



Polycarbonate (PC)

Carlos Buitrago
Introduction to Polymers
CE 435



OVERVIEW

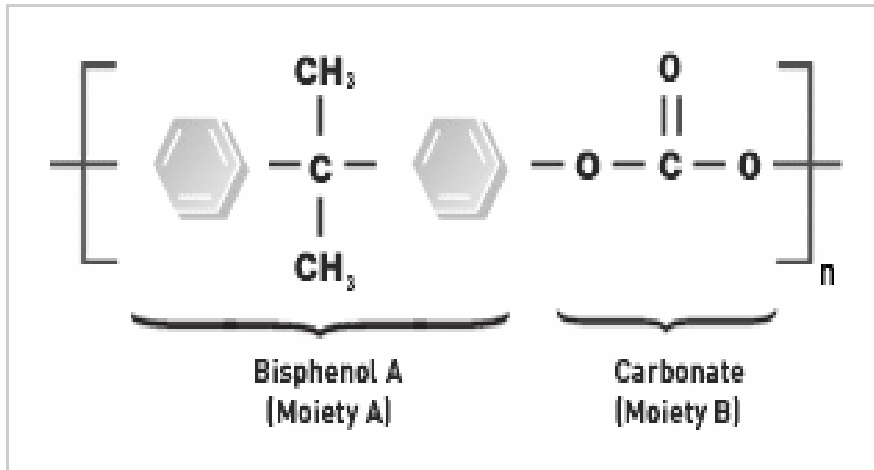
- Introduction
- Structure of PC
- Synthesis
- Manufacturing
- Physical Properties of PC
- Applications of PC
- PC Blends
- Questions



INTRODUCTION

- Polycarbonate (PC), was first developed in 1953 by Bayer in Germany, and General Electric in the US independently. Its most popular trade name is LEXAN[®]
- PC is one of the high performance heterochain polymeric materials that comprise the family of “engineering thermoplastics”
- PC is a good material choice in industry not only due to its characteristics, but also because its processing is environmentally friendly, and it can be recycled

STRUCTURE OF PC



LG-DOW (n.d.). Molecular structure of polycarbonate.

<http://www.lg-dow.com/tech/tech.htm>

- The Characteristic high glass transition temperature ($T_g = 145^\circ\text{C}$) of PC is caused by the minimal molecular rotation about the bonds

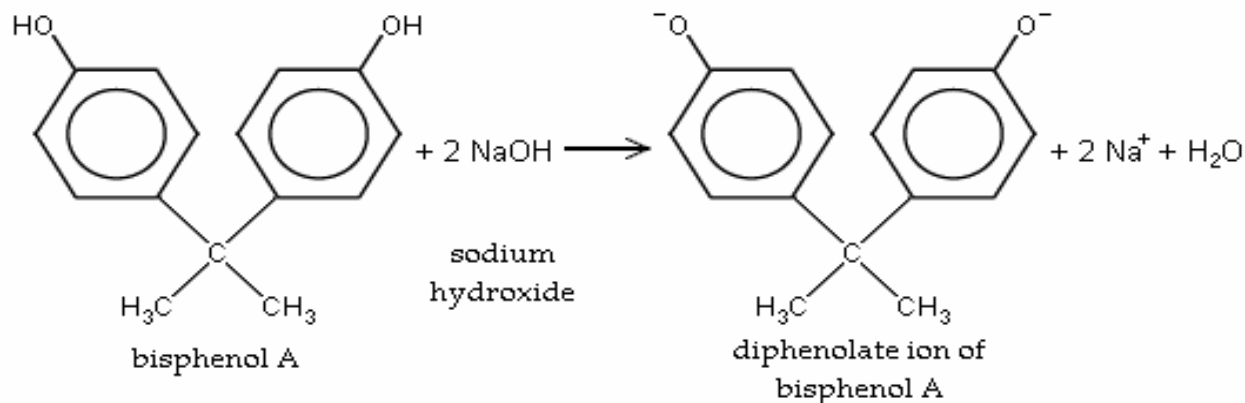
- A polycarbonate molecule is composed by a Bisphenol A part and a carbonate group
- Bisphenol A contains two aromatic rings, which are responsible for PC's stiff backbone
- The Bisphenol A group also contributes to PC's inability to crystallize. This amorphous structure gives the polymer its particular transparency

SYNTHESIS

PC is most often synthesized from **Bisphenol A** and **phosgene** by a step-growth polymerization in which Cl^- ions are eliminated every time the monomers react. This kind of step-growth polymerization is often called a condensation process

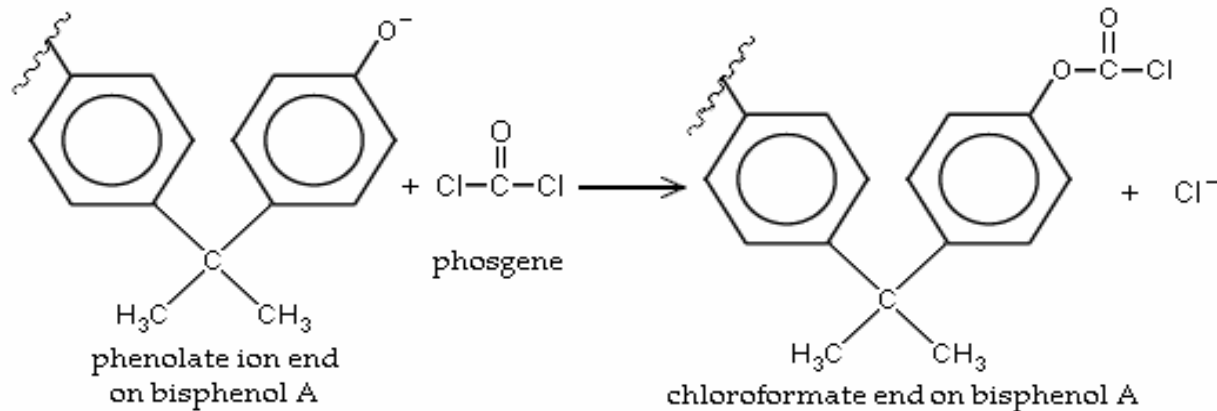
Polymerization Steps

1. The Bisphenol A groups are reacted with proton acceptors such as NaOH to obtain the polymerization functional groups



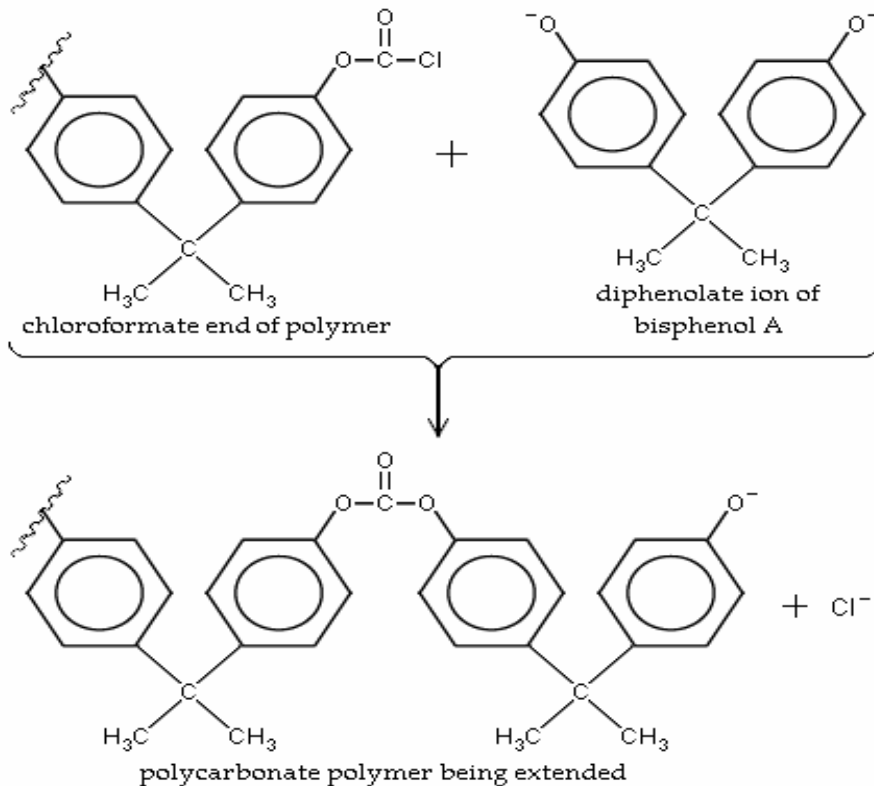
Polymerization steps (Cont'd)

2. The deprotonated Bisphenol A reacts with Phosgene and a catalyst at temperatures between 25 and 35°C. This way, a Polycarbonate monomer is formed, and the catalyst (often times Pyridine), is eliminated along with the chloride anion



Polymerization steps (Cont'd)

3. In order to react more Bisphenol A and phosgene into the chain, chloride anions are always eliminated



In another approach, Diphenyl Carbonate (R-O-CO-O-R) and Bisphenol A, can be reacted at temperatures between 180-220°C to yield PC and a phenol molecule. This process results in more impurity, and is more expensive because higher temperatures are necessary



MANUFACTURING

Polycarbonate is transformed from pellets into the desired shape for its intended application by melting the polycarbonate and forcing it under pressure into a mold or die to give it the desired shape depending on the application. This process is repeated thousands of times

Extrusion

The molten PC is passed through a die that gives the material its final shape. After this, the melt is cooled rapidly. Long pipes and sheets are created by this process

Molding

The PC melt is pressed into a mold with the defined shape of the final product. The melt is then cooled inside the mold. This process is ideal for specific parts such as automotive and computer parts

PHYSICAL PROPERTIES OF PC

- It maintains good mechanical properties between -40°F and 280°F
- High strength that makes it resistant to impact and fracture
- It can be easily colored, it's non-toxic, and can be absolutely transparent up to 2 In. in width
- PC also features high electrical and heat resistance
- It is biologically inert
- Readily recyclable and cost effective

APPLICATIONS OF PC

- PC's outstanding strength makes it suitable for bullet-resistant or shatter-resistant glass applications
- PC's relatively low weight in comparison to other high strength materials and its high ductility make it attractive to be used in lenses and windows
- It has also been used as a flame retardant and an electrical insulator
- Small filters for the extrusion of small particles
- CD's, DVD's. Automotive, cell phone, and laptop parts.



The header features five circles in a horizontal row. From left to right: a solid light purple circle, an empty light purple circle outline, the text 'PC BLENDS' in a bold purple font centered between the second and fourth circles, another empty light purple circle outline, and a final solid light purple circle.

PC BLENDS

PC can be blended to enhance its properties:

- PC/ABS blends exhibit high ductility and impact strength at temperatures below those of pure PC
- PC tends to scratch easily, Silicone-polycarbonate copolymers can yield a hard thermoplastic that doesn't get scratched. Many more properties can be achieved depending on the composition

QUESTIONS





REFERENCES

Rodriguez, F., Cohen, C., Ober, C., Archer, L., Principles of Polymer Systems.
Taylor & Francis, New York, London, 2003

LG-DOW (n.d.). Properties of polycarbonate.
<http://www.lg-dow.com/tech/Wheather.htm>

British Plastics Federation (n.d.). Polycarbonate PC.
http://www.bpf.co.uk/bpfindustry/Polycarbonate_PC

Ashby, M., Johnson, K. Materials and design Butterworth Heinemann, Oxford,
2002

Association of Plastic Manufacturers (n,d.). Polycarbonate.
<http://www.plasticseurope.com>

Polycarbonate, definition and much more (n,d.).Synthesis of Polycarbonate.
<http://www.answers.com/topic/polycarbonate>