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[54] POLYPROPYLENE FOAM SHEETS

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[51] **Int. Cl.**[5] **C08J 9/08**; C08J 9/14

[52] **U.S. Cl.** **521/143**; 264/45.1; 264/45.5; 264/51; 264/53; 264/54; 264/321; 428/316.6; 428/318.8; 521/79; 521/134; 521/144

[58] **Field of Search** 521/142, 143, 79

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[57] **ABSTRACT**

A thermoformable, rigid or semi-rigid polypropylene foam sheet having a smooth surface and a uniform cell structure and a density of at least 2.5 lbs/ft^3 is prepared by extruding a mixture of a nucleating agent, a physical blowing agent and a polypropylene resin having a high melt strength and high melt elasticity.

5 Claims, 3 Drawing Sheets

FIG. 1

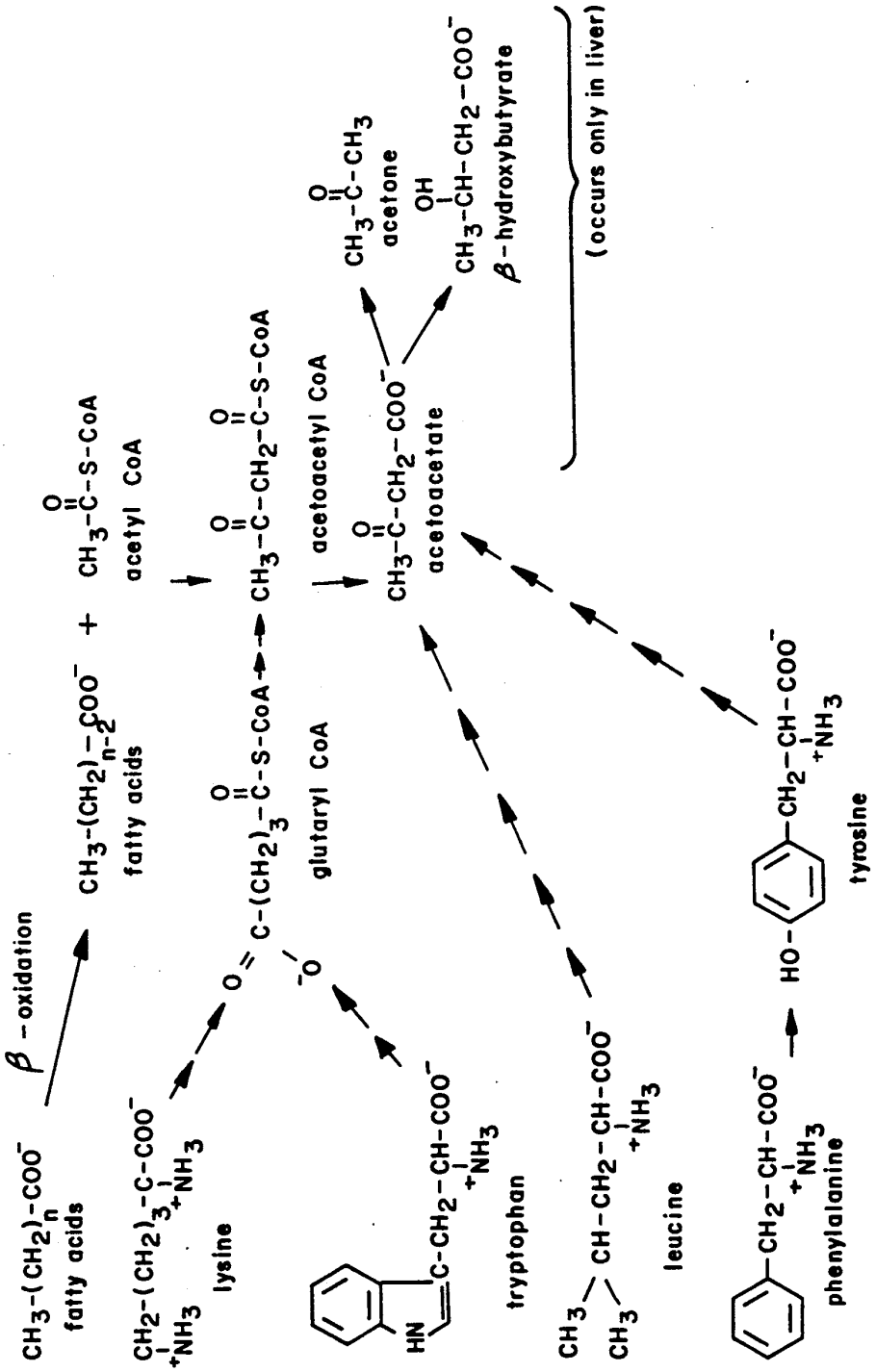


FIG. 2

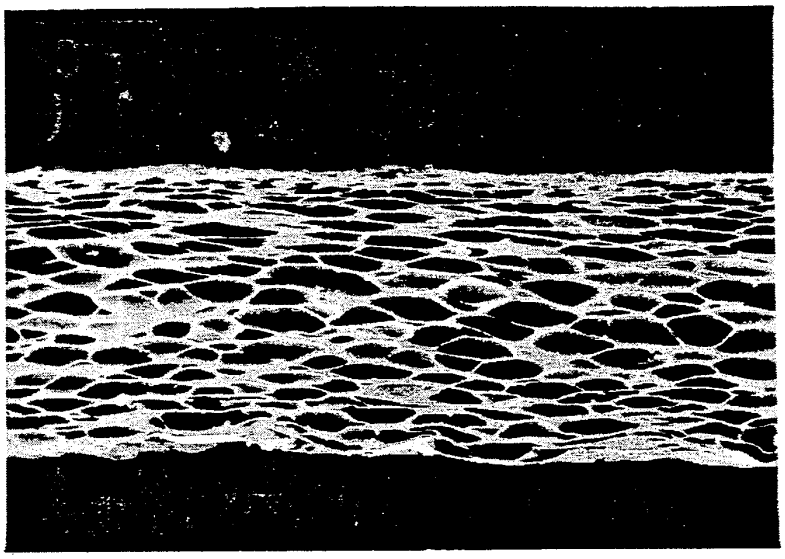


FIG. 3

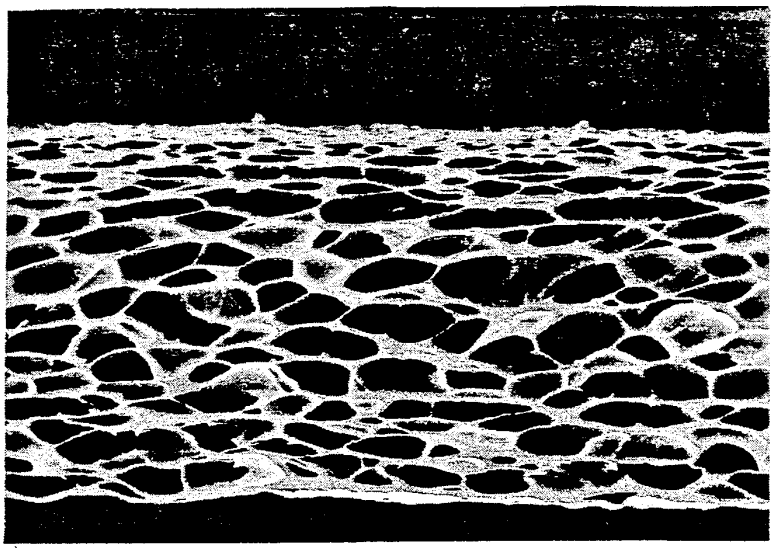


FIG. 4

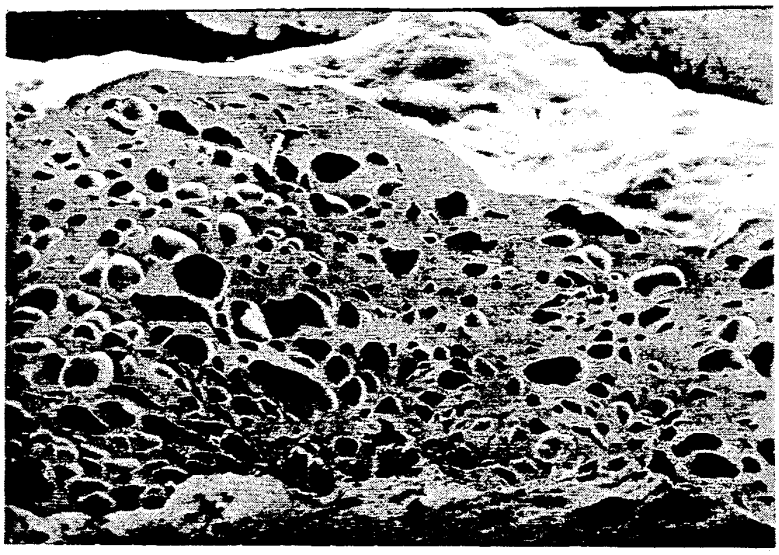
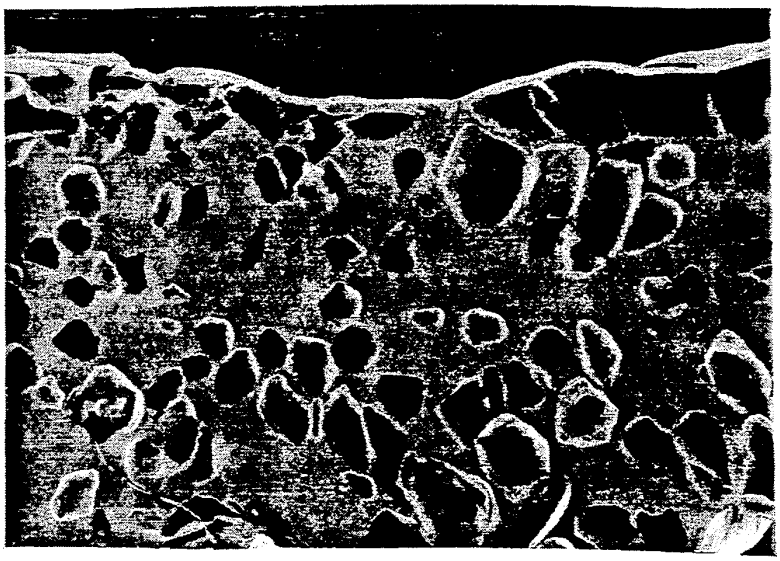


FIG. 5



POLYPROPYLENE FOAM SHEETS

BACKGROUND OF THE INVENTION

1. Field of Invention

This invention relates to polypropylene foam sheets and a process for their manufacture. Specifically, this invention relates to polypropylene foam sheets which are rigid or semi-rigid and thermoformable into shaped articles for use in packaging and service applications.

2. Description of the Prior Art

A foamed plastic or cellular plastic has an apparent density which is decreased by the presence of numerous voids or cells dispersed throughout its mass (ASTM D883-80C). The cells may be interconnected (open-celled) and/or discrete and independent (closed-celled).

The prior art discloses various methods for the preparation of foamed plastics. These include leaching out a solid or liquid which is dispersed in a plastic, sintering small particles of a plastic and dispersing cellular particles in a plastic. However, the most widely used method involves the dispersion of a gaseous phase throughout a fluid polymer phase and the retention of the resultant expanded form.

The theory of the expansion process and the properties of various foamed plastics are reviewed in "Cellular Plastics", in Encyclopedia of Polymer Science and Engineering, vol. 3, pp. 1–59 (1985), which is incorporated herein by reference. As disclosed therein, the expansion process consists of three steps: creation of small discontinuities or cells in a fluid or plastic phase, growth of these cells to a desired volume and stabilization of the resultant cellular structure by physical or chemical means.

The formation of discontinuities or bubbles within the fluid polymer, may arise from gases that are injected into the fluid polymer, low boiling liquids that are incorporated into the system as blowing agents and volatilize due to increased temperature or decreased pressure, gases that are produced as a result of a chemical reaction within the fluid polymer and chemical blowing agents which undergo thermal decomposition to form a gas.

The rate of growth of the bubbles or cells depends upon the viscoelastic nature of the polymer phase, the blowing agent pressure, the external pressure on the foam, the cell size and the permeation rate of the blowing agent through the polymer phase.

Cell or bubble stabilization relates to cell wall stability and the drainage of material from the membrane or wall which separates cells. Increasing the viscosity of the fluid reduces the drainage effect. The viscosity increase may be caused by chemical reactions which increase molecular weight through polymerization or crosslinking, or by temperature reduction, ultimately below the second order transition or crystallization temperature to prevent polymer flow.

The present invention relates to rigid or semi-rigid foam sheets for use in food service applications. The prior art has utilized polystyrene for the manufacture of foam sheets for these applications. However, polystyrene articles suffer from low service temperature, and little or no photochemical or biological degradability and are relatively expensive.

Polypropylene does not have these undesirable characteristics. Various processes have been reported in the prior art for the preparation of flexible or rigid polypropylene foams. The processes are designed to promote the three-step process described hereinbefore, i.e. creation of cells in a fluid or plastic phase, growth of the cells and stabilization of the resultant cellular structure.

Blowing agents used in the preparation of polypropylene foam include azodicarbonamide (Lee et al, J. Appl. Polym. Sci. 32, 4639 (1986); EPO Pat. Appl. EP 190,021), chlorofluorocarbons (EPO Pat. Appl. EP 1791, EP 71,981, EP 181,637; U.K. Pat. 1,400,494; U.K. Pat. Appl. GB 2,099,434 A), carbon dioxide (EPO Pat. Appl. EP 291,764), hydrocarbons, e.g. propane, butane, pentane (U.K. Pat. 1,400,494; U.K. Pat. Appl. GB 2,099,434 A) and water (EPO Pat. Appl. EP 122,460).

Crystallization rate accelerators and/or nucleating agents used in the preparation of polypropylene foam include titanium dioxide (EPO Pat. Appl. EP 122,460; U.K. Pat. Appl. GB 2,099,434 A talc (U.K. Pat. 1,400,494; U.K. Pat. Appl. GB 2,099,434 A), silica and silicates (EPO Pat. Appl. EP 1791; U.S. Pat. 4,467,052), zeolite 4A (EPO Pat. Appl. EP 178,282, EP 178,283), sodium benzoate (Colton, Plast. Eng. 44(8), 53 (1988) and dibenzylidene sorbitol (EPO Pat. Appl. EP 178,282).

Citric acid-sodium bicarbonate combinations are considered as blowing agents in some patents and as nucleating agents in other patents (EPO Pat. Appl. EP 178,283; U.K. Pat. 1,400,494; U.K Pat. Appl. GB 2,099,434 A; U.S. Pat. 4,467,052).

The use of crosslinking agents during the preparation of a polypropylene foam has been reported in the prior art and include peroxides (Nojiri et al, Furukawa Review 2, 34 (1982) through Chem. Abstracts 97, 21725ou (1982); EPO Pat. Appl. EP 181,637, 190,021) in the absence or presence of multifunctional vinyl monomers, azido functional silanes (EPO Pat. Appl. EP 181,637), vinyltrimethoxysilane (Lee et al, J. Appl. Polym. Sci. 32, 4639 (1986) and ionizing radiation in the presence of polyacrylic monomers (Nojiri et al, Furukawa Review 2, 34 (1982); U.S. Pat. No. 4,424,293).

Low density polypropylene foams "free from creases on the surface" have been prepared by incorporating high molecular weight fatty amides, amines or esters in the molten polyolefin (EPO Pat. Appl. EP 1791).

The prior art teaches that polypropylene is not a unique material, i.e. processes that are applicable to the preparation of foam or microcellular structures from other polymers are applicable to the preparation of polypropylene foams.

EPO Pat. Appl. EP 1791 describes "a process for the preparation of expanded thermoplastic synthetic resins" and discloses polyethylene, ethylene-vinyl acetate copolymer and isotactic polypropylene as the applicable thermoplastic resins.

EPO Pat. Appl. EP 71,981 describes "foamed polypropylene resin molded articles" and discloses the use of ethylene-propylene copolymer as well as polypropylene.

EPO Pat. Appl. EP 122,460 describes "resin foam produced by an aqueous medium" and discloses polymer foams from polypropylene, polyethylene and polystyrene.

EPO Pat. Appl. EP 291,764 describes the "extrusion of propylene polymer foam sheets" and discloses a process for extruding blends of ethylene-propylene block copolymers containing less than 20% ethylene with block copolymers containing less than 5% ethylene or random ethylene-propylene copolymers or polypropylene.

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