Gas Permeation using the 6FDA-1,4-trip-direct polymer

Mark Wilson | Jenny Wiegand & Dr. Ruilan Guo |
John Adams High School, 808 S. Twyckenham Dr., South Bend, IN 46615

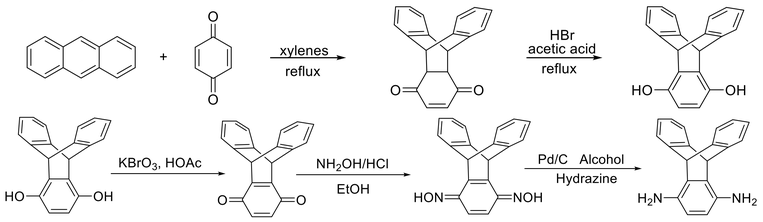
Research Background

Gas separation through polymer membranes is a field of chemical engineering involving the synthesis and analysis of permeable polymers. A polymer's permeability can be directly related to the fractional free volume of the material. This free volume can be increased by including bulky molecules in the polymer backbone to interfere with the chains' ability to pack closely, giving the gas molecules more space to diffuse. With this in mind, this project focused on a polymer based on a very bulky unit called triptycene, which is made up of three benzene "blades" that can disrupt chain packing. Once synthesized, this polymer will be tested for the permeabilities of gas pertaining to various industrial separation applications, such as H_2, CH_4, N_2, and CO_2.

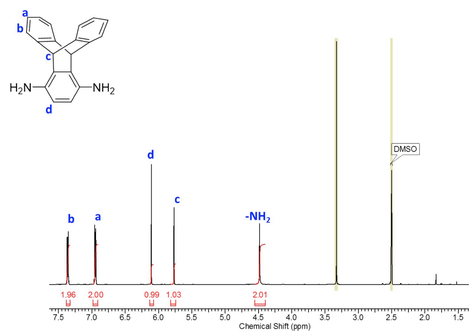
Research Focus

6FDA takes a Trip – Polymerize/Analyze the 6FDA's Trip (6FDA-1,4-trip-direct) – more rigid/high free-volume

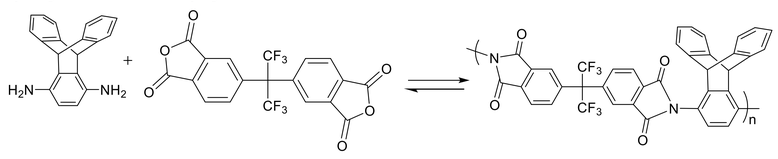
- Reaction scheme for the triptycene-1,4-diamine monomer synthesis



- NMR results of the triptycene-1,4-diamine synthesis



Reaction scheme for the formation of the 6FDA-1,4-trip-direct polymer from triptycene-1,4-diamine and 6FDA



Curricular Application

- Understanding kinetic molecular theory (KMT) and the behavior of particles (particularly in the gas phase)
- Understanding that molecular make-up and structure can lead to conformations that allow for tuning of gas permeability
- From here the following concepts can be addressed
  - Analogues to polymers
  - Common, simple polymers and their uses
  - Diffusion of gases
  - Separation of gases in a mixture

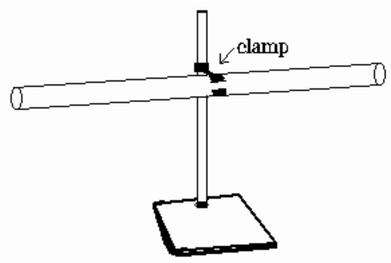
Curriculum Process

Make Connections	Curriculum Apply	Active Apply	Report Back
			
Discussions: -KMT, gas diffus., kinetics -nomenclat., monomers, polymers	Using discussions to inquire how to connect/relate the concepts inside/outside the lab	Using knowledge gained from discussions to conduct lab investigations	Provide analysis and feedback regarding the investigation and the results gathered

Curricular Activity

- Following discussions involving kinetic molecular theory (KMT) and the behavior of gases, students will conduct a lab investigation that allows for the observation and analysis of diffusion of gases. At a more advanced level, there is room for application of reaction kinetics
- Organic nomenclature allows for the identification and creation of molecules that can lead into polymerization. From this concept, students will be involved in lab investigations that will make polymer-based bouncing balls. Various materials and procedures will be provided, and there will be potential for tuning variables and reagents as a means of inquiry expansion.

Curricular Apparatus



- Left: Gaseous diffusion will be analyzed using a clamped gas tube. Corks containing each gas will be placed in the ends of the tubes.
- Right: Polymer-based bouncing balls will be made from common, simple materials.

Conclusions & Future Work

- Successful synthesis of the triptycene-1,4-diamine monomer
  - Further analysis showed high yield and purity of the monomer
- Successful polymerization of the 6FDA-1,4-trip-direct polymer requires further analysis
- With successful polymerization, future work will include:
  - Creating a film from the 6FDA-1,4-trip-direct
  - Analysis of polymer properties (thermal properties, molecular weight, solubility, density, and fractional free volume)
- The ultimate goal is to be able to test for the polymer's gas permeabilities (H_2, CH_4, N_2, Ar, and CO_2)
- Discovering more avenues and methods to improve and build upon the current curricular investigations

Acknowledgements

Prof. Guo– Thank you for providing me with the opportunity to learn, study, and research in your lab. I have really appreciated the kind, supportive, and encouraging environment you have created. Seeing how you interact with your students continues to motivate to keep cultivating these same characteristics within my classroom and with my students! Thank you!

Guo Group! – It has been an awesome summer! All of you have really been such a close-knit, and helpful family. I have truly been impacted by how hard each of you work while never failing to be mindful of each other and the needs within the lab. Thank you for being so open, helpful, and quite funny! PS..Save me an oven!

Jenny – WOW! Thank you! In so many ways, I owe my enjoyable experience to you! You have been so generous and patient, and such a great mentor! Thank you for all of your guidance and for making everything so simple and relatable. I wish you the absolute best in everything, and may you always know your neighbors! ☺