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4. Polymer Analysis in Restricted Environment

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ABSTRACT:

Chemical industrial processes have become "business as usual" due to their energy-intensive production methods and unappealing branding. Because of its high energy requirements, polycarbonate (PC) production has grown to be a major industrial operation. Furthermore, many hazardous chemicals are used in the manufacturing process. Polymers provide remarkable performance characteristics that are desired by a wide range of modern society consumers, but the fate of polymers in the environment has become a massive management problem. Polymer applications provide molecular structures that product engineers seeking long-lasting properties find appealing. These properties are also important in terms of polymer or plastic environmental lifetimes. Reports of microbial degradation of polymeric materials have recently emerged, presenting new emerging technological opportunities to reduce the massive pollution threat posed by the use of polymers/plastics. There is a substantial literature from which potential biological technology development directions can be deduced.

KEYWORDS:

Polymers, plastics degradation, microbial degradation, biofilms, extent of degradation.

Introduction:

Traditional polymer materials, particularly plastics, have evolved over decades. In terms of raw material and energy utilisation, as well as waste generation, their manufacturing is extremely efficient. Due to manufacturing scale and process optimization, the products have a number of excellent properties, including water and microorganism impermeability, high mechanical strength, low density (suitable for transporting goods), and low cost [1]. However, if they are not recycled, some of their most useful properties, such as chemical, physical, and biological inertness and durability, cause them to accumulate in the environment. Unfortunately, the accumulation of plastics and other materials is becoming a major problem for all countries worldwide. In 1869, the first synthetic polymer was invented in response to a commercial $10,000 prize for developing a suitable replacement for ivory.

A never-ending stream of discoveries and inventions contributed to the development of new polymers to meet society's various needs. Polymers are composed of long chains of atoms organised in repeating components or units that frequently outnumber those found in nature. Plastic can be defined as pliable and easily shaped material. It is now used to refer to polymeric materials. [2] Plastics are organic polymers with high molecular weight derived from various hydrocarbon and petroleum materials. Plastic has gained popularity in the production and packaging of intermediate and finished goods. Over the last several decades, plastics have accumulated, filling vast portions of landfills and causing an ecological disaster. Plastics and the goods that contain them have been destroyed or recycled, potentially releasing heavy metals into the environment as toxins. [3]

Polymer Structures and Features:

A polymer is a valuable chemical composed of numerous repeating units. The suffix "-mer" refers to the basic repeating unit of a polymer, whereas "poly-mer" refers to a chemical made up of many repeating units. Polymers can be chemically synthesised in a variety of ways, depending on the chemical properties of the monomers, to produce the desired product.

Nature provides numerous examples of polymers that can be used directly or transformed to form materials needed by society to meet specific needs. [4] The polymers under consideration are primarily composed of carbon and hydrogen, with additional functionalities of oxygen, nitrogen, and chlorine (see Figure 4.1).

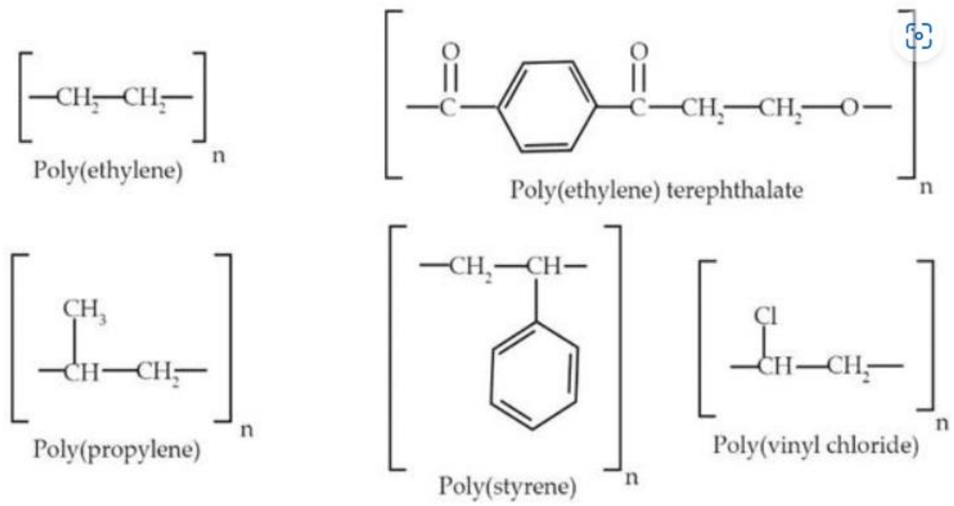

Figure 4.1: Shows the Structures of The Major Commercial Thermoplastic Polymers

Polymer characteristics such as chemical resistance, thermal and electrical insulation, strength and light weight, and a plethora of applications where no alternative exists all contribute to polymer's appeal. [5] Polymers are widely used in industries such as automotive, building and construction, and packaging.

XRF Technology for Qualitative and Quantitative Analysis:

XRF occurs when a fluorescent (or secondary) x-ray is emitted from a sample excited by a primary x-ray source. XRF is an excellent technology for qualitative and quantitative material composition analysis because this fluorescence is unique to the sample's elemental composition. In this analysis, a 4200-watt system with 6 primary beam filters, 4 collimators, up to 9 crystals, 2 detectors, helium purge, and a 5GN+ Rh X-ray tube for ultra-light element analysis was used. It also had sample analysis security features.

Biological Degradation:

Organic substrates (polymers) are converted to small molecular weight fragments that can then be degraded to carbon dioxide and water via biodegradation [16, 17, 18, 19, 20, 21]. The physical and chemical properties of a polymer are critical for biodegradation. The efficiency of microorganism biodegradation is directly related to polymer properties such as molecular weight and crystallinity.

Exo-enzymes, which have reactivity ranging from oxidative to hydrolytic, are initially involved in polymer degradation. Depolymerization refers to their action on the polymer. [6] In general, exo-enzymes degrade complex polymer structures into smaller, simpler units that can be consumed by the microbial cell to complete the degradation process.

Polymer degradation results in the formation of process end-products such as CO_2, H_2O, or CH_4 during the degradation path leading to mineralization. As a terminal electron acceptor, oxygen is required in the aerobic degradation process. Aerobic conditions result in the formation of CO_2 and H_2O, as well as the cellular biomass of microorganisms, during the degradation of plastic forms. In the presence of sulfidogenic conditions, polymer biodegradation produces CO_2 and H_2O.

Polymer degradation in anaerobic conditions produces organic acids, H_2O, CO_2, and CH_4. When comparing aerobic and anaerobic degradation, it is discovered that the aerobic process is more efficient. In terms of energy production, the anaerobic process produces less energy due to a lack of O2, which acts as an electron acceptor and is more efficient than CO_2 and SO_4^{-2}.

Review of Literature:

SAPs are water-absorbing compounds that swell to many times their original size and weight when exposed to it. They are networks of cross-linked hydrophilic polymer chains. The network has the ability to swell and hold a large amount of water while remaining physically intact (Buchholz and Graham, 1997[7]; Mahdavinia et al., 2004[8]).

Water-absorbent polymeric materials that are commercially available are known to be partial neutralization products of cross-linked polyacrylic acids, partial hydrolysis products of starch-acrylonitrile copolymers, and starch-acrylic acid graft copolymers. The biodegradability of the material is currently an important focus of research in this field due to the renewed emphasis on environmental protection issues (Lenzi et al., 2003[9]).

Objectives:

- Research the biodegradation of polyethylene film
- Research the factors influencing polymer biodegradation
- Research the properties of major commercial thermoplastic polymers
- Research xrf technology

Research Methodology:

A research methodology is a standardized approach to addressing a research topic through data collection, data analysis, and study results. A research technique is a method for carrying out a research study.

The systematic gathering and analysis of facts and information for the advancement of knowledge in any field is known as research. The study's goal is to solve intellectual and practical problems using systematic techniques.

To apply the analytical and descriptive methods to the research, close reading and detailed analysis of secondary sources are required. It is critical to obtain additional perspectives in order to expand on the textual analysis, which would necessitate close reading of a few secondary materials.

Result and Discussion:

Table 4.1: Characteristics of major commercial thermoplastic polymers

Polymer	Abbreviation	Density(23/4^{o}C)	Crystallinity(%)	Lifespan(year)
Polyethylene	PE	0.91-0.925	50	10-600
Polypropylene	PP	0.94-0.97	50	10-600
Polystyrene	PS	0.902-0.909	0	50-80
Polyethylene glycol terephthalate	PET	1.03-1.09	0-50	450
Polyvinyl chloride	PVC	1.35-1.45	0	50-100+

Polymer degradation strategies are currently available in chemical, thermal, photo, and biological forms.

The physical properties shown in Table 1 differ only slightly in density but significantly in crystallinity and lifespan. [10-11] Crystallinity has been shown to be important in biodegradation processes involving specific polymers.

Table 4.2: Defining temperatures for some selected polymers

Substance	T_{DA} °C
Polystyrene	449.3
"	445.8
"	447.7
Mean:	447.6
RSD (%):	0.39
Nitrile	480.6
"	485.9
"	486.8
"	485.4
Mean:	484.7
RSD (%):	0.58
Latex	407.2
"	404.2
"	406.9
"	406.1
Mean:	406.1
RSD (%):	0.33
Polypropylene	477.0
"	474.0
"	477.7
"	472.9
"	478.4
Mean:	476.0
RSD (%):	0.51

Substance	T_{DA} °C	T_{DB} °C
CPVC	339.4	483.9
"	341.8	485.3
"	341.9	480.1
"	344.5	494.4
"	341.9	489.2
Mean:	341.9	486.6
RSD (%):	0.53	1.12
LDPE	N/A	491.3
"	439.1	502.0
"	N/A	502.7
"	N/A	492.6
"	430.8	501.3
Mean:	435.0	497.98
RSD (%):	1.35	1.11

There is enough resolution to make definite statements about the identity of all but the most degraded samples, as evidenced by the data in Table 4.2, which lists several experimental values for various polymers. [12]

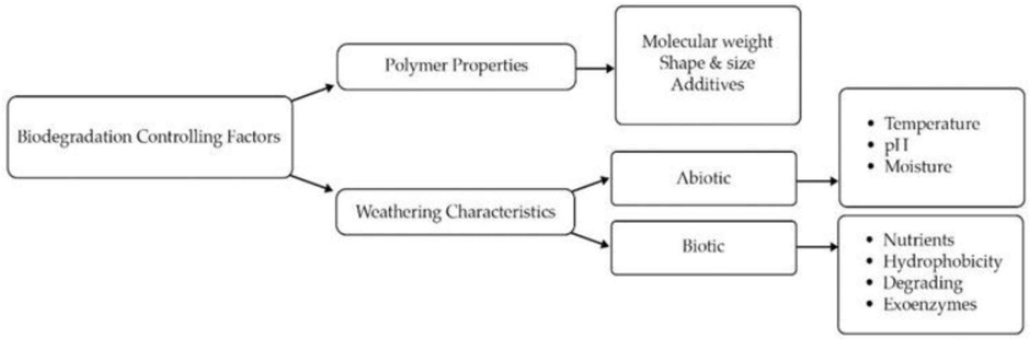

Figure 4.2: Factors Influencing Polymer Biodegradation

Because microbial colonization is dependent on surface features that allow microorganisms to establish a locus from which to expand growth, a polymer's molecular weight can be extremely limiting. Because microbial attachment to the polymer surface occurs and polymer material is used in amorphous sections of the polymer surface, polymer crystallinity can play an important role. [13-14] Polymer additives are low molecular weight organic chemicals that can serve as a starting point for microbial colonization due to their ease of biodegradation (Figure 4.2)

The mineralization curves for an oxo-biodegradable HDPE/LLDPE blend biodegraded in composting conditions at two different temperatures are shown in Figure 4.3. [15]

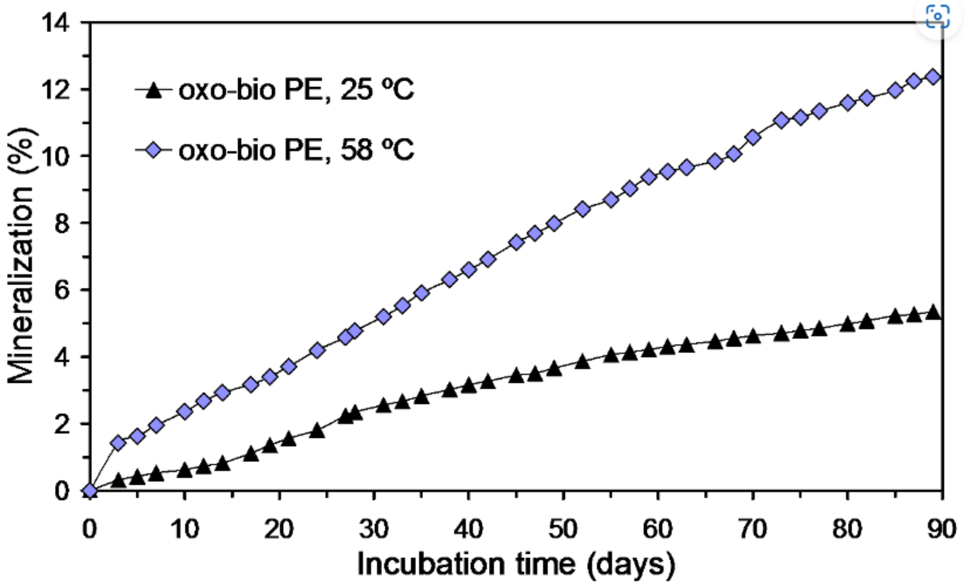

Figure 4.3: Biodegradation of Polyethylene Films in Compost/Perlite as a Function of Incubation Time at 25 and 58oC and 50% Relative Humidity.

Conclusion:

Despite a strong predisposition that many of these polymers were resistant to biodegradation, the major commercial polymers have been shown to be biodegradable in a variety of situations. It remains to be seen whether bioremediation can play a significant role in polymer waste management. Massive waste polymer treatment technology must be robust enough to be dependable on a large scale, as well as adaptable to conditions found throughout the environment where this treatment is required. The status of information relating to the application of biodegradation treatment to existing and future polymer solid waste is in the early stages of development for several waste polymers.

References:

1. Buchholz F.L. and Graham A.T. (1997) Modern superabsorbent polymer technology, Wiley, New York
2. Mahdavinia G.R., Pourjavadi A., Hosseinzadeh H. and Zohuriaan M.J., (2004), Modified chitosan 4 Superabsorbent hydrogels from poly (acrylic acid-co-acrylamide) grafted chitosan with salt- and pH-responsiveness properties, European Polymer Journal, 40,1399-1407.
3. Lenzi F., Sannino A., Borriello A., Porro F., Capitani D. and Mensitieri G., (2003), Probing the degree of crosslinking of a cellulose based super absorbing hydrogel through traditional and NMR techniques, Polymer, 44, 1577-1588
4. Dhodapkar R., Rao, N.N., Pande S.P. and Kaul S.N., (2006), Removal of basic dyes from aqueous medium using a novel polymer-Jalshakti, Bioresource Technology, 97, 877-885.
5. Dhodapkar R., Rao N.N., Pande S.P., Nandy T. and Devotta S., (2007), Adsorption of cationic dyes on super absorbent polymer and photocatalytic regeneration of the adsorbent, Reactive and Functional Polymers, 67 ,540-548
6. Yousif E, Haddad R. Photodegradation and photo stabilization of polymers, especially polystyrene: Review. Springer Plus. 2013; 2:398. DOI: 10.1186/2193-1801-2-398
7. Ojeda T. Polymers and the environment. In: Yılmaz F, editor. Polymer Science. London: Intech Open; 2013. pp. 1-34. DOI: 10.5772/51057
8. Geyer R, Jambeck JR, Law KL. Production, use, and fate of all plastics ever made. Science Advances. 2017;3(7). DOI: 10.1126/sciadv.1700782
9. Zhang B, Blum FD. Thermogravimetric studies of adsorbed PMMA, polyemer preprints. 2002;43(1):484–5.
10. Sichina WJ. Characterization of polymers using TGA. Boston (MA): Perkin Elmer, 2001 Application Notes: PETech-78
11. Kale SK, Deshmukh AG, Dudhare MS, Patil VB. Microbial degradation of plastic: A review. Journal of Biochemical Technology. 2015;6(2):952-961. ISSN: 0974-2328
12. Pathak VM. Review on the current status of polymer degradation: A microbial approach. Bioresour Bioprocess. 2017;4(1):15. DOI: 10.1186/s40643-017-0145-9
13. Ahmed T, Shahid M, Azeem F, Rasul I, Shah AA, Noman M, et al. Biodegradation of plastics: Current scenario and future prospects for environmental safety. Environmental Science and Pollution Research. 2018; 8:7287-7298. DOI: 10.1007/s11356-018-1234-9
14. TokiwaYet al2009Biodegradability of plastics. International journal of molecular sciences. 1037223742.

15. AurasRLimL-T2010Poly (lactic acid): synthesis, structures, properties, processing and applications. Wiley, 2010.