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Commentary Article

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Biodegradable Polymers in the Development of Long-Acting Injectable Formulations

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DESCRIPTION

Long-Acting Injectable (LAI) formulations have become a game-changer in the field of drug delivery since they can sustain therapeutic drug levels for long periods of time with just one dose. This is especially helpful for long-term illnesses including diabetes, schizophrenia and hormone therapy that need for regular medication compliance. The employment of biodegradable polymers, which enable regulated drug release and do away with the necessity for surgical removal upon drug depletion, is a essential step in the development of LAI formulations. The benefits, modes of action, difficulties and potential applications of biodegradable polymers in the creation of LAI formulations are examined in this essay.

Biodegradable polymers are substances that, when subjected to natural biological processes, can decompose into non-toxic byproducts such carbon dioxide, water and biomass. Their ability to encapsulate Active Pharmaceutical Ingredients (APIs) and release them gradually makes them extremely desirable for use in medical applications, especially in drug delivery systems. By adjusting their chemical structure, these polymers' degradation rate may be precisely controlled, giving researchers exact control over the drug release profile. Poly (Lactic-Co-Glycolic Acid) (PLGA), Polylactic Acid (PLA) and Polycaprolactone (PCL) are common biodegradable polymers utilized in LAI formulations. Particularly PLGA is commonly utilized because of its high biocompatibility and variable rate of breakdown, which varies based on the ratio of lactide to glycocolide and can last for weeks or months. These polymers

are frequently utilized as implants, microspheres, or *in situ*-forming gels, each of which has unique benefits for regulated drug release.

Mechanisms of Drug Release

In most LAI formulations, a combination of polymer degradation and diffusion leads to the drug release from biodegradable polymers. The medicine is first released by diffusion either with the polymer surface or through the polymer matrix. When the polymer starts to break down, the release mechanism changes to erosion, which is the breakdown of the polymer matrix causing the medicine to be encapsulated to come out. Hydrolysis, which occurs when water molecules enter the polymer matrix and break the ester bonds, is the main process that controls the breakdown of biodegradable polymers. This process results in a decrease in molecular weight and ultimately polymer disintegration. The presence of additives or plasticizers, the copolymer ratio, the molecular weight of the polymer and crystallinity can all affect the rate of degradation and, in turn, the pace at which the medicine releases. Because glycolic acid is more hydrophilic, a larger glycolide concentration, for instance, usually leads to a quicker breakdown rate in PLGA-based systems. On the other hand, a higher lactide concentration might delay degradation and lengthen the time that the medicine is released. Researchers may create LAI formulations that release medications over a chosen timescale, from a few days to several months, by carefully choosing and adjusting the polymer composition.

Applications of Biodegradable Polymers in LAI Formulations

Biodegradable polymers have been effectively utilized in several LAI formulations in numerous therapeutic domains. Hormonal therapy is one of the most prominent uses. As an example, depot formulations of leuprolide acetate, a Gonadotropin-Releasing Hormone (GnRH) agonist used to treat endometriosis, premature puberty and prostate cancer, have been developed using PLGA-based microspheres. With just one injection, these formulations can effectively suppress hormones for up to three months, greatly enhancing patient compliance. The treatment of schizophrenia is another well-known use for biodegradable polymers in the development of long-acting antipsychotic formulations. To maintain therapeutic drug levels for up to two months, aripiprazole lauroxil, an extended-release prodrug of aripiprazole, is made with Poly (Lactic-Co-Glycolic Acid) (PLGA). By lowering the chance of relapse and enhancing overall treatment results, this long-acting formulation helps address the problem of non-adherence in patients with schizophrenia. LAI formulations for the treatment of chronic pain have also investigated the use of biodegradable polymers. Substances such as buprenorphine, which are classified as opioids, can provide prolonged pain relief for several weeks or months when they are encapsulated in PLGA-based implants or microspheres. Because it lowers the frequency of administration and keeps medication levels constant, this strategy not only improves patient convenience but also lowers the risk of opioid dependence.