Reclaiming Raw Materials From Styrofoam With D-limonene Solvent

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Introduction

The goal of our experiment is to recycle styrofoam back into its raw materials. After obtaining styrene form styrofoam, the styrene can be used to produce fresh styrofoam, SB latex or SB rubber.

Two methods that we thought that could be used to successfully do this are:

1. Melt or dissolve Styrofoam in order to recreate styrene
2. Biodegrade styrofoam through microorganisms and superworms which can digest styrofoam.

*Styrofoam refers to expanded polystyrene, in which air pockets are blown into the styrene.

Why Styrofoam

- Styrofoam is non-biodegradable. According to Washington University, Styrofoam takes 500 years to decompose.
- Since styrofoam is not recycled, styrofoam products dumped in landfills are there to stay. With enough Styrofoam products produced each day to circle the earth if lined up end to end, the potential for major ecological impact is great.
- Styrofoam and Styrofoam products fill up 30 percent of our landfill space, and landfills are fast becoming full.
- Styrofoam is a toxic substance and a reasonably anticipated human carcinogen.
- As its density is less than of water it floats in water bodies affecting aquatic life.

Research - Melting and Dissolving

- Styrofoam has a low melting point which makes it easy to melt with heat (possible option)
- When styrofoam is dissolved/melted many harmful substances are released which should be collected responsibly
- Styrofoam can be dissolved in many compounds such as gasoline or oil but these are harmful to both the environment as well as our bodies
- As styrofoam is an organic compound, it can be chemically recycled (the hydro-carbon bonds can be broken)
- D-Limonene, a natural solvent, extracted from citrus fruits is a solvent styrofoam can dissolve in easily and does not pose any mutagenic, carcinogenic, or nephrotoxic risk to humans, and has proven to be safe.

Research - Decomposition

- Mealworm, a tiny worm, which is the larvae form of the darkling beetle, can subsist on a diet of Styrofoam and other forms of polystyrene
- In laboratory conditions, 100 mealworms ate between 34 and 39 milligrams of Styrofoam per day
- Putida, a soil bacterium, has the ability to degrade styrene oil into an alternative biodegradable plastic PHA. This material can be applied in medical, pharmaceutical, and orthopedic industries to create tools and gadgets necessary
- Styrofoam can be mainly degraded into CO2 and fecula (starch)

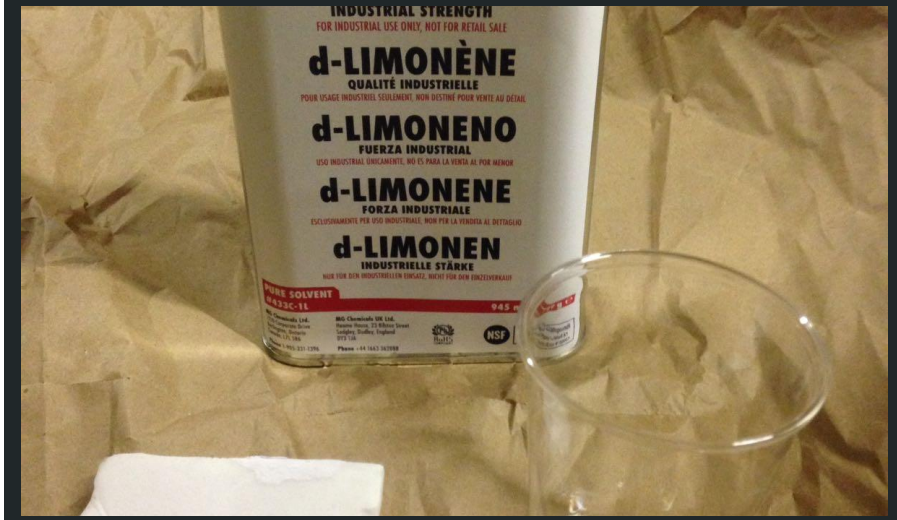
Experiment

Will d-Limonene dissolve styrofoam to create usable styrene without producing harmful substances?

Hypothesis: Styrofoam can be dissolved and styrene can be extracted from the solution

Experiment Design

We put 1 gram of styrofoam in 10 milliliters of d-limonene to see if it would dissolve, and let the d-limonene evaporate to reclaim styrene.



Results

To the right, the styrofoam is shown dissolving in the d-limonene. The dissolved styrofoam can be observed after all the d-limonene has been evaporated. This styrene can be reused and repurposed into new styrofoam.

Analysis & Interpretation

- Styrofoam can dissolve in d-limonene because of specific molecular interactions between it and organic liquids, such as d-limonene.
- This is because the interaction between a polymer and a liquid depends on their cohesive energy densities (CED), which is related to polarity/non-polarity of the molecules
- From CED values of various materials and liquids, we can calculate a parameter, in physical chemistry known as Hildebrand Solubility Parameter
- In order to be able to dissolve a polymer, the liquid must have a HSP value close to that of the polymer.
- CED value of polystyrene is 9.1 while the CED value of toluene (a chemical very similar to d-limonene, and also can dissolve styrofoam) is 8.9 Source: www.uobabylon.edu.iq/eprints/pubdoc_12_7221_348.docx

Conclusions

- As can be seen from our experiment results, and backed up by the analysis, styrofoam can be dissolved in a non harmful solvent; d-limonene.
- After the solvent has been extracted through means of evaporation, raw material styrene is left and it can be reused instead of extracting fresh raw materials out of the ground again to create a multitude of products.
- All in all, we can conclude that that styrofoam can be dissolved in d-limonene solution and raw materials (styrene) can be reclaimed afterwards.

Final Solution

As concluded, styrofoam can be dissolved using a safe solvent; d-limonene. Therefore, our solution to battle landfills full of non-biodegradable styrofoam by dissolving it and reclaiming raw materials is as follows:

1. Collect waste and sort out any styrofoam products
2. Clean styrofoam to remove dirt and debris. Basic rinsing with water is acceptable, as any uncleared debris will either float to the top of the solvent tank or can be filtered out later
3. Submerge styrofoam wastes in d-limonene solvent
4. Allow time for solvent to evaporate
5. Filter/ cleanse styrene to remove any remaining foreign substances
6. Claim styrene and repurpose the raw material into new styrene products

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