FMRI RET 2014 - Sorption of Organic Vapors by Polymers using a Quartz Crystal Microbalance

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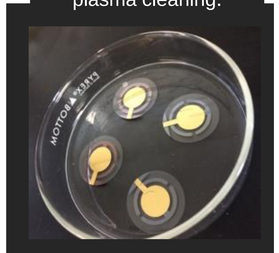
Abstract

Sorption of benzene and cyclohexane by poly(iso-butylene) (PIB) and polydimethylsiloxane (PDMS) were measured using a Quartz Crystal Microbalance. In order to check for proper functioning of the apparatus our data using PIB was compared to published literature. New trials using PDMS were then conducted.

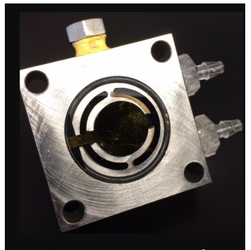
Background

Measuring the solubility of organic compounds in polymers is difficult because diffusion of molecules through polymers can be a time consuming process. A reduction in the thickness of the polymer yields faster results but makes measuring of the smaller mass more difficult. The use of a quartz crystal microbalance has proven helpful due to its sensitivity and quickness in measuring.

Preparation of the Quartz crystals included chloroform soaks and plasma cleaning.



Objectives

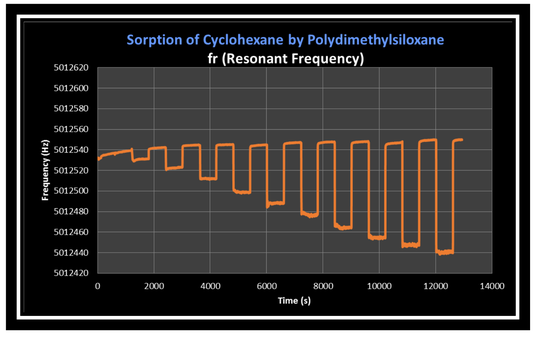


A quartz crystal coated with PDMS is place within the temperature controlled cell.

The objectives of this study were three-fold. The first was to set up the apparatus to the established working parameters, Upadhyayula (1). In order to check the functionality of the apparatus we compared our results to those of Wang (2), and Wibawa (3). Finally, when compatible results were obtained, we tested new samples .

Approach

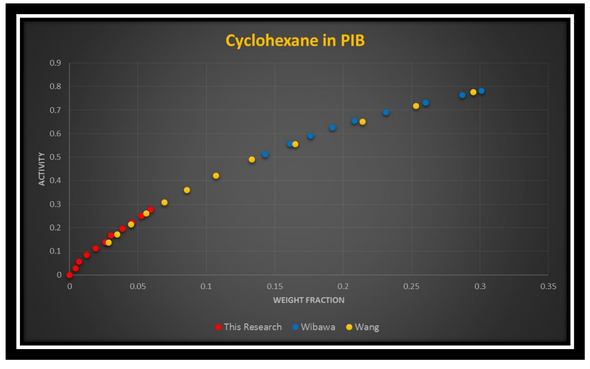
Using the quartz crystal microbalance allowed the solubility in a thin layer of polymer to be tested by measuring the frequency shift Δf_0 before and after coating the crystal with polymer. The solvent was carried through the system by nitrogen and was exposed to the polymer-coated quartz crystal that was contained within the temperature controlled cell.

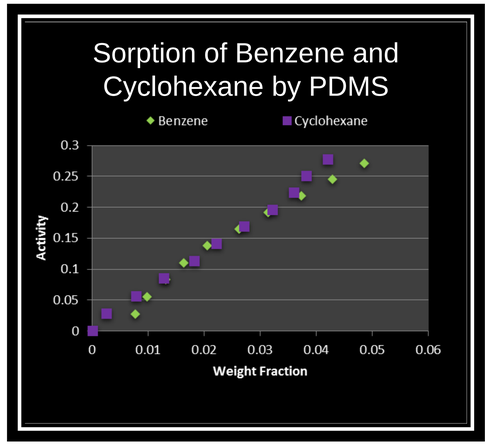


When equilibrium between the polymer and gas stream was reached, the additional frequency shift Δf was noted. The weight fraction (W_1) of the organic species in the polymer film was calculated from

$$W_1 = \Delta f/(\Delta f+\Delta f_0)$$

After setting up the apparatus our next goal was to run it using an established set of parameters to be sure that it was accurate. Our data, shown in the graph to the right in red, clearly demonstrates a correlation to the results of two published works (Wibawa and Wang).





New tests were run to explore the solubility in a PDMS layer when exposed to cyclohexane and benzene. Future studies will examine various polymers and organic compounds.

Conclusions

The data collected during this investigation can be used to strengthen the existing knowledge on solubility of solvents in polymers. Application in other fields could include removal of environmental pollutants, identification of desired or undesired materials during fabrication, and precise sensors that could not only tell you if a substance is present but in what concentration. Further study is needed to determine the best process for coating the quartz crystals.

Referenced Resources

Upadhyayula, Anant K. "Sorption of Organic Vapors by Copolymers of Poly(styrene-butadiene) Using a Piezoelectric Microbalance." Thesis. University of South Florida, 2005. Print.

Wang, Ning-He, Shigeki Takishima, and Hirokatsu Masuoka. "Solubility Measurements of Benzene and Cyclohexane in Molten Polyisobutylene by the Piezoelectric-quartz Sorption Method and Its Correlation by the Modified Dual-sorption Model." KAGAKU KOGAKU RONBUNSHU 15.2 (1989): 313-21. Web.

Wibawa, Gede, Masaki Takahashi, Yoshiyuki Sato, Shigeki Takishima, and Hirokatsu Masuoka. "Solubility of Seven Nonpolar Organic Solvents in Four Polymers Using the Piezoelectric–Quartz Sorption Method." Journal of Chemical & Engineering Data 47.3 (2002): 518-24. Web.

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