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POLYPROPYLENE FILM MODIFIED WITH FATTY ACID AMIDE AND POLYETHYLENE

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This invention relates to polypropylene compositions, particularly films made therefrom, having substantially reduced blocking tendencies and coefficients of friction.

One of the major drawbacks of thin polypropylene films is their film-to-film coefficient of friction which often makes it difficult to feed single sheets thereof to automatic packaging equipment, and the like. Another disadvantage of such films is their tendency to block which is defined as the tendency of two or more film surfaces to adhere to each other while under pressure. This blocking phenomenon manifests itself in packaging operations wherein a roll of film is used making it difficult, if not impossible, to remove the film from the roll.

An object of this invention is to provide polypropylene compositions which possess reduced film-to-film coefficients of friction. Another object is to provide polypropylene compositions which, upon conversion into sheets and films, possess improved resistance to blocking. A further object is to provide improved polypropylene compositions with respect to blocking and coefficient of friction without adversely affecting other properties of films made therefrom to a significant extent, such as transparency, haze, vapor permeability, and the like. Other objects will be apparent from the description of the invention given below.

It has now been found that the addition of from 0.005 percent to up to about 2.0 percent by weight of an amide of a higher fatty acid to predominantly isotactic polypropylene greatly improves its gloss, clarity and slip, together with a greatly reduced propensity to block. The term, amide of a higher fatty acid, is intended to apply to amides of saturated and unsaturated water-insoluble monocarboxylic acids having from 8 to 18 carbon atoms in the molecule thereof, such as are present as free acids or their glycerides in fatty oils.

Typical fatty acid amides found useful in obtaining the improved polypropylene compositions of this invention are the amide of dodecanoic acid, the amide of tetradecanoic acid, the amide of hexadecanoic acid, the amide of octadecanoic acid, the amide of 9-octadecanoic acid (i.e. oleic acid), the amide of 9,12-octadecadienoic acid (i.e. linoleic acid), and the like. Although the individual fatty acid amide may be used satisfactorily, commercially available mixtures of various fatty acid amides which may contain up to about five percent by weight of free fatty acid have been found to effectively impart the desired novel properties to polypropylene to a greater extent. Unexpectedly, amides of acids which do not fall within the foregoing definitions are not effective for the purposes of the present invention. For example, as shown herein below, the amide of 13-docosenoic acid (erucic acid) is ineffective as a slip agent for polypropylene films.

The optimum concentration of fatty acid amide depends on both the nature of the particular polypropylene involved (e.g. average molecular weight and molecular weight distribution), and the nature and amounts of other non-resinous components such as pigments, fillers and the like present in the compositions, but in general, quantities between about 0.05 and 0.5 weight percent of the

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amides of this invention are sufficient, with quantities between 0.1 and 0.3 weight percent being preferred.

In another embodiment of this invention, it has been unexpectedly found that the addition of between about 0.1 and 4.0 weight percent of high or low density polyethylene to the primary compositions of this invention improves the slip characteristics thereof. Preferably, the amount of polyethylene so-added is between about 0.5 and 1.5 weight percent. The polyethylenes useful in accordance with this embodiment may be film grade conventional low density polyethylene or film grade linear polyethylene; i.e. either low density or linear polyethylenes having the molecular weights, flow rates and other properties generally associated with those commercially available for preparing films and coatings.

It is difficult at times to produce polypropylene films having both good slip characteristics and good clarity. Thus, better slip is sometimes obtained at extrusion temperatures between about 400° and 425° F.; however, the films prepared at such temperatures may be somewhat more hazy than are those prepared at higher temperatures, e.g. between about 450° and 500° F. On the other hand, although clarity can generally be improved at these latter higher temperatures, slip may decrease. Unexpectedly, it has been discovered according to the present invention that the incorporation of the foregoing quantities of low density or linear polyethylene along with the primary slip agents of this invention results in polypropylene films having both good slip and good clarity, even when they are prepared at high extrusion temperatures; e.g. as high as 550° F. This latter discovery is quite unexpected since polyethylene films generally contain more haze than do polypropylene films.

It is a necessary requirement of the extrusion method employed in this invention that the extrusion temperature be controlled within certain limits. Thus, in the usual slit-die method of preparing thermo-plastic films the temperature in the nozzle should be between about 400° and about 550° F., preferably 450° to 525° F.

When temperatures substantially below or above this range are used either the clarity or the slip properties, or both, are disadvantageously affected.

The compositions of this invention may be prepared by any method suitable for insuring a uniform mixture of polypropylene and additives in the final fabricated article. Suitable methods include addition of the amide as a solid, in solution, or in the form of a slurry in water or other non-solvent, to the polypropylene in either the dry fluff or molding powder form followed by drying and tumbling. The amide may also be incorporated therein by melt blending the ingredients in conventional apparatus, such as a Banbury mixer, heated rolls, or a plasticator. A concentrate of the amide in polypropylene can be made by one of the aforesaid methods and this concentrate can in turn be blended with polypropylene molding powder by tumbling or other suitable means. Moreover, various combinations of the above methods can be used.

One convenient measure of film slip properties are the coefficients of friction, both static and dynamic, as determined by the Moving Sled-Stationary Film method subsequently described. Coefficients of friction exceeding 0.60 indicate poor slip; values of 0.60 to 0.46 indicate fair (marginal) slip, i.e. the films would be useful in certain applications but not entirely satisfactory for others; and values of 0.45 or less indicate good slip.

In the examples given herein below static slip and dynamic slip are measured between two film surfaces. The equipment used for this purpose is a Table Model Instron Tester equipped with a slip table which is secured to the crosshead. The test sled used according to

this method is a rectangular metal block, 4 inches by 2.5 inches wrapped with a 0.25 inch thick rubber sheet. The block is equipped with a hook and film clamping means, and the sled has a total weight of 500 gr. \pm 5 gr. The slip table has a pulley attached to it, and when the device is in use, a line secured on one end to the strain gauge of the Tester is run through the pulley and attached to the hook on the sled. Thus, in operation, when the cross-head and the slip table move downwardly, the sled is pulled from one end of the table to the other.

In order to conduct the slip tests two pieces of film are cut for each run, one being 14 inches by 3.5 inches and the other being 9 inches by 2.5 inches. The larger piece of film is centered on the slip table with its test surface uppermost, and with one end thereof secured to the table with pressure sensitive tape at a point 1 inch short of the end of the table. The smaller sample is wrapped around the test sled with the test side of the sample outermost at the bottom thereof and the ends of the sample are secured on top of the sled. The cross-head is then started at a rate of 10 inches per minute and the static and dynamic slip values are read from the strain gauge.

In accordance with this test method the slip, i.e. the coefficient of friction, equals the force required to effect movement between the two film surfaces divided by the normal force brought to bear by the sled or

$$\text{Slip} = \frac{\text{Force in gr.} \times 2}{1000}$$

The same equation is applicable to measurements of both static and dynamic slip. Thus, static slip is read from the instrument upon initiation of movement of the sled, and dynamic slip is read in terms of the force necessary to maintain movement once initiated.

The chief advantage of the amide-containing compositions of this invention resides in the fact that these compositions allow the production of transparent polypropylene films, tubes, and other shaped articles having greatly reduced film-to-film coefficient or friction. Although the compositions of this invention are composed essentially of polypropylene containing small amounts of specific amides, or said amides and film grade polyethylene, the compositions may also contain small amounts of other desirable additives, such as antioxidants, dyes and pigments, plasticizers, antistatic agents, and the like, provided the additional ingredients are not present in amounts sufficient to alter the efficacy of the amides of this invention. The compositions of this invention are particularly useful for fabrication by extrusion into thin films, sheets, blown tubing, and the like. The compositions may also be cast, extruded, or molded into films, sheets, rods, tubes and piping, filaments and other shaped articles. The compositions may also be used for coating paper, cloth, wire, metal foil, glass fiber mats, synthetic and natural textiles and other substrates.

The examples that follow are given as illustrative embodiments of the present invention and are not to be taken as limiting the same. In these examples, the quantities of additives given are in terms of weight percent of additives based upon the total weight of polypropylene plus additives. The slip values are obtained in accordance with the method described hereinabove. The specimens tested in the examples are films of approximately 1 mil thickness prepared by the use of conventional slit-die chill-roll melt extrusion techniques. In these examples, haze was measured in accordance with ASTM D-1003-59T using the Hazemeter.

EXAMPLES 1 THROUGH 5

Polypropylene films were prepared at various extrusion temperatures containing various concentrations of a mixture of amides having the composition:

- 91% of 9-octadecanamide
- 6% of octadecanamide
- 3% of 9,12-octadecadienamide

Polypropylene films containing none of the foregoing were similarly prepared as controls. The slip values compiled in accordance with the method described hereinabove as well as the quantities of additives and extrusion temperatures are tabulated in Table I.

Table I

Example	Additive Concentr. Percent	Extrusion Temp., °F.	Slip		Haze, percent
			Static	Dynamic	
1-----	0.1	450	0.2	-----	1.5
2-----	0.1	500	0.4	-----	2.0
3-----	0.2	400	0.4	-----	1.5
4-----	0.5	440	0.4	0.2	1.6
5-----	0.5	440	-----	0.3	1.6
Control A-----	0.0	450	8.0	-----	0.5
Control B-----	0.0	500	10.0	-----	1.0

EXAMPLES 6 AND 7

The procedure of Examples 1 through 5 was repeated with the following mixture of amides:

- 22% of hexadecanamide
- 75% of octadecanamide
- 3% of 9-octadecanamide

Table II

Example	Additive Concentr. Percent	Extrusion Temp., °F.	Static Slip
6-----	0.1	400	0.6
7-----	0.2	410	0.6

EXAMPLES 8 AND 9

The procedure of the foregoing examples was repeated with the following mixture:

- 49% of dodecanamide
- 17% of tetradecanamide
- 9% of hexadecanamide
- 8% of octanamide
- 7% of decanamide
- 6% of 9-octadecanamide
- 2% of octadecanamide
- 2% of 9,12-octadecadienamide

Table III

Example	Additive Concentr., Percent	Extrusion Temp., °F.	Slip	
			Static	Dynamic
8-----	0.1	400	0.4	0.4
9-----	0.2	400	0.3	0.3

CONTROLS C, D AND E

The procedure of the foregoing examples was repeated using the amide of 13-docosenoic acid.

Table IV

Control	Additive Concentr., Percent	Extrusion Temp., °F.	Slip	
			Static	Dynamic
C-----	0.0	450	N.S.	-----
D-----	0.1	450	N.S.	N.S.
E-----	0.2	450	N.S.	-----

¹ No slip.

EXAMPLE 10

Polypropylene film, containing 0.2% of the amide mixture of Example 1 plus 1.0% of high density polyethylene (Super Dylan), was melt-extruded at 450° F. This film had a static coefficient of friction of 0.35 and a haze of 2.3%.

EXAMPLES 11 THROUGH 15

The procedure of Example 10 was repeated with 1.0% of high density polyethylene (Super Dylan) plus the tabulated amounts of the amide mixture of Example 8. Control F is a repeat of Example 12, but it contains no polyethylene. Similarly, Control G is a repeat of Example 14, except that it contains no polyethylene, and Control H contains 1% of said polyethylene. It is apparent from the data found in Table V that the combination of polyethylene plus amide enables one to use less of the amides and/or higher extrusion temperatures with concomitant reductions in slip and haze.

Table V

Example	Amide Concentr., Percent	Extrusion Temp., ° F.	Static Slip	Haze, Percent
11.....	0.05	440	0.50	3.5
12.....	0.10	450	0.25	3.5
Control F.....	0.10	450	N.S.	-----
13.....	0.10	500	0.60	2.3
14.....	0.20	450	0.25	-----
Control G.....	0.20	450	0.70	-----
15.....	0.20	500	0.25	2.3
Control H.....	-----	500	1.50-SS	1.6

¹ Alternately sticking and slipping.

Any polypropylene suitable for preparing substantially transparent self-supporting films may be used for the purposes of this invention. Film grade polypropylene having a Flow Rate of from about 2 to about 20 is satisfactory, the Flow Rate being measured by the method described in U.S. patent application Serial No. 791,251, filed February 5, 1959, by Casey et al. Generally, film grade polypropylene having a Flow Rate between about 4 and about 10 is used, preferably film grade poly-

propylene having a Flow Rate between about 5 and about 7.

The invention claimed is:

1. A process for preparing polypropylene films which comprises (A) admixing substantially crystalline isotactic polypropylene with between about 0.1 and 4.0 weight percent of polyethylene and from about 0.005 to about 2.0 weight percent of a material selected from the group consisting of an amide of a water-insoluble monocarboxylic acid having from 8 to 18 carbon atoms, and mixtures of said amides, (B) melt extruding the so-formed admixture at a temperature between about 400 and 550° F., and (C) recovering a polypropylene film having a static coefficient of friction no higher than 0.6 and no more than about 3.5% haze as determined by ASTM D-1003-59T.

2. The process of claim 1 wherein the quantity of said material is from about 0.05 to 0.5 weight percent.

3. The process of claim 1 wherein the quantity of said material is between about 0.1 and 0.3 weight percent.

4. The process of claim 1 wherein said coefficient of friction is no greater than 0.3.

5. The process of claim 1 wherein the quantity of polyethylene is between about 0.5 and 1.5 weight percent.

6. The process of claim 5 wherein the quantity of said material is from about 0.05 to 0.5 weight percent.

7. The process of claim 5 wherein the quantity of said material is from about 0.1 to 0.3 weight percent.

8. The process of claim 5 wherein said coefficient of friction is no greater than 0.3.

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