J Biotechnol Biomater 2017, 7:2 (Suppl)
http://dx.doi.org/10.4172/2155-952X.C1.074

Materials based on thermoplastic starch as polymeric matrix

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Starch has been considered as one of the most promising bioplastics primarily because of its attractive combination of availability and price. Thermoplastic starch (TPS) can be obtained by destruction of starch granules in the presence of plasticizers under specific conditions. Polyols such as glycerol, glycol, sorbitol, and sugars are the most widely used plasticizers. The main disadvantages of TPS consist in pronounced hydrophilic nature, the fast degradation rate and, in some cases, unsatisfactory mechanical properties. In spite of some industrial applications of TPS exist, high volume production of TPS-based materials is rare at present and occurs only in exceptional cases for non-demanding products. In this lecture the principles for substantial improvement of ultimate propereties of TPS are discussed. A number of possible modifications have been investigated to affect the mechanical properties, water uptake, and the structure of the materials. The experiments were aimed to the optimization of the ratio of amylose and amylopectin, selection of appropriate plasticizers including their mixtures, modification of hydrophilicity by chemical modification of hydrophobic functional groups or via crosslinking of TPS, and mixing the TPS with hydrophobic biodegradable polymers added as the minor component. In most cases the optimization resulted in a substantial changes of properties of TPS-based materials. The possible routes are discussed resulting in modified starch- based materials being able to compete with standard plastics in more demanding applications.

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Conducting biomaterials for regenerative medicine

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Electrical fields play important roles in a multitude of biological processes, which has inspired the development of electroactive biomaterials (e.g. bionic ears/eyes, cardiac pacemakers, neural electrodes), some of which have been clinically translated. The tuneable properties of conducting electroactive polymers (CPs or EAPs, respectively) such as derivatives of polyaniline, polypyrrole or polythiophene make them attractive components of biomaterials for drug delivery devices, electrodes or tissue scaffolds. With a view to develop conducting polymers for drug delivery, we have developed solution processable polymers (e.g. block copolymers, supramolecular polymers) on a multigram scale, loaded them with a clinically relevant drug and studied its delivery in the absence/presence of electrical stimulation, and such systems offer a route to triggering the delivery in response to electricity. Likewise, with a view to develop tissue scaffolds, we have developed polymer-based materials with various morphologies (e.g. films, fibers, foams) that were electrically conductive with derivatives of polypyrrole or polythiophene. The cells were cultured (human stem cells, human fibroblasts, or rat Schwann cells) thereon and their behaviour was studied in the absence/presence of electrical stimulation, observing enhancement of stem cell differentiation towards osteogenic outcomes, or increased nerve growth factor production from Schwann cells, when exposed to electrical stimuli. I will present the most recent developments from my group.

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