

AL Chemistry Group Project Topic 2 – Green Chemistry Polycarbonate Plastic Production

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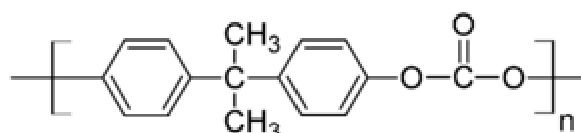
Introduction

Polycarbonate is a kind of plastic used in a variety of applications due to its toughness, heat and electrical resistance, lightweight. DVDs, sunglasses, electronic equipment, bulletproof windows and medical devices are made of polycarbonate. It is just one-sixth as heavy as glass.

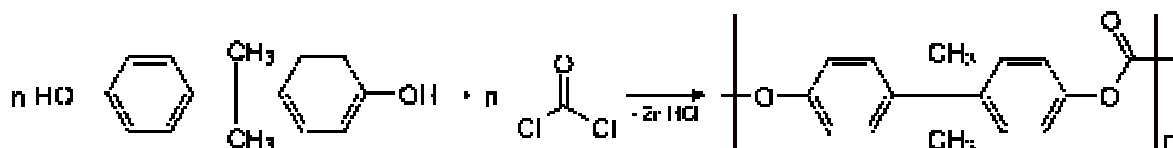


Production process

It is called polycarbonate because it contains carbonate groups. It has a structure shown below.



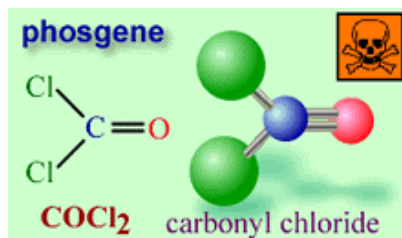
Polycarbonate plastics are produced by the reaction of bisphenol A and phosgene (COCl_2) in the traditional method.



Less hazardous Synthesis and Designing safer chemicals

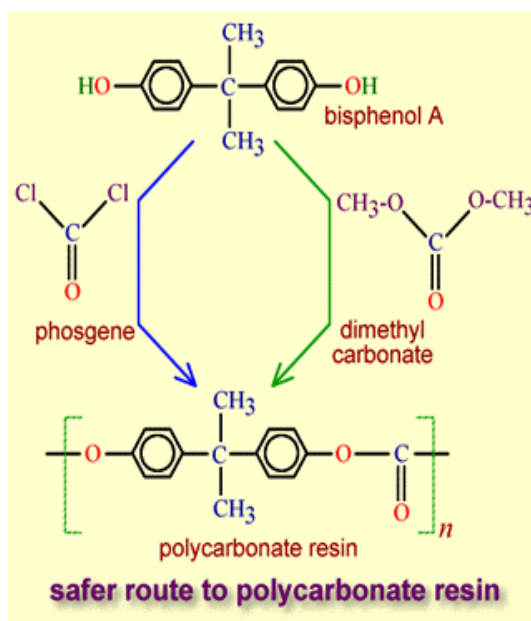
According to the traditional method in producing polycarbonates, the reactant phosgene is a gaseous compound which is highly toxic. It is used as a chemical weapon in the First World War due to its high vapour

density. It means the toxic gas will not easily disperse and be diluted in the air. Phosgene is a colourless gas and has unnoticeable odour, leakage is difficult to detect. It will damage the blood-air barrier in lungs and causes suffocation.



In addition, the production of phosgene produces carbon tetrachloride (CCl_4) as a by-product which is undesirable. Exposure of high concentration of CCl_4 may affect the central nervous system, degenerate the liver and kidneys and even death.

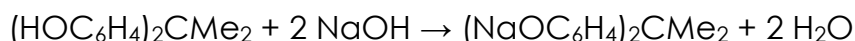
However, there is a greener and safer method in producing polycarbonate which uses dimethyl carbonate as the reactant instead of phosgene.



Comparison between traditional and safer method

For traditional method, the phosgene is a dangerous reagent which is poisonous.

It exists as a gaseous compound at room temperature that means it is difficult to handle. The first step of the production of polycarbonate requires the use of sodium hydroxide to produce diphenoxide which will react with phosgene:



This approach also suffered from slow reaction rates and therefore a faster and safer method is needed.

For the safer method, the dimethyl carbonate is a harmless reagent and exists as a liquid compound at room temperature. This makes it easier to handle compared with phosgene. No solvent is required in the reaction. This approach is faster and safer than that using phosgene as the reactant.

Atom Economy

The reaction between bisphenol A and phosgene produces hydrogen chloride as a by-product which is strong acid and is highly corrosive.

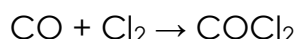


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If we use dimethyl carbonate as the reactant in the production of polycarbonates, the by-product is methanol and it can be used as the raw material in converting back into dimethyl carbonate. Also, methanol is relatively harmless.

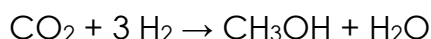
Use of renewable resources

The phosgene used in the traditional method is produced by passing carbon monoxide and chlorine gas through porous activated carbon, which acts as a catalyst.



*The chlorine gas used here is not renewable.

Methanol can be converted into the reactant, dimethyl carbonate used in the greener method in the production of polycarbonate. It can be produced by the reaction between carbon dioxide and hydrogen gas.



*Hydrogen is renewable or not depends on the way it is produced.

Catalysis

For traditional method, activated carbon is needed to produce phosgene.

Activated carbon is carbon



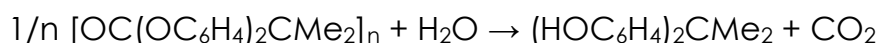
produced from carbonaceous materials such as peat, wood and coal. These raw materials are instilled into certain chemicals like acid, strong base or salt of them such as potassium hydroxide and sodium hydroxide. After that, the raw materials are "carbonized" at temperature in the range 600-900°C.

However, this "activation" of carbon is difficult.

For the greener method, copper chloride with a 5% potassium chloride additive is needed to produce dimethyl carbonate. This catalysis is much easier than the activation of carbon.

Degradation

Although polycarbonates are heat-resistant, they will undergo hydrolysis when in contact with water above 60°C and release bisphenol A as the following equation.



Furthermore, polycarbonate will be decomposed under thermal degradation. It softens when temperature reaches about 140°C and melts at 220°C.

Pay attention to the gases or fumes given off during burning or thermal decomposition, they are toxic and will cause respiratory irritation!

Accident prevention

When we need to clean the containers which are made of polycarbonate plastic, sodium hypochlorite bleach and other alkali cleaners must not be used. They will catalyze the release of bisphenol A. High bisphenol A levels may increase the risk of developing coronary heart disease and diabetes.

Furthermore, cleaners containing ammonia or acetone should not be used since polycarbonate plastics dissolve in their presence. If you are going to clean the grease or oils on the surface of the polycarbonate containers, alcohol is one of the recommended organic solvent which you need.

Conclusion

Polycarbonate plastics have a variety use in our daily life, but we

should be careful when cleaning them and avoid in contact with hot water.

Sources

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<http://www.wisegeek.com/what-is-polycarbonate.htm>

<http://www.icis.com/V2/chemicals/9076147/polycarbonate/process.html>

<http://en.wikipedia.org/wiki/Polycarbonate>

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