

Optimizing Viscosity Formulation for an Environmentally Sound Approach to Sealant Production.

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Overview

Liquid viscosities are needed by process engineers for quality control, while design engineers required the property to fix optimum conditions for the chemical process and operations as well as for the calculation of the power requirements or the unit operations such as mixing, pipeline design, etc.

Motivation

Gathering viscosity data on a material gives manufacturers the ability to predict how the material will behave in the real world. In an industrial set up, viscosities of fluid mixtures (meaning homogenous mixtures resulting out of mixing two or more fluids) are often needed for the design of the different unit operations and processes. Constraints on the availability of time, facilities and expertise, often force the designer to use an estimated value. The objective of this summer's RET was to extend the pot-life for coatings or adhesives to decrease material waste. The data that was collected was measured using a digital Brookfield DV-II + Pro Viscometer alongside a PC computer.

The Brookfield viscometer works by rotating a cylindrical spindle of known surface area in a fluid and finding the torque of the spindle. Torque is computed as the force acting on the outer surface of the spindle times the radius.



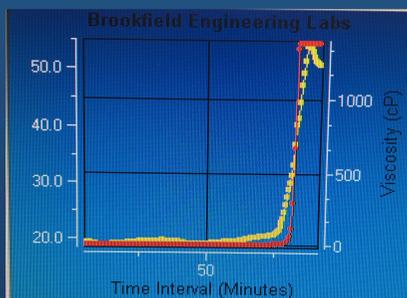
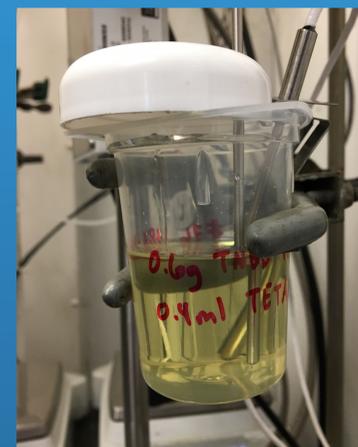
Figure 1: An image of the Brookfield DV-II+ Pro Viscometer and Figure 2: the RV6 spindle.

Methodology

Amine and other additives will delay the start of polymerization for longer working time. Our methodology involved four explorations: 1) Explore various amines with low toxicity that extends pot-life. 2) Explore range of monomers with one or two amine additives. 3) Explore other Trialkylborane-amine complexes. 4) Explore aldehydes to delay polymerization.

Initially, the issue was dealing with pyrophoric liquids (TNBB & TNDB) which has the ability to spontaneously ignite without the influence of heat or fire. Fortunately, by combining these pyrophoric liquids with TETA or MOPA, the added amines doesn't give it a chance to air oxidize. We would then take a monomer (either HPA-DMC or HBA-DMC), add an amine (such as TNBB-MOPA, TNDB-MOPA, OR TNBB-TETA), and then at times add a second amine (such as t-BNH₂, MCDA, MOPA, or TETA) in a plastic beaker and then set that beaker onto the viscometer to observe the time it took to polymerize at maximum temperature. Based on the client's specifications, we wanted to time our polymerization to reach ninety minutes.

Figure 3, 4, 5 top to bottom: An image of the samples on the viscometer from start of experiment to days spent in the walk-in hood and an image of the viscosity graph of sample #11 which polymerized at 90 minutes.



Results

Initially, we started with a trend graph created from Excel spreadsheet of data prior to my placement and noticed a possible exponential pattern. The research found that the monomers used also had some inhibitors that affected the timing of polymerization as well. However, the resulting trends from further testing definitely weren't exponential.

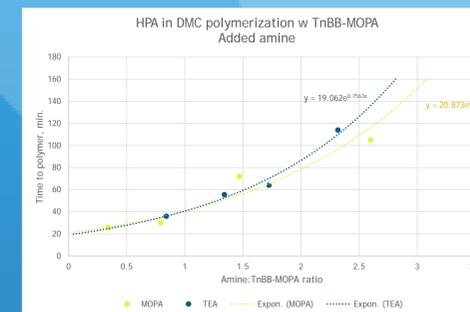


Figure 6: An image of the polymerization graph of monomer HPA-DMC with various amines.

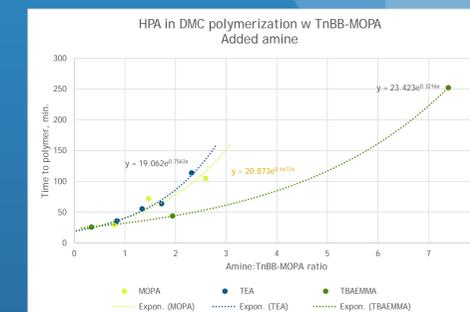


Figure 7: An image of the continuation of the polymerization graph of monomer HPA-DMC with various amines.

Conclusion

In conclusion, too much amine dilutes the monomer which eventually levels out the exponential trend towards a linear relationship. The implications for this research allowed the researchers to record different polymerization rates in regards to monomers with added amines versus monomers without added amines. The data also suggests that certain combinations of monomers and amines were not as exothermic.

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