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Controlled Drug Delivery with Biodegradable Polymers

Localized drug delivery continues to gain traction over systemic drugs as it allows for higher potency and reduced side effects. For example, cancer treatment efficacy depends on the dose of the drug that reaches the tumor, and polymer wafers, nanofibrous scaffolds, and hydrogels have been used for localized drug delivery (Woodring et al., ACS Appl Bio Mater. 2023).

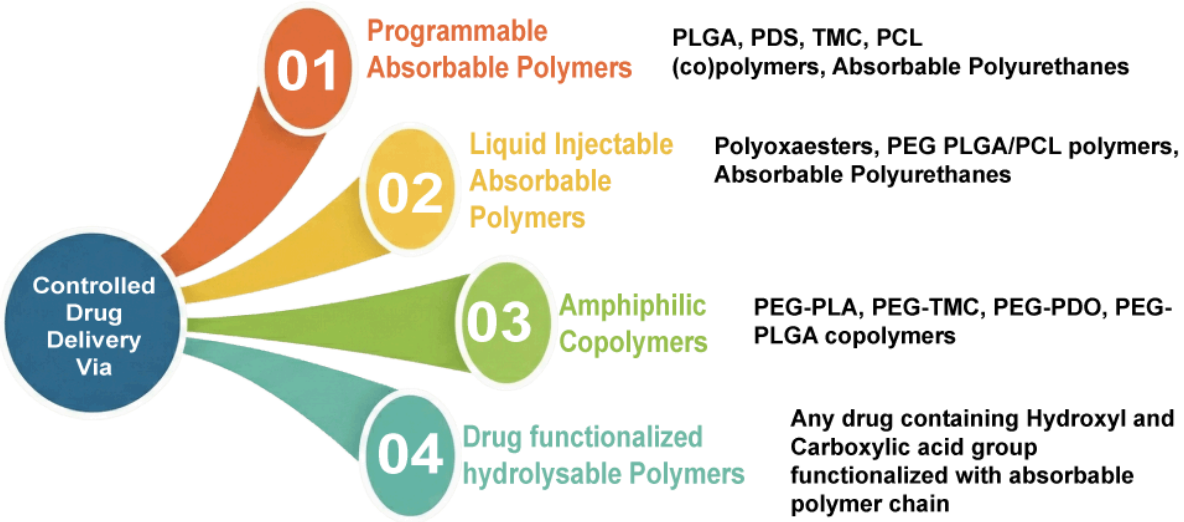
Controlled drug delivery systems offer several advantages over conventional systems: target specificity, metabolism protection, defined drug release, and better patient compliance. However, they also have some drawbacks such as possible toxicity from the materials used, dose dumping, invasive procedures to place/remove the drug delivery device, and higher manufacturing costs (Adepu et al., Molecules. 2021). The drug delivery route (oral, topical, ocular, parenteral, etc.) determines to a great extent the environmental conditions the biomaterial will be subject to (e.g., pH) and guides the hydrophilicity, surface chemistry, degradation, rheological and mechanical properties.

Depending on the desired method of drug release, delivery systems may be dissolution, diffusion, water-penetration, chemically, or nanoparticle-based controlled. Biomaterial properties requirements for each delivery method need to be precisely designed and controlled. At Bezwada Biomedical, we have been developing fully biodegradable biomaterials for controlled drug release for decades. Designing polymers to exact specifications from our absorbable polymer technology portfolio is where we specialize.

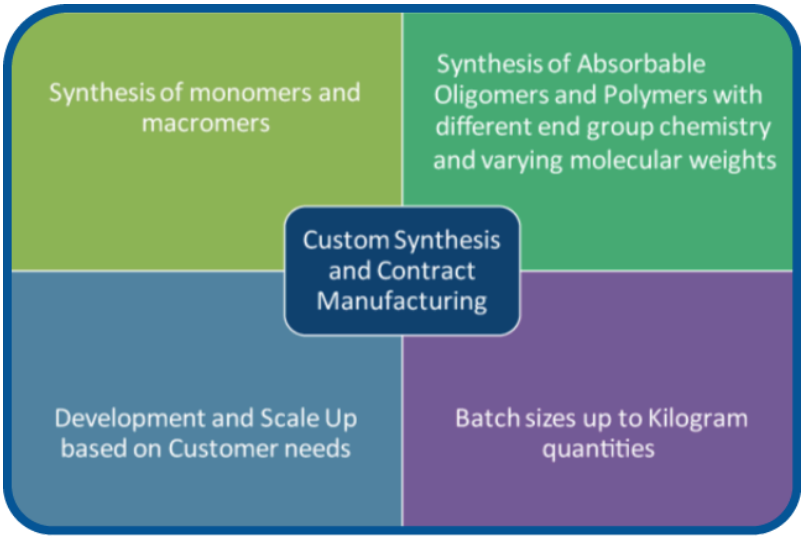
We have three main technology platforms for our drug delivery biomaterials: PEG (polyethylene glycol), PLGA (polylactic glycolic acid), and PU (polyurethane). PEG is the most used polymer in drug delivery but has also been plagued by fast degradation and mechanical instability. Our PEG co-polymers, acrylates, and diacrylates are designed to overcome the typically weak mechanical properties of PEG biomaterials through the use of different crosslinkers. Furthermore, absorption is controlled by developing biomaterials with different molecular weights so that degradation rate can be fully tuned.

PLGA biomaterials are well established as drug delivery platforms either as homopolymers or copolymers. At Bezwada Biomedical, we specialize in copolymers beyond PLGA such as PDLA/PCL, PCL/PGA, PCL/PLA, PTMC/PLA, PTMC/PDLA, etc. (PCL, polycaprolactone, PTMC, polytrimethylene carbonate). These copolymer designs allow for precise tuning of critical properties such as degradation rate and mechanical properties. For example, in PCL/PGA copolymers, caprolactone helps in reducing the hardness and toughness of pure polyglycolide polymers and also to decrease its hydrolytic degradation rate. In PCL/PLA, the presence of the lactide repeat units reduces the degree of close packing between caprolactone units leaving the polymer with nice elastic properties while maintaining a relatively slow degradation profile, which is particularly desirable in controlled drug release platforms. Similarly, the flexible and non-crystalline nature of polytrimethylene carbonate makes it useful in drug delivery applications in PTMC/PLA and PTMC/PDLA copolymers.

Polyurethanes have emerged as an attractive alternative biomaterial for drug delivery (Wienen et al., Journal of Controlled Release, 2023). Their excellent biocompatibility and tunable mechanical properties and degradation rates offer several advantages over PEG and PLGA platforms. Bezwada Biomedical has developed the most comprehensive absorbable polyurethane technology portfolio in the industry, with a unique differentiator: our **polyurethanes undergo complete degradation** of not only the soft segments but also the hard segments. Our polyurethanes are completely hydrolysable into safe and biocompatible products; our technology has been commercialized by Abyrx® through the MONTAGE® resorbable bone putty product line. Degradation rate is tunable through degradable isocyanates such as glycolate and caprolactone diisocyanates.



Visit Bezwada Biomedical for the complete portfolio of absorbable polymers and reach out to discuss your specific application and requirements. Our ISO 13485 certified facilities are used to produce GMP-grade biomaterials, and we routinely work on the spectrum of early R&D feasibility projects to manufacturing scale and commercialization.



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