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(72) Herman,James N., US
(72) Hiltner, James E., US
(73) Owens-Illinois Plastic Products Inc., US

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(54) **CONTENANT DE PLASTIQUE RESULTANT DU MELANGE PAR FUSION DE PLASTIQUE RECYCLE ET DE POLYMERES D'ETHYLENE**

(54) **PLASTIC CONTAINER MADE FROM A FUSION BLEND OF POST CONSUMER PLASTIC AND ETHYLENE POLYMERS**

(57) A plastic container made from a fusion blend of a post consumer plastic and ethylene polymers and comprising post consumer resin of homopolymer high density polyethylene resin and a small amount of linear low density polyethylene resin. In another form, the container is made from a blend of post consumer homopolymer high density polyethylene resin, virgin high density polyethylene resin with a small amount of linear low density polyethylene resin. The physical properties of the container including stress crack resistance are maintained as contrasted to the loss of such physical properties that have been heretofore resulted from the use of post consumer resins.

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PLASTIC CONTAINER MADE FROM A FUSION BLEND OF POST CONSUMER PLASTIC AND ETHYLENE POLYMERS

Abstract of the Disclosure

A plastic container made from a fusion blend of a post consumer plastic and ethylene polymers and comprising post consumer resin of homopolymer high density polyethylene resin and a small amount of linear low density polyethylene resin. In another form, the container is made from a blend of post consumer homopolymer high density polyethylene resin, virgin high density polyethylene resin with a small amount of linear low density polyethylene resin. The physical properties of the container including stress crack resistance are maintained as contrasted to the loss of such physical properties that have been heretofore resulted from the use of post consumer resins.

This invention relates to plastic containers and particularly to plastic containers made of post consumer resin.

Background and Summary of the Invention

In the use of plastic materials for containers such as bottles, it has been found desirable to attempt to recycle and reuse the plastic which is commonly known as post consumer plastic (PCP) or post consumer resin (PCR). In attempts to make containers from such materials, it has been found that the properties have been adversely affected.

Specifically when containers are made from post consumer high density polyethylene (HDPE) container scrap, it has been found that the containers have diminished physical properties and particularly diminished distance to stress cracking. Such containers also have been used for packaging of certain types of liquid detergent products. The use of such containers to package liquid detergent products has been somewhat restricted, however, by reason of the fact that many types of liquid detergent products accelerate the tendency of the container to exhibit stress cracking. Stress cracking is evidenced by the appearance of hazy cracks in the container which are aesthetically unpleasing to the ultimate consumer. In extreme cases, stress cracking can lead to leakage of the contents from the container. Stress cracking can occur when the containers are for liquid products including liquid detergents and liquid hypochlorite bleaches.

It has been suggested that such post consumer resin be utilized because large quantities of high density polyethylene post consumer resin are available due to the extensive use of high density polyethylene in large containers for milk and water. Post consumer resin from such containers contain contaminants of paper and other plastic resins, for example, from closures such that it has been generally thought that it can not be used to make satisfactory plastic containers.

Accordingly among objectives of the present invention are to provide a blend of post consumer resin from high density polyethylene containers and the like which will have substantially resistance to stress cracking and which will have minimal diminution in other physical properties permitting its use for various kinds of containers, that are used for containing various products.

In accordance with the invention, plastic containers are made from a fusion blend of a post consumer resin and a small amount of linear low density polyethylene resin. In another form, containers are made from a blend of post consumer homopolymer high density polyethylene resin, virgin high density polyethylene copolymer resin with a small amount of linear low density polyethylene resin. The physical properties of the container including stress crack resistance are maintained as contrasted to the loss of such physical properties that have been heretofore resulted from the use of post consumer resins.

In accordance with the invention, pellets or flakes of a homopolymer high density polyethylene resin from post consumer

resin (PCR) and pellets of linear low density polyethylene were mixed and fusion blended. The containers were blow molded and subjected to testing for stress cracking, top load and drop impact.

In another form the blend included virgin high density copolymer resin.

The blends contain about 10-95% by weight of post consumer resin, 0-75% by weight of virgin high density polyethylene copolymer and 2.5-25% by weight of linear low density polyethylene resin.

Post consumer resin as used herein contains primarily the plastic from high density polyethylene homopolymer containers used for packaging milk, small amounts of colored plastic containers and possible polypropylene resin from syrup bottles, multi-layer ketchup bottles and caps. Such post consumer resin has the properties set forth in the following Table I.

Table I

PROPERTY		SPECIFIED VALUE
Material Density		.961 ± .002 natural
Melt Flow - Melt Index		0.75 ± 0.2 dgm
Polypropylene		
(Includes Multi-layer Bottles)		Not to exceed 3%
Fines		<0.01%
Moisture		<0.01%
Contamination		
	Paper	<0.01%
	Plastic-Dens. >1.0 gm/cc	<0.1%
	Metal fragments	None
	Other (glass, stone)	None

The virgin high density homopolymer resin contains linear high-density ethylene polymer. Each of the linear high-density ethylene copolymer included in the blends will have a density of at least about 0.94 gm/ml, a melt index of less than about 0.5 gm/10 min. and will have polymerized therein at least about 98 mol % ethylene with any comonomer polymerized therein being an alpha-monoolefin containing about 3 to 12 carbon atoms. Such linear high-density ethylene polymers are known and reported in the art and are commercially available from numerous commercial producers. Such linear high-density ethylene polymers are prepared by polymerizing ethylene, optionally in the presence

of an alpha-monoolefin comonomer containing 4 to 12 carbon atoms in the presence of certain metallic catalysts such as chromium catalysts, e.g. CrO_3 supported on silica-alumina supports, and the Ziegler-Natta catalysts, e.g. $TiCl_3$ employed in conjunction with certain aluminum alkyl cocatalysts. The requisite density and melt index desired in the polymer are obtained by proper control of polymerization conditions including temperature, pressure, comonomer concentration, and the concentration of terminating agents such as hydrogen. The preferred linear high-density ethylene polymers will have a density of at least about 0.94 gm/ml. The especially preferred polymers will have a density of at least about 0.95 gm/ml.

Stress crack resistance is conventionally conducted with test methods as established by Technical Bulletin PBI 11-1978 of the Plastic Bottle Institute, Rev.1-1991 or ASTM D2561-70 (Reapproved 1989).

The linear low-density ethylene polymer(s) included in the blends of the invention have a density in a range of about 0.91 to about 0.93 gm/ml, preferably in a range of about 0.92 to about 0.93 gm/ml, and especially about 0.925 gm/ml. The linear, low-density ethylene polymers will have a melt index of less than about 2.0 and preferably less than about 1.0 gm/10 min. It is desirable for the melt index to be close to the melt index of the linear high-density ethylene polymer included in the blend. These polymers are ethylene copolymers having polymerized about 2-6 and preferably about 4-6 mol % of an alpha-monoolefin containing 3 to 12 carbon atoms with the balance of

the monomer polymerized therein being ethylene. The linear low-density ethylene polymers employed in the present invention have long linear chains with controlled numbers of relatively short chain branches attached to the linear chain along its entire length. These sides chains or "branches" are short and will contain from about 1 to 10 carbon atoms depending upon the particular alpha-monoolefin employed in the preparation of the polymer. The linear low-density ethylene polymers differ structurally from low-density ethylene polymers made by high-pressure free radical initiated polymerizations in having few, if any, long chain branches.

The linear low-density ethylene polymers are commercially available from multiple commercial sources. Such polymers are prepared by copolymerizing ethylene with an alpha-monoolefin containing about 3 to 12 carbon atoms in the presence of certain metallic catalysts of the same general type employed to prepare the linear high-density ethylene polymers discussed supra. The polymerization conditions employed in their preparation differ somewhat, and somewhat modified catalysts will be employed. One of the techniques to prepare such polymers involves copolymerizing ethylene and butene 1 in the vapor phase in a fluidized bed process. By reason of the constraints imposed by carrying out the polymerization in the vapor phase, the ethylene polymers prepared by this process are limited to copolymers of ethylene and butene 1. By operating in solvent systems, copolymers can be prepared from alpha-monoolefin comonomers containing up to 12 carbon atoms. The preferred

linear low-density ethylene polymers for inclusion in the blends of the invention will be ethylene copolymers having polymerized therein at least one alpha-monoolefin comonomer containing 6 to 12 carbon atoms, and which optionally also will have copolymerized therein butene 1.

The following Table II summarizes one set of tests that have been conducted.

32 OZ. PINCH WAIST OVAL

Run #	1	2	3	4	5	6	7	8	9	10	11	12	13
% PCR	25	25	25	25	50	50	50	75	75	75	90	95	100
% Virgin COP.	72.5	70	65	50	47.5	45	40	22.5	20	15			
% LLDPE	2.5	5	10	25	2.5	5	10	2.5	5	10	10	5	
Gram Weights (20 Bottles)													
Mean	46.37	46.51	46.77	46.91	46.63	46.86	46.94	46.46	46.64	46.34	47.78	46.77	46.53
STD. Dev.	.387	.350	.435	.251	.211	.181	.229	.177	.246	.252	.207	.194	.228
Top Load (10 Bottles)													
Pounds	36.1#	35.0#	38.5#	39.6#	42.1#	39.6#	43.4#	45.5#	42.8#	44.1#	42.0#	44.9#	45.8#
Drop Test (25 Bottles)													
Bruceton													
EMFH	6.9'	6.75'	9.5'+	9.25'	8.75'	8.3'	9.15'	9.5'+	9.25'	9.25'	9.25'	7.58'	8.13'
ESCR													
140 Degrees (10 Bottles)													
Days to 1st Fail	25	6	30	35	6	2	5	2	2	3	3	2	1
Days to 50% Fail	33		37		10	7	15	2	3	7	4	3	1
ESCR													
120 Degrees (10 Bottles)													
Days to 1st Fail	2	4	3	6	3	3	4	2	2	3	2	2	1
Days to 50% Fail	5	11	9	7	4	4	6	2	2	4	3	2	1

**Variable #4 and #6 bottles have been in 140 degree stress crack test for 51 days as of 2/7/92. 50% failure has yet to occur.

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In another series of test blends of linear low density polyethylene (LLDPE) combined with post consumer high density polyethylene (HDPE) bottle scrap (PCR) and virgin HDPE polymer. The linear low density polymer was in a fusion blend with a pigment as a carrier of 50% linear low density polymer and 50% pigment. Bottles were subsequently tested along with control bottles made without incorporating LLDPE resin as shown in the following Table III:

Table III

Composition	ESCR, F50, Days 120 Deg. W/TP LD.	140 Deg.	Top Load LBS.	Drop Impact EMFH	
1st Bottle Design - 32 Ounce Detergent					
Control, 100% HDPE Copolymer	26	63	42.5 LBS.	8'	11"
25% PCR, 75% HDPE Copolymer	18	56	36.6 LBS.	9'	2"
25% PCR, 72.5% HDPE Copolymer Plus 2.5% LLDPE	16	82	41.7 LBS.	6'	3"
50% PCR, 50% HDPE Copolymer	8*	51	40.2 LBS.	7'	0"
50% PCR, 45% HDPE Copolymer Plus 5% LLDPE	16	50	42.6 LBS.	6'	7"
*Did Not Meet Specifications For ESCR.					
2nd Bottle Design - 64 Ounce Detergent, With Handle					
Control, 96% HDPE Copolymer, 4% Colorant	41 Days, PROD. "A"				
50% PCR, 41% HDPE Copolymer, 4% Colorant Plus 5% LLDPE	27 Days, PROD. "A"	140 Deg. PROD. "B" >7 Days.			
3rd Bottle Design - 128 Ounce, With Handle					
Control, 96% HDPE Copolymer, 4% Colorant	140 Deg, >19 Days		87.9 LBS.	4'	5"
50% PCR, 41% HDPE Copolymer, 4% Colorant Plus 5% LLDPE	140 Deg, >19 Days		89.4 LBS.	3'	10"
(50% PCR, 46$ HDPE Copolymer 4% Colorant)	140 Deg,> 19 Days		80.3 LBS.	3'	9"

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It can be seen that improved results were obtained when the linear low density polyethylene was preblended with pigment.

CLAIMS

1. A plastic container made from a fusion blend consisting essentially of

25 to 95% by weight of post consumer plastic resin of homopolymer high density polyethylene plastic having a density of about 0.961 and a melt index of 0.75 ± 0.2g/10min,

2.5 to 25% by weight of linear low density polyethylene having a density in the range of 0.92 to 0.93 g/ml, and a melt index of less than 1.0 g/10 min and having polymerized 2-6 mole % of an alpha-monoolefin containing 3 - 12 cabon atoms with the balance of the monoolefin polymerized therein being ethylene, and

15 to 72.5% by weight percent of virgin linear high density polyethylene copolymer resin having a density of at least 0.94 g/ml, a melt index of less than 0.5 g/10 min and having polymerized therein at least 98 mole % ethylene with any comonomer polymerized therein being an alpha-monoolefin containing about 3-12 carbon atoms.

2. The plastic container set forth in claim 1 wherein said post consumer resin and linear low density polyethylene resin are fusion blended before being mixed with the virgin high density polyethylene copolymer resin.

3. The plastic container set forth in claim 1 or 2 including a color concentrate wherein said linear low density polyethylene resin is used as a carrier for said color concentrate in a fusion blend before being blended with said post consumer resin and said virgin high density polyethylene copolymer resin.