

Microencapsulated Pancreatic Islet Cell Technology

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Abstract

Research with the long-term goal of creating an artificial pancreas for diabetic patients has led to developments of biomaterials that are used to encapsulate tissue and cell transplants. These membranes are important in terms of several parameters: mechanical strength (to withstand osmotic pressures), selective permeability (allowing nutrients and beneficial proteins while blocking host immune proteins), and biocompatibility (nontoxic both to the insulin-secreting cells contained inside, and to the outside host tissue environment). Alginate-based hydrogels are the most commonly used material, formed from alginate polyanion crosslinked with a polycation. Amphiphilic membranes formed from polyisobutylene, which have a telechelic structure, are also discussed. Factors such as composition, applied polycation coatings, micro- and nano-scale (thickness and diameter), and surface energy all have a significant impact on these device requirements.

1. A Brief Understanding of the Need for Pancreatic Transplantations

1.1. Development of the Islet Transplant

Diabetes mellitus is a condition caused by a lack of insulin secretion (type I) or decreased sensitivity of tissues to insulin (type II), leading to unstable blood glucose levels and impaired carbohydrate metabolism [1]. Over time, patients with diabetes may additionally develop other serious complications such as excessive dehydration, body tissue degradation, kidney and heart diseases, and increased risk for potentially fatal catastrophic events such as hyperglycemic shock, heart attack, or stroke. In some cases, blood glucose levels can effectively be controlled by daily insulin injections that include both fast- and long-acting insulin. However, this option also requires constant and intensive medical services, leads to a restricted and regulated lifestyle, and exposes patients to increased frequency of hypoglycemia [2]. For patients who have a history of severe metabolic complications, experience failure with exogenous insulin treatment (for instance, repeated hypoglycemic episodes caused by over-reduced glucose levels), or are planning to obtain a kidney transplant due to renal disease, a surgical transplantation of the entire pancreas, or its functioning islet cells, may be a more effective alternative [3]. Since 1966, when the first pancreas transplantation was performed simultaneously with a kidney transplant (University of Minnesota), the success rates of patients achieving long-term insulin independence has steadily increased to the present day. Nevertheless, data compiled from U.S. cases between 2005 to 2009 still shows 3-year insulin-independence rates ranging from 60 % to 80 % (those with pancreas and kidney transplants tend to be more successful than pancreas-alone transplants) [2].

On the other hand, islet cell transplantation, typically performed by injecting insulin-secreting beta-cells percutaneously into the liver via the portal vein, is a less invasive procedure