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Recycling of Styrofoam (EPS) with Limonene

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I. INTRODUCTION:

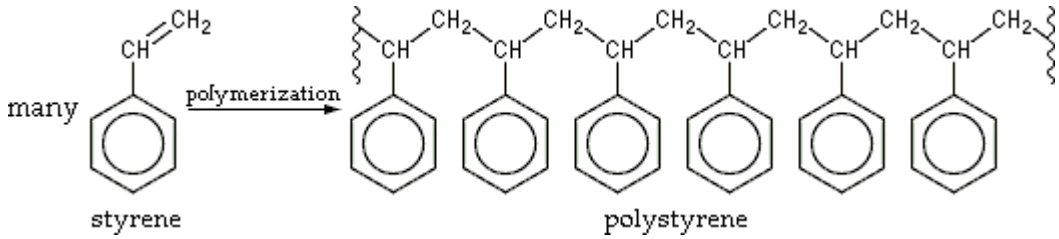
Thesedays,asmany environmentalproblemsarebecominganissue,people arestartingto pay attention to the environment. Especially, people have started to realize that the soilpollution from indiscreet trash reclamation is a serious problem, as it causes many sideeffects.For example, as people bury huge amounts of trash in the ground, without giving it time todecompose,thegroundstartstobepolluted,sothearea nearthesanitarylandfillcannotbeused forotheruses, such as farmland.Also, the specific trash that cannot be decomposed naturally becomes a hugeproblem,asitjuststaysinthegroundwithoutdisap pearing,andkeepspollutingtheground.

As a representative example, Styrofoam does not decompose naturally,and it is known as a material that has a huge volume, so many people have problemsthrowing it away or recycling it. Not many companies recycle this material,Styrofoam,asitcostsalargeamountofmoney anditisnoteasytodecomposeorrecycleit.

Many new technologies are developed to recycle these kinds of materials that do notdecomposein naturalways,andpeopleneedtoknow moreaboutthe materialtorecycleitin the right way, so it can behelpfulfornaturetoo.

Usesof Styrofoam: Polystyrene, a strong plastic created from styrene, can be injected, extruded, or blow molded to make a very useful manufacturing materialcalledStyrofoam.Styrofoamis wellknownas itis useforbeveragecups andpackaging.However,PolystyreneinStyrofoamisa lsousedinbuildingmaterials, householditems,andelectricalappliances, such as light switchesandplates**.**

ChemistryinStyrofoam : To understand the chemistry of Styrofoam, people need to understand Polystyrenefirst,as Styrofoamismadeup of Polystyrene.Polystyreneisanaromaticpolymerthatis madefromthearomatic monomerstyrene,which is a liquid hydrocarbon that is commercially manufactured from petroleum by thechemicalindustry. It is oneofthemostwidely used plastics.



Thepropertyofpolystyreneisbasedonitsstru ctureof it.It is un-reactive in a chemical way, so it is used to create products that are usercontainers forchemicals,solvents,andfoods.Thisstabilityisfromt he transformationofcarbondouble bondsinto carbon singlebondwhichis less reactive.Polystyreneismostlyflexibleand canforma moldablesolidorviscousliquid.Theattractionof Polystyrene is due to the short-range van der Waals attraction between chains. As themolecules and long hydrocarbon chain consist of thousands of atoms, the total attractiveforcebetween themolecules is large.But when it is heated, the chain takes on higher degrees of conformation and slides pasteachother.Thechain canslidealongeachotherduetotheweakintermolecular power,renderingthe bulksystemflexible andstretchable.

ProblemswithStyrofoam: Styrofoam known as Expanded polystyrene foam **(EPS)**is a lightweight cellular plastic material.Styrofoam is 98% air, which makes the item bulky and hard to dispose directly. Styrofoam is hard to be recycled directly from the recycling bin. According to the EPA each year Americans throw away 25,000,000,000

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Styrofoam cups. Even 500 years from now, the foam coffee cup you used this morning will be sitting in a landfill, because of the materials and chemicals that make up Styrofoam or polystyrene foam take an incredible amount of time to break down in the environment. It may also be ingested by animals and eventually block their digestive tracts ultimately causing their deaths by starvation. The manufacturing process of Styrofoam also consumes petroleum, which is a non-renewable resource, and benzene, which is known to be carcinogenic to humans.

The recycling of polystyrene is not for cost benefits it's for the benefit of our environment. The skinny of it is we should all be avoiding products that can last forever in our landfills. Styrofoam is a great packaging material, according to its insulating and protectiveproperties.However,oncegoodsaredeliveredwithStyrofoampackagesandpeopleopenthem,Styrofoambecomes waste material thatcompanies must pay to disposeof.Also, there is no such good way for individuals to recycle Styrofoam easily, so usingStyrofoam is becoming a problem. It is conservatively estimated that hundreds ofthousandsof tonsofwasteStyrofoamisproducedandsenttolandfillseachyear.This Styrofoamwill notbe decomposed fora long time andwill pollutetheground.Thismaterialisverylightweightcomparedto itsvolumesoitisnothardtoimaginehowmuchlandfill spaceisfilled with tonsand tonsof Styrofoam.Also,unfortunately,therearenot manyrecyclingprogramsthatacceptStyrofoam,soitisreally important to find other new ways to recycle or make the volume smaller for thisStyrofoam.

Limonene : Limoneneisahydrocarbonthatisclassifiedascyclicterpene.It hasthemolecularformula of C10H16. It is a colorless liquid at room temperature with a strong smell oforange.Itisfoundincitrusfruitslikelemon andorange.Itisa chiralmolecule,and as itiscommon with such form, biological sources produce one enantiomer, the principalindustrialsource, citrusfruit,contains d-limonene.As the main odor constituent of citrus, d-limonene is used in food manufacturing as aflavoring,such as orangeoil.

Limonene is increasingly being used as an environmentally friendly alternative to mineraloilsasasolventforcleaningpurposes,suchastheremovalof oilfrommachineparts,sinceit is more easily biodegradable than mineral oils, and produced from a renewable source,such as citrus oil, as a byproduct of orange juice manufacturing. As it is a stronghydrocarbon,it also can beused to dissolveStyrofoam,as Acetonedid.

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II. EXPERIMENT:

Part1:Testingsolubilityof Styrofoamineachsolution

Procedure	Picture
1)Thepeelof the orangewassqueezedonthe side of a Styrofoam cup, and theobservation was recorded in the next fiveminutes.	
2) The inside fruit part of the lemon wasremoved from the peel, and the peel wassqueezedonthesideofthe Styrofoamcup,andthe observation was recorded in the nextfiveminutes.	
3) The peel of a grapefruit was squeezedon the side of a Styrofoam cup, and theobservationwasrecordedinthenextfiveminutes.	
4) The inside fruit part of the lime wasremoved from the peel, the peelwassqueezedonthesideof the Styrofoamcup,and the observation was recorded in thenextfive minutes.	
5) The orange extract was spread on theside of a Styrofoam cup with a brush, andthe observation was recorded in the nextfiveminutes.	
6) The lemon extract was spread on the sideof a Styrofoam cup with a brush, and theobservation was recorded in the next fiveminutes.	

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7) The orange juice was spread on the sideof a Styrofoam cup with a brush, and theobservation was recorded in the next fiveminutes.	
8) The lemon juice was spread on the sideof a Styrofoam cup with a brush, and theobservation was recorded in the next fiveminutes.	
9) The grapefruit juice was spread on theside of a Styrofoam cup with a brush, andthe observation was recorded in the nextfiveminutes.	

10) Three same size pieces of the Styrofoam cup were cut, and placed in each two different nail polish, which are regular and acetone-free, and Acetone, and the observation was recorded in next five minutes. polish

Regularnail	Acetonefreenailpolish	Acetone
		

Observations:

RESULT	**PICTURE**
Theblackpaperwasplacedtosee thehole. The side Styrofoam was dissolved in**orange peel oil**, and it waspossibleto seethrough.	
Theblackpaperwas placedtosee thehole. The side Styrofoam was slightlydissolved in**lemon peel oil**, but it was notstrongenough to make a hole.	

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The black paper was placed to see the hole. The side Styrofoam was dissolved by **grapefruit peel oil**, and it waspossibleto seethrough.	
The black paper was placed to see the hole. The side Styrofoam was slightlydissolved by lime peel oil, but it was notstrongenoughtomakeahole.Itjustmadethe surface area of the Styrofoam cupbumpy.	
Theorangeextract,lemonextract,orangejuice,lemonjuice,and grapefruitjuicedidnotwork.	
• In the regular nail polish, about five minutes later, the piece of Styrofoam cupdissolvedslightly, and it shrank. • In the acetone-free nail polish, about five minutes later, the piece of Styrofoamcupdissolved slightly, and it shrank. • In the Acetone, about 2 minutes later, the piece of Styrofoam cup dissolvedfaster than other nail polishes, and the piece of Styrofoam cup shrank but didnotdissolveperfectly.	

Part2:DissolveStyrofoaminOrangeandLemonpeelextract

Orangepeelextract	**Lemonpeelextract**
	
Styrofoamboxdissolvedbyorangepeelextractfortwo minutes. After two minutes, the left length oft Styrofoamboxwas: Trial 1 : 4cmTrial 2 : 4.5cmTrial 3 : 4.5cmTrial 4 : 4cmTrial5 : 5cm	Styrofoamboxdissolvedbylemonpeelextractfortwo minutes. After two minutes, the left length oft Styrofoamboxwas: Trial 1 : 5cmTrial 2 : 5.5cmTrial 3 : 6.5cmTrial 4 : 6cmTrial5 : 6cm

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III. RESULT AND DISCUSSION:

Thefirstexperimentwastestingthedissolvin gStyrofoamabilityof limoneneinorange,lemon,grapefruit, and lime peel.Itwasalsoforprovingthatlimoneneisonlycontain ed in the peelofthe fruit,notinside. Allfruitoilfromthe peel of each fruit worked well to dissolvetheStyrofoamcup.Orange peel oil showed the best ability to dissolve Styrofoam, and a Grapefruit was thenext. Lemon and Lime did not work strongly, so this shows that orange peel contains alargeamount of limoneneinit.Orange extract and lemon extract could not dissolve the Styrofoam cupwas that it is made from the inside part of the fruit.Three different types of acetones were used in this experiment to compare the speed ofdissolving Styrofoam to the natural fruit oil.Acetone that is used in chemical experimentsshows the extremely fast speed of dissolving Styrofoam. Regular Nail Polish, which ismade of acetone showed a slower speed of dissolving a piece of Styrofoam cupcomparedto thepeel oil.This is because nail polish should be connected directly to humanskin, so it contains lessacetone compared to the chemical acetone. Acetone-Free Nail Polish shows the slowest speedof dissolvingpiecesofStyrofoam.

The orange peel extract started todissolvetheStyrofoam boxquickly for the first 20 secondsand showed its yellow colour on the box.However, later on, the speed of dissolving slowed down, and it stoppeddissolvingtheboxafter2minutes.Whentheora ngepeelextract completeditsdissolvingprocessafter2minutes,allfive trialsshowsa similarlengthofthe leftStyrofoambox.

In the case of the lemon peel extract, it showed almost the same process as orange peel extract,except for the length of leftover Styrofoam..Itwasslightlylongerthanorangepeelextra ct,whichmeansorangepeelextracthasabetterability to dissolve Styrofoam.

IV. CONCLUSION

The purpose of this experiment was fully achieved, as it proved that limonene, inspecificfruitpeel,such as oranges, grapefruits, lemons, and limes. canbeagoodwaytorecycleStyrofoam,whichcausesse riousenvironmentalproblems thesedays.Orange peel oil has more limonene as compared to lemon peel oil, so it has a better ability to dissolveStyrofoam.

These experiments also proved that limonene will be a good eco-friendly solution fortheground pollutionbyStyrofoam,which does notdecomposenaturally.

If the way of extracting peel oil from orange and lemon peel easily is developed,people can use limonene from the peel in their house to recycle Styrofoam easilywithoutwasting money and spaceonit.Thisideashouldbe explored among allthepeopleovertheworld,sotheycanrecycleStyrofo amwisely in aneco-friendly way.

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