Degradation Studies & Advantages of CO_2-Based Polymers

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BACKGROUND

Polymers are substances that consist of the same molecular structure repeating over and over. One of the most common industrial usages of polymers is to create plastics and adhesives. However, current synthetics derived from petroleum, a nonbiodegradable source, comprise 90% of today's plastics. These petroleum-based polymeric structures only experience degradation at a surface level causing many of them to possess long half-lives, tout large carbon footprints, and resist decomposition. Environmental concerns arising from petroleum-based polymers have led to increased efforts to explore the commercial viability of CO_2 , or carbon dioxide, as a source for polymeric materials. CO_2 is classified as a greenhouse gas due to its readily combustible nature. However, it is this combustibility that makes CO_2 a great source for polymer synthesis as it is a method of producing energy. CO_2 is also a renewable resource, biodegradable, and yields nontoxic byproducts. CO_2-derived polymers such as polycarbonate, polypropylene carbonate (PPC), and polyurethane (PUR) are promising advancements in plastic production due to the advantages they possess over more common derivatives.

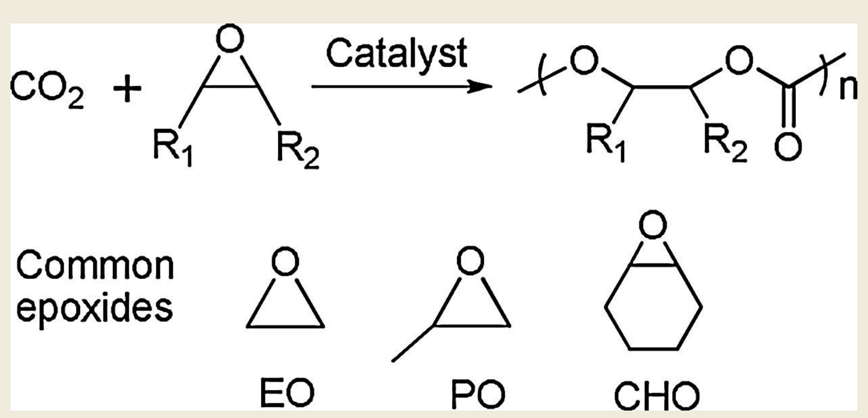

Figure 1.) CO_2-based polymer synthesis is depicted. Many CO_2-based polymers are synthesized from epoxides.

METHODS

In this literature study, I compiled data on the traits, structures, and degradation factors of several CO_2-based polymers. I focused on three specific CO_2-based polymers: Polycarbonate, Polypropylene Carbonate (PPC), and Polyurethane (PUR).

CO_2-Based Polymer Synthesis

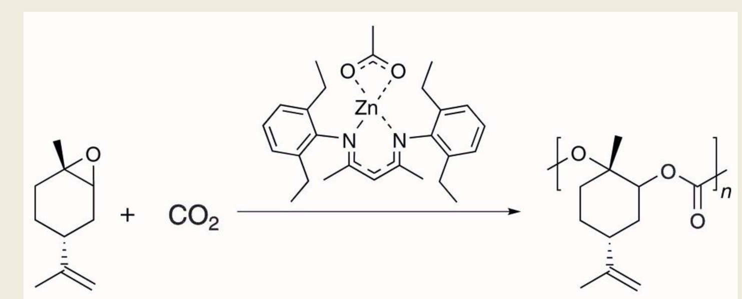

Figure 2.) Aromatic Polycarbonate

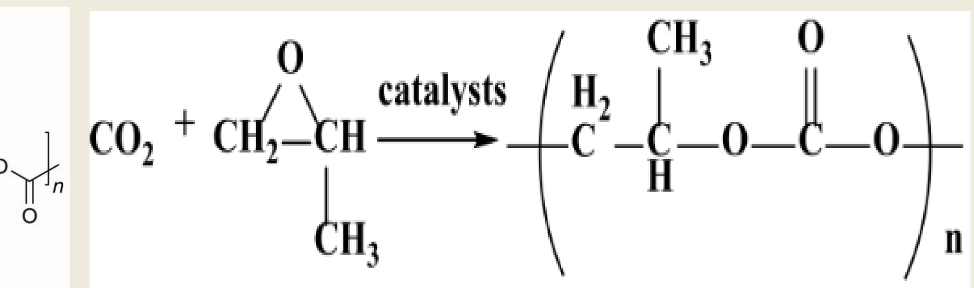

Figure 3.) PPC

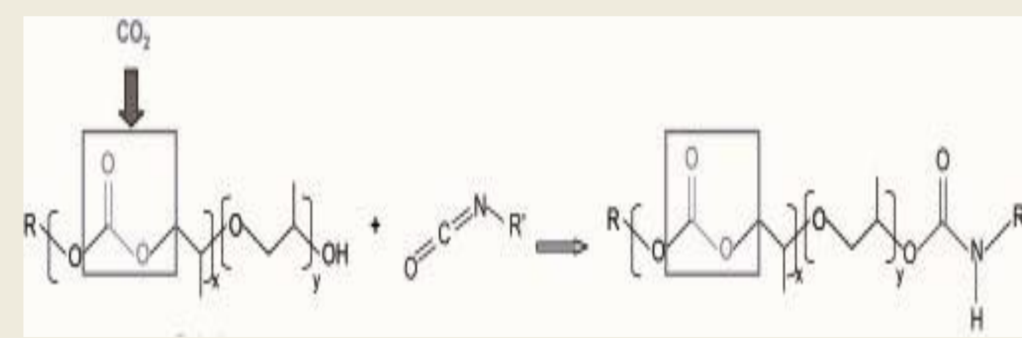

Figure 4.) PUR from CO_2 derived polyol

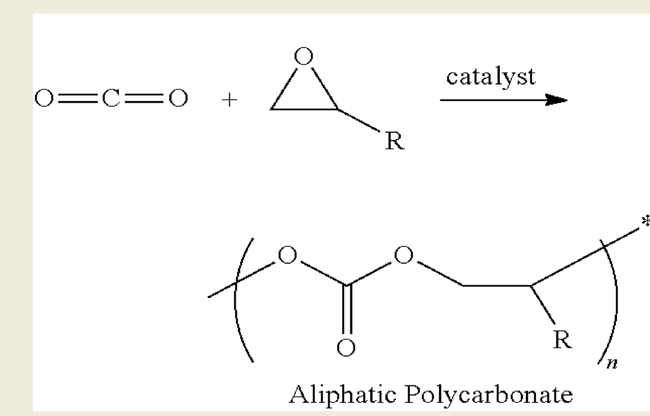

Figure 5.) Aliphatic Polycarbonate

Polymer	Temperature Parameters(°C)	Tensile Strength (Mpa)
Polycarbonate	-20° to140°	55 to75
Polyurethane (PUR)	-62° to 93°	43 to 46
Polypropylene Carbonate (PPC)	-30° to 82°	22 to 44

Figure 6.) Temperature parameters and tensile strength of Polycarbonate, PUR, and PPC are displayed. CO_2-based polymers are categorized as thermoplastics, touting notable resistances to high temperatures and possessing high molecular weights.

Degradation of Biodegradable Polymers

A polymer is defined as biodegradable if most of its mass is readily degradable by natural means. Biodegradable polymers have chemical properties that encourage microorganisms to feed on them and break down the structures . In the figures below, from left to right, the degradation of Polycarbonate in seawater and photo-oxidatively are depicted.

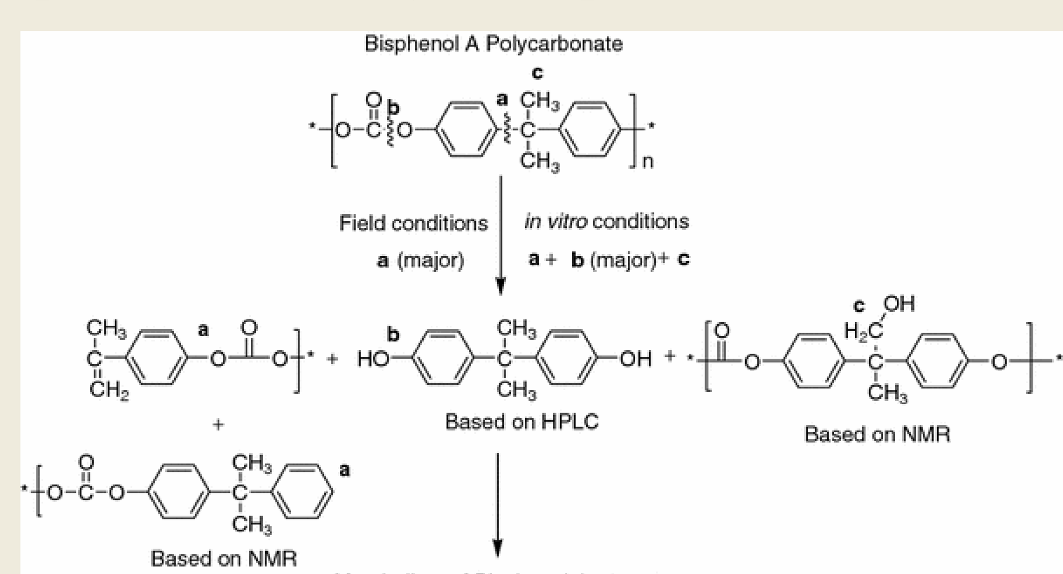

Figure 7.) Polycarbonate degradation in seawater

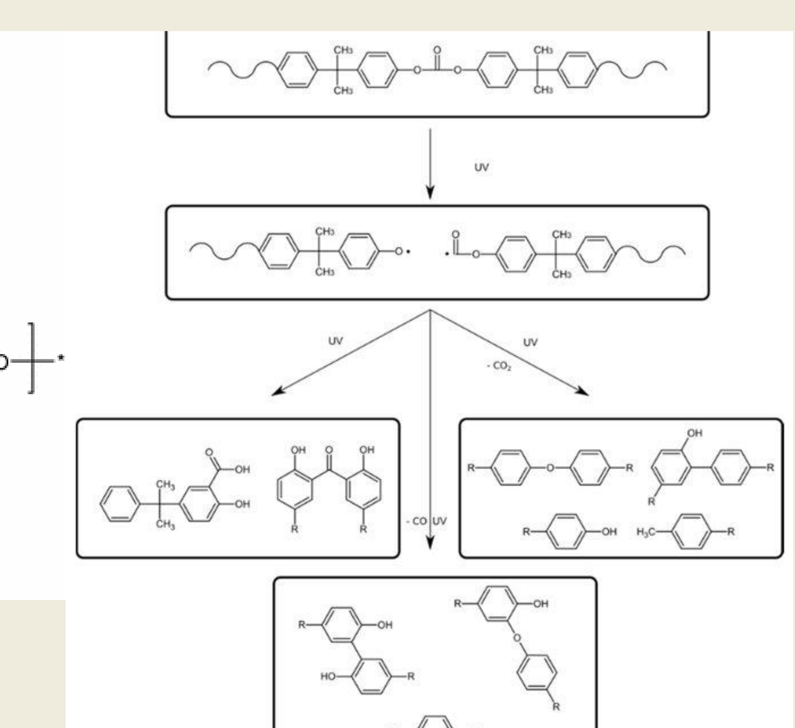

Figure 8.) Photo-oxidative degradation of Polycarbonate

CONCLUSION

CO_2-based polymers such as Polycarbonate, PPC, and PUR possess characteristics that give them advantages over petroleum-derived polymers. The makeup of these polymers encourage natural degradation giving them significantly shorter lifespans than their petroleum-based counterparts, can be synthesized from abundant sources, and possess high temperature viability and tensile strengths. These advantages make this family of polymers a prime candidate to replace nonbiodegradable derivatives in plastic production.

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