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APPLICATIONS& FAMILIES OF BIODEGRADABLE POLY (ESTER AMIDE) S

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ABSTRACT

Biodegradable polymers that have several applications, including the biomedical industry, are in high demand today. It takes a lot of research and development to create a polymer with the right mix of features, including cheap cost, biodegradability, and simplicity in thermal processing. To achieve these aims, several methods have been used, including the synthesis of novel polymers, the utilization of natural monomers, and the chemical modification of traditional polymers. Poly(ester amide)s (PEAs) have shown great promise as biodegradable materials due to their unique ability to combine hydrolysable ester groups (-COO-) in their backbone with strong intermolecular hydrogen bonding interactions established between their amide groups (-NHCO-), resulting in favorable thermal and mechanical properties. There is a lot written on PEAs right now, thus it seems important to organize the information in terms of synthesis, characteristics, and applications. Melt polycondensation of 1,4-butanediol, dimethyl adipate, and a premade bisamidediol based on 1,4-diaminobutane and -caprolactone yielded high molecular weight segmented poly (ester amide) s. Polymers with hard segment contents ranging from 10 to 85 mol% were generated by adjusting the bisamidediol to 1, 4-butanediol ratio. Crystal structure research using FT-IR and WAXD showed that poly (ester amide) s crystallize in a -type phase, which is structurally analogous to the -phase of even-even nylons. These polymers all have a structure that is micro-phase divided, with a rigid hard phase that is rich in amides and a more pliable soft phase that is rich in esters. The melting points of crystals made up of a single ester amide sequence are lower for the polymers than those made up of two or more such sequences, and vice versa.

I. INTRODUCTION

The necessity to employ environmentally friendly and, in some cases, biocompatible materials has pushed a number of contemporary businesses, such as agriculture, the automotive industry, medicine, and packaging, to prioritize the research and development of biodegradable polymers. Businesses of all stripes have limitless opportunity to create their ideal goods because to the flexibility of biodegradation rates.

Biodegradable polymers that may be used in packaging are gaining more attention than those made for any other purpose since it is estimated that more than 40% of plastics are used in this sector. Suitable polyester and starch-based polymers have been commercialized, and certain PEAs have even been made available to consumers for use as package wrap.

Novel biodegradable and biocompatible polymer research are urgently required due to the fast development and tight focus of the biomedical industry. These must be temporary in nature and biodegrade when their role is fulfilled, among other requirements.

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II. SPECIFIC APPLICATIONS OF POLY (ESTER AMIDE) S

Drug Delivery Systems

- **Microspheres for Drug Delivery**

Novel synthetic degradable polymers for controlled release of drugs and proteins have been the focus of much study since the 1990s. Polymers based on lactide and glycolide units were the first to be developed because of their biodegradability and proven safety as suture materials. Because of their malleability, they found widespread use in the pharmaceutical business, where they could be taken orally or injected. After the success of these tests, further aliphatic polyesters such poly (-caprolactone) were investigated. Since high levels of crystallinity and hydrophobicity may reduce medication release, new polymers, copolymers, and blends may be necessary. A completely new category of materials with desired properties might be manufactured using this technique.

Poly (ether-ester amide) s have recently been the subject of study for their possible use as drug delivery systems in the pharmaceutical sector. In specifically, biodegradable aliphatic polymers were synthesized and tested for use in controlled drug delivery. These polymers are built from polyester building blocks, hydrophilic triethyleneoxide segments with a low molecular weight, and amino acid residues (see Figure 1).

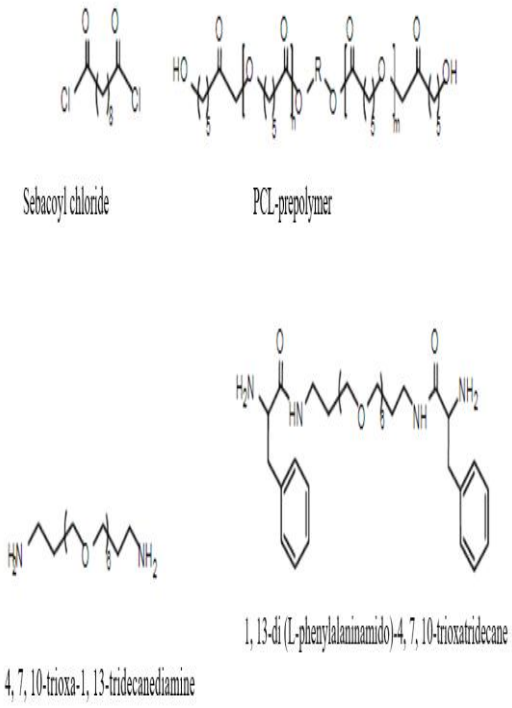

Figure 1. Reagents involved in the synthesis of poly (ether-ester amide) s with applications as drug delivery systems.

You may alter the polymers' chemical and physical characteristics by changing either their composition (i.e., the ester/amide ratio) or the length and type of the degradable ester blocks and the hydrophilic segments. In addition, peptide bonds possibly vulnerable to enzyme breakdown were produced by the insertion of short sequences of suitable amino acid residues throughout the chain. There were two stages to the synthesis:

1. The formation of a -COCl end capped oligoester and sebacoyl dichloride from a hydroxyl terminated polycaprolactone macromer (2000 g/mol)

2. Either 1,13-di(L-phenylalaninamido)-4,7,10-trioxatridecanediamine or 4,7,10-trioxa-1,13-tridecanediamine may be used to lengthen the chain. Semi crystalline, structurally similar to poly (-caprolactone), and melting at temperatures comparable to those of high molecular weight poly (-caprolactone) were the characteristics of the produced polymers. The polydispersity index was almost and the molecular weights ranged from

3. The widely used emulsification-solvent evaporation approach has been used to successfully create high-quality micro particles from these polymers, and medications with varying physicochemical qualities (such as diclofenac, dicumarol, and nicardipine hydrochloride) have been successfully encapsulated inside microspheres.

The better release compared to poly (-caprolactone) was attributed to the new poly (ether ester amide) s' higher hydrophilicity and reduced crystallinity.

- **Coatings for Drug Delivery**

PEA coatings are bioabsorbable and elastomeric, making them ideal for the covalent conjugation of medicines. It is also simple to adjust the degradation and medication release rates by changing the microstructure and content of the material.

Since the rate of PEA degradation tends to rise in tandem with inflammation, this property may be used to regulate the pace at which a therapy agent is released (for instance, when the chemical is directly connected to polymer side chains).

Oxygen free radical scavengers (such as tempamine) have been examined in conjunction with PEA coatings because they have a beneficial influence on the vascular healing response by reducing tissue harm caused by the poisonous free radicals generated during inflammation.

More specifically, it has been shown that copoly (ester amide) s derived from -amino acids (such L-leucine and L-lysine), diols, and dicarboxylic acids are biocompatible with artery walls.

In vivo investigations also showed that stents coated with PEA and loaded with 50% tempamine resulted in less arterial harm than stents loaded directly with the medication (i.e. without the polymer coating).

Several stents with PEA coatings have been patented for use in a variety of medical settings, including the treatment of vascular occlusions, thrombosis, and restenosis. The stent is often coated in a polymer solution that has a medicinal ingredient scattered throughout it.

After the solvent has evaporated, a layer of polymer and the therapeutic ingredient impregnated in the polymer will be left on the stent's surface.

III. MAIN FAMILIES OF FUNCTIONALIZED POLY (ESTER AMIDE) S

Functionalized Poly (Ester Amide) s

By adding functional pendant groups, PEAs may be chemically conjugated with a broad range of medicines, targeting groups, cell signaling molecules, and other biological agents, greatly expanding their potential applications. In addition, PEAs with pre-existing functional groups may provide a potent and economical strategy for customizing features including hydrophilicity, biodegradation rate, and mechanical and thermal properties.

Not until L-lysine copolymers with pendant carboxylic groups were created in the early 2000s were efforts to obtain functionalized PEAs realized and published.

The second strategy relied on reactive double bonds in the PEA backbone, which were supplied by unsaturated diols and dicarboxylic acids.

Hydrogels prepared through fotogelation from these materials showed promise as drug transporters and will be addressed more below.

The pendant amine group was reclaimed after a deprotection process after bis (L-lysine), -alkylene diester was inserted into a PEA. Due to the complexity of the synthesis and purification procedures, as well as the cost of the raw materials, this approach looks to be prohibitively costly.

Thermal polycondensation with the production of metal halide salts as a driving factor allowed for the simple synthesis of PEAs with regular sequences formed from diamine, dicarboxylic acid, and glycolic acid units (section 2.2.4.).

As shown in Figure 2, no secondary processes, such as transesterification, were present at the necessary polymerization conditions, making this method applicable even when L-lysine esters were utilized as the diamine unit.

Interest in these materials, for instance, as drug delivery vehicles, was increased by the prospect of connecting molecules having pharmacological action to the carboxylic acid groups of lysine.

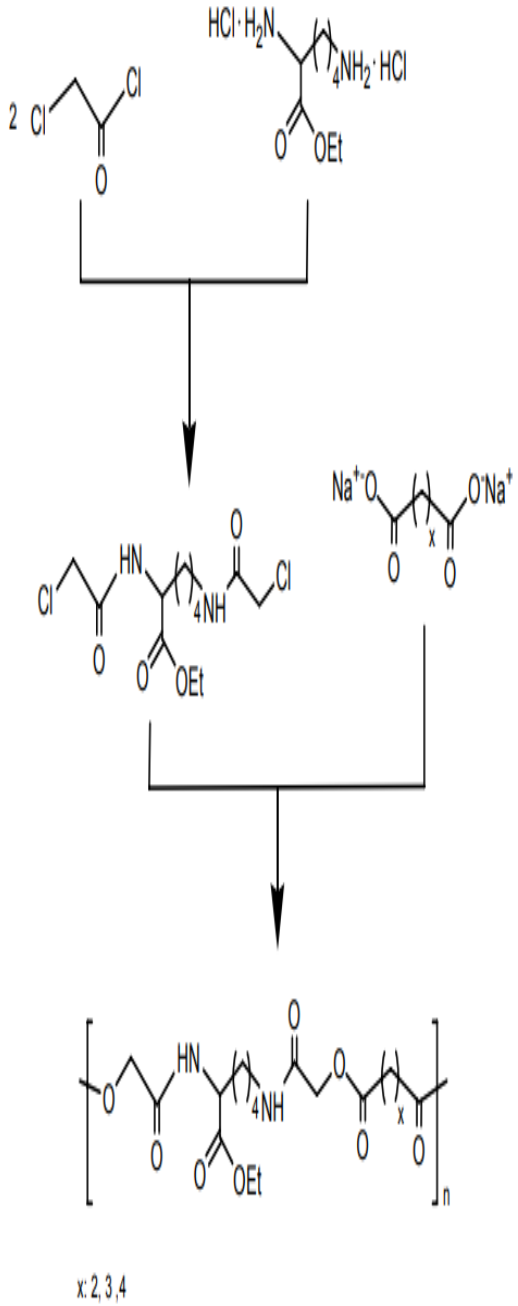

Figure 2. Synthesis of functionalized poly (ester amide) s derived from glycolic acid by a thermal polycondensation reaction induced by the formation of metal halide salts.

IV. CONCLUSION

Methods for manufacturing and analyzing biodegradable PEAs have been the focus of much study since the 1990s. There is already a wealth of literature on polymerization techniques and the development of PEAs with tunable composition and microstructure. PEAs seem to be particularly promising biodegradable materials because the development of hydrogen bonding connections between amide groups leads in mechanical and thermal qualities that are unusual in polyesters, the most important family of biodegradable polymers to far. With the ability to include natural -amino acids, carbohydrates, or poly(ethylene oxide) segments, PEAs may serve as both low-cost commodity materials and highly specialized materials, such as in the biomedical industry.

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