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Chinnaswamy , et al. **March 5, 1996**

Biodegradable polymers

Abstract

To prepare a biodegradable plastic, biodegradable materials such as starches and a non-biodegradable polymer such as a polystyrene, polyurethane, polyethylene, polypropylene, or polycarbonate are treated: (1) under heat, pressure and reagents to break the polymers; and (2) by adding to them an oxidizing agent. This treatment forms and/or makes available reactive groups for bonding: (1) on the biodegradable material groups such as aldehyde or hydroxyl groups in the case of the carbohydrates and amine groups in the case of proteins and certain other compounds such as urea; and (2) on the non-biodegradable plastic groups such as aldehydes, methyl, propyl, ethyl, benzyl or hyroxyl groups. In one embodiment, plastic and starch are processed in an extruder by: (1) mixing a starch in a range of between 15 percent and 80 percent, an oxidizing agent and an agent to break up the starch and the plastics; and (2) subjecting the combination to sufficient heat and/or pressure to break the plastic into shorter chains and bond monosaccharides to monomers from the non-biodegradable polymer.

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SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide a novel biodegradable polymer.

It is a further object of the invention to provide a novel process for making biodegradable polymers.

It is a still further object of the invention to provide a novel biodegradable polymer in which a carbohydrate or protein or possibly lipids may be substituted in percentages between 15 percent and 80 percent while preserving a substantial number of the desirable properties of the polymer.

It is a still further object of the invention to make a novel biodegradable polymer using a process which causes chemical modification of a carbohydrate or protein or possibly lipids or urea and a non-biodegradable polymer to make a biodegradable polymer.

It is a still further object of the invention to provide a novel biodegradable plastic and process for incorporating carbohydrates or proteins or possibly lipids into polystyrene, polyurethane, polyethylene, polypropylene, or polycarbonate plastics in quantities greater than 15 percent while preserving many of the functional characteristics of the plastic.

It is a still further object of the invention to provide a novel foam plastic product and method of making it.

It is a still further object of the invention to provide a novel film plastic product and method of making it.

In accordance with the above and further objects of the invention, a biodegradable polymer is provided having polymeric chains that include both hydrocarbon monomers from a non-biodegradable polymer and other biodegradable groups such as monosaccharides or amino acids or the like that render the polymer biodegradable. In these polymers, the biodegradable groups and hydrocarbon monomers are bonded or interconnected by single and/or double bond covalent linkages, hydrocarbon or bridge bonds, Van der Waals' forces or the like to each other. The biodegradable groups may be obtained from carbohydrates, proteins, lipids, urea or other materials that can result in groups that combine with the hydrocarbon monomers from the plastic while retaining biodegradability.

In preparing the biodegradable plastic, the biodegradable group and a non-biodegradable polymer such as a polystyrene, polyurethane, polyethylene, polypropylene, or polycarbonate are treated: (1) under heat, pressure and reagents to break the polymers; and (2) by adding to them an oxidizing agent. This treatment forms and/or makes available reactive groups for bonding: (1) on the biodegradable material such as aldehyde or hydroxyl groups in the case of the carbohydrates and amine groups in the case of proteins and certain other compounds such as urea; and (2) on the non-biodegradable polymers such as aldehydes, methyl, propyl, ethyl, benzyl or hyroxyl groups.

In one embodiment, the non-biodegradable polymer is treated by: (1) adding to it a carbohydrate in a range of between 15 percent and 80 percent, an oxidizing agent and an agent to break up the starch or similar carbohydrates; and (2) subjecting the combination

to sufficient heat and/or pressure to break the polymer into shorter chains and bond monosaccharides to monomers from the non-biodegradable polymer.

In one example of this embodiment, the non-biodegradable polymer is polystyrene, the oxidizing agent is citric acid and the substance for degrading the starch is sodium bicarbonate. The heat and pressure is provided by extruding the combination at high temperatures to form a biodegradable foam plastic in which the sodium bicarbonate and citric acid: (1) release carbon dioxide as a foaming agent; (2) oxidize the methyl groups of the styrene to form groups such as aldehyde groups which react with groups on the starch; and (3) form sodium hydroxide to degrade the starch and thus to form aldehydes such as formaldehyde or hydroxyl groups to react with the styrene. Similarly, proteins can be degraded to amino acids or aldehyde compounds having reactive amine or carboxyl groups to react with the hydroxyl or aldehyde groups of the oxidized carbohydrate.

As can be understood from the above description, the biodegradable polymer of this invention and the method of making it have several advantages, such as for example: (1) the biodegradable polymer retains its physical characteristics with a large percentage of carbohydrate added or protein or other biodegradable material; (2) the biodegradable polymer effectively degrades when discarded; (3) the process permits the inclusion of a large amount of carbohydrate; and (4) the biodegradable polymer is less expensive than other biodegradable polymers.

For a complete disclosure of the invention please consult the full patent.