high pressure n-hexane in samples was measured via our designed batch apparatus in different conditions.

Experimental

The schematic view of our design chamber with internal volume of 4 cc was shown in Figure 1. It is equipped with pressure controller gage. The sample beads was placed into the chamber and the chamber was electrically heated at different high temperatures (Figure 1). The samples were saturated by n-hexane at the selected high pressure for each experiment. For measuring the solubility of n-hexane in samples, the samples was weighted firstly (m_1). After reaching a suitable high pressure in the chamber, the sorption period was started to reaching the saturation



state which this time was 10 hours. Finally, solubility measurement was conducted by decreasing the temperature of the chamber while the pressure of the chamber is still high. As soon as the temperature reached below the boiling temperature of n-hexane, the sample was taken out the chamber and weighted (m_2). The n-hexane solubility of the sample was defined as $(m_2 - m_1)/m_1$. The chamber was sealed very carefully and before experiments was checked by nitrogen purge. No leakage was observed in chamber.

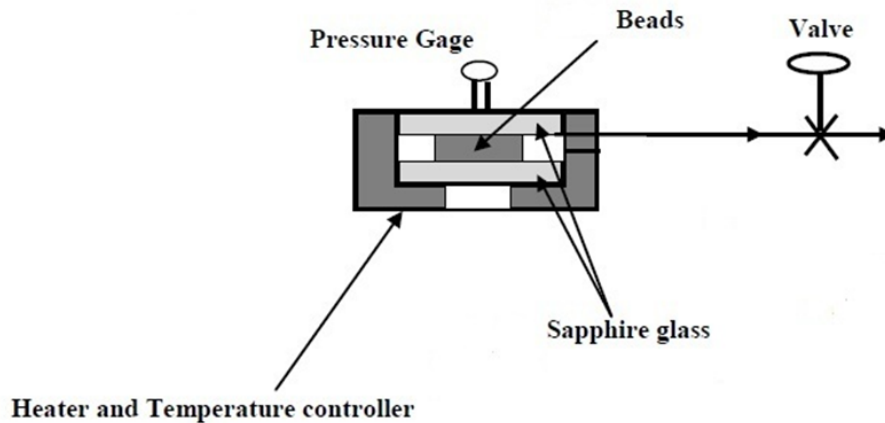


Figure1. The design high pressure batch chamber.

As well as, to measure the diffusivity of n-hexane in synthesized particles using the same apparatus, the relative amount of dissolved n-hexane in samples versus sorption time (isotherm curve) was determined at various pressure and temperature levels. Diffusion coefficients of n-hexane in beads were measured at the pressure range and at the temperatures of 95 °C and 130 °C by determination of the time evolution of the particles weight to a new steady state weight. Fick's second diffusion law [4,5] was used to estimate the diffusion coefficient from the weight data by:

$$\frac{\partial c}{\partial t} = D(c_0) \frac{\partial^2 c}{\partial x^2} \quad (1)$$

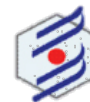
$$x = L \quad (2) \quad \frac{\partial c}{\partial x} = 0 \quad t \geq 0$$

$$0 \leq x < L \quad t = 0 \quad c = c_i \quad (3)$$

$$x = 0 \quad t \geq 0 \quad c = c_0 \quad (4)$$

The analytical solution for the above equation with mentioned boundary conditions was given by [5]:

$$c = c_0 - \sum_{n=0}^{\infty} \frac{4(c_0 - c_i)(-1)^n}{2n+1} \cos\left[\frac{(2n+1)\pi x}{2L}\right] \exp\left[\frac{-D_t(c_0)(2n+1)^2 \pi^2 t}{4L^2}\right] \quad (5)$$



where L is the thickness of the sample. c_i and c_o , are the concentration of n-hexane at the initial state and at the surface of the sample in equilibrium with n-hexane inside the chamber during the measurement, respectively. The solution of the equation (5) could be written as:

$$\frac{\Delta w_{hex}(t)}{\Delta w_{hex}(t = \infty)} = 1 - \sum_n^{\infty} \frac{8}{(2n+1)^2 \pi^2} \exp\left[-\frac{D_{mut} (2n+1)^2 \pi^2 t}{4L^2}\right] \quad (6)$$

where $\Delta w_{hex}(t)$ is the weight of dissolved n-hexane in samples at time t .

Results and discussion

As it can be observed in Figure 2, by considering the Henry law, the solubility of n-hexane rises with increasing of pressure at $T=110^\circ\text{C}$ for both polymers. It is clear that the solubility of n-hexane in ABS is higher than SAN. The temperature dependency of solubility is investigated in Figure 3, in which with temperature increment, the n-hexane solubility in samples is decreased.

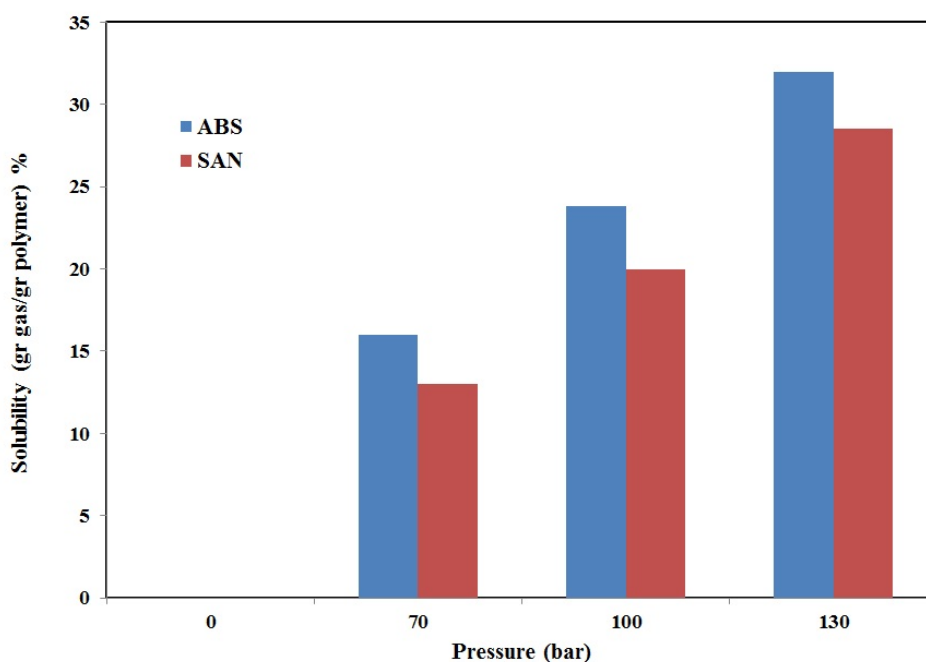


Figure2. The solubility of n-hexane in different samples versus pressure at $T=120^\circ\text{C}$.

The diffusivity measurements were conducted at the same conditions of dissolution experiments. Figure 4 shows the correlation between the relative amounts of dissolved n-hexane in samples with sorption time at $T=95^\circ\text{C}$ (the left hand side of equation (6)). The solid line represents the calculation results by equation (6) and the symbols are the experimental data. The variation of diffusion coefficients of n-hexane in polymers, versus average n-hexane pressure, at two temperatures are shown in Figure. 5. As shown in Figure 6, the diffusion coefficients are slightly increased with increasing of the temperature. The diffusivity of n-hexane in ABS is higher than SAN which this behavior was seen in the solubility experiment.

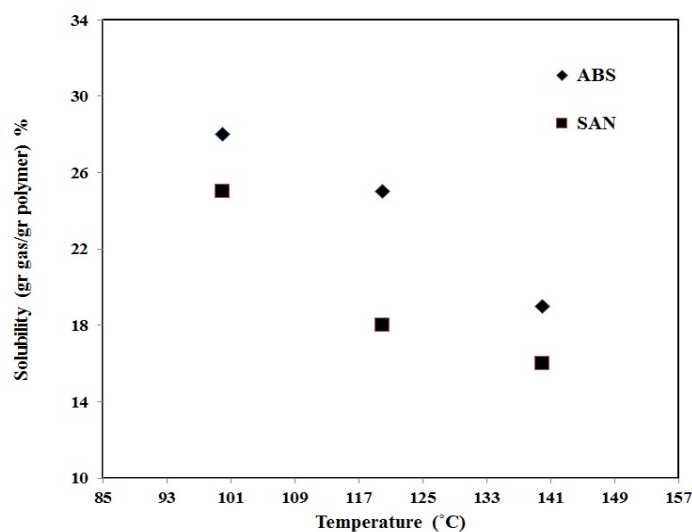
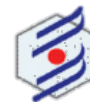


Figure 3. The temperature dependency of solubility in different samples in P=110 bar.

Conclusions

In this study, it was tried to determine experimentally the solubility of n-hexane in ABS and SAN polymers. The solubility of n-hexane in samples was improved with increasing of saturation pressure and declined with rising of temperature. Also the solubility of n-hexane in ABS was higher than SAN.

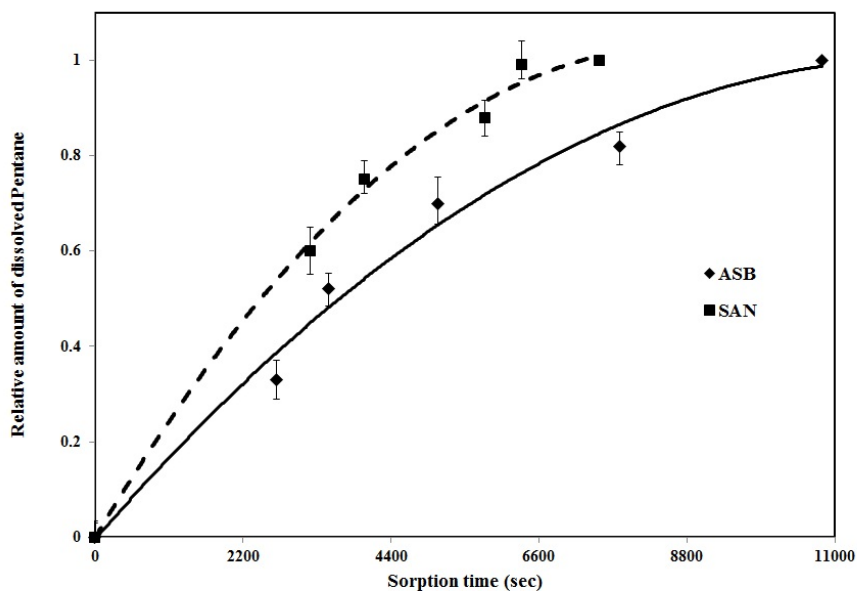


Figure 4. The relative amounts of dissolved n-hexane in ABS and SAN at T=95°C.

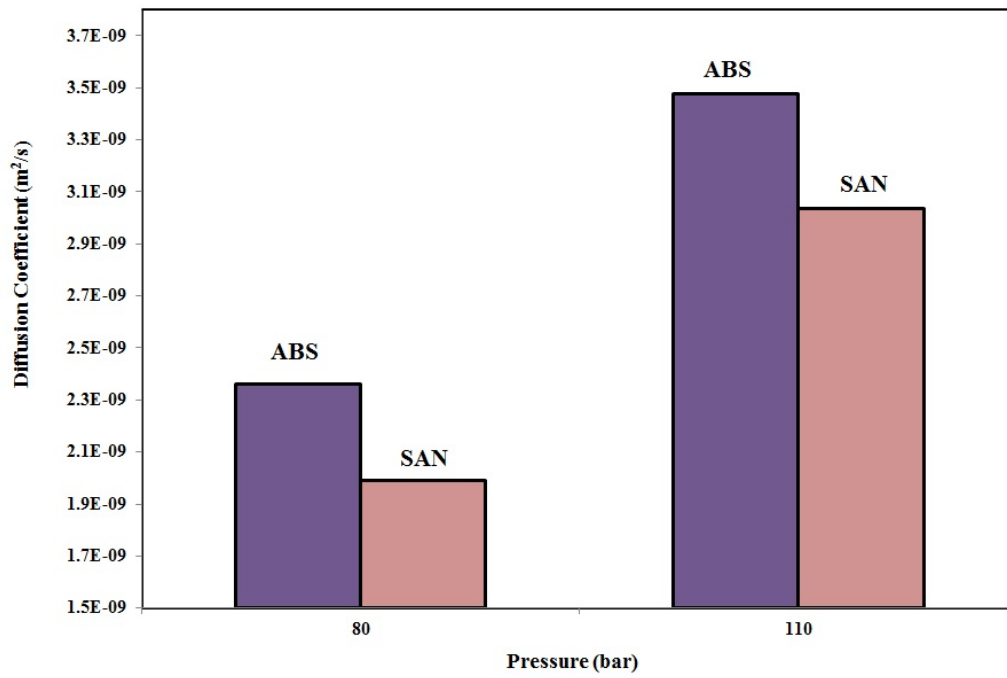
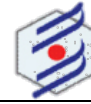


Figure 5. The variation of diffusion coefficients of n-hexane in polymers

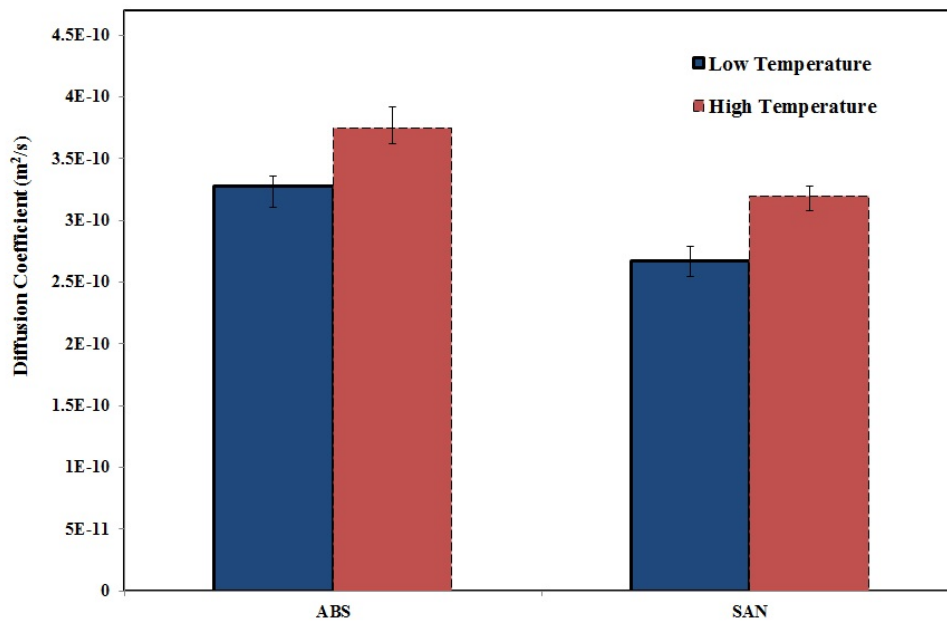
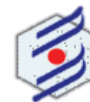


Figure 6. The temperature effect on the diffusivity of n-hexane in polymers



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