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(54) Title: BLENDED FLUOROPOLYMER COMPOSITIONS HAVING MULTIPLE MELT PROCESSIBLE FLUOROPOLYMERS

(57) Abstract: Fluoropolynier compositions that include multiple fluoropolymer components and, in exemplar)' applications, may be applied as coatings to either rigid or flexible substrates. The compositions may themselves be applied as basecoats or overcoats, or may be combined with other components to formulate basecoats or overcoats, In one embodiment, the compositions include at least one low molecular weight polytetrafluoroethylene (LPTFE) and at least two chemically different melt proccessible fluoropolymers(MPF). Tn another embodiment, the compositions include at least one high molecular weight polytetrafluoroethylene (HPTFE), at least one low molecular weight polytetrafluoroethylene (LPTFE), and at least two chemically different melt processible fluoropolymers (MPF). After being applied to a substrate, optionally over a basecoat and/or a midcoat and then cured, the present compositions form coatings that demonstrate improved characteristics, such as improved release characteristics, abrasion resistance, translucency /transparency, and permeability, for example.

BLENDED FLUOROPOLYMER COMPOSITIONS HAVING MULTIPLE MELT PROCESSIBLE FLUOROPOLYMERS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority under Title 35, U.S.C. §119(e) to U.S. Provisional Patent Application Serial Number 61/287,929, filed December 18, 2009, entitled MULTIPLE-COMPONENT BLENDED FLUOROPOLYMER COMPOSITIONS, and to U.S Provisional Patent Application Serial Number 61/296,553, filed January 20, 2010, entitled BLENDED FLUOROPOLYMER COMPOSITIONS WITH MULTIPLE MELT PROCESSIBLE FLUOROPOLYMERS, the entire disclosures of which are hereby expressly incorporated by reference herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention.

[0002] The present invention relates to fluoropolymers and, in particular, relates to fluoropolymer compositions having improved properties, such as coatings of the type that may be applied to either rigid or flexible substrates in which a non-stick and/or abrasion resistant surface is desired. In particular, the present invention relates to fluoropolymer compositions that include multiple fluoropolymer components and may be used to form coatings having improved non-stick or release characteristics and/or improved abrasion resistance, as well as films and/or blended powder compositions.

2. Description of the Related Art.

[0003] Fluoropolymers are long-chain polymers comprising mainly ethylenic linear repeating units in which some or all of the hydrogen atoms are replaced with fluorine. Examples include polytetrafluoroethylene (PTFE), methylfluoroalkoxy (MFA), fluoro ethylene propylene (FEP), perfluoroalkoxy (PFA), poly(chlorotrifluoroethylene) and poly(vinylfluoride).

[0004] Non-stick coating systems including fluoropolymers are applied in single or multiple coats to the surface of a substrate to provide a coated substrate having a non-stick coating to which extraneous materials will not adhere. In a multiple layer coating system, the non-stick coating generally includes a primer and a topcoat, and optionally, one or more midcoats.

[0005] The use of non-stick coating systems which are applied to a substrate in multiple layers has been known for many years. The primers for such systems typically contain a heat resistant organic binder resin and one or more fluoropolymer resins, along with various opaque pigments and fillers. The midcoats contain mainly fluoropolymers with some amounts of opaque pigments, fillers and coalescing aids, while the topcoats are almost entirely composed of fluoropolymers, such as entirely high molecular weight polytetrafluoroethylene (HPTFE), or HPTFE with a small amount of a melt-processible fluoropolymer.

[0006] Glasscloth is one example of a flexible substrate that may be coated with a fluoropolymer coating. The coating typically includes a high molecular weight polytetrafluoroethylene (HPTFE), either by itself or including small amounts of additional polymers and/or fillers. One coating technique involves feeding a glasscloth web through a dip tank containing a dispersion of the fluoropolymer, and then feeding the coated web upwardly through a drying and sintering oven tower to cure or fix the coating. This process is usually repeated a number of times whereby up to 10 or more coating layers may be applied.

[0007] What is needed are improved fluoropolymer compositions for applications such as coatings for rigid and/or flexible substrates that demonstrate improved characteristics, such as improved release and/or abrasion resistance.

SUMMARY OF THE INVENTION

[0008] The present disclosure provides fluoropolymer compositions that include multiple fluoropolymer components and, in exemplary applications, may be applied as coatings to either rigid or flexible substrates. The compositions may themselves be applied as basecoats or overcoats, or may be combined with other components to formulate basecoats or overcoats. In one embodiment, the compositions include at least one low molecular weight polytetrafluoroethylene (LPTFE) and at least two chemically different melt processible fluoropolymers (MPF). In another embodiment, the compositions include at

least one high molecular weight polytetrafluoroethylene (HPTFE), at least one low molecular weight polytetrafluoroethylene (LPTFE), and at least two chemically different melt processible fluoropolymers (MPF). After being applied to a substrate, optionally over a basecoat and/or a midcoat and then cured, the present compositions form coatings that demonstrate improved characteristics, such as improved release characteristics, abrasion resistance, translucency/transparency, and permeability, for example.

[0009] In one form thereof, the present disclosure provides a fluoropolymer composition, including at least one low molecular weight polytetrafluoroethylene (LPTFE) having a first melt temperature (T_m) of 335° C or less; and at least two melt processible fluoropolymers, including: a first melt-processible fluoropolymer (MPF); and a second melt-processible fluoropolymer (MPF), the second melt-processible fluoropolymer (MPF) chemically different from the first melt-processible fluoropolymer (MPF).

[0010] In one embodiment, the fluoropolymer composition lacks high molecular weight polytetrafluoroethylene (HLPTFE) having a number average molecular weight (M_n) of at least 500,000. The at least one LPTFE may be present in an amount of between 10 wt.% and 70 wt.%, and the at least two MPFs may be together present in an amount of between 30 wt.% and 90 wt.%, based on the total solids weight of the at least one LPTFE and the at least two MPFs, or the at least one LPTFE may be present in an amount of between 40 wt.% and 60 wt.%, and the at least two MPFs may be together present in an amount of between 40 wt.% and 60 wt.%, based on the total solids weight of the at least one LPTFE and the at least two MPFs.

[0011] In another embodiment, the composition may further include at least one high molecular weight polytetrafluoroethylene (HPTFE) having a number average molecular weight (M_n) of at least 500,000. The at least one HPTFE may be present in an amount of between 1 wt.% and 89 wt.%, based on the total solids weight of the at least one HPTFE, the at least one LPTFE, and the at least two MPFs, or the at least one LPTFE may be present in an amount of between 16 wt.% and 60 wt.%, the HPTFE may be present in an amount of between 1 wt.% and 60 wt.%, and the at least two MPFs may be together present in an amount of between 1 wt.% and 60 wt.%, based on the total solids weight of the at least one HPTFE, the at least one LPTFE, and the at least two MPFs. The at least two MPFs may each be present in an amount of between 1 wt.% and 30 wt.%, based on the total solids weight of the at least one HPTFE, the at least one LPTFE, and the at least two MPFs.

[0012] The at least one LPTFE may have a first melt temperature (T_m) selected from the group consisting of 332° C or less, 330° C or less, 329° C or less, 328° C or less, 327° C or less, 326° C or less, and 325° C or less and/or may be obtained via emulsion polymerization without being subjected to agglomeration, thermal degradation, or irradiation.

[0013] The composition may be in the form of an aqueous dispersion, and may be applied to a substrate as a coating.

[0014] In another form thereof, the present disclosure provides a method of coating a substrate, the method including the steps of: providing a substrate; applying a coating composition to the substrate, the coating composition including: at least one low molecular weight polytetrafluoroethylene (LPTFE) having a first melt temperature (T_m) of 335° C or less; and at least two melt processible fluoropolymers, including: a first melt-processible fluoropolymer (MPF); and a second melt-processible fluoropolymer (MPF), the second melt-processible fluoropolymer (MPF) chemically different from the first melt-processible fluoropolymer (MPF); and curing the composition to form a coating.

[0015] The method may include the additional steps, prior to the applying a coating composition step, of: applying a primer to the substrate, the primer including at least one fluoropolymer; and optionally, at least partially curing the primer. The method may further include the additional steps, following the applying a primer step and prior to the applying a coating composition step, of: applying a midcoat to the substrate, the midcoat including at least one fluoropolymer; and optionally, at least partially curing the midcoat. The substrate may be selected from the group consisting of a rigid substrate and a flexible substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become more apparent and the invention itself will be better understood by reference to the following description of embodiments of the disclosure taken in conjunction with the accompanying drawings, wherein:

[0017] Figs. 1-18 correspond to Example 2, wherein:

[0018] Fig. 1 is a DSC plot of the first melt peaks and fusion peak of Run 31 of Example 2;

[0019] Fig. 2 is a DSC plot of the remelt peak of Run 31 of Example 2;

[0020] Fig. 3 is a DSC plot of the first melt peaks and fusion peak of Run 23 of Example 2;

[0021] Fig. 4 is a DSC plot of the first remelt peak of Run 23 of Example 2;

[0022] Fig. 5 is a DSC plot of the first melt peaks and fusion peak of Run 30 of Example 2;

[0023] Fig. 6 is a DSC plot of the remelt peak of Run 30 of Example 2;

[0024] Fig. 7 is a DSC plot of the first melt peaks and fusion peaks of Run 22 of Example 2;

[0025] Fig. 8 is a DSC plot of the remelt peaks of Run 22 of Example 2;

[0026] Fig. 9 is a DSC plot of the first melt peaks and fusion peaks of Run 3 of Example 2;

[0027] Fig. 10 is a DSC plot of the remelt peaks of Run 3 of Example 2;

[0028] Fig. 11 is a DSC plot of the first melt peaks and fusion peaks of Run 41 of Example 2;

[0029] Fig. 12 is a DSC plot of the remelt peaks of Run 41 of Example 2;

[0030] Fig. 13 is a DSC plot of the first melt peaks and fusion peaks of Run 29 of Example 2;

[0031] Fig. 14 is a DSC plot of the remelt peaks of Run 29 of Example 2;

[0032] Fig. 15 is a DSC plot of the first melt peaks and fusion peaks of Run 38 of Example 2;

[0033] Fig. 16 is a DSC plot of the remelt peaks of Run 38 of Example 2;

[0034] Fig. 17 is a DSC plot of the first melt peaks and Fusion peaks of Run 39 of Example 2;

[0035] Fig. 18 is a DSC plot of the remelt peaks of Run 39 of Example 2;

[0036] Figs. 19-30 correspond to Example 1, wherein:

[0037] Fig. 19 is an exemplary plot showing the positions of values for PFA (MPF), SFN-D (LPTFE), TE3887N (LPTFE) and FEP (MPF) for the coutour plots of Figs 20-30;

[0038] Fig. 20 is a contour plot showing coating gloss as a function of composition;

[0039] Fig. 21 is a contour plot showing contact angle as a function of composition;

[0040] Fig. 22 is a contour plot showing coating pencil hardness as a function of composition;

[0041] Fig. 23 is a normalized contour plot showing the mean of the contact angle, gloss, and pencil hardness testing;

[0042] Fig. 24 is a normalized contour plot showing the mean of the minimum remelt temperature, contact angle, gloss, and pencil hardness testing;

[0043] Fig. 25a is a contour plots showing the number of DSC peaks observed during first melt;

[0044] Fig. 25b is a contour plots showing the number of DSC peaks observed during fusion;

[0045] Fig. 25c is a contour plots showing the number of DSC peaks observed during second melt;

[0046] Fig. 26 is a contour plot showing the difference between the total enthalpy of fusion and the total first melt enthalpy;

[0047] Fig. 27 is a contour plot showing the diffrence between the total enthalpy of remelting and the total first melt enthalpy;

[0048] Fig. 28 is a contour plot showing the minimum first melt temperature;

[0049] Fig. 29 is a contour plot showing the minimum fusion temperature; and

[0050] Fig. 30 is a contour plot showing the minimum remelt temperature.

[0051] Corresponding reference characters indicate corresponding parts throughout the several views. The exemplifications set out herein illustrate embodiments of the disclosure, and such exemplifications are not to be construed as limiting the scope of the disclosure in any manner.

DETAILED DESCRIPTION

[0052] The present invention provides fluoropolymer compositions that include multiple fluoropolymer components and, in exemplary applications, may be applied as coatings to either rigid or flexible substrates. The compositions may themselves be applied as basecoats or overcoats, or may be combined with other components to formulate basecoats or overcoats. In one embodiment, the compositions include at least one low molecular weight polytetrafluoroethylene (LPTFE) and at least two chemically different melt processible fluoropolymers (MPF). In another embodiment, the compositions include at least one high molecular weight polytetrafluoroethylene (HPTFE), at least one low molecular weight polytetrafluoroethylene (LPTFE), and at least two chemically different melt processible fluoropolymers (MPF). After being applied to a substrate, optionally over a basecoat and/or a midcoat and then cured, the present compositions form coatings that

demonstrate improved characteristics, such as improved release characteristics, abrasion resistance, translucency/transparency, and permeability, for example.

[0053] Suitable substrates to which the present fluoropolymer compositions may be applied, as well as coating types, are discussed below in Section I; suitable high molecular weight polytetrafluoroethylene (HPTFE) components are discussed below in Section II; suitable low molecular weight polytetrafluoroethylene (LPTFE) components are discussed below in Section III; suitable melt processible fluoropolymer (MPF) components are discussed below in Section IV; suitable engineering polymers are discussed below in Section V; suitable application procedures and formulations are discussed below in Section VI; physical properties and characterization procedures are discussed below in Section VII; and the Examples follow.

[0054] Fluoropolymer blends including LPTFE and a single type of MPF are disclosed in detail in U.S. Patent Application No. 12/468,580, filed on May 19, 2009, entitled BLENDED FLUOROPOLYMER COMPOSITIONS; fluoropolymer blends including high molecular weight polytetrafluoroethylene (HPTFE), LPTFE, and a single type of MPF are disclosed in detail in U.S. Patent Application No. 12/567,330, filed on September 25, 2009, entitled BLENDED FLUOROPOLYMER COATINGS FOR RIGID SUBSTRATES and in U.S. Patent Application No. 12/567,446, filed on September 25, 2009, entitled BLENDED FLUOROPOLYMER COMPOSITIONS AND COATINGS FOR FLEXIBLE SUBSTRATES; each are assigned to the assignee of the present invention, and the disclosures of each are expressly incorporated herein by reference.

[0055] In a first embodiment, the present blended fluoropolymer compositions include at least one LPTFE and at least two chemically different MPFs, but do not include high molecular weight polytetrafluoroethylene (HPTFE). In this respect, the blended fluorpolymer compositions of the first embodiment can be considered to be blended MPFs with an additive in the form of at least one LPTFE.

[0056] In a second embodiment, the present blended fluorpolymer compositions include at least one HPTFE, at least one LPTFE, and at least two chemically different MPFs. In this respect, the blended fluorpolymer compositions of the second embodiment can be considered to include the fluropolymer compositions of the first embodiment used as an additive to a coating system that includes HPTFE.

[0057] In each of the first and second embodiments, the blended fluoropolymer compositions include at least two chemically different MPF's, as defined herein.

[0058] The compositions may be in the form of aqueous dispersion or powders, for example, and may be used in the particular types of applications discussed herein as well as in traditional applications in which MPFs are known to be used. Also, the present blended fluoropolymer compositions can be used alone, or may be formulated with other types of fluoropolymers or non-fluoropolymers, optionally together with suitable additives, such as fillers, pigments, surfactants, etc.

I. Substrates and Coating Types

[0059] a. Rigid Substrates.

[0060] Suitable rigid substrates to which the present compositions may be applied include metals, metal alloys, ceramics, and/or rigid plastic materials. Examples include cookware, bakeware, industrial components such as rollers, or any other rigid substrate to which a coating formed of the present compositions is desired.

[0061] The rigid substrate may optionally be coated with a primer (or basecoat) and/or a midcoat prior to application of the present coating compositions. The primer and midcoat may be any type of fluoropolymer-based coating, and commercially available coatings based on high molecular weight PTFE and/or other fluoropolymers are widely available. The particular compositions of the primer and/or midcoat may vary widely, and are not thought to be critical with respect to the improved properties demonstrated by the coatings disclosed herein.

[0062] b. Flexible Substrates.

[0063] Suitable flexible substrates to which the present compositions may be applied include glasscloth of the type commonly used in applications such as food conveyer belts for continuous ovens, architectural fabrics of the type used in stadium roofs and radar domes, as well as heat sealing belts, circuit boards, cooking sheets, and tenting fabrics, for example. "Glasscloth" or "glass cloth" is a textile material made of woven fibers such as, for example, linen, glass, or cotton.

[0064] Other flexible substrates that may be coated with the present compositions include any material including natural or synthetic fibers or filaments, including staple fiber, fiberfill, yarn, thread, textiles, nonwoven fabric, wire cloth, ropes, belting, cordage, and webbing, for example. Exemplary fibrous materials which may be coated with the present coating compositions include natural fibers, such as vegetable, animal, and mineral fibers,

including cotton, cotton denim, wool, silk, ceramic fibers, and metal fibers, as well as synthetic fibers, such as knit carbon fabrics, ultra high molecular weight polyethylene (UHMWPE) fibers, poly(ethylene terephthalate) (PET) fibers, para-aramid fibers, including poly-paraphenylene terephthalamide or Kevlar®, and meta-aramid fibers, such as Nomex®, each available from E.I. du Pont de Nemours and Company, polyphenylene sulfide fibers, such as Ryton®, available from Chevron Phillips Chemical Co., polypropylene fibers, polyacrylic fibers, polyacrylonitrile (PAN) fibers, such as Zoltek®, available from Zoltek Corporation, polyamide fibers (nylon), and nylon-polyester fibers, such as Dacron®, available from Invista North America.

[0065] The flexible substrate may optionally be coated with a primer (or basecoat) and/or a midcoat prior to application of the present coating compositions. The primer and midcoat may be any type of fluoropolymer-based coating, and commercially available coatings based on high molecular weight PTFE and/or other fluorpolymers are widely available. The particular compositions of the primer and/or midcoat may vary widely, and are not thought to be critical with respect to the improved properties demonstrated by the coatings disclosed herein.

[0066] c. Coating Types.

[0067] In one embodiment, the present compositions are applied over an underlying coating, or undercoat, which undercoat may be cured, partially cured, or uncured prior to the application of the present compositions. The undercoat may be a basecoat, which is the coating applied directly to an underlying substrate (sometimes referred to as a primer), optionally together with one or more midcoats. In these embodiments, the present coating may be referred to herein as either an "overcoat" or a "topcoat" and these terms are generally interchangeable. In other embodiments, the present compositions may be applied directly to a substrate to form a coating in direct contact with the substrate whereby the coating is not applied over any undercoats. In further embodiments, the present coating system may itself also be an undercoat.

II. High molecular weight polytetrafluoroethylene (HPTFE)

[0068] In some embodiments, the present compositions include at least one type of traditional high molecular weight polytetrafluoroethylene PTFE (HPTFE).

[0069] The number average molecular weight (M_n) of the HPTFE is typically at least 500,000, and may be at least 1,000,000, and suitable HPTFE in the form of liquid dispersions and/or powders are available from many commercial sources. Liquid HPTFE dispersions typically include surfactants for stability, though "unstabilized" HPTFE dispersions, typically having less than 1.0 wt.% surfactant, are also available and may also be used. When a powder is used, the powder will typically be dispersed in a liquid to prepare the coating composition.

[0070] In some embodiments, the HPTFE may include a small amount of modifying co-monomer, in which case the HPTFE is a co-polymer known in the art as "modified PTFE" or "trace modified PTFE". Examples of the modifying co-monomer include perfluoropropylvinylether (PPVE), other modifiers, such as hexafluoropropylene (HFP), chlorotrifluoroethylene (CTFE), perfluorobutylethylene (PFBE), or other perfluoroalkylvinylethers, such as perfluoromethylvinylether (PMVE) or perfluoroethylvinylether (PEVE). The modifying co-monomer will typically be present in an amount less than 1% by weight, for example, based on the weight of the HPTFE.

[0071] The HPTFE is typically of the type produced by a polymerization process that is well known in the art as dispersion polymerization or emulsion polymerization. In some embodiments, however, the HPTFE may be of the type produced by the polymerization process well known in the art as granular or suspension polymerization, which yields PTFE known in the art as granular PTFE resin or granular PTFE molding powder.

III. Low molecular weight polytetrafluoroethylene (LPTFE)

[0072] The present compositions include at least one type of low molecular weight polytetrafluoroethylene (LPTFE).

[0073] The LPTFE is typically provided in the form of a liquid dispersion and, in most embodiments will be an aqueous dispersion, though the LPTFE may be dispersed in other solvents and/or LPTFE originally in an aqueous phase may be phase transferred into another solvent, such as organic solvents including hexane, acetone, or an alcohol.

[0074] The LPTFE will typically have a mean particle size of 1.0 microns (μm) or less, 0.9 microns (μm) or less, 0.75 microns (μm) or less, 0.5 microns (μm) or less, 0.4 microns (μm) or less, 0.3 microns (μm) or less, or 0.2 microns (μm) or less, as measured by a suitable manner such as by laser light diffraction by ISO 13320. In some embodiments, the

LPTFE may have a mean particle size as low as 30, 50, 100, or 150 nm, or as large as 200, 250, or 350 nm, for example.

[0075] The number average molecular weight (M_n) of the LPTFE will typically be less than 500,000 and, in most embodiments, may be as low as 10,000 or greater, 20,000 or greater, or 25,000 or greater, or may be as high as 200,000 or less, 100,000 or less, or 70,000 or less, 60,000 or less, or 50,000 or less, for example.

[0076] An alternative manner of characterizing the molecular weight of the LPTFE is by its first melt temperature (T_m), as determined by a suitable method such as differential scanning calorimetry (DSC), which first melt temperature (T_m) for LPTFE may be either equal to or less than 335°C. In other embodiments, the first melt temperature of the LPTFE may be either equal to or less than 332°C, either equal to or less than 330°C, either equal to or less than 329°C, either equal to or less than 328°C, either equal to or less than 327°C, either equal to or less than 326°C, or either equal to or less than 325°C.

[0077] The LPTFE may be provided in the form of an aqueous dispersion which is stabilized, unstabilized, or minimally stabilized. As used herein, "unstabilized" or "minimally stabilized" refers to an aqueous dispersion that includes less than 1.0 wt.% of a traditional surfactant, such as non-ionic surfactant or an anionic surfactant, based on the weight of the LPTFE aqueous dispersion. In some embodiments, the LPTFE dispersion may be provided in the form of an aqueous dispersion having less than 1.0 wt.% surfactant, less than 0.8 wt.% surfactant, less than 0.6 wt.% surfactant, or even less than 0.5 wt.% surfactant. In other embodiments, the LPTFE dispersion may be provided in the form of an aqueous dispersion that is "stabilized", typically having 1-12 wt.% surfactant. However, the nature of the stabilization package employed is not a critical feature of this invention.

[0078] Also, as discussed below, the LPTFE may be provided in the form of a solid micropowder.

[0079] The LPTFE will typically be in the form of a low molecular weight PTFE homopolymer. However, in other embodiments, the LPTFE may include a small amount of modifying co-monomer, in which case the PTFE is a co-polymer known in the art as "modified PTFE" or "trace modified PTFE". Examples of the modifying co-monomer include perfluoropropylvinylether (PPVE), other modifiers, such as hexafluoropropylene (HFP), chlorotrifluoroethylene (CTFE), perfluorobutylethylene (PFBE), or other perfluoroalkylvinylethers, such as perfluoromethylvinylether (PMVE) or

perfluoroethylvinylether (PEVE). The modifying co-monomer will typically be present in an amount less than 1% by weight, for example, with respect to the PTFE.

[0080] Suitable LPTFE dispersions include SFN-D, available from Chenguang R.I.C.I, Chengdu, 610036 P.R. China, as well as TE3887N, available from DuPont. Other exemplary LPTFE micropowders include Dyneon TF-9207, available from Dyneon LLC, LDW-410, available from Daikin Industries, Inc., and MP-25, MP-55, MP-8T and UF 8TA, each available from Laurel Products.

[0081] These fluoropolymers have characteristics set forth in the table below:

Characteristics of exemplary low molecular weight polytetrafluoroethylenes (LPTFE)

LPTFE	Solids content (wt.%)	Molecular weight (Mn) (estimated)	Mean particle size (μm)	Surfactant (wt.%, based on weight of LPTFE) (type)	First melt temperature (DSC) (°C)
SFN-D	50	10,000 - 20,000	0.19	5%	324.5 - 326
TE3887N	60	65,000 - 70,000	0.2	6% (non-ionic)	327.6
LDW-410	40	80,000 – 90,000	0.2	5%	329.4
TF-9207	100	65,000 - 70,000	13.27	N/A	327.6
MP-8T	100	ca. 25,000	1.32	N/A	323.1
MP-10	100	100,000	0.84	N/A	330
MP-55	100	40,000 – 50,000	11.06	N/A	324.3
MP-25	100	ca. 130,000	0.28	N/A	332
UF-8TA	100	ca. 95,000	1.22	N/A	331.5

[0082] Exemplary types of LPTFE are discussed below.

[0083] a. LPTFE produced by dispersion polymerization or emulsion polymerization and which is thereafter not agglomerated, irradiated, or thermally degraded.

[0084] In some embodiments, the LPTFE is produced by a polymerization process that is well known in the art as dispersion polymerization or emulsion polymerization. These polymerization processes may be conducted with chain transfer agents, which reduce the average molecular weight of the fluoropolymers produced, and/or via other methods whereby

the polymerization process is controlled to form a liquid dispersion of directly polymerized particles of PTFE having low molecular weight (LPTFE).

[0085] In these embodiments, the LPTFE, after being produced by dispersion polymerization or emulsion polymerization, is thereafter not agglomerated, irradiated, or thermally degraded. In particular, the LPTFE has not been subjected to any agglomeration steps during its manufacture, and therefore retains a small mean particle size. Further, the LPTFE has not been subjected to thermal degradation to reduce its molecular weight. Still further, the LPTFE has also not been subjected to irradiation, such as by high energy electron beam, to reduce its molecular weight. In these embodiments, the LPTFE dispersions will not demonstrate a spectrum and/or will be below a detection limit when subjected to electron paramagnetic resonance (EPR) or electron spin resonance (ESR) spectroscopy, as opposed to irradiated PTFE, which will demonstrate such a spectra and/or will otherwise have detectable free radicals.

[0086] These types of LPTFE dispersions are provided as aqueous dispersions that are obtained via a controlled dispersion or emulsion polymerization process to produce directly polymerized LPTFE that is not thereafter subjected to agglomeration, thermal degradation, or irradiation. These types of LPTFE dispersions will be appreciated by those of ordinary skill in the art to be distinct from other PTFE materials that are commercially available.

[0087] First, these types of LPTFE dispersions are distinct from PTFE that is produced by the polymerization process well known in the art as granular or suspension polymerization, which yields PTFE known in the art as granular PTFE resin or granular PTFE molding powder. Granular PTFE resins will typically have a high molecular weight, such as a number average molecular weight (M_n) of at least 1,000,000 or more and a first melt temperature (T_m) greater than the 335°C, typically much greater than 335°C. Granular PTFE resin is typically provided in solid, powder form including particles having a mean particle size of several microns, typically from 10 to 700 microns (μm). These resins may also be provided as fine cut resins having a mean particle size of 20 to 40 microns (μm), for example.

[0088] Additionally, these types of LPTFE dispersions may be distinct from lower molecular weight materials prepared from high molecular weight granular PTFE resins that have been degraded by irradiation or thermal degradation to form low molecular weight materials known as granular PTFE micropowders, which typically have a particle size

ranging between 0.2 and 20 microns (μm). Examples of granular PTFE micropowders include Zonyl® MP1200, MP1300, and MP1400 resins, available from DuPont (Zonyl® is a registered trademark of E.I. du Pont de Nemours & Co.).

[0089] Second, these types of LPTFE dispersions are also distinct from high molecular weight PTFE dispersions made from dispersion or emulsion polymerization conducted without chain transfer agents to thereby polymerize a high molecular weight PTFE having a number average molecular weight (M_n) of at least 1,000,000 or more, and a first melt temperature (T_m) greater than the 335°C, typically much greater than 335°C. These high molecular weight PTFE dispersions are typically stabilized with a traditional surfactant present in an amount greater than 1.0 wt.%, typically much greater than 1.0 wt.%.

[0090] Additionally, these types of LPTFE dispersions are also distinct from high molecular weight PTFE dispersions that are produced via dispersion or emulsion polymerization and thereafter coagulated or agglomerated.

[0091] Still further, these types of LPTFE dispersions are distinct from high molecular weight PTFE dispersions that are produced via dispersion or emulsion polymerization and thereafter coagulated or agglomerated, and then are subjected to thermal degradation or irradiation to form low molecular weight PTFE powders, known in the art as PTFE micropowders, which are provided as solid powders having a particle size between 0.2 and 20 microns (μm), such as for use in extrusion and other applications. Examples of PTFE micropowders include Zonyl® MP1000, MP1100, MP1500 and MP1600 resins, available from DuPont (Zonyl® is a registered trademark of E.I. du Pont de Nemours & Co.). However, as discussed below, these types of LPTFE micropowders may also be used in the present invention.

[0092] Third, these types of LPTFE dispersions are distinct from LPTFE micropowders that are polymerized via dispersion or emulsion polymerization in the presence of chain transfer agents, and then are agglomerated to form PTFE micropowders having an average particle size of between 0.2 and 20 microns (μm), for example.

[0093] b. LPTFE micropowders.

[0094] In a second embodiment, the LPTFE may be in the form of an LPTFE micropowder.

[0095] A first type of LPTFE micropowders are derived from high molecular weight PTFE dispersions that are produced via dispersion or emulsion polymerization and thereafter coagulated or agglomerated, and then subjected to thermal degradation or irradiation to form

low molecular weight PTFE powders, known in the art as PTFE micropowders and referred to herein as LPTFE micropowders, which are typically provided as solid powders having a particle size typically between 0.2 and 20 microns (μm).

[0096] Examples of these types of LPTFE micropowders include Zonyl® MP1000, MP1100, MP1500 and MP1600 resins, available from DuPont (Zonyl® is a registered trademark of E.I. du Pont de Nemours & Co.); and MP-25, MP-55, and UF 8TA, each available from Laurel Products.

[0097] A second type of LPTFE micropowders are derived from high molecular weight granular PTFE resins that have been degraded by irradiation or thermal degradation to form low molecular weight materials known as granular PTFE micropowders, which typically have a particle size ranging typically between 2 and 20 microns (μm).

[0098] Examples of these types of LPTFE micropowders include Zonyl® MP1200, MP1300, and MP1400 resins, available from DuPont (Zonyl® is a registered trademark of E.I. du Pont de Nemours & Co.) and MP-8T and MP-10, available from Laurel Products.

[0099] A third type of these types LPTFE micropowders are polymerized via dispersion or emulsion or suspension polymerization in the presence of chain transfer agents, and then may be agglomerated to form LPTFE micropowders having an average particle size of typically between 0.2 and 20 microns (μm), for example.

IV. Melt processible fluoropolymers (MPFs)

[00100] In some embodiments, the present compositions also include a component in the form of at least two chemically different melt processible fluoropolymers (MPF), such as perfluoroalkoxy (PFA) (copolymers of tetrafluoroethylene (TFE) and perfluoroalkylvinyl ethers), generally including methylfluoroalkoxy (MFA) (a copolymer of tetrafluoroethylene (TFE) and perfluoromethylvinyl ether (PMVE)), ethylfluoroalkoxy (EFA) (a copolymer of tetrafluoroethylene (TFE) and perfluoroethylvinyl ether (PEVE)), and perfluoroalkoxy (PFA) (copolymers of tetrafluoroethylene (TFE) and perfluoropropylvinyl ether (PPVE)); and copolymers of tetrafluoroethylene (TFE) and hexafluoropropylene (HFP), known as fluorinated ethylene propylene (FEP), for example.

[00101] Each of the foregoing MPF's, as well as the HPTFE and LPTFE disclosed herein, are known in the art as "perfluorinated" fluoropolymers, meaning that the hydrogen atoms of their alkane and/or alkoxy analogs have been completely substituted by fluorine

atoms, it being understood that perfluorinated fluoropolymers are considered inert or non-reactive.

[00102] As used herein, "chemically different", when used in connection with the MPFs disclosed herein, refers to MPFs of differing type, as opposed to grade. For example, a type of PFA and a type of FEP would be chemically different, while two PFAs of different grades would not. However, two MPFs having different modifying co-monomers would also be "chemically different" even if they were nominally referred to as the same polymer type. Also, for purposes of this disclosure, MFA, EFA, PFA, and FEP are each chemically different from one another.

[00103] The MPF may be produced by a polymerization process that is well known in the art as dispersion polymerization or emulsion polymerization. These polymerization processes may be conducted with chain transfer agents, which reduce the average molecular weight of the fluoropolymers produced, and/or via other methods whereby the polymerization process is controlled to form a liquid dispersion of directly polymerized particles of MPF.

[00104] In most embodiments, the MPF, after being produced by dispersion polymerization or emulsion polymerization, is thereafter not agglomerated, irradiated, or thermally degraded. In particular, the MPF will not have been subjected to any agglomeration steps during its manufacture, and therefore retains a small mean particle size as described below.

[00105] The liquid dispersion of MPF in most embodiments will be an aqueous dispersion, though the MPF may be dispersed in other solvents and/or MPF originally in an aqueous phase may be phase transferred into another solvent, such as organic solvents including hexane, acetone, or an alcohol.

[00106] The MPF, when produced as described above, will typically have a mean particle size of 1.0 microns (μm) or less, 0.9 microns (μm) or less, 0.75 microns (μm) or less, 0.5 microns (μm) or less, 0.4 microns (μm) or less, 0.3 microns (μm) or less, or 0.2 microns (μm) or less. In particular, the MPF may have a mean particle size as low as 30, 50, 100, or 150 nm, or as large as 200, 250, or 350 nm, for example.

[00107] In other embodiments, MPF powders could also be used.

[00108] The MPF may be provided in the form of an aqueous dispersion which is stabilized, unstabilized, or minimally stabilized. As used herein, "unstabilized" or "minimally stabilized" refers to an aqueous dispersion that includes less than 1.0 wt.% of a traditional surfactant, such as non-ionic surfactant or an anionic surfactant, based on the

weight of the MPF aqueous dispersion. In some embodiments, the MPF dispersion may be provided in the form of an aqueous dispersion having less than 1.0 wt.% surfactant, less than 0.8 wt.% surfactant, less than 0.6 wt.% surfactant, or even less than 0.5 wt.% surfactant. In other embodiments, the MPF dispersion may be provided in the form of an aqueous dispersion that is "stabilized", typically having 1-12 wt.% surfactant.

[00109] Typically, the melt flow rate (MFR) of the MPF will be greater than 0.5 g/10 min and, in one embodiment, may be about 2 g/10 min or higher, as determined by ASTM D1238.

[00110] Also, the MPF will typically have a co-monomer content, *i.e.*, a content of one or more monomers other than tetrafluoroethylene (TFE), of about 3.0 wt.% or greater, such as 4.0 wt.% or greater, 4.5 wt.% or greater, 5.0 wt.% or greater, 5.5 wt.% or greater, or 6.0 wt.% or greater.

[00111] Suitable MPF dispersions include TE7224 (PFA), available from DuPont, 6900Z (PFA), available from Dyneon LLC, TE9568 (FEP), available from DuPont, Neoflon ND-110 (FEP), available from Daikin, and Hyflon XPH 6202-1 (MFA), available from Solvay. These MPF dispersions have characteristics set forth in the below:

Characteristics of exemplary melt processible fluoropolymers (MPFs)

MPF (type)	**Solids content (wt.%)**	**Mean particle size (μm)**	**Melt flow rate (MFR) (g/10 min)**	**First melt temperature (DSC) (°C)**
DuPont TE7224 (PFA)	58.6	0.26	2.4	313.0 (shoulder 321.2)
Dyneon 6900Z (PFA)	49.4	0.31	19.4	310.25
DuPont TE9568 (FEP)	55.6	0.17	11.9	257.84
Daikin Neoflon ND-110 (FEP)	56.5	0.16	--	232.83
Solvay Hyflon XPH 6202-1 (MFA)	27.2	0.28	4.5	306.31 (shoulder 287.29)

V. Engineering polymers

[00112] In some embodiments, fluoropolymer compositional blends of the first and second embodiments discloses herein may be added to at least one engineering polymer that is not a fluoropolymer, in order to form a modified engineering polymer coating composition.

An "engineering polymer" as used herein is a polymer that is not a fluoropolymer, and exhibits superior mechanical and thermal properties over a wide range of conditions.

[00113] Suitable engineering polymers include PolyEther Ether Ketone (PEEK), PolyEther Sulphone (PES), PolyPhenylene Sulfide (PPS), PolyAmide Imide (PAI), Epoxy polymers (inc. BPA, BPF, Phenollic, Novolac, BIS A Free), Polyester, Polyurethane (PU), Acrylic, PolyCarbonate (PC).

[00114] Descriptions of the typical properties of these engineering polymers are set forth below.

[00115] PolyEther Ether Ketone (PEEK). PEEK can be manufactured by step growth polymerization. It is a semi-crystalline thermoplastic that exhibits excellent mechanical properties and chemical resistance, which are maintained at higher temperatures due to it being highly resistant to thermal degradation. PEEK has a glass transition temperature of about ~143°C and a melt point about ~343°C.

[00116] Polyether Sulphone (PES). PES can be manufactured by nucleophilic aromatic substitution. It is a high temperature resistant non-crystalline material that has good continuous operation temperature (about ~200°C). It shows good resistance to organic and aqueous environments. Depending on grade, PES has a glass transition temperature of about ~193°C and a melt point of about 255°C.

[00117] Polyphenylene Sulphide (PPS). PPS has a resistance to heat, acid and alkaline conditions and has good abrasion resistance. It has a glass transition temperature of about 85°C and melting point of about ~285°C. PPS is semi-crystalline and has excellent solvent and thermal performance.

[00118] Polyamide Imide (PAI). PAI is a thermoplastic amorphous polymer that has exceptional thermal and chemical resistance properties. Examples of which are those produced by Solvay under the "Torlon" brand trade name. PAI is capable of operating at continuous temperatures of about ~260°C and has a glass transition temperature of about 280°C.

[00119] Epoxy Polymers. Epoxy polymers are manufactured in a number of ways, the most commonly known being through the reaction of epichlorohydrin and bisphenol A to result in a bisphenol A Epoxy resin. The most common epoxy resins are bisphenol A- and F-based or Novolac-based being manufactured from a Phenolic-based feedstock. Epoxy polymers have exceptional chemical resistance and depending on type, good continuous heat

resistance. The glass transition temperature and melt point vary dependent upon the polymer backbone.

[00120] Polyester Polymers. Polyesters are most commonly found in the thermoplastic form, however, thermosetting polymers are also available. They have glass transitions in the region of (but not limited to) 70°C and melt points ~265°C.

[00121] Polyurethanes (PU). PU's are manufactured typically through the addition reaction of polyisocyanates with polyalcohols. The glass transitions and melt points depending on polymer matrix and application.

[00122] Fluorpolymer blends that may be added to at least one engineering polymer according to the present disclosure include: (1) a blend of at least one LPTFE and at least one MPF, (2) a blend of at least one HPTFE, at least one LPTFE, and at least one MPF, and (3) any of the multiple component fluoropolymer blends disclosed herein.

VI. Application procedures and coating formulations

[00123] To form the present blended fluoropolymer compositions, liquid dispersions of the various components are blended together. When one or more of the components are initially provided in solid, *i.e.*, powder form, the powder will typically be dispersed in a liquid medium to form a liquid dispersion prior to blending with other components. The order of blending is not considered to be important, and one of ordinary skill in the art will recognize that the wet weights of liquid dispersions of the components discussed herein may be selected based on the solids contents of the dispersions and the desired relative weight percent ratios of the components that are desired.

[00124] The relative ratios, fractions, or weight percents of the components described below are based on the total solids weight of the components, excluding non-fluoropolymer components that may be present, such as water or other solvents, surfactants, pigments, fillers, and other compositions.

[00125] The compositions described herein may also include suitable additives, such as surfactants, fillers, reinforcement additives, and pigments, if desired, or, as embodied in the Examples herein in connection with some of these components, may be formulated to specifically lack some or all of these components. Also, in some embodiments, the compositions may include only fluoropolymers, or may include only perfluorinated fluoropolymers, and may lack other types of polymers.

[00126] The compositions can be prepared by any standard formulation technique such as simple addition and low shear mixing. The compositions may be applied over a primer and/or midcoat by any known technique. Although the primer and midcoat, if present, will typically each include at least one fluoropolymer, the particular compositions of the primer and/or midcoat may vary widely, and are not thought to be critical with respect to the improved properties demonstrated by the coatings disclosed herein.

[00127] The coatings may be applied to a dry film thickness (DFT) of between 4 and 100 microns, depending on the application, and may be cured at a temperature above about 140°C for between 1 and 30 minutes, depending on the applied thickness. Depending on the application and degree of thickness desired, the coatings may be applied in several layers.

[00128] It has been found that blending of the dispersions facilitates interaction of the LPTFE and MPF(s), and of the HPTFE, LPTFE and MPF(s), on a submicron level to facilitate intimate blending such that, when the blended fluoropolymer composition is dried, a crystal structure representing a true alloy of the fluoropolymers is formed, having melt characteristics that differ from those of the individual fluoropolymers. The blended fluoropolymer composition may be used to provide a coating having improved abrasion resistance, gloss, adhesion, and higher contact angles.

[00129] In addition, when used with the engineering polymers discussed in Section V herein, the blended fluoropolymer dispersions disclosed herein provide coatings that are capable of providing icophobicity.

[00130] a. Compositions that do not include engineering polymers.

[00131] For the first embodiment, in which the blended compositions include at least one LPTFE and at least two chemically different MPFs (but do not include HPTFE), the propotions of the components may be as follows, based on total solids weight of the at least one LPTFE and the at least two MFPs in the blended fluoropolymer compositions:

[00132] (i). The LPTFE(s) may comprise as little as 2%, 5 wt.%, 10 wt.%, or 15 wt.%, or as much as 85 wt.%, 90 wt.%, 95 wt.%, or 98 wt.% of the blended fluoropolymer composition, and may be present within any range delimited by these values and/or by the values in the Examples herein. In one embodiment, the LPTFE may comprise between 10 wt.% and 70 wt.% of the blended fluoropolymer composition, such as between 30 wt.% and 90 wt.% of the blended fluoropolymer composition. In another embodiment, the LPTFE may comprise between 20 wt.% and 60 wt.% of the blended fluoropolymer composition. In

another embodiment, the LPTFE may comprise between 40 wt.% and 60 wt.% of the blended fluoropolymer composition.

[00133] (ii). The combined MPFs may comprise as little as 2 wt.%, 10 wt.%, or 15 wt.%, or as much as 85 wt.%, 90 wt.%, 95 wt.%, or 98 wt.% of the blended fluoropolymer composition, and may be present within any range delimited by these values and/or by the values in the Examples herein. In one embodiment, the combined MPFs may comprise between 40 wt.% and 80 wt.% of the blended fluoropolymer composition. In another embodiment, the combined MPFs may comprise between 40 wt.% and 60 wt.% of the blended fluoropolymer composition. In another embodiment, the combined MPFs may comprise between 36 wt.% and 64 wt.% of the blended fluoropolymer composition.

[00134] From Example 1 below, particular embodiments include: (1) 10-64 wt.% FEP, 16-64 wt.% PFA, and 20-60 wt.% LPTFE; (2) 12-24 wt.% FEP, 24-64 wt.% PFA, and 20-60 wt.% LPTFE, and (3) 12-16 wt.% FEP, 24-48 wt.% PFA and 40-60 wt.% LPTFE.

[00135] For the second embodiment, in which the blended compositions include at least one HPTFE, at least one LPTFE, and at least two chemically different MPFs, the proportions of the components may be as follows, based on total solids weight of the at least one HPTFE, the at least one LPTFE, and the at least two MFPs in the blended fluoropolymer compositions:

[00136] (i). The LPTFE(s) may comprise as little as 2 wt.%, 5 wt.%, 10 wt.%, or 15 wt.%, or as much as 85 wt.%, 90 wt.%, 95 wt.%, or 98 wt.% of the blended fluoropolymer composition, and may be present within any range delimited by these values and/or by the values in the Examples herein. In one embodiment, the LPTFE may comprise between 10 wt.% and 90 wt.% of the blended fluoropolymer composition, such as 24 wt.% of the blended composition. In another embodiment, the LPTFE may comprise between 16 wt.% and 60 wt.% of the blended fluoropolymer composition.

[00137] (ii). The combined MPFs may comprise as little as 2 wt.%, 10 wt.%, or 15 wt.%, or as much as 85 wt.%, 90 wt.%, 95 wt.%, or 98 wt.% of the blended fluoropolymer composition, and may be present within any range delimited by these values and/or by the values in the Examples herein. In one embodiment, the combined MPFs may comprise between 10 wt.% and 90 wt.% of the blended fluoropolymer composition, such as 24 wt.% of the blended composition. In another embodiment, the combined MPFs may comprise between 1 wt.% and 60 wt.% of the blended fluoropolymer composition.

[00138] (iii). The HPTFE(s) may comprise between 1 wt.% and 89 wt.% or 90 wt. % of the blended fluoropolymer composition, such as 60 wt. % of the blended fluoropolymer composition. In another embodiment, the HPTFE may comprise between 1 wt.% and 60 wt.% of the blended fluoropolymer composition.

[00139] From Example 2 below, particular embodiments include: (1) 16-60 wt.% LPTFE, 1-30 wt.% FEP, 1-30 wt.% PFA and 1-60 wt.% HPTFE or, more particularly, 16-60% LPTFE, 8-18% FEP, 8-18% PFA, and 40-60% HPTFE.

[00140] From Example 3 below, particular embodiments include: (1) 60-84 wt.% HPTFE, 4-12 wt.% PFA, 2-18 wt.% FEP and 4-30 wt.% LPTFE.

[00141] b. Compositions that include engineering polymers.

[00142] The total engineering polymer weight content, based on solids weight of all polymers in the composition, may be as little as 15 wt.% to as great as 85 wt.% for both spray applications and coil applications. In compositions that include engineering polymers, the LPTFE may comprise as little as 5 wt.%, 10 wt.%, 11 wt.%, or 16 wt.%, or as much as 24 wt.%, 36 wt.%, or 95 wt.% by weight of the composition, and may be present within any range delimited by these values or by the values in the Examples herein. The combined MPFs may comprise as little as 5 wt.%, 10 wt.%, 12 wt.% or 16 wt.%, or as much as 24 wt.%, 36 wt.%, or 95 wt.% of the composition, and may be present within any range delimited by these values or by the values in the Examples herein.

[00143] In one embodiment, the combined MPFs may comprise between 5 wt.% and 36 wt.% of the composition, such as 23 wt.% of the composition, and the LPTFE may comprise between 10 wt.% and 36 wt.% of the blended fluoropolymer composition such as 16 wt.% of the blended fluoropolymer composition.

[00144] The HPTFE may comprise between 40 wt.% and 90 wt. % of the composition such as 60 wt. % of the composition or any range delimited by the values in the Examples herein.

VII. Physical properties and characterization procedures

[00145] a. First melt, fusion, and second melt (remelt) temperatures.

[00146] The present compositions, when applied to a substrate, either directly to the substrate or over an underlying coating, or formed into a film, exhibit first melt, fusion, and

second melt (remelt) temperatures described in the Examples below, as measured by differential scanning caloimetry (DSC).

[00147] For DSC analysis, blended fluoropolymer compositions were prepared as follows. The given amounts of aqueous fluoropolymer dispersions were mixed under air in a mixer for 30 minutes to ensure homogenous mixture of the dispersions. The mixture was mixed under low to medium shear to avoid coagulation of blended dispersion. A plastic eye-dropper was used to place a known weight of the mixed, blended dispersion into a pre-weighed drying dish. The dispersion was flashed at 100°C in an oven for 30 minutes, and the residual powder was then dried at 200°C for an additional 30 minutes. After the dried powder cooled to room temperature, the powder was weighed and the percent solids in the mixed dispersion were calculated. The blended fluoropolymer powder was then ready for DSC analysis.

[00148] For DSC analysis, 10 mg (+/- 1 mg) of the dried powder was placed in a aluminum DSC sample pan, and the pan was sealed with a standard lid. The heating and cooling cycles of the DSC were as follows: (1) ramp 15.0°C/min to 400°C; (2) isothermal for 1.00 min; (3) ramp 15.0°C/min to 135°C; (4) isothermal for 1.00 min; (5) ramp 15.0°C/min to 400°C; and (6) air cool.

[00149] The melting peaks were obtained during the (1) ramping up heating process. The crystallization peaks were obtained in the (3) cooling process. The 2nd melting peaks were obtained at the (5) heating process.

[00150] b. Contact angle.

[00151] The present compositions, when applied to a substrate, either directly to the substrate or over an underlying coating, or formed into a film, exhibit a contact angle of at least 100° in water, and may have a contact angle of at least 110°, 120°, 125°, 130°, or 135°, and may have a contact angle within any range delimited by these values and/or by the values in the Examples herein, as measured for a water droplet according to the Young Relation. Contact angle may be measured according to ASTM D7334-08 with any suitable commercially available instrument, such as the "Drop Shape Analysis" system (DSA10), available from Kruss GmbH of Hamburg, Germany.

[00152] c. Gloss.

[00153] The present compositions, when applied to a substrate, either directly to the substrate or over an underlying coating, or formed into a film, exhibits a measured gloss, in % reflectance, of at least 10, and may have a measured gloss of at least 15, 25, 30, 35, 40, or

45, and may have a measured gloss within any range delimited by these values and/or by the values in the Examples herein, as measured at 60° with any suitable commercially available instrument, such as a Microgloss 60° glossmeter, available from Byk-Gardner, in accordance with the following standards: BS3900/D5, DIN EN ISO 2813, DIN 67530, EN ISO 7668, ASTM D523, ASTM D1455, ASTM C346, ASTM C584, ASTM D2457, JIS Z 8741, MFT 30064, TAPPI T 480. Units of measurement are expressed as % reflectance.

[00154] d. Pencil test.

[00155] The pencil test protocol is below.

[00156] 1. Equipment and Materials.

[00157] 1.1 A set of hardness pencils varying in hardness from 4B (softest) to 8H (hardest). Leads in mechanical holders may be used also.

[00158] 1.2 Extra fine sandpaper (400 grit).

[00159] 1.3 Pencil sharpener, preferably of the drafting type that removes only wood, and produces a blunt, unsharpened lead.

[00160] 2. Procedure.

[00161] 2.1 Arrange pencils in order from softest to hardest. The order of pencils is set forth in the table below, each correlated to a number which may be used for statistical analysis of the results as in Exmaple 1, where 4B is the softest and 8H is the hardest:

4B	3B	2B	B	HB	F	H	1H	2H	3H	4H	5H	6H	7H	8H
-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9

[00162] 2.2 Sharpen pencils. If possible, remove only the wood and do not sharpen the lead. This is unnecessary if leads in mechanical holders are used.

[00163] 2.3 Place the sandpaper on a smooth flat surface. Holding the pencil as vertical as possible on the sandpaper, abrade the end of the lead to produce a perfectly round and flat tip. The edges of the tip should be sharp and form a 90° angle with the sides of the lead. Touch the tip lightly with fingertip or soft tissue to remove excess lead dust.

[00164] 2.4 Hold the coated test object firmly on a flat surface. Select a pencil that is harder than you expect the coating to be. Hold the pencil in a normal writing manner and place the tip against the coated object to form a 45° angle with the plane of the coating.

[00165] 2.5 Push the pencil firmly and with one smooth 5 cm stroke into the coating at a 45° angle. The objective is to penetrate the coating, and push it off the substrate. If the lead crumbles, stop testing.

[00166] 2.6 Examine the coating. If the pencil has nicked or gouged the coating, select the next softer pencil and repeat 2.4 and 2.5 until a pencil is reached that does not penetrate the coating.

[00167] 3. Evaluation.

[00168] 3.1 The hardness rating of the coating is equal to the first pencil that does not penetrate and gouge the coating.

[00169] 4. Precautions.

[00170] 4.1 Dress the tip of the lead for each test. With practice, it will be possible to use the lead twice for each dressing by rotating it 180° and using the opposite edge. For reproducibility, it is a good idea to run two tests for each pencil when evaluating the hardness of a coating.

[00171] 4.2 Specify the substrate on which the test is performed. Coatings will have slightly lower pencil hardness on soft substrates such as aluminum than on hard steel substrates.

[00172] 4.3 Make sure that the coating has been applied at the proper film thickness. Coatings will have a slightly higher apparent hardness if they are applied at low film thickness especially if the substrate is steel.

[00173] 4.4 Specify the temperature at which the test is performed. Coatings become softer at elevated temperature.

[00174] 5. References.

[00175] 5.1 ASTM D-3363

[00176] 5.2 BS Au 148 Part 6

EXAMPLES

[00177] The following non-limiting Examples illustrate various features and characteristics of the present invention, which is not to be construed as limited thereto. Throughout the Examples and elsewhere herein, percentages are by weight unless otherwise indicated.

Example 1

First Embodiment

Fluoropolymer blends with multiple MPFs (LPTFE/MPF1/MPF2)

Basic and thermal properties

[00178] In this Example, blends were prepared including the following components as described above: at least one LPTFE, and at least two chemically different MPFs, but not including HPTFE. In this Example, the two MPFs employed were FEP and PFA. The blends in this Example were made by mixing aqueous dispersions of the components, and the resulting blends were then drawn down as films for gloss, contact angle, and pencil test characterization and, for the thermal analysis, were coagulated and dried for DSC measurement, as discussed in Section VII above.

[00179] Panels were prepared for gloss, contact angle and pencil hardness testing as follows. In Mix A and Mix B, the value for deionized water (DIW) appears more than once as such may originate from more than one of the components in the mixtures.

1. Make liquid blend of MPF and LPTFE in the desired ratios.
2. Add the formulation to the blend created in step 1. Use the following formulation and percentages shown in the table below to make the blends for drawdown using the following procedure.
    a. Make a blend of dispersions. Calculate the % solids of the blend.
    b. Divide the % solids by 35
    c. Subtract 1.15. The result is the % water to add by volume to the dispersion blend.
    d. Add 15% by volume of the Dispersion Solution shown in the table below
    e. Add the amount of water calculated in step 3.
    f. Add 0.4% Triethanolamine by overall volume
3. Blend the mix gently to avoid air bubbles.
4. Using a pipet apply a small amount to an aluminum degreased panel.
5. Draw the coating down the panel in a smooth motion using a 3 mil wet path bird applicator.
6. Flash the panel for approximately 5-10 minutes at 200°F.
7. Move the panel to 400°F and flash an additional 3-5 minutes.
8. Cure the panel for 10 minutes at 750°F.

Dispersion Solution

50% Carbowax PE Glycol 1450 in DIW	55.00

Glycerine	30.00
Carbopol EP-1	5.00
DIW	10.00

[00180] Table 1 below is a summary of the blends examined in this Example. In Table 1, "Total MPF" designates the total amount of MPF, which was FEP, PFA, or a combination of the foregoing, wherein the FEP used was TE 9568 FEP (55.6% solids), available from DuPont and the PFA used was TE 7224 PFA (58.6 % solids), each described above in Section IV. "LPTFE" designates the total amount of LPTFE, wherein the LPTFE's used were SFN-D, available from Chenguang R.I.C.I, Chengdu, 610036 P.R. China and TE3887N, available from DuPont, each described above in Section II. "Coord LPTFE" and "Coord MPF" represent the coordinates of the compositions on the composition plots XX-YY of Figs. 19-30.

Table 1

Fluoropolymer Blends

Run #	SFN-D	TE3887N	FEP	PFA	Total LPTFE	Total MPF	Coord MPF	Coord LPTFE
1	0	0	0	1	0	1	0	0
2	0	0	0.05	0.95	0	1	0.05	0
3	0	0	0.2	0.8	0	1	0.2	0
4	0	0	0.4	0.6	0	1	0.4	0
5	0	0	0.5	0.5	0	1	0.5	0
6	0	0	0.6	0.4	0	1	0.6	0
7	0	0	0.8	0.2	0	1	0.8	0
8	0	0	1	0	0	1	1	0
9	0	0.1	0	0.9	0.1	0.9	0	-0.1
10	0	0.1	0.9	0	0.1	0.9	0.9	-0.1
11	0	0.2	0	0.8	0.2	0.8	0	-0.2
12	0	0.2	0.8	0	0.2	0.8	0.8	-0.2
13	0	0.2	0.16	0.64	0.2	0.8	0.16	-0.2
14	0	0.2	0.32	0.48	0.2	0.8	0.32	-0.2
15	0	0.2	0.4	0.4	0.2	0.8	0.4	-0.2
16	0	0.2	0.48	0.32	0.2	0.8	0.48	-0.2
17	0	0.2	0.64	0.16	0.2	0.8	0.64	-0.2
18	0	0.25	0.75	0	0.25	0.75	0.75	-0.25
19	0	0.3	0	0.7	0.3	0.7	0	-0.3
20	0	0.4	0	0.6	0.4	0.6	0	-0.4
21	0	0.4	0.12	0.48	0.4	0.6	0.12	-0.4
22	0	0.4	0.24	0.36	0.4	0.6	0.24	-0.4

Run #	SFN-D	TE3887N	FEP	PFA	Total LPTFE	Total MPF	Coord MPF	Coord LPTFE
23	0	0.4	0.3	0.3	0.4	0.6	0.3	-0.4
24	0	0.4	0.36	0.24	0.4	0.6	0.36	-0.4
25	0	0.4	0.48	0.12	0.4	0.6	0.48	-0.4
26	0	0.4	0.6	0	0.4	0.6	0.6	-0.4
27	0	0.45	0	0.55	0.45	0.55	0	-0.45
28	0	0.45	0.55	0	0.45	0.55	0.55	-0.45
29	0	0.5	0	0.5	0.5	0.5	0	-0.5
30	0	0.5	0.1	0.4	0.5	0.5	0.1	-0.5
31	0	0.5	0.2	0.3	0.5	0.5	0.2	-0.5
32	0	0.5	0.25	0.25	0.5	0.5	0.25	-0.5
33	0	0.5	0.3	0.2	0.5	0.5	0.3	-0.5
34	0	0.5	0.4	0.1	0.5	0.5	0.4	-0.5
35	0	0.5	0.5	0	0.5	0.5	0.5	-0.5
36	0	0.55	0	0.45	0.55	0.45	0	-0.55
37	0	0.55	0.45	0	0.55	0.45	0.45	-0.55
38	0	0.6	0	0.4	0.6	0.4	0	-0.6
39	0	0.6	0.08	0.32	0.6	0.4	0.08	-0.6
40	0	0.6	0.16	0.24	0.6	0.4	0.16	-0.6
41	0	0.6	0.2	0.2	0.6	0.4	0.2	-0.6
42	0	0.6	0.24	0.16	0.6	0.4	0.24	-0.6
43	0	0.6	0.32	0.08	0.6	0.4	0.32	-0.6
44	0	0.6	0.4	0	0.6	0.4	0.4	-0.6
45	0	0.7	0	0.3	0.7	0.3	0	-0.7
46	0	0.75	0.25	0	0.75	0.25	0.25	-0.75
47	0	0.8	0	0.2	0.8	0.2	0	-0.8
48	0	0.8	0.04	0.16	0.8	0.2	0.04	-0.8
49	0	0.8	0.08	0.12	0.8	0.2	0.08	-0.8
50	0	0.8	0.1	0.1	0.8	0.2	0.1	-0.8
51	0	0.8	0.12	0.08	0.8	0.2	0.12	-0.8
52	0	0.8	0.16	0.04	0.8	0.2	0.16	-0.8
53	0	0.8	0.2	0	0.8	0.2	0.2	-0.8
54	0	0.9	0	0.1	0.9	0.1	0	-0.9
55	0	0.9	0.1	0	0.9	0.1	0.1	-0.9
56	0	1	0	0	1	0	0	-1
57	0.05	0	0.05	0.9	0.05	0.95	0.05	0.05
58	0.05	0	0.35	0.6	0.05	0.95	0.35	0.05
59	0.06	0	0.0244	0.9146	0.061	0.939	0.0244	0.061
60	0.08	0	0.05	0.875	0.075	0.925	0.05	0.075
61	0.08	0	0.2	0.725	0.075	0.925	0.2	0.075
62	0.08	0	0.35	0.572	0.078	0.922	0.35	0.078

Run #	SFN-D	TE3887N	FEP	PFA	Total LPTFE	Total MPF	Coord MPF	Coord LPTFE
63	0.09	0	0.3182	0.5909	0.0909	0.9091	0.3182	0.0909
64	0.1	0	0	0.9	0.1	0.9	0	0.1
65	0.1	0	0.9	0	0.1	0.9	0.9	0.1
66	0.1	0	0.05	0.85	0.1	0.9	0.05	0.1
67	0.1	0	0.215	0.685	0.1	0.9	0.215	0.1
68	0.2	0	0	0.8	0.2	0.8	0	0.2
69	0.2	0	0.8	0	0.2	0.8	0.8	0.2
70	0.2	0	0.16	0.64	0.2	0.8	0.16	0.2
71	0.2	0	0.32	0.48	0.2	0.8	0.32	0.2
72	0.2	0	0.4	0.4	0.2	0.8	0.4	0.2
73	0.2	0	0.48	0.32	0.2	0.8	0.48	0.2
74	0.2	0	0.64	0.16	0.2	0.8	0.64	0.2
75	0.25	0	0	0.75	0.25	0.75	0	0.25
76	0.25	0	0.75	0	0.25	0.75	0.75	0.25
77	0.3	0	0	0.7	0.3	0.7	0	0.3
78	0.3	0	0.7	0	0.3	0.7	0.7	0.3
79	0.4	0	0	0.6	0.4	0.6	0	0.4
80	0.4	0	0.12	0.48	0.4	0.6	0.12	0.4
81	0.4	0	0.24	0.36	0.4	0.6	0.24	0.4
82	0.4	0	0.3	0.3	0.4	0.6	0.3	0.4
83	0.4	0	0.36	0.24	0.4	0.6	0.36	0.4
84	0.4	0	0.48	0.12	0.4	0.6	0.48	0.4
85	0.4	0	0.6	0	0.4	0.6	0.6	0.4
86	0.45	0	0	0.55	0.45	0.55	0	0.45
87	0.45	0	0.55	0	0.45	0.55	0.55	0.45
88	0.47	0	0	0.53	0.47	0.53	0	0.47
89	0.5	0	0	0.5	0.5	0.5	0	0.5
90	0.5	0	0.1	0.4	0.5	0.5	0.1	0.5
91	0.5	0	0.2	0.3	0.5	0.5	0.2	0.5
92	0.5	0	0.25	0.25	0.5	0.5	0.25	0.5
93	0.5	0	0.3	0.2	0.5	0.5	0.3	0.5
94	0.5	0	0.4	0.1	0.5	0.5	0.4	0.5
95	0.5	0	0.5	0	0.5	0.5	0.5	0.5
96	0.55	0	0	0.45	0.55	0.45	0	0.55
97	0.55	0	0.45	0	0.55	0.45	0.45	0.55
98	0.6	0	0	0.4	0.6	0.4	0	0.6
99	0.6	0	0.08	0.32	0.6	0.4	0.08	0.6
100	0.6	0	0.16	0.24	0.6	0.4	0.16	0.6
101	0.6	0	0.2	0.2	0.6	0.4	0.2	0.6
102	0.6	0	0.24	0.16	0.6	0.4	0.24	0.6

Run #	SFN-D	TE3887N	FEP	PFA	Total LPTFE	Total MPF	Coord MPF	Coord LPTFE
103	0.6	0	0.32	0.08	0.6	0.4	0.32	0.6
104	0.6	0	0.4	0	0.6	0.4	0.4	0.6
105	0.65	0	0.35	0	0.65	0.35	0.35	0.65
106	0.7	0	0	0.3	0.7	0.3	0	0.7
107	0.7	0	0.3	0	0.7	0.3	0.3	0.7
108	0.75	0	0.25	0	0.75	0.25	0.25	0.75
109	0.8	0	0	0.2	0.8	0.2	0	0.8
110	0.8	0	0.04	0.16	0.8	0.2	0.04	0.8
111	0.8	0	0.08	0.12	0.8	0.2	0.08	0.8
112	0.8	0	0.1	0.1	0.8	0.2	0.1	0.8
113	0.8	0	0.12	0.08	0.8	0.2	0.12	0.8
114	0.8	0	0.16	0.04	0.8	0.2	0.16	0.8
115	0.8	0	0.2	0	0.8	0.2	0.2	0.8
116	0.85	0	0	0.15	0.85	0.15	0	0.85
117	0.85	0	0.15	0	0.85	0.15	0.15	0.85
118	0.9	0	0.1	0	0.9	0.1	0.1	0.9
119	1	0	0	0	1	0	0	1

[00181] Observed data is set forth in Table 2 below, wherein:

GLOSS = measured gloss, per Section VII above;

NORM GLOSS = normalized gloss, calculated as: [Gloss - Minimum (Gloss)] /[Maximum (Gloss) - Minimum (Gloss)];

CONTACT ANGLE (CA) = contact angle, per Section V above;

NORM CA = normalized contact angle, calculated as: [Contact Angle - Minimum (Contact Angle)] / [Maximum (Contact Angle) - Minimum (Contact Angle];

PENCIL = pencil test measurement, per Section VII above, where the value in Table 2 below is the mean of the number of measured results, as indicated by "# Data" in Table 1 above;

NORM PENCIL = normalized pencil test measurement, calculated as: [PENCIL - Minimum (PENCIL)] /[Maximum (PENCIL) - Minimum (PENCIL)];

NORM min remelt = normalized "min remelt", calculated as: [min remelt - Minimum (min remelt)] /[Maximum (min remelt) - Minimum (min remelt)], wherein "min remelt" is the temperature of the lowest remelt peak for a given sample;

Norm (CA, Gloss, Hard) = the mean of (NORM CA, NORM PENCIL, and NORM GLOSS); and

Norm (Remelt, CA, Gloss, Hard) = the mean of (NORM CA, NORM PENCIL, NORM GLOSS, and NORM min remelt).

Table 2

Observed data

Run #	GLOSS	NORM GLOSS	Contact Angle	NORM CA	Pencil	NORM PENCIL	norm min remelt	CA,GLOSS,HARD	remelt,CA,Gloss,hard
1	50.2	0.64	122.81	0.33	0	0.38	0.70	0.45	0.51
2	71	0.99	122.66	0.32	-2	0.13	0.76	0.48	0.55
3	67.1	0.92	118.61	0.13	-2	0.13	0.33	0.39	0.38
4	67.7	0.93	116.43	0.03	4	0.88	0.10	0.61	0.48
5	51.8	0.66	116.23	0.02	3	0.75	0.10	0.48	0.38
6	67.7	0.93	116.90	0.05	4	0.88	0.12	0.62	0.49
7	41.5	0.49	115.97	0.01	4	0.88	0.12	0.46	0.37
8	68.7	0.95	118.63	0.13	5	1.00	0.15	0.69	0.56
9	51.1	0.65	119.26	0.16	0	0.38	0.62	0.40	0.45
10	50.5	0.64	117.35	0.07	4	0.88	0.13	0.53	0.43
11	51.1	0.65	125.83	0.47	-2	0.13	0.61	0.41	0.46
12	69	0.96	119.17	0.16	4	0.88	0.14	0.66	0.53
13	41.1	0.48	124.89	0.42	5	1.00	0.63	0.63	0.63
14	40.2	0.47	124.63	0.41	4	0.88	0.12	0.58	0.47
15	37.8	0.42	123.89	0.38	5	1.00	0.12	0.60	0.48
16	38.7	0.44	124.72	0.41	5	1.00	0.09	0.62	0.49
17	69	0.96	122.42	0.31	5	1.00	0.12	0.75	0.60
18	57.4	0.76	120.55	0.22	4	0.88	0.12	0.62	0.49
19	48.1	0.60	118.87	0.14	-3	0.00	0.62	0.25	0.34
20	70	0.97	128.48	0.59	-3	0.00	0.61	0.52	0.54
21	64.8	0.88	133.79	0.84	3	0.75	0.63	0.82	0.77
22	60.6	0.81	131.62	0.74	3	0.75	0.18	0.77	0.62
23	66.7	0.92	129.12	0.62	3	0.75	0.13	0.76	0.60
24	46	0.56	131.02	0.71	0	0.38	0.14	0.55	0.45
25	40.7	0.47	128.65	0.60	4	0.88	0.12	0.65	0.52
26	67.6	0.93	123.68	0.37	4	0.88	0.13	0.72	0.58
27	47.4	0.59	129.22	0.62	-3	0.00	0.61	0.40	0.46
28	32.5	0.33	127.54	0.55	5	1.00	0.11	0.63	0.50
29	64.3	0.88	135.05	0.89	4	0.88	0.61	0.88	0.81
30	56.8	0.75	134.97	0.89	-3	0.00	0.63	0.55	0.57

Run #	GLOSS	NORM GLOSS	Contact Angle	NORM CA	Pencil	NORM PENCIL	norm min remelt	CA,GLOSS,HARD	remelt,CA,Gloss,hard
31	50.7	0.64	133.21	0.81	5	1.00	0.18	0.82	0.66
32	41.8	0.49	132.58	0.78	1	0.50	0.15	0.59	0.48
33	30.6	0.30	132.70	0.79	-3	0.00	0.14	0.36	0.31
34	29.3	0.28	132.02	0.75	4	0.88	0.14	0.64	0.51
35	25.8	0.22	128.94	0.61	3	0.75	0.11	0.53	0.42
36	66.6	0.91	123.33	0.35	-3	0.00	0.61	0.42	0.47
37	61.5	0.83	129.46	0.63	5	1.00	0.11	0.82	0.64
38	42.4	0.50	125.16	0.43	-3	0.00	0.60	0.31	0.38
39	39	0.45	136.06	0.94	-3	0.00	0.62	0.46	0.50
40	42	0.50	135.12	0.90	5	1.00	0.65	0.80	0.76
41	30.5	0.30	134.65	0.88	-3	0.00	0.25	0.39	0.36
42	27.1	0.24	134.73	0.88	-2	0.13	0.16	0.42	0.35
43	27	0.24	130.08	0.66	4	0.88	0.13	0.59	0.48
44	24.4	0.20	130.10	0.66	4	0.88	0.12	0.58	0.46
45	65.3	0.89	131.69	0.74	-3	0.00	0.60	0.54	0.56
46	17.7	0.08	133.48	0.82	-2	0.13	0.11	0.34	0.28
47	64.3	0.88	132.18	0.76	-3	0.00	0.37	0.55	0.50
48	25.3	0.21	137.02	0.99	-3	0.00	0.64	0.40	0.46
49	21.4	0.15	136.59	0.97	-2	0.13	0.98	0.41	0.55
50	12.8	0.00	137.33	1.00	-3	0.00	1.00	0.33	0.50
51	15.2	0.04	136.21	0.95	1	0.50	0.29	0.50	0.44
52	27.1	0.24	133.65	0.83	1	0.50	0.12	0.52	0.42
53	13.9	0.02	132.66	0.78	-2	0.13	0.08	0.31	0.25
54	54.6	0.71	131.72	0.74	-3	0.00	0.98	0.48	0.61
55	19.7	0.12	133.58	0.83	-3	0.00	0.11	0.31	0.26
56	22.9	0.17	133.29	0.81	-3	0.00	0.98	0.33	0.49
57	71.7	1.00	122.21	0.30	-2	0.13	0.76	0.47	0.54
58	67.8	0.94	115.82	0.00	-1	0.25	0.33	0.39	0.38
59	69.5	0.96	123.72	0.37	-3	0.00	0.76	0.44	0.52
60	69.2	0.96	123.56	0.36	-2	0.13	0.76	0.48	0.55
61	63	0.85	119.64	0.18	-3	0.00	0.31	0.34	0.33
62	56.2	0.74	117.94	0.10	-1	0.25	0.32	0.36	0.35
63	68.3	0.94	117.61	0.08	-1	0.25	0.35	0.43	0.41
64	68.2	0.94	126.32	0.49	-1	0.25	0.57	0.56	0.56
65	57.8	0.76	118.58	0.13	5	1.00	0.04	0.63	0.48
66	62	0.84	124.46	0.40	-2	0.13	0.80	0.45	0.54
67	63.2	0.86	119.55	0.17	-2	0.13	0.31	0.38	0.36
68	65.1	0.89	127.30	0.53	-1	0.25	0.82	0.56	0.62
69	52.6	0.68	119.61	0.18	5	1.00	0.08	0.62	0.48
70	60.4	0.81	125.06	0.43	3	0.75	0.20	0.66	0.55

Run #	GLOSS	NORM GLOSS	Contact Angle	NORM CA	Pencil	NORM PENCIL	norm min remelt	CA,GLOSS,HARD	remelt,CA,Gloss,hard
71	63.4	0.86	123.22	0.34	4	0.88	0.12	0.69	0.55
72	63.3	0.86	124.44	0.40	4	0.88	0.11	0.71	0.56
73	56.1	0.74	123.70	0.37	0	0.38	0.11	0.49	0.40
74	45.4	0.55	121.05	0.24	-2	0.13	0.12	0.31	0.26
75	70.6	0.98	128.29	0.58	-2	0.13	0.85	0.56	0.63
76	48	0.60	121.28	0.25	5	1.00	0.03	0.62	0.47
77	64.9	0.89	131.07	0.71	-2	0.13	0.86	0.57	0.65
78	37.7	0.42	117.28	0.07	0	0.38	0.04	0.29	0.23
79	60.2	0.81	131.03	0.71	-3	0.00	0.88	0.50	0.60
80	50.7	0.64	131.99	0.75	-1	0.25	0.67	0.55	0.58
81	49.1	0.62	129.87	0.65	3	0.75	0.12	0.67	0.53
82	35.9	0.39	130.87	0.70	1	0.50	0.12	0.53	0.43
83	33.1	0.34	128.76	0.60	-2	0.13	0.13	0.36	0.30
84	22.4	0.16	125.97	0.47	-3	0.00	0.11	0.21	0.19
85	51.4	0.66	123.61	0.36	0	0.38	0.06	0.46	0.36
86	49.6	0.63	134.30	0.86	-3	0.00	0.83	0.49	0.58
87	52.3	0.67	123.02	0.34	-1	0.25	0.05	0.42	0.33
88	58.9	0.78	130.43	0.68	-3	0.00	0.95	0.49	0.60
89	63.2	0.86	135.34	0.91	-3	0.00	0.91	0.59	0.67
90	42.7	0.51	134.79	0.88	-3	0.00	0.68	0.46	0.52
91	36.3	0.40	133.06	0.80	-2	0.13	0.22	0.44	0.39
92	27.5	0.25	132.48	0.78	-1	0.25	0.15	0.42	0.36
93	27.5	0.25	131.29	0.72	-3	0.00	0.13	0.32	0.27
94	17.3	0.08	127.64	0.55	0	0.38	0.12	0.33	0.28
95	41.2	0.48	124.28	0.39	-1	0.25	0.07	0.38	0.30
96	55.7	0.73	135.35	0.91	-3	0.00	0.92	0.55	0.64
97	43.1	0.51	124.36	0.40	-2	0.13	0.01	0.35	0.26
98	46.7	0.58	133.88	0.84	-3	0.00	0.66	0.47	0.52
99	31.3	0.31	135.83	0.93	-3	0.00	0.68	0.41	0.48
100	32.8	0.34	131.26	0.72	-3	0.00	0.24	0.35	0.33
101	21	0.14	132.82	0.79	-2	0.13	0.13	0.35	0.30
102	22	0.16	131.42	0.73	-2	0.13	0.15	0.34	0.29
103	16.2	0.06	128.09	0.57	0	0.38	0.15	0.33	0.29
104	61.2	0.82	124.46	0.40	-2	0.13	0.05	0.45	0.35
105	53.9	0.70	125.29	0.44	0	0.38	0.04	0.50	0.39
106	30.4	0.30	131.10	0.71	-3	0.00	0.94	0.34	0.49
107	37.7	0.42	123.44	0.35	0	0.38	0.00	0.38	0.29
108	37.2	0.41	127.12	0.53	-3	0.00	0.10	0.31	0.26
109	30.4	0.30	131.85	0.75	-3	0.00	0.93	0.35	0.49
110	19.9	0.12	133.65	0.83	-3	0.00	0.95	0.32	0.48

Run #	GLOSS	NORM GLOSS	Contact Angle	NORM CA	Pencil	NORM PENCIL	norm min remelt	CA,GLOSS,HARD	remelt,CA,Gloss,hard
111	16.3	0.06	133.21	0.81	-3	0.00	0.22	0.29	0.27
112	18.9	0.10	132.98	0.80	-3	0.00	0.85	0.30	0.44
113	15	0.04	132.16	0.76	-2	0.13	0.19	0.31	0.28
114	15.6	0.05	130.64	0.69	0	0.38	0.07	0.37	0.30
115	44.3	0.54	127.52	0.54	-3	0.00	0.10	0.36	0.29
116	51.3	0.65	129.55	0.64	-2	0.13	0.95	0.47	0.59
117	32.3	0.33	122.46	0.31	4	0.88	0.95	0.51	0.62
118	43.1	0.51	125.99	0.47	-2	0.13	0.93	0.37	0.51
119	30	0.29	134.25	0.86	4	0.88	0.96	0.67	0.74

[00182] From the data presented in Table 2 it can be seen that some of the three component blends have generally better properties than the other blends, such as higher gloss, contact angle, and greater pencil hardness.

[00183] Thermal data is summarized in Tables 3, 4, and 5 below for 1st Melt, Fusion and 2nd Melt (remelt) respectively.

Table 3

1st melt DSC data

Run #	1st melt_1	1st Melt_3	1st melt_4	1st melt_5	1st_melt_6	# 1st melt	min first melt	DH first melt 1	DH 1st Melt 3	DH first Melt 4	DH first Melt 5	DH first Melt 6	total 1st DH
1		313.4				1.0	313.4		6.9	1.3			8.2
2	260.5	315.1	322.1			3.0	260.5	2.3	34.0	1.5			37.8
3	259.5	313.2	320.7			3.0	259.5	3.5	31.6	1.4			36.5
4	260.3	312.6	321.0			3.0	260.3	12.4	25.2	4.2			41.8
5	259.2	312.6	321.5			3.0	259.2	8.8	22.4	1.0			32.2
6	260.1	311.6	320.8			3.0	260.1	13.9	11.0	0.8			25.6
7	259.8	311.2	321.2			3.0	259.8	18.7	7.0	0.6			26.3
8	257.4					1.0	257.4	18.2					18.2
9		312.9	321.0		326.4	3.0	312.9		38.9	2.2		6.4	47.6
10	258.9				326.8	2.0	258.9	26.7				8.1	34.9
11		313.0	321.0		326.6	3.0	313.0		37.5	2.5		13.2	53.2
12	259.2				326.9	2.0	259.2	17.1				12.5	29.6
13	257.9	313.1	320.5		326.7	4.0	257.9	1.6	23.2	1.8		12.6	39.2
14	260.8	313.6	321.7		328.0	4.0	260.8	4.9	17.6	1.6		11.7	35.8
15	260.8	313.3	322.0		327.9	4.0	260.8	11.2	15.0	1.6		11.6	39.3
16	259.2	311.6	320.9		326.7	4.0	259.2	10.8	11.7	1.4		11.4	35.2
17	259.5	311.4			326.7	3.0	259.5	20.4	6.4			12.6	39.5
18	259.0				327.0	2.0	259.0	15.4				16.6	32.0
19		313.0	322.1		326.7	3.0	313.0		26.8	2.6		19.3	48.7

Run #	1st melt_1	1st Melt_3	1st melt_4	1st melt_5	1st_melt_6	# 1st melt	min first melt	DH first melt 1	DH 1st Melt 3	DH first Melt 4	DH first Melt 5	DH first Melt 6	total 1st DH
20		313.1	322.0		327.0	3.0	313.1		21.2	2.7		25.2	49.1
21	260.2	313.1			327.0	3.0	260.2	2.2	19.1			27.2	48.4
22	259.4	313.9	321.6		328.3	4.0	259.4	3.9	12.7	1.7		23.9	42.2
23	261.2	313.7			328.4	3.0	261.2	6.7	11.3			24.9	42.9
24	261.1	313.7			328.5	3.0	261.1	4.4	7.2			24.6	36.1
25	258.9	312.0			327.5	3.0	258.9	8.4	3.6			25.5	37.6
26	259.2				328.0	2.0	259.2	9.5				25.2	34.7
27		313.2	320.7		327.1	3.0	313.2		22.4	1.8		28.7	52.9
28	260.0				328.3	2.0	260.0	9.1				29.9	39.0
29		313.0			327.1	2.0	313.0		19.6			35.0	54.5
30	260.4	313.3			327.4	3.0	260.4	2.4	17.9			32.7	53.1
31	258.5	314.2			328.7	3.0	258.5	3.0	10.4			31.5	44.9
32	261.0	313.9			328.4	3.0	261.0	2.7	9.4			31.3	43.5
33	261.1	313.7			328.4	3.0	261.1	4.4	7.5			30.9	42.9
34	260.2	312.7			327.8	3.0	260.2	7.5	4.5			30.2	42.3
35	258.9				327.8	2.0	258.9	7.6				31.5	39.1
36		313.2			327.2	2.0	313.2		17.0			36.8	53.8
37	255.4				328.0	2.0	255.4	4.0				40.6	44.6
38		313.1			327.3	2.0	313.1		16.6			39.8	56.4
39	260.3	313.1			327.2	3.0	260.3	2.1	15.4			39.9	57.4
40	259.4	314.4			328.8	3.0	259.4	1.6	8.5			35.9	46.0
41	259.1	314.2			328.7	3.0	259.1	1.6	8.0			36.9	46.6
42	261.2	314.1			328.9	3.0	261.2	1.8	5.7			37.1	44.6
43	259.7	321.7			327.6	3.0	259.7	5.3	4.8			36.7	46.8
44	258.4				327.7	2.0	258.4	5.5				40.0	45.5
45		313.0			327.4	2.0	313.0		10.2			45.5	55.7
46	259.1				327.9	2.0	259.1	3.0				55.7	58.7
47		313.1			327.5	2.0	313.1		8.5			48.8	57.3
48	262.2	313.4			327.9	3.0	262.2	1.1	9.0			50.0	60.1
49	257.3	313.2			327.7	3.0	257.3	0.2	6.7			50.7	57.7
50					329.2	1.0	329.2					64.5	64.5
51	261.4	314.6			329.0	3.0	261.4	1.6	6.0			48.7	56.3
52	259.6	314.5			327.7	3.0	259.6	1.7				64.1	65.8
53	258.6				327.7	2.0	258.6	2.0				53.5	55.4
54		313.1			327.5	2.0	313.1		5.8			58.8	64.6
55	258.7				325.7	2.0	258.7	20.4				9.7	30.1
56					327.6	1.0	327.6					64.2	64.2
57		314.4	321.5		326.5	3.0	314.4		40.9	1.8		0.1	42.7
58	258.4	313.9	321.6		326.5	4.0	258.4	2.8	29.3	1.5		0.1	33.7
59		315.0	321.7		326.7	3.0	315.0		41.0	1.7		0.1	42.8
60		314.6	321.6		326.6	3.0	314.6		38.8	1.6		0.1	40.5
61	258.6	314.4	321.8		326.5	4.0	258.6	1.4	30.5	1.7		1.1	34.7
62	260.0	315.2	327.3		322.8	4.0	260.0	3.6	21.6	1.0		1.1	27.3
63	260.3	314.8	322.5		327.0	4.0	260.3	4.4	25.6	1.3		1.1	32.5
64		313.4			325.5	2.0	313.4		36.5				36.5
65	256.6				324.7	2.0	256.6	19.6				7.0	26.6
66		314.7	321.9		326.6	3.0	314.7		33.3	1.9		3.2	38.5
67	258.8	314.0	321.9		326.5	4.0	258.8	1.5	29.4	1.6		1.2	33.7
68		313.7			325.6	2.0	313.7		23.7				23.7
69	256.6				324.9	2.0	256.6	16.6					16.6
70	259.5	313.0	320.6		325.7	4.0	259.5	9.6	29.4	2.6		9.0	50.6
71	259.6	312.5	321.5		325.9	4.0	259.6	4.3	19.3	2.5		8.3	34.3
72	260.0	312.4	321.3		326.0	4.0	260.0	9.0	16.8	2.3		8.2	36.3
73	260.0	312.1			326.2	3.0	260.0	12.3	13.4			9.8	35.5

Run #	1st melt_1	1st Melt_3	1st melt_4	1st melt_5	1st_melt_6	# 1st melt	min first melt	DH first melt 1	DH 1st Melt 3	DH first Melt 4	DH first Melt 5	DH first Melt 6	total 1st DH
74	259.3	311.3			325.5	3.0	259.3	17.1	7.3			9.3	33.6
75		313.5			325.3	2.0	313.5		21.2				21.2
76	256.4				325.0	2.0	256.4	18.5				14.2	32.7
77		313.6			325.4	2.0	313.6		16.0				16.0
78	256.5				325.2	2.0	256.5	15.3				16.6	31.8
79		313.4			325.2	2.0	313.4		11.8				11.8
80	259.7	313.0			325.7	3.0	259.7						0.0
81	260.1	312.8			325.9	3.0	260.1	4.7	16.9			20.6	42.2
82	259.5	312.5		324.3	325.7	4.0	259.5	5.0	14.1		10.5	9.9	39.4
83	259.6	312.2			325.6	3.0	259.6	6.7	12.0			20.8	39.5
84	259.7	312.3			325.8	3.0	259.7	18.4	7.8			19.4	45.6
85	256.4				325.3	2.0	256.4	11.7				20.8	32.6
86		313.3			325.4	2.0	313.3		14.6				14.6
87	256.5				325.0	2.0	256.5	11.0				29.7	40.7
88						0.0							0.0
89		313.6			325.5	2.0	313.6		8.3				8.3
90	260.5	313.0			325.7	3.0	260.5	5.7	20.3			33.4	59.3
91	259.8	312.9			325.8	3.0	259.8	2.4	15.0			26.7	44.0
92	260.1	312.8			325.9	3.0	260.1	3.7	12.5			26.3	42.5
93	259.7	312.5			325.6	3.0	259.7	4.9	11.3			26.2	42.5
94	259.8	312.4			325.7	3.0	259.8	9.7	7.1			25.8	42.6
95	257.1				325.3	2.0	257.1	8.2				28.8	36.9
96		313.3			325.5	2.0	313.3						0.0
97	256.7				325.2	2.0	256.7	8.2				36.5	44.8
98		313.2			325.2	2.0	313.2		7.7				7.7
99	260.6	313.2			325.9	3.0	260.6	1.5	17.3			32.5	51.2
100	259.9	312.8			325.8	3.0	259.9	4.8	15.1			32.1	52.0
101	260.2	312.8			325.7	3.0	260.2	8.8	14.0			32.1	54.9
102	260.0	312.8			326.0	3.0	260.0	3.4	10.0			31.7	45.1
103	260.0	312.9			325.6	3.0	260.0	7.1	7.2			31.3	45.7
104	256.8				325.3	2.0	256.8	7.4				38.1	45.5
105	256.5					1.0	256.5	5.4				42.4	47.9
106		313.0			325.2	2.0	313.0						0.0
107	256.2				325.2	2.0	256.2	4.8				46.7	51.5
108	258.5				325.6	2.0	258.5	5.0					5.0
109		313.0			326.9	2.0	313.0					58.6	58.6
110	260.3	312.7			325.6	3.0	260.3	2.3	13.9			45.9	62.1
111	260.3	312.7			325.7	3.0	260.3	2.2	11.6			45.7	59.5
112	260.6	313.0			326.0	3.0	260.6	1.5	10.5			44.5	56.5
113	260.4	313.3			326.0	3.0	260.4	4.2	9.7			44.4	58.3
114	260.1	313.5			325.6	3.0	260.1	2.1	7.5			43.5	53.2
115	258.4					1.0	258.4	4.1					4.1
116					325.4	1.0	325.4						0.0
117	255.9				325.4	2.0	255.9	0.6				39.1	39.6
118	259.5				326.0	2.0	259.5	0.8					0.8
119					325.5	1.0	325.5						0.0

[00184] Table 3 shows the first melt temperature (°C) and heat of melting (ΔH J/g) for the various blends of Table 1. It will be noticed that the various components exhibit their melt points in the blends at temperatures typical for their chemistry, *i.e.*, FEP at ca. 255-260°C, PFA at ca. 312-314°C, and LPTFE at ca. 324-328°C. Within Table 3, the numerical

identifiers (i.e., the "1" in "Fusion_1" and "DH fusion 1") indicate the peak numbers in the DSC traces from the lowest to the highest melt temperatures.

Table 4

Fusion peak DSC data

Run #	Fusion_1	Fusion_4	Fusion_5	Fusion_6	Fusion_7	#fusion	min fusion	DH fusion 1	DH FUSION4	DH fusion 5	DH fusion 6	DH Fusion 7	Total fusion DH
1		281.7				1	281.7		16.12				16.12
2	231	283.4				2	231	1.537	18.94				20.48
3	233.4	284.1				2	233.4	3.026	22.13				25.16
4	231.4	285				2	231.4	10.51	16.83				27.34
5	232.3	286.7				2	232.3	6.605	16.1				22.71
6	233	283.6				2	233	19.1	12.1				31.2
7	235.5	279				2	235.5	20.19	6.867				27.06
8	234.3					1	234.3	13.92					13.92
9		286.7		293.7		2	286.7		8.938		22.36		31.3
10	237.7			300.6		2	237.7	20.01			9.755		29.77
11		284.4		297.7		2	284.4		8.676		25.64		34.32
12	238.2			306.2		2	238.2	12.86			14.77		27.63
13	239.7	284.2		298.2		3	239.7	3.942	9.426		21.82		35.19
14	233.9	286.2		300.9		3	233.9	10.92	7.631		19.64		38.19
15	233.9	285.5		301.8		3	233.9	7.382	5.185		17.6		30.17
16	233.7	283.6		301		3	233.7	7.695	3.693		16.25		27.64
17	235.3	285.6		303.6		3	235.3	7.859	1.289		14.92		24.07
18	237.9			307.4		2	237.9	12.58			18.81		31.39
19		283.6		301.2		2	283.6		8.186		30.39		38.58
20		283.1		304.1		2	283.1		9.222		36.23		45.45
21	246.7	283.7		304.7		3	246.7	1.934	9.391		33.4		44.73
22	235.7	285.6		307.1		3	235.7	7.637	6.515		30.51		44.66
23	234.9	285		307.6		3	234.9	2.764	4.128		28.26		35.15
24	234.5	284.4		308.4		3	234.5	5.112	3.981		28.32		37.41
25	236	283.5		307.9		3	236	12.4	3.276		29.49		45.17
26	238			309.9		2	238	8.677			29.43		38.11
27		282.6		305.1		2	282.6		7.125		36.55		43.68
28	237.5			310.3		2	237.5	7.118			35.27		42.39
29		282.4		306.4		2	282.4		14.07		41.67		55.74
30		283.2		306.9		2	283.2		8.007		39.59		47.6
31	238.7	284.3		308.8		3	238.7	6.876	7.623		37.01		51.51
32	236.1	284.7		309.6		3	236.1	1.474	3.467		35.67		40.61
33	234.7	283.9		310	325.7	4	234.7	2.442	2.973		35.19	30.93	71.54
34	235.2	285.1		309.5		3	235.2	5.714	2.41		34.6		42.72
35	235.9			310.6		2	235.9	6.039			36.12		42.16
36		282		307.4		2	282		10.9		43.74		54.64
37	236.2			311.6		2	236.2	5.573			43.19		48.76
38		281.6		308.3		2	281.6		8.623		45.82		54.44
39		282.8		308.9		2	282.8		3.904		45.57		49.47
40	240.6	283.6		310.6		3	240.6	1.943	4.715		41.61		48.27
41	235.8	283.6		311.1		3	235.8	2.745	4.224		42.51		49.48
42	235.2	284.5		311.4		3	235.2	1.539	2.847		42.76		47.15
43	235.4			310.5		2	235.4	2.96			44.26		47.22

Run #	Fusion_1	Fusion_4	Fusion_5	Fusion_6	Fusion_7	#fusion	min fusion	DH fusion 1	DH FUSION4	DH fusion 5	DH fusion 6	DH Fusion 7	Total fusion DH
44	236.6			311.7		2	236.6	4.391			47.38		51.77
45		281.2		310.3		2	281.2		3.323		52.98		56.3
46	235.9			312.5		2	235.9	3.112			55.71		58.82
47		287.7		311.9		2	287.7		4.553		56.73		61.28
48		285.2		312		2	285.2		1.055		57.61		58.67
49	241.9	283.3		312.4		3	241.9	0.503	3.249		60.12		63.87
50				315.8		1	315.8				70.48		70.48
51	229.9			313.9		2	229.9	0.395			60.32		60.71
52	234			312.5		2	234						0
53	233.8			313		2	233.8	2.907			59.65		62.56
54				313.8		1	313.8				70.19		70.19
55	237.6			296.9		2	237.6	14.5			11.91		26.41
56				315.1		1	315.1				73.27		73.27
57	248.3	285.3				2	248.3	0.966	23.66				24.63
58	231.7	19.64				2	19.64	4.946	19.64				24.59
59	249.4	285.2				2	249.4	1.558	24.35				25.91
60	249	286.2				2	249	1.409	24.35				25.76
61	233.1	285.1				2	233.1	3.022	20.73				23.75
62	231.3	283.5				2	231.3	4.113	15.34				19.45
63	232	284.1				2	232	5.533	17.93				23.46
64	251.1			292.5		2	251.1				32.84		32.84
65	236.1			287		2	236.1	9.077			6.75		15.83
66	240.9	288.3				2	240.9	0.729	24.55				25.28
67	232.8	285				2	232.8	4.236	21.44				25.68
68	249.1			291.9		2	249.1	0.491			28.58		29.07
69	236.7			292.5		2	236.7	9.148			8.945		18.09
70	241.1	286.5		294.1		3	241.1	2.332	7.634		14.09		24.06
71	232.7	288.1		296.6		3	232.7	11.16	7.56		18.94		37.66
72	233.2	288.1		297.1		3	233.2	5.993	16.82		5.347		28.16
73	233.7			297.9		2	233.7	6.124			18.78		24.9
74	248.8		288.7	301.5		3	248.8	9.42		2.715	11.95		24.09
75	254.5			296.5		2	254.5	8.373			32.49		40.86
76	234.7			299.7		2	234.7	12.19			16.59		28.78
77	252.1			297.3		2	252.1				35		35
78	233.7			303.4		2	233.7	10.84			18.58		29.42
79		281.8		300.2		2	281.8		0.761		33.34		34.1
80	245.2	284.9		300.2		3	245.2				18.48		18.48
81	233	286		302.6		3	233	4.751	8.479		26.51		39.74
82	232.8	285.9		303.6		3	232.8	5.552	25.58		7.563		38.7
83	233.5	285.3		304.2	325.7	4	233.5	7.298	6.557		25.14	30.93	69.93
84	233.9		291	306	325.7	4	233.9	9.094		3.04	22.41	30.93	65.47
85	233.5			306.2		2	233.5	7.718			26.88		34.6
86		281.2		301.9		2	281.2		1.202		36.03		37.23
87	236.7			307.6		2	236.7	4.827			30.5		35.33
88		281.6		302.7		2	281.6						0
89		281.6		302.7		2	281.6		1.01		36.84		37.85
90		285		304.7		2	285		10.78		40.27		51.05
91	234.6	286		304.5		3	234.6	4.71	9.45		32.82		46.98
92	233	285.8		305.2		3	233	5.721	31.87		8.326		45.92
93	233.6	285.6		305.9		3	233.6	4.633	6.257		31.61		42.5
94	259.8			312.4	325.7	3	259.8	6.177			4.744	30.93	41.85
95	232.9			307.6	325.7	3	232.9	6.001			33.15	30.93	70.08
96				304		1	304				47.41		47.41

Run #	Fusion_1	Fusion_4	Fusion_5	Fusion_6	Fusion_7	#fusion	min fusion	DH fusion 1	DH FUSION4	DH fusion 5	DH fusion 6	DH Fusion 7	Total fusion DH
97	233.8			308.2		2	233.8	3.902			38.78		42.68
98		284.3		304.4		2	284.3				50.38		50.38
99		284.9		304.7		2	284.9		7.247		39.78		47.03
100	239.6	286.3		306.3		3	239.6	3.047	9.435		39.72		52.2
101	235.5		292.3	306.7		3	235.5	1.561		38.19	7.819		47.57
102	233.6		291.1	307.4		3	233.6	5.371		6.899	38		50.27
103	235.5			308.2		2	235.5	4.801			40.45		45.25
104	229.5			307.7		2	229.5	5.141			37.2		42.34
105	232.3			307.9		2	232.3	2.522			41.81		44.33
106				306.3		1	306.3				56.82		56.82
107	229.4			308.4	325.7	3	229.4	2.492			44.91	30.93	78.33
108	233.4			308.8		2	233.4	3.599			52		55.6
109				308		1	308				57.31		57.31
110		285.8		307.9		2	285.8		7.217		55.6		62.82
111	246.5	288.2		309.4		3	246.5	2.446	8.696		57.5		68.64
112	238.3			309.6		2	238.3	0.557			58.42		58.98
113	236.2			309.6		2	236.2	1.549			59.04		60.59
114	222.8			311.9		2	222.8	2.217			55.21		57.43
115	233.1			309.4	325.7	3	233.1	2.106			54.17	30.93	87.21
116				308.8		1	308.8				58.19		58.19
117	225.8			309.9		2	225.8	0.53			50.65		51.18
118				310.7		1	310.7				64.22		64.22
119				311.2		1	311.2				64.61		64.61

Table 5

2nd melt DSC data

Run #	2nd melt_1	2nd melt_2	2nd melt_3	2nd melt_4	2nd Melt_6	2nd Melt_7	#2nd melt	min 2nd melt	DH 2nd melt1	DH 2ND MELT 2	DH 2ND MELT3	DH 2ND MELT 4	DH 2nd Melt 6	DH 2nd Melt7	Total 2nd DH
1				305.1			1	305.1				13.82			13.82
2				310.4			1	310.4				25.90			25.90
3	273.2			309.1			2	273.2	6.40			21.17			27.57
4	253.7			309.2			2	253.7	10.75			15.85			26.60
5	252.9			309.4			2	252.9	7.02			15.23			22.25
6	254.7			309.0			2	254.7	3.99			9.59			13.58
7	254.8			307.9			2	254.8	8.40			4.34			12.74
8	257.5						1	257.5	14.18						14.18
9			298.7			314.6	2	298.7			17.89			20.46	38.35
10	256.2				322.1	327.4	3	256.2	17.09				5.21	3.66	25.96
11			297.7			318.0	2	297.7			14.97			24.26	39.23
12	256.4				324.2	327.6	3	256.4	12.12				7.50	5.61	25.23
13				299.7		319.2	2	299.7				11.67		21.12	32.79
14	255.3			300.7		321.3	3	255.3	2.53			6.72		17.87	27.12
15	255.4			301.1		322.0	3	255.4	5.37			6.12		16.97	28.46
16	252.9			300.7		321.0	3	252.9	4.91			2.22		15.26	22.38
17	255.3			298.2		323.4	3	255.3	24.86			2.35		14.72	41.93
18	255.1					328.0	2	255.1	10.49					17.28	27.77
19			298.4			320.8	2	298.4			9.31			29.42	38.73
20			297.6			323.0	2	297.6			13.95			35.74	49.69
21				299.3		323.9	2	299.3				12.37		32.63	45.00

Run #	2nd melt _1	2nd melt _2	2nd melt _3	2nd melt_4	2nd Melt_ 6	2nd Melt _7	#2nd melt	min 2nd melt	DH 2nd melt1	DH 2ND MELT 2	DH 2ND MELT3	DH 2ND MELT 4	DH 2nd Melt 6	DH 2nd Melt7	Total 2nd DH
22	260.0			300.8		326.0	3	260.0	2.19			9.64		30.79	42.63
23	255.6			301.1		326.6	3	255.6	4.61			5.90		28.35	38.86
24	256.7			301.1		326.7	3	256.7	3.45			3.61		27.53	34.59
25	254.8					325.8	2	254.8	5.78					29.57	35.35
26	256.1					328.8	2	256.1	6.51					28.08	34.59
27			297.6			323.9	2	297.6			8.64			37.24	45.88
28	254.1					328.7	2	254.1	8.67					32.10	40.77
29			297.4			324.3	2	297.4			6.95			38.49	45.44
30				299.2		325.8	2	299.2				8.96		38.41	47.37
31	260.5			300.9		327.4	3	260.5	1.83			8.49		36.98	47.31
32	258.0			300.7		327.2	3	258.0	1.85			4.50		35.10	41.45
33	256.9			300.7		327.9	3	256.9	2.52			3.11		34.15	39.78
34	256.5					328.1	2	256.5	3.63					34.31	37.94
35	254.6					328.8	2	254.6	4.53					33.79	38.32
36			297.3			325.5	2	297.3			8.79			43.01	51.80
37	254.3					328.8	2	254.3	3.99					40.62	44.61
38			296.8			321.4	2	296.8			8.01			45.37	53.38
39				298.7		326.5	2	298.7				5.25		44.77	50.02
40				300.8		328.5	2	300.8				7.34		41.01	48.35
41	266.4			301.0		328.8	3	266.4	2.16			5.48		42.27	49.92
42	258.4			305.4		329.7	3	258.4	1.43			2.91		41.33	45.68
43	256.1					328.8	2	256.1	6.15					42.87	49.02
44	254.7					329.1	2	254.7	4.12					44.43	48.55
45			296.5			327.2	2	296.5			3.07			51.85	54.92
46	254.2					329.7	2	254.2	2.82					51.93	54.75
47		277.1				324.3	2	277.1		2.81				38.49	41.30
48				300.7		329.3	2	300.7				4.49		57.35	61.84
49						329.4	1	329.4						64.73	64.73
50						331.5	1	331.5						69.35	69.35
51	269.4					330.8	2	269.4	1.50					58.87	60.37
52	255.4					329.3	2	255.4	6.87					56.75	63.62
53	251.9					329.7	2	251.9	3.47					58.34	61.81
54						329.4	1	329.4						68.34	68.34
55	254.3				320.9	325.5	3	254.3	13.97				4.10	6.29	24.35
56						329.9	1	329.9						70.83	70.83
57				310.3			1	310.3				27.05			27.05
58		273.5		309.7			2	273.5		3.43		20.75			24.18
59				310.7			1	310.7				29.65			29.65
60				310.6			1	310.6				27.71			27.71
61		271.2		311.5			2	271.2		2.56		23.23			25.79
62		272.3		312.2			2	272.3		4.77		19.60			24.37
63		274.8		311.8			2	274.8		4.02		19.52			23.54
64			294.3			314.2	2	294.3						32.58	32.58
65	248.4					324.1	2	248.4	14.65					6.54	21.19
66				313.9			1	313.9				32.37			32.37
67		271.2		311.3			2	271.2		2.07		22.46			24.53
68						315.8	1	315.8						20.92	20.92
69	251.4					325.1	2	251.4	9.67					2.12	11.79
70	262.2			302.5	317.1		3	262.2	6.96			12.32	30.24		49.52
71	254.9			304.9		318.7	3	254.9	3.03			7.44		17.85	28.32
72	254.0			304.9		319.2	3	254.0	7.73			6.12		16.75	30.60
73	254.6			305.5		320.1	3	254.6	10.71			4.47		14.58	29.76
74	254.8					327.8	2	254.8	11.57					64.65	76.22
75						318.3	1	318.3						28.74	28.74

Run #	2nd melt _1	2nd melt _2	2nd melt _3	2nd melt_4	2nd Melt_ 6	2nd Melt _7	#2nd melt	min 2nd melt	DH 2nd melt1	DH 2ND MELT 2	DH 2ND MELT3	DH 2ND MELT 4	DH 2nd Melt 6	DH 2nd Melt7	Total 2nd DH
76	247.6					322.3	2	247.6	10.68					14.84	25.52
77						319.7	1	319.7						25.07	25.07
78	248.0					324.3	2	248.0	9.42					17.34	26.76
79						321.2	1	321.2						30.43	30.43
80				303.2	321.9		2	303.2				14.80	43.45		58.25
81	254.9			303.4		323.1	3	254.9	4.68			10.15		26.31	41.14
82	254.7			303.7		323.2	3	254.7	3.66			7.48		25.22	36.36
83	255.8			309.3		323.9	3	255.8	3.25			5.32		24.61	33.18
84	254.6			309.8		325.3	3	254.6	15.81			4.13		33.58	53.52
85	250.0					325.1	2	250.0	6.26					22.19	28.45
86						316.5	1	316.5						34.27	34.27
87	249.2					325.5	2	249.2	6.33					30.14	36.47
88						326.9	1	326.9						42.13	42.13
89						323.3	1	323.3						34.98	34.98
90				303.5		325.1	2	303.5				9.60		39.89	49.49
91	263.4			304.0		324.3	3	263.4	1.46			9.18		32.87	43.51
92	257.8			305.8		324.6	3	257.8	1.43			6.26		31.63	39.32
93	256.0			307.2		324.8	3	256.0	2.40			4.65		31.35	38.40
94	255.2					320.1	2	255.2	7.35					14.58	21.93
95	251.0					325.7	2	251.0	5.47					27.54	33.01
96						324.5	1	324.5						40.07	40.07
97	245.3					325.7	2	245.3	6.71					37.66	44.37
98				302.1		325.1	2	302.1						52.52	52.52
99				303.5		325.1	2	303.5				14.80		39.87	54.67
100	265.7			307.6		325.4	3	265.7	5.13			9.10		38.73	52.97
101	255.9			305.1		325.5	3	255.9	5.49			6.11		39.05	50.65
102	258.0			306.3		325.8	3	258.0	1.06			3.83		37.65	42.54
103	257.7					320.1	2	257.7	2.78					14.58	17.36
104	248.8					325.8	2	248.8	4.74					40.73	45.47
105	248.3					326.4	2	248.3	3.66					42.24	45.90
106						326.4	1	326.4						58.08	58.08
107	244.7					325.8	2	244.7	2.61					44.98	47.59
108	253.1					326.1	2	253.1	2.88					49.50	52.38
109						325.1	1	325.1						63.49	63.49
110						327.3	1	327.3						58.55	58.55
111	263.8				317.6	326.7	3	263.8	1.86				15.37	46.36	63.59
112					318.8	327.2	2	318.8					11.29	43.07	54.36
113	261.3				319.2	327.4	3	261.3	1.61				13.51	42.64	57.76
114	250.7				318.1	320.1	3	250.7	2.01				10.54	14.58	27.13
115	253.0					326.5	2	253.0	2.06					52.51	54.57
116						327.1	1	327.1						53.41	53.41
117						326.9	1	326.9						40.61	40.61
118						325.7	1	325.7						37.66	37.66
119						327.8	1	327.8						64.65	64.65

[00185] Within Tables 4 and 5, the numerical identifiers (*i.e.*, the "1" in "2nd melt_1" and "DH 2nd melt1") indicate the peak numbers in the DSC traces from the lowest to the highest melt temperatures. The data in Tables 4 and 5 reveal that in the case of many of the 3-component blends, after first melting many of the components virtually lose their thermal signature and, in particular, the low melt points associated with FEP are virtually lost for

many of the blends shown. This behavior is mirrored for the remelt peaks shown in Table 5 where several blends lose their FEP signature, for example, Runs 49-50.

[00186] It is thought that the thermal data exhibited by the blends is indicative of extensive and intimate mixing of the various components leading to the formation of a type of fluoropolymer alloy. These formulations are also associated with an unparalleled combination of gloss, water contact angle, and hardness, which is illustrated by the Normalized data of Table 2.

[00187] In this connection, the data of Table 2 above show that many of the blends are generally associated with the higher values of the composite variables including Norm (CA, Gloss, Hard) and Norm (Remelt, CA, Gloss, Hard). In particular Run 21 has an excellent combination of properties with increased hardness yet no perceptible FEP signature and hence a high remelt temperature. These formulations will imbue coating systems employing them with desirable properties based on these characteristics, as demonstrated by other Examples herein.

[00188] The data are also summarized in Figs 19-30. Figure 19 illustrates the construction of Figs 20-30, they are essentially two ternary mixture plots conjoined along the PFA: FEP axis (Y-axis). The origin represents 100% PFA (TE7224) negative values on the X-axis represent increasing weight fractions of TE3887N (LPTFE) whereas positive values on the X-axis represent increasing weight fractions of SFN-D (LPTFE). 100% FEP represented by the coordinate (0, 1) is 100% TE9568. As might be anticipated Figs 20-30 often show symmetry about the Y-axis but this is not absolute, reflecting the effect of different LPTFEs on the precise compositions for desirable properties. The findings of Figs 20-30 are now discussed in more detail.

[00189] Fig 20 shows coating gloss as a function of composition, there are 3 main regions of composition for enhanced gloss: A) 50- 85% FEP, 1-40% LPTFE and 15-50% PFA; B) 5-40% FEP, 30-55% LPTFE and 40-95% PFA; and C) 5-40% FEP, 1-40% LPTFE and 1-40% PFA.

[00190] Fig 21 shows coating contact angle with water as a function of composition. The main region of composition for enhanced contact angle is 1-40% FEP, 30-100% LPTFE and 0-60% PFA.

[00191] Fig 22 shows coating pencil hardness as a function of composition. The main region of composition for enhanced pencil hardness is 10- 90% FEP, 1-80% LPTFE and 1-50% PFA.

[00192] Fig 23 and Fig 24 are the normalized plot for the mean of contact angle, gloss pencil hardness and minimum remelt temperature they are calculated as follows:

GLOSS = measured gloss,

NORM GLOSS = normalized gloss, calculated as: [Gloss - Minimum (Gloss)] /[Maximum (Gloss) - Minimum (Gloss)];

CONTACT ANGLE (CA) = contact angle in water

NORM CA = normalized contact angle, calculated as: [Contact Angle - Minimum (Contact Angle)] / [Maximum (Contact Angle) - Minimum (Contact Angle];

PENCIL = pencil test measurement, per Section VII

NORM PENCIL = normalized pencil test measurement, calculated as: [PENCIL - Minimum (PENCIL)] /[Maximum (PENCIL) - Minimum (PENCIL)];

NORM min remelt = normalized "min remelt", calculated as: [min remelt - Minimum (min remelt)] /[Maximum (min remelt) - Minimum (min remelt)], wherein "min remelt" is the temperature of the lowest remelt peak for a given sample;

Norm (CA, Gloss, Hard) = the mean of (NORM CA, NORM PENCIL, and NORM GLOSS); and

Norm (Remelt, CA, Gloss, Hard) = the mean of (NORM CA, NORM PENCIL, NORM GLOSS, and NORM min remelt).

[00193] Fig 23 shows desirable regions of higher normalized (CA, Gloss, Hardness) in 3 regions of composition: A) 10-40% LPTFE, 50-70% FEP and 30-50% PFA; B) 5-40% LPTFE, 20-40% FEP and 60-85% PFA; C) 20-80% LPTFE, 5-35% FEP and 60-95% PFA. Fig 24 shows desirable regions of higher normalized (CA, Gloss, Hardness, Minimum Remelt temperature) at 0-80% LPTFE, 5-30% FEP and 70-95% PFA.

[00194] Figs 25a, 25b, and 25c show the number of DSC peaks observed during First Melt, Fusion and Second Melt, respectively. It can be seen the numbers of DSC peaks observed decreases with each melting of the polymer blend this is indicative of reduction in the numbers of phases present and the presence of mixed phases, *i.e.*, alloying.

[00195] Figs 26 is the difference between the total fusion enthalpy and the total first melt enthalpy and Fig 27 shows the difference between the total remelt enthalpy and the first melt enthalpy in J/g. These plots both show regions where total crystallinity of the sample increased after melting (where values are positive). Regions of greatest increase often being associated with a reduction in the number of melt peaks; a further indication of the development of new more crystalline phases associated with the intimate mixing of the

component fluoropolymers. These higher crystalline phases are in regions broadly corresponding to those associated with the enhanced normalized properties as exhibited in Figs 23-24, *i.e.*, 10-85% LPTFE, 5-30% FEP and 70-95% PFA. Fig 28 is the minimum first melt temperature, Fig 29 is the minimum fusion temperature and Fig 30 is the minimum remelt temperature. Simple comparison of Figs. 28-30 reveals that the mimimum melt temperature generally increases on further melting. In particular the generally lower FEP melt peak becomes less evident and in fact absent in many cases. The regions associated with these runs are also generally in accord with the regions of enhanced properties discussed above.

Table 6

Summary of Selected 3-Component (2 MPF and LPTFE) Formulations with Desirable Properties

Run #	FEP	PFA	LPTFE	GLOSS	Contact Angle	Pencil	CA,GLOSS,HARD	remelt,CA,Gloss,hard	1st melt_1	min 2nd melt
21	0.12	0.48	0.4	64.8	133.79	3	0.8231	0.7746	260.16	299.3
40	0.16	0.24	0.6	42	135.117	5	0.7978	0.7599	259.4	300.79
31	0.2	0.3	0.5	50.7	133.207	5	0.8175	0.6586	258.46	260.46
13	0.16	0.64	0.2	41.1	124.887	5	0.634	0.634	257.94	299.73
22	0.24	0.36	0.4	60.6	131.617	3	0.7656	0.6182	259.43	259.96
23	0.3	0.3	0.4	66.7	129.12	3	0.7613	0.6024	261.16	255.57
17	0.64	0.16	0.2	69	122.42	5	0.7538	0.5958	259.48	255.25
80	0.12	0.48	0.4	50.7	131.993	-1	0.5485	0.5799	259.72	303.19
30	0.1	0.4	0.5	56.8	134.967	-3	0.546	0.5665	260.37	299.21
72	0.4	0.4	0.2	63.3	124.437	4	0.7111	0.5602	259.98	253.99

[00196] From Table 6 we can conclude that selected 3-Component (2MPF, 1LPTFE) systems have between 10-64% FEP, 16-64% PFA and 20-60% LPTFE. In particular between 12-24% FEP, 24-64% PFA and 20-60% LPTFE. And most particularly between 12-16% FEP, 24-48% PFA and 40-60% LPTFE.

[00197] Formulation 21 is particularly remarkable as, it has a minimum remelt temperature of 299.3°C though it contains 12% FEP, the FEP melt peak has disappeared indicating that it is now contained in a mixed phase or alloy, note its first melt temperature was 260.16°C. Formulation 21 is also hard with a very high contact angle in water as well as being very glossy.

Example 2

Second Embodiment

Fluoropolymer blends with multiple MPFs (HPTFE/LPTFE/MPF1/MPF2)

Basic and thermal properties

[00198] As defined in this Example, a "4-component" blend contains all of the following components as described above: at least one HPTFE, at least one LPTFE, and at least two chemically different MPFs. In this Example, the two MPFs employed are FEP and PFA. The blends in this Example were made by mixing aqueous dispersions of the components, and the resulting blends were then drawn down as films for gloss, contact angle, and pencil test characterization and, for the thermal analysis, were coagulated and dried for DSC measurement, as discussed in Section VII above.

[00199] Panels were prepared for gloss, contact angle and pencil hardness testing as follows. In Mix A and Mix B, the value for deionized water (DIW) appears more than once as such may originate from more than one of the component in the mixtures.

1. Make liquid blend of MPF, LPTFE, and HPTFE in the desired ratios.
2. Add the appropriate formulation to the blend created in step 1. Use the following formulations and percentages to make the blends for drawdown.
3. For PFA use Mix B (below) without PFA. Multiply the amount created in step 1 by 2/3.
4. For FEP use Mix A (below) without FEP. Multiply the amount created in step 1 by 0.70.
5. Blend the mix gently to avoid air bubbles.
6. Using a pipet apply a small amount to an aluminum degreased panel.
7. Draw the coating down the panel in a smooth motion using a 3 mil wet path bird applicator.
8. Flash the panel for approximately 5-10 minutes at 200°F.
9. Move the panel to 400°F and flash an additional 3-5 minutes.
10. Cure the panel for 10 minutes at 750°F.

Mix A

Component	Weight %
DIW	63.15
PE 1450 DIW Solution	15.15
Triethanolamine	4.00

Component	Weight %
Silwet L-77	2.85
Aromatic 100	3.75
DIW	8.10
Carbopol EP-1	3.00

Mix B

Component	Weight %
PE 1450 DIW Solution	29.25
DIW	52.00
Surfynol 440	4.50
10% FC-4430 in DIW	6.95
Morpholine	0.40
ASE60	6.90

[00200] Table 7 below is a summary of the blends examined in this Example, wherein the column "#data" is the number of repeats for the runs, hence all the data are averages of these repeated runs. Four runs were made of 4 component blends, i.e. Runs 22, 23, 30 and 31 respectively. In Table 7, "Total MPF" designates the total amount of MPF, which was FEP, PFA, or a combination of the foregoing, wherein the FEP used was TE 9568 FEP (55.6% solids), available from DuPont and the PFA used was TE 7724 PFA (58.6 % solids), each described above in Section IV. "Total LPTFE" designates the total amount of LPTFE, wherein the LPTFE's used were SFN-D, available from Chenguang R.I.C.I, Chengdu, 610036 P.R. China and TE3887N, available from DuPont, each described above in Section II. "HPTFE" designates the HPTFE used, which was D310, available from Daikin.

Table 7

Fluoropolymer Blends

Run #	# Data	Total MPF	Total LPTFE	LPTFE (SFN-D)	LPTFE (TE3887N)	FEP (TE 9568)	PFA (TE 7724)	HPTFE (D310)
1	6	0.8	0.2	0	0.2	0.4	0.4	0
2	6	0.8	0.2	0.2	0	0.4	0.4	0
3	12	0.6	0.4	0.2	0.2	0.3	0.3	0
4	6	0.6	0.4	0	0.4	0.3	0.3	0
5	6	0.6	0.4	0.4	0	0.3	0.3	0
6	6	0.5	0.5	0	0.5	0.25	0.25	0
7	6	0.5	0.5	0.5	0	0.25	0.25	0
8	10	0.4	0.6	0.3	0.3	0.2	0.2	0
9	6	0.4	0.6	0	0.6	0.2	0.2	0

Run #	# Data	Total MPF	Total LPTFE	LPTFE (SFN-D)	LPTFE (TE3887N)	FEP (TE 9568)	PFA (TE 7724)	HPTFE (D310)
10	6	0.4	0.6	0.6	0	0.2	0.2	0
11	6	0.2	0.8	0	0.8	0.1	0.1	0
12	6	0.2	0.8	0.8	0	0.1	0.1	0
13	28	0	1	0	1	0	0	0
14	9	0	1	0.5	0.5	0	0	0
15	12	0	1	1	0	0	0	0
16	8	0	0.8	0	0.8	0	0	0.2
17	6	0	0.8	0.8	0	0	0	0.2
18	9	0.6	0	0	0	0.3	0.3	0.4
19	9	0	0.6	0	0.6	0	0	0.4
20	9	0	0.6	0.3	0.3	0	0	0.4
21	6	0	0.6	0.6	0	0	0	0.4
22	9	0.36	0.24	0.12	0.12	0.18	0.18	0.4
23	11	0.24	0.36	0.18	0.18	0.12	0.12	0.4
24	6	0	0.5	0	0.5	0	0	0.5
25	6	0	0.5	0.5	0	0	0	0.5
26	17	0	0.4	0.2	0.2	0	0	0.6
27	6	0	0.4	0.4	0	0	0	0.6
28	3	0	0.4	0	0.4	0	0	0.6
29	6	0.4	0	0	0	0.2	0.2	0.6
30	9	0.24	0.16	0.08	0.08	0.12	0.12	0.6
31	9	0.16	0.24	0.12	0.12	0.08	0.08	0.6
32	6	0	0.2	0.2	0	0	0	0.8
33	4	0	0.2	0	0.2	0	0	0.8
34	10	0	0	0	0	0	0	1
35	24	1	0	0	0	1	0	0
36	61	1	0	0	0	0.5	0.5	0
37	18	1	0	0	0	0	1	0
38	3	0.33	0.27	0	0.27	0	0.33	0.4
39	3	0.3	0.3	0	0.3	0.3	0	0.4
40	3	0.3	0.3	0.3	0	0.3	0	0.4
41	9	0.6	0	0	0	0.3	0.3	0.4

[00201] Observed data is set forth in Table 8 below, wherein:

GLOSS = measured gloss, per Section VII above;

NORM GLOSS = normalized gloss, calculated as: [Gloss - Minimum (Gloss)] /[Maximum (Gloss) - Minimum (Gloss)];

CONTACT ANGLE (CA) = contact angle, per Section VII above;

NORM CA = normalized contact angle, calculated as: [Contact Angle - Minimum (Contact Angle)] / [Maximum (Contact Angle) - Minimum (Contact Angle];

PENCIL = pencil test measurement, per Section VII above, where the value in Table 7 below is the mean of the number of measured results, as indicated by "# Data" in Table 6 above;

NORM PENCIL = normalized pencil test measurement, calculated as: [PENCIL - Minimum (PENCIL)] /[Maximum (PENCIL) - Minimum (PENCIL)];

NORM min remelt = normalized "min remelt", calculated as: [min remelt - Minimum (min remelt)] /[Maximum (min remelt) - Minimum (min remelt)], wherein "min remelt" is the temperature of the lowest remelt peak for a given sample;

Norm (CA, Gloss, Hard) = the mean of (NORM CA, NORM PENCIL, and NORM GLOSS); and

Norm (Remelt, CA, Gloss, Hard) = the mean of (NORM CA, NORM PENCIL, NORM GLOSS, and NORM min remelt).

Table 8

Observed data

Run #	GLOSS	NORM GLOSS	Contact Angle (CA)	NORM CA	PENCIL	NORM PENCIL	norm min remelt	Norm (CA, Gloss, Hard)	Norm (Remelt, CA, Gloss, Hard)
1	37.8	0.46	123.89	0.38	5.0	1.00	0.12	0.61	0.49
2	63.3	0.88	124.44	0.40	4.0	0.88	0.11	0.72	0.57
3	54.2	0.73	131.65	0.67	3.3	0.78	0.22	0.73	0.60
4	66.7	0.94	129.12	0.58	3.0	0.75	0.13	0.75	0.60
5	35.9	0.42	130.87	0.64	1.0	0.50	0.12	0.52	0.42
6	41.8	0.52	132.58	0.71	1.0	0.50	0.15	0.58	0.47
7	27.5	0.28	132.48	0.70	-1.0	0.25	0.15	0.41	0.35
8	38.7	0.47	135.20	0.80	-1.6	0.18	0.11	0.48	0.39
9	30.5	0.33	134.65	0.78	-3.0	0.00	0.25	0.37	0.34
10	21.0	0.18	132.82	0.71	-2.0	0.13	0.13	0.34	0.29
11	12.8	0.04	137.33	0.88	-3.0	0.00	1.00	0.31	0.48
12	18.9	0.14	132.98	0.72	-3.0	0.00	0.85	0.29	0.43
13	22.9	0.21	133.29	0.73	-3.0	0.00	0.98	0.31	0.42
14	11.2	0.01	137.48	0.89	-3.0	0.00	0.97	0.30	0.36
15	30.0	0.33	134.25	0.77	-2.0	0.13	0.96	0.41	0.54
16	45.8	0.59	132.35	0.70	-3.0	0.00	0.99	0.43	0.57
17	29.7	0.32	136.03	0.83	-3.0	0.00	0.97	0.38	0.53

Run #	GLOSS	NORM GLOSS	Contact Angle (CA)	NORM CA	PENCIL	NORM PENCIL	norm min remelt	Norm (CA, Gloss, Hard)	Norm (Remelt, CA, Gloss, Hard)
18	53.2	0.71	120.83	0.27	5.0	1.00	0.16	0.66	0.53
19	52.0	0.69	132.03	0.68	-3.0	0.00	0.99	0.46	0.59
20	48.4	0.63	135.48	0.81	-3.0	0.00	0.99	0.48	0.61
21	54.3	0.73	134.71	0.78	-3.0	0.00	0.97	0.50	0.62
22	48.4	0.63	138.65	0.93	2.7	0.71	0.95	0.76	0.81
23	44.9	0.57	139.02	0.95	4.4	0.92	0.73	0.81	0.79
24	48.2	0.63	132.12	0.69	-3.0	0.00	0.98	0.44	0.57
25	44.0	0.56	131.95	0.68	-3.0	0.00	0.98	0.41	0.55
26	54.5	0.73	133.43	0.74	0.1	0.38	0.98	0.62	0.71
27	50.1	0.66	132.62	0.71	-3.0	0.00	0.97	0.46	0.58
28	47.8	0.62	131.60	0.67	-3.0	0.00	0.98	0.43	0.57
29	56.8	0.77	120.40	0.25	4.5	0.94	0.37	0.65	0.58
30	51.7	0.69	134.05	0.76	3.0	0.75	0.40	0.73	0.65
31	55.1	0.74	136.39	0.85	4.0	0.88	0.95	0.82	0.85
32	52.7	0.70	131.11	0.65	-3.0	0.00	0.96	0.45	0.58
33	51.3	0.68	128.86	0.57	-3.0	0.00	0.97	0.42	0.55
34	56.5	0.77	125.64	0.45	-2.0	0.13	0.93	0.45	0.50
35	68.7	0.97	118.63	0.19	5.0	1.00	0.15	0.72	0.58
36	51.8	0.69	116.23	0.10	3.7	0.83	0.10	0.54	0.46
37	50.2	0.66	122.81	0.34	0.0	0.38	0.70	0.46	0.52
38	59.4	0.81	130.94	0.64	-3.0	0.00	0.66	0.49	0.53
39	57.2	0.78	134.32	0.77	0.0	0.38	0.14	0.64	0.52
40	58.8	0.80	135.93	0.83	0.0	0.38	0.26	0.67	0.57
41	53.2	0.71	120.83	0.27	5.0	1.00	0.16	0.66	0.53

[00202] From the data presented in Table 8 it can be seen that the 4-component blends have generally better properties than the other blends, such as higher gloss, contact angle, and greater pencil hardness.

[00203] Thermal data is summarized in Tables 9, 10, and 11 below for 1st Melt, Fusion and 2nd Melt (remelt) respectively.

Table 9

1st melt DSC data

Run #	1st melt1	1st Melt3	1st melt4	1st melt5	1st melt6	1st melt7	min 1st melt
1	260.8	313.3	322.0	.	327.9	.	260.8
2	260.0	312.4	321.3	.	326.0	.	260.0
3	259.5	313.2	.	.	327.0	.	259.5
4	261.2	313.7	.	.	328.4	.	261.2
5	259.5	312.5	.	324.3	325.7	.	259.5
6	261.0	313.9	.	.	328.4	.	261.0
7	260.1	312.8	.	.	325.9	.	260.1
8	259.5	313.3	.	.	327.0	.	259.5
9	259.1	314.2	.	.	328.7	.	259.1
10	260.2	312.8	.	.	325.7	.	260.2
11	.	.	.	.	329.2	.	329.2
12	260.6	313.0	.	.	326.0	.	260.6
13	.	.	.	.	327.6	.	327.6
14	.	.	.	.	327.2	.	327.2
15	.	.	.	.	325.5	.	325.5
16	.	.	.	.	327.4	333.3	327.4
17	.	.	.	.	325.3	330.2	325.3
18	259.6	312.9	321.1	.	.	337.8	259.6
19	.	.	.	.	327.3	335.3	327.3
20	.	.	.	.	326.8	336.1	326.8
21	.	.	.	.	325.0	334.5	325.0
22	60.4	13.8			26.2	38.9	60.4
23	259.1	313.5	.	.	326.9	336.7	259.1
24	.	.	.	.	327.2	335.9	327.2
25	.	.	.	.	325.4	336.9	325.4
26	.	.	.	.	326.5	338.0	326.5
27	.	.	.	.	325.2	337.9	325.2
28	.	.	.	.	326.8	336.8	326.8
29	259.5	313.1	321.0	.	.	339.4	259.5
30	260.1	313.5	.	.	326.7	339.4	260.1
31	260.4	313.8	.	.	326.2	338.9	260.4
32	.	.	.	.	325.9	339.4	325.9
33	.	.	.	.	326.2	338.3	326.2
34	.	.	.	.	327.6	338.8	332.1
35	257.4	.	.	.	.	.	257.4

Run #	1st melt1	1st Melt3	1st melt4	1st melt5	1st melt6	1st melt7	min 1st melt
36	259.2	312.6	321.5	.	.	.	259.2
37	.	313.4	.	.	.	.	313.4
38	.	314.0	.	.	327.7	337.8	314.0
39	259.3	.	.	.	327.4	337.2	259.3
40	259.4	.	.	325.2	326.0	337.1	259.4
41	259.6	312.9	321.1	.	.	337.8	259.6

Run #	DH 1st melt 1	DH 1st Melt 3	DH 1st Melt 4	DH 1st Melt 5	DH 1st Melt 6	DH 1st Melt 7	Total 1st DH
1	11.23	14.96	1.57	.	11.55	.	39.31
2	8.97	16.84	2.29	.	8.18	.	36.27
3	7.18	15.54	.	.	.	.	22.72
4	6.71	11.33	.	.	24.89	.	42.93
5	4.96	14.05	.	10.52	9.89	.	39.42
6	2.74	9.44	.	.	31.34	.	43.51
7	3.72	12.53	.	.	26.26	.	42.51
8	4.84	12.63	.	.	.	.	17.47
9	1.63	8.04	.	.	36.92	.	46.58
10	8.79	13.97	.	.	32.12	.	54.88
11	.	.	.	.	64.48	.	64.48
12	1.49	10.50	.	.	44.50	.	56.49
13	.	.	.	.	64.19	.	41.27
14	.	.	.	.	.	.	
15	.	.	.	.	.	.	
16	.	.	.	.	45.23	19.52	64.75
17	.	.	.	.	.	10.33	10.33
18	3.86	13.47	1.46	.	.	27.42	46.21
19	.	.	.	.	47.10	25.79	72.89
20	.	.	.	.	38.07	22.18	52.86
21	.	.	.	.	.	25.77	25.77
22	5.48	9.89	.	.	42.93	.	58.31
23	2.57	7.48	.	.	24.30	.	34.35
24	.	.	.	.	43.39	28.09	71.48
25	.	.	.	.	31.84	30.85	62.69
26	.	.	.	.	32.66	37.11	63.22
27	.	.	.	.	25.46	39.69	65.15
28	.	.	.	.	38.56	35.20	73.76
29	5.08	10.77	1.89	.	.	41.18	58.93

Run #	DH 1st melt 1	DH 1st Melt 3	DH 1st Melt 4	DH 1st Melt 5	DH 1st Melt 6	DH 1st Melt 7	Total 1st DH
30	8.27	11.57	.	.	39.88	.	59.72
31	5.48	9.89	.	.	42.93	.	58.31
32	.	.	.	.	12.65	41.25	53.90
33	.	.	.	.	16.61	50.10	66.71
34	.	.	.	.	.	66.64	26.66
35	18.18	.	.	.	.	.	18.18
36	8.82	22.41	0.98	.	.	.	21.12
37	.	6.91	1.28	.	.	.	8.19
38	.	14.11	.	.	18.90	22.51	55.52
39	6.31	.	.	.	30.07	25.59	61.97
40	2.82	.	.	16.23	6.54	28.95	54.54
41	3.86	13.47	1.46	.	.	27.42	46.21

[00204] Table 9 shows the first melt temperature (°C) and heat of melting (ΔH J/g) for the various blends of Table 7. Within Table 9, the numerical identifiers (*i.e.*, the "1" in "DH 1st melt 1") indicate the peak numbers in the DSC traces from the lowest to the highest melt temperatures. It will be noticed that the various components exhibit their melt points in the blends at temperatures typical for their chemistry, *i.e.*, FEP at ca. 255-260°C, PFA at ca. 312-314°C, LPTFE at ca. 324-328°C, and HPTFE at ca. 330-340°C.

Table 10

Fusion peak DSC data

Run #	Fusion 1	Fusion 4	Fusion 5	Fusion 6	min Fusion	DH Fusion 1	DH Fusion 4	DH Fusion 5	DH Fusion 6	Total Fusion DH
1	233.9	285.5	.	301.8	233.9	7.38	5.19	.	17.60	30.17
2	233.2	288.1	.	297.1	233.2	5.99	16.82	.	5.35	28.16
3	232.9	285.2	.	305.5	232.9	3.47	6.69	.	28.42	38.59
4	234.9	285.0	.	307.6	234.9	2.76	4.13	.	28.26	35.15
5	232.8	285.9	.	303.6	232.8	5.55	25.58	.	7.56	38.70
6	236.1	284.7	.	309.6	236.1	1.47	3.47	.	35.67	40.61
7	233.0	285.8	.	305.2	233.0	5.72	31.87	.	8.33	45.92
8	236.1	284.6	.	309.3	236.1	0.62	4.69	.	42.75	48.06
9	235.8	283.6	.	311.1	235.8	2.75	4.22	.	42.51	49.48
10	235.5	.	292.3	306.7	235.5	1.56	.	38.19	7.82	47.57
11	.	.	.	315.8	315.8	.	.	.	70.48	70.48
12	238.3	.	.	309.6	238.3	0.56	.	.	58.42	58.98
13	.	.	.	315.1	315.1	.	.	.	73.27	47.10

Run #	Fusion 1	Fusion 4	Fusion 5	Fusion 6	min Fusion	DH Fusion 1	DH Fusion 4	DH Fusion 5	DH Fusion 6	Total Fusion DH
14	.	.	.	314.6	314.6	.	.	.	69.54	23.18
15	.	.	.	311.2	311.2	.	.	.	64.61	64.61
16	.	.	.	314.5	314.5	.	.	.	61.30	61.30
17	.	.	.	315.4	315.4	.	.	.	69.39	69.39
18	234.3	.	291.3	303.1	234.3	4.09	.	8.75	16.18	29.02
19	.	.	.	314.9	314.9	.	.	.	64.29	64.29
20	.	.	.	315.1	315.1	.	.	.	60.87	60.87
21	.	.	.	315.2	315.2	.	.	.	62.29	62.29
22	.	.	.	311.7	311.7	.	.	.	45.56	45.56
23	.	.	292.2	311.4	292.2	.	.	4.82	39.06	43.88
24	.	.	.	314.9	314.9	.	.	.	69.22	69.22
25	.	.	.	314.6	314.6	.	.	.	54.55	54.55
26	.	.	.	314.5	314.5	.	.	.	52.11	52.11
27	.	.	.	314.3	314.3	.	.	.	57.20	57.20
28	.	.	.	314.6	314.6	.	.	.	60.72	60.72
29	238.7	.	291.5	306.8	238.7	1.78	.	8.55	20.05	30.38
30	241.5	.	293.1	309.9	241.5	0.79	.	6.68	30.29	37.76
31	.	.	.	311.7	311.7	.	.	.	45.56	45.56
32	.	.	.	313.0	313.0	.	.	.	44.43	44.43
33	.	.	.	313.6	313.6	.	.	.	47.63	47.63
34	.	.	.	311.1	311.1	.	.	.	38.02	15.21
35	234.3	.	.	.	234.3	13.92	.	.	.	13.92
36	232.3	286.7	.	.	232.3	6.61	16.10	.	.	14.89
37	.	281.7	.	.	281.7	.	16.12	.	.	16.12
38	.	284.8	.	309.9	284.8	.	8.60	.	32.45	41.05
39	232.4	.	.	313.5	232.4	7.47	.	.	46.94	54.41
40	239.0	.	.	313.5	239.0	5.74	.	.	43.94	49.68
41	234.3	.	291.3	303.1	234.3	4.09		8.75	16.18	29.02

Table 11

2nd melt DSC data

Run #	2nd Melt 1	2nd Melt 2	2nd Melt 3	2nd Melt 4	2nd Melt 6	2nd Melt 7	min 2nd Melt
1	255.4	.	.	301.1	.	322.0	255.4
2	254.0	.	.	304.9	.	319.2	254.0
3	263.8	.	.	302.3	.	326.9	263.8
4	255.6	.	.	301.1	.	326.6	255.6
5	254.7	.	.	303.7	.	323.2	254.7
6	258.0	.	.	300.7	.	327.2	258.0
7	257.8	.	.	305.8	.	324.6	257.8
8	254.3	.	.	302.1	.	324.7	254.3

Run #	2nd Melt 1	2nd Melt 2	2nd Melt 3	2nd Melt 4	2nd Melt 6	2nd Melt 7	min 2nd Melt
9	266.4	.	.	301.0	.	328.8	266.4
10	255.9	.	.	305.1	.	325.5	255.9
11	.	.	.	.	.	331.5	331.5
12	.	.	.	.	318.8	327.2	318.8
13	.	.	.	.	.	329.9	329.9
14	.	.	.	.	.	329.3	329.3
15	.	.	.	.	.	327.8	327.8
16	.	.	.	.	.	330.2	330.2
17	.	.	.	.	.	328.7	328.7
18	258.7	.	.	306.9	.	320.8	258.7
19	.	.	.	.	.	330.4	330.4
20	.	.	.	.	.	330.3	330.3
21	.	.	.	.	.	329.2	329.2
22	.	.	.	.	.	327.5	327.5
23	.	.	.	308.0	.	328.3	308.0
24	.	.	.	.	.	329.9	329.9
25	.	.	.	.	.	29.6	29.6
26	.	.	.	.	.	329.8	329.8
27	.	.	.	.	.	329.0	329.0
28	.	.	.	.	.	330.0	330.0
29	.	276.7	.	305.3	.	323.2	276.7
30	.	279.7	.	304.0	.	327.3	279.7
31	.	.	.	.	.	327.5	327.5
32	.	.	.	.	.	327.9	327.9
33	.	.	.	.	.	328.5	328.5
34	.	.	.	.	.	325.5	325.5
35	257.5	.	.	.	.	.	257.5
36	252.9	.	.	309.4	.	.	252.9
38	.	.	.	302.3	.	326.3	302.3
39	256.7	.	.	.	.	329.9	256.7
40	267.3	.	.	.	.	328.8	267.3
41	258.7	.	.	306.9	.	320.8	258.7

Run #	DH 2nd Melt 1	DH 2ND Melt 2	DH 2ND Melt 3	DH 2ND Melt 4	DH 2nd Melt 6	DH 2nd Melt 7	Total 2nd DH
1	5.37	.	.	6.12	.	16.97	28.46
2	7.73	.	.	6.12	.	16.75	30.60
3	1.32	.	.	6.02	.	42.13	49.47

Run #	DH 2nd Melt 1	DH 2ND Melt 2	DH 2ND Melt 3	DH 2ND Melt 4	DH 2nd Melt 6	DH 2nd Melt 7	Total 2nd DH
4	4.61	.	.	5.90	.	28.35	38.86
5	3.66	.	.	7.48	.	25.22	36.36
6	1.85	.	.	4.50	.	35.10	41.45
7	1.43	.	.	6.26	.	31.63	39.32
8	4.12	.	.	7.25	.	28.06	39.43
9	2.16	.	.	5.48	.	42.27	49.92
10	5.49	.	.	6.11	.	39.05	50.65
11	.	.	.	.	.	69.35	69.35
12	.	.	.	.	11.29	43.07	54.36
13	.	.	.	.	.	70.83	45.53
14	.	.	.	.	.	67.39	22.46
15	.	.	.	.	.	64.65	64.65
16	.	.	.	.	.	56.41	56.41
17	.	.	.	.	.	66.42	66.42
18	5.69	.	.	8.29	.	18.69	32.67
19	.	.	.	.	.	70.43	70.43
20	.	.	.	.	.	62.05	62.05
21	.	.	.	.	.	61.14	61.14
22	.	.	.	.	.	52.38	52.38
23	.	.	.	9.27	.	39.24	48.51
24	.	.	.	.	.	59.75	59.75
25	.	.	.	.	.	51.03	51.03
26	.	.	.	.	.	53.57	53.57
27	.	.	.	.	.	53.96	53.96
28	.	.	.	.	.	63.19	63.19
29	.	5.62	.	8.69	.	17.94	32.25
30	.	6.78	.	4.85	.	32.27	43.90
31	.	.	.	.	.	52.38	52.38
32	.	.	.	.	.	41.25	41.25
33	.	.	.	.	.	43.76	43.76
34	.	.	.	.	.	31.20	12.48
35	14.18	.	.	.	.	.	14.18
36	7.02	.	.	15.23	.	.	14.59
38	.	.	.	12.82	.	31.29	44.11
39	6.52	.	.	.	.	43.86	50.38
40	2.67	.	.	.	.	41.39	44.06
41	29.02	5.69	.	8.29	.	18.69	32.67

[00205] Within Tables 10 and 11, the numerical identifiers (*i.e.*, the "1" in "Fusion 1" and "2nd melt 1" and "DH 2nd melt1") indicate the peak numbers in the DSC traces from the lowest to the highest melt temperatures.

[00206] However, the data in Tables 10 and 11 reveal that in the case of the 4-component blends, after first melting many of the components virtually lose their thermal signature and, in particular, the low melt points associated with FEP are virtually lost for 3 of the four 4-component blends shown, *i.e.*, runs 22, 23 and 31. For two of these blends, the PFA fusion peak is also virtually absent, *i.e.*, Runs 22 and 31 and the fusion data only reveal 1 fusion peak for these materials. This behavior is mirrored for the remelt peaks shown in Table 11. Essentially, after the first melting virtually all that remains on fusion and remelting is one peak at a temperature normally associated with PTFE. This is quite remarkable as, in the case of Run 22, for example, 36 wt.% of the formulation is either FEP or PFA which are associated with much lower melt points.

[00207] It is thought that the thermal data exhibited by the 4-component blends is indicative of extensive and intimate mixing of the various components leading to the formation of a type of fluoropolymer alloy. These formulations are also associated with an unparalleled combination of gloss, water contact angle, and hardness, which is illustrated by the Normalized data of Table 8.

[00208] In this connection, the data of Table 8 above show that the 4 component blends, *i.e.*, Runs 22, 23, 30 and 31, are associated with the highest values of the composite variables including Norm (CA, Gloss, Hard) and Norm (Remelt, CA, Gloss, Hard). These formulations will imbue coating systems employing them with desirable properties based on these characteristics, as demonstrated by other Examples herein.

[00209] Exemplary actual DSC plots of from certain Runs of Tables 8-10 are given in Figs. 1-18 and summarized in Table 12 below.

Table 12

Various Fluoropolymer Blends with DSC Plots shown Figs (1-18)

Run #	Blend Type	# 1st Melt Peaks	Min 1st Melt °C	# Fusion Peaks	Min Fusion °C	# Re-melt Peaks	Min Re-melt °C	Fig. # (1st Melt & Fusion)	Fig. # (2nd Melt)
3	FLP	3	261.2	3	232.9	3	263.8	9	10
22	FLPH	4	260.4	3	311.7	3	327.5	7	8
23	FLPH	4	259.1	2	292.2	2	308.0	3	4

Run #	Blend Type	# 1st Melt Peaks	Min 1st Melt °C	# Fusion Peaks	Min Fusion °C	# Re-melt Peaks	Min Re-melt °C	Fig. # (1st Melt & Fusion)	Fig. # (2nd Melt)
29	FPH	3	259.5	3	238.7	3	276.7	13	14
30	FLPH	4	260.1	3	241.5	3	279.7	5	6
31	FLPH	4	260.4	1	311.7	1	327.5	1	2
38	LPH	3	314.0	2	284.8	2	302.3	15	16
39	LFH	3	259.3	2	232.4	2	256.7	17	18
41	FPH	3	259.6	3	234.3	3	258.7	11	12

[00210] Closer examination of these plots reveals that, in most cases, traces of minor peaks associated with PFA and FEP can be found even for the 4-component blends during fusion and remelting, except for Run 31 (Figs 6-7). However, for 4-component blends in general, these minor peaks are very small (and absent in Run 31), indicating that these components have somehow become largely associated with the PTFE present in the blend. As mentioned above, such blends have been found to exhibit exceptional properties as shown in Table 12 above.

[00211] Table 12B summarizes the 4-component blends which yielded desirable properties as derived from the maximum observed values of Norm(Remelt, CA, Gloss, Hard)

Table 12B

Selected 4-Component Fluoropolymer Blends

Run #	LPTFE	FEP	PFA	HPTFE	GLOSS	Contact Angle (CA)	PENCIL	Norm (CA, Gloss, Hard)	Norm (Remelt, CA, Gloss, Hard)
31	0.24	0.08	0.08	0.6	55.1	136.39	4	0.82	0.85
22	0.24	0.18	0.18	0.4	48.4	138.65	2.7	0.76	0.81
23	0.36	0.12	0.12	0.4	44.9	139.02	4.4	0.81	0.79
26	0.4	0	0	0.6	54.5	133.43	0.1	0.62	0.71
30	0.16	0.12	0.12	0.6	51.7	134.05	3	0.73	0.65
21	0.6	0	0	0.4	54.3	134.71	-3	0.5	0.62
20	0.6	0	0	0.4	48.4	135.48	-3	0.48	0.61
3	0.4	0.3	0.3	0	54.2	131.65	3.3	0.73	0.6
4	0.4	0.3	0.3	0	66.7	129.12	3	0.75	0.6
19	0.6	0	0	0.4	52	132.03	-3	0.46	0.59

[00212] From Table 12B it can be seen that the selected 4-component blends contain 16-60% LPTFE, 1-30% FEP, 1-30% PFA and 1-60% HPTFE or, more particularly, 16-60% LPTFE, 8-18% FEP, 8-18% PFA, and 40-60% HPTFE.

[00213] Run 31 is a remarkable combination of high gloss, contact angle and hardness.

Example 3

Coating compositions and application to a flexible substrate, *e.g.*, glasscloth

[00214] In this Example, coating compositions were made of blended fluoropolymers, including HPTFE, LPTFE, and two chemically different MPFs. These coating compositions were coated onto glasscloth over basecoats and/or midcoats, and the resulting coating systems were tested for abrasion resistance, release properties, and other properties in the remaining Examples.

[00215] The formulations of the basecoat and midcoats are set forth in Tables 13A and 13B, respectively, and are expressed as wet weight fractions whereas the topcoat components, set forth in Table 13C, are expressed as dry weight fractions, with one topcoat applied in each coating.

Table 13A

Basecoat Formulations

Coating #	Sub-strate	Grade of Substrate	HPTFE	Water	Solids	# of passes
F(Controls A - D)	Glasscloth	2116	0.5	0.5	30	2
F(1) – F(44)	Glasscloth	2116	0.5	0.5	30	2

Table 13B

Midcoat Formulations

Coating #	HPTFE	Water	Solids	# of passes
F(Controls A-D)	0.92	0.08	50	2
F(1) – F (44)	0.92	0.08	50	2

Table 13C

Topcoat Formulations

Coating #	Base Coat	Mid Coat	HPTFE	PFA	FEP	LPTFE	Gloss	Coating Weight
F(Control A)	PTFE	PTFE	1	0	0	0	20.6	248
F(Control B)	PTFE	PTFE	1	0	0	0	15.8	280
F(Control C)	PTFE	PTFE	0	1	0	0	7.8	307
F(Control D)	PTFE	PTFE	0	0	0	1	18.9	293
F(1)	PTFE	PTFE	0.6	0.08	0.08	0.24	41.98	295
F(2)	PTFE	PTFE	0.4	0.18	0.18	0.24	31.29	291
F(3)	PTFE	PTFE	0.4	0.12	0.12	0.36	25.63	291
F(4)	PTFE	PTFE	0.6	0.12	0.12	0.16	44.08	290
F(5)	PTFE	PTFE	0.74	0.04	0.18	0.04	44.23	290
F(6)	PTFE	PTFE	0.662	0.118	0.18	0.04	39	290
F(7)	PTFE	PTFE	0.6	0.217	0.063	0.12	38.18	289
F(8)	PTFE	PTFE	0.84	0.1	0.02	0.04	41.38	292
F(9)	PTFE	PTFE	0.84	0.04	0.02	0.1	42.82	291
F(10)	PTFE	PTFE	0.701	0.122	0.137	0.04	41.83	289
F(11)	PTFE	PTFE	0.6	0.04	0.13	0.23	40.35	289
F(12)	PTFE	PTFE	0.749	0.191	0.02	0.04	42.9	290
F(13)	PTFE	PTFE	0.64	0.04	0.02	0.3	42.38	289
F(14)	PTFE	PTFE	0.666	0.04	0.07	0.224	43.05	290
F(15)	PTFE	PTFE	0.699	0.04	0.136	0.124	45.95	290
F(16)	PTFE	PTFE	0.675	0.115	0.02	0.19	44.22	294
F(17)	PTFE	PTFE	0.674	0.214	0.072	0.04	44.83	294
F(18)	PTFE	PTFE	0.77	0.04	0.075	0.115	46.43	298
F(19)	PTFE	PTFE	0.6	0.162	0.02	0.218	42.8	294
F(20)	PTFE	PTFE	0.6	0.04	0.18	0.18	45.25	297
F(21)	PTFE	PTFE	0.6	0.106	0.067	0.227	44.22	294
F(22)	PTFE	PTFE	0.84	0.04	0.02	0.1	49.42	292
F(23)	PTFE	PTFE	0.668	0.196	0.02	0.116	46.42	297
F(24)	PTFE	PTFE	0.6	0.08	0.02	0.3	42.02	297
F(25)	PTFE	PTFE	0.748	0.115	0.02	0.117	48.28	299
F(26)	PTFE	PTFE	0.6	0.28	0.02	0.1	43.7	298
F(27)	PTFE	PTFE	0.66	0.04	0.18	0.12	46.57	300
F(28)	PTFE	PTFE	0.84	0.04	0.08	0.04	52.08	299
F(29)	PTFE	PTFE	0.707	0.04	0.02	0.233	42.33	296
F(30)	PTFE	PTFE	0.774	0.113	0.073	0.04	49.92	293
F(31)	PTFE	PTFE	0.84	0.04	0.08	0.04	51.55	295
F(32)	PTFE	PTFE	0.765	0.04	0.02	0.175	47.65	295
F(33)	PTFE	PTFE	0.6	0.18	0.18	0.04	46.37	296
F(34)	PTFE	PTFE	0.6	0.28	0.08	0.04	46.38	296

Coating #	Base Coat	Mid Coat	HPTFE	PFA	FEP	LPTFE	Gloss	Coating Weight
F(35)	PTFE	PTFE	0.66	0.28	0.02	0.04	47.98	292
F(36)	PTFE	PTFE	0.74	0.04	0.18	0.04	50.82	296
F(37)	PTFE	PTFE	0.6	0.134	0.134	0.132	43.42	295
F(38)	PTFE	PTFE	0.64	0.04	0.02	0.3	41.92	293
F(39)	PTFE	PTFE	0.6	0.216	0.144	0.04	47.12	295
F(40)	PTFE	PTFE	0.6	0.107	0.18	0.113	45.02	298
F(41)	PTFE	PTFE	0.6	0.28	0.08	0.04	44.5	298
F(42)	PTFE	PTFE	0.84	0.1	0.02	0.04	51.17	298
F(43)	PTFE	PTFE	0.66	0.28	0.02	0.04	46.58	300
F(44)	PTFE	PTFE	0.6	0.04	0.06	0.3	39.9	301

[00216] The fluoropolymer components of the Topcoats were as follows:

[00217] PTFE (HPTFE) – Daikin D310, solids = 60%.

[00218] PFA - du Pont PFA TE7224, Lot# 0804330005, Solids = 58.6%).

[00219] FEP - du Pont FEP TE9568, solids = 54.0%).

[00220] LPTFE - SFN-D, Chenguang, except that topcoat F(45) was made with Dyneon 9207 TF PTFE micropowder.

[00221] All of the coating compositions were mixed using a standard mixer under medium shear for 5–7 minutes. All mixed coatings were applied to glasscloth in the laboratory using draw down bars. The glasscloth substrate grades are set forth in Table 12A above, produced by PD Interglas or Porcher Industries. The coated substrate is subjected to a flash off in a laboratory box oven set at 260°C (500°F) for 2 minutes followed by curing in a laboratory box oven set at 400°C (752°F) for 2 minutes.

[00222] F(Control)A was a standard product produced using conventional PTFE dispersions by AFC (Advanced Flexible Composites) and no modifications or further coatings were applied to this sample. The basecoat, midcoat and PTFE of the topcoat of the control samples were all standard PTFE dispersions. F(Control B, C and D) were standard products produced using conventional PTFE dispersions by AFC (Advanced Flexible Composites) with one additional topcoat as detailed in Table 13C.

Example 3A

Determination of roughness, gloss, and contact angle

[00223] In this Example, roughness, gloss, and contact angle of the coatings were determined. The test protocols are as follows.

[00224] Roughness. A stylus type surface roughness detector equipped with an analyzer that provides a tracing of the surface was used according to EN ISO 13565, such as the following: Mitutoyo Surftest 402 surface roughness detector and analyzer, available from Mitutoyo Canada, 2121 Meadowvale Blvd, Mississauga, Toronto, Ontario, ON L5N 5N1, and Perthometer M2P / M3P / M4P surface roughness detector and analyzer (Mahr GmbH – Carl-Mahr-Str.1, D-37073 Göttingen, Germany). These instruments measure Ra (arithmetic mean deviation of the roughness profile, measured in microns) and Pc (peak count). The procedure is as follows. First, prepare the sample to be measured. Due to the configuration of most detectors this may require cutting the sample to obtain a flat surface accessible to the detector. Set the detector roughness range to the level just higher than the expected roughness to be measured. Set the length of trace, scale magnification and measurement units (English or metric). Calibrate the detector according to the manufacturer's instructions using a known reference standard. In the same manner, measure the roughness of the sample surface. Make at least 6 measurements.

[00225] Gloss. Gloss measurements were attained using a Miniglossmeter 110V 20°-60°, available from Sheen Instruments, at an angle of 60°. The gloss meter conformed to the following standards: BS3900/D5, DIN EN ISO 2813, DIN 67530, EN ISO 7668, ASTM D523, ASTM D1455, ASTM C346, ASTM C584, ASTM D2457, JIS Z 8741, MFT 30064, TAPPI T 480. Units of measurement are expressed as % reflectance.

[00226] Contact Angle. Contact angle was measured for a water droplet and is expressed in degrees, as determined according to ASTM D7334-08 using the "Drop Shape Analysis" system (DSA10), available from Kruss GmbH of Hamburg, Germany, according to the Young Relation.

[00227] The results are set forth in Table 14 below:

Table 14

Roughness, Gloss and Contact Angle

Formula	RA	Gloss	CA- Water
F(Control A)	2.42	20.6	.
F(Control B)	1.37	15.8	.
F(Control C)	2.79	7.8	
F(Control D)	0.77	18.9	
F(1)	0.7	41.98	
F(2)	0.58	31.29	
F(3)	0.6	25.63	
F(4)	0.48	44.08	
F(5)	0.47	44.23	
F(6)	0.49	39	104.88
F(7)	0.41	38.18	100.86
F(8)	0.45	41.38	104.93
F(9)	0.54	42.82	105.4
F(10)	0.48	41.83	101.97
F(11)	0.52	40.35	107.71
F(12)	0.5	42.9	106.71
F(13)	0.5	42.38	104.11
F(14)	0.53	43.05	104.69
F(15)	0.51	45.95	104.3
F(16)	0.49	44.22	104.26
F(17)	0.63	44.83	103.27
F(18)	0.52	46.43	107.57
F(19)	0.48	42.8	107.5
F(20)	0.51	45.25	103.38
F(21)	0.54	44.22	104.75
F(22)	0.66	49.42	105.36
F(23)	0.64	46.42	104.82
F(24)	0.63	42.02	107.07
F(25)	0.56	48.28	104.85
F(26)	0.49	43.7	102.88
F(27)	0.65	46.57	105.8
F(28)	0.4	52.08	113.81
F(29)	0.54	42.33	106.04
F(30)	0.48	49.92	112.42
F(31)	0.52	51.55	103.38
F(32)	0.44	47.65	106.37
F(33)	0.45	46.37	109.3
F(34)	0.55	46.38	109.54
F(35)	0.51	47.98	109.49
F(36)	0.45	50.82	108.84

Formula	RA	Gloss	CA- Water
F(37)	0.49	43.42	106.58
F(38)	0.47	41.92	110.26
F(39)	0.54	47.12	107.65
F(40)	0.6	45.02	108.77
F(41)	0.61	44.5	107.11
F(42)	0.44	51.17	113.48
F(43)	0.5	46.58	111.26
F(44)	0.49	39.9	108.15

[00228] The results in Table 14 above show a significant improvement in smoothness, an increase in gloss, and an increase in the contact angle of water over the control topcoats for coating compositions made in accordance with the first and second embodiments of the present invention when applied to flexible glass substrates.

Example 3B

Reciprocating abrasion test

[00229] A reciprocating abrasion test (RAT) was conducted on each coating under the test protocol set forth at the end of this Example. The results are set forth in Table 15 below:

Table 15

Reciprocating abrasion test (RAT)

Formula	RAT Ambient initial	RAT ambient 10%
F(Control A)	2000	4000
F(Control B)	2000	5000
F(Control C)	9000	14000
F(Control D)	5000	11000
F(1)	9000	13000
F(2)	10000	15000
F(3)	6000	11000
F(4)	6000	9000
F(5)	5000	10000
F(6)	6000	9000
F(7)	8000	12000
F(8)	16000	20000
F(9)	7000	11000

Formula	RAT Ambient initial	RAT ambient 10%
F(10)	12000	17000
F(11)	12000	17000
F(12)	5000	8000
F(13)	10000	14000
F(14)	4000	9000
F(15)	17000	22000
F(16)	6000	10000
F(17)	8000	15000
F(18)	6000	8000
F(19)	5000	9000
F(20)	8000	10000
F(21)	5000	8000
F(22)	4000	8000
F(23)	8000	17000
F(24)	6000	11000
F(25)	6000	11000
F(26)	6000	9000
F(27)	13000	16000
F(28)	9000	19000
F(29)	6000	11000
F(30)	7000	12000
F(31)	3000	8000
F(32)	6000	11000
F(33)	5000	10000
F(34)	8000	13000
F(35)	15000	22000
F(36)	10000	14000
F(37)	10000	17000
F(38)	3000	5000
F(39)	3000	6000
F(40)	3000	6000
F(41)	6000	9000
F(42)	9000	11000
F(43)	14000	20000
F(44)	4000	10000

[00230] The results in the table above show that there is up to 300% improvement in linear abrasion resistance over the control topcoat A with the topcoats made in accordance with the first and second embodiments of the present invention when applied to flexible glass substrates.

Reciprocating abrasion rest (RAT).

[00231] The reciprocating abrasion test was conducted based on the complete protocol set forth below with the following modifications: (1) the coated sample were tested until 10% exposure of substrate; (2) the test was performed using a 3kg weight at ambient temperature; and (3) the Scotchbrite 3M (7447) pads were changed every 1000 cycles.

[00232] The complete test protocol is as follows:

[00233] Scope. This test measures the resistance of coatings to abrasion by a reciprocating Scotch-Brite pad. The test subjects coating abrasion in a back and forth motion. The test is a measure of the useful life of coatings that have been subjected to scouring and other similar forms of damage caused by cleaning. TM 135C is specific to a test apparatus built by Whitford Corporation of West Chester, PA. However, it is applicable to similar test methods such as the one described in British Standard 7069-1988.

[00234] Equipment and Materials.

[00235] (1) A test machine capable of holding a Scotch-Brite abrasive pad of a specific size to the surface to be tested with a fixed force and capable of moving the pad in a back and forth (reciprocating) motion over a distance to 10 - 15 cm (4 to 6 inches). The force and motion are applied by a free falling, weighted stylus. The machine must be equipped with a counter, preferably one that may be set to shut off after a given number of cycles.

[00236] (2) Scotch-Brite pads of required abrasiveness cut to required size. Scotch-Brite pads are made by 3M Company, Abrasive Systems Division, St Paul, MN 55144-1000. Pads come in grades with varying levels of abrasiveness as follows:

Lowest --7445, **7448**, 6448, **7447**, 6444, **7446**, 7440, 5440 -- Highest

[00237] Scotch-Brite pads may be used at temperatures up to 150°C (300°F). Equivalent pads may be used.

[00238] (3) Hot plate to heat test specimens. (Optional)

[00239] (4) Detergent solution or oil for performing test in with a liquid. (Optional)

[00240] Procedure.

[00241] Before beginning the test, the end point must be defined. Usually, the end point is defined when some amount of substrate has been exposed. However, the end point may be defined as a given number of strokes even if substrate is not exposed. The present

inventors use a 10% exposure of substrate over the abraded area as the standard definition of end point. Other end points may be used.

[00242] Secure the part to be tested under the reciprocating pad. The part must be firmly fastened with bolts, clamps or tape. The part should be as flat as possible and long enough so that the pad does not run off an edge. Bumps in the surface will wear first, and overrunning an edge can tear the pad and cause premature scratching and a false result.

[00243] Cut a piece of Scotch Brite of required abrasiveness to the exact size of the "foot" of the stylus. The present inventors use Grade 7447 as standard, and the "foot" of the stylus on the test machine is 5 cm (2 inches) in diameter. Attach the pad to the bottom of the "foot." The Scotch-Brite pad is fixed to the "foot" by means of a piece of "Velcro" glued to the bottom of the foot.

[00244] If the machine has an adjustable stroke length, set the required length. The present inventors use a 10 cm (4 inch) stroke length as standard. Lower the pad onto the surface of the piece to be tested. Make sure that the weight is completely free. The present inventors used a 3.0 Kg weight as standard, but this can be varied.

[00245] If the machine is equipped with a counter, set the counter to the required number of strokes. One stroke is a motion in one direction. If the machine does not have an automatic counter, the counter must be watched so that the machine can be turned off at the proper time. The machine is stopped at various intervals to change the abrasive pad. The abrasiveness of the pad changes (usually becomes less effective) as the pad fills with debris. The present inventors changed pads at intervals of 1,000 strokes. One thousand strokes is the preferred interval between pad changes.

[00246] Start the test machine. Allow to run until an end point is reached or until a required number of strokes are attained before changing the pad.

[00247] Inspect the test piece carefully at the beginning and end of each start up. As the end point is approached, the substrate will begin to show through the coating. When close to the end point, observe the test piece constantly. Stop the machine when the end point has been reached.

[00248] Evaluation.

[00249] Record the following for the test machine:

[00250] 1. Grade and size of Scotch-Brite pad.

[00251] 2. Load on stylus

[00252] 3. Number of strokes between pad changes.

[00253] 4. Length of stroke.

[00254] 5. Definition of end point.

[00255] 6. Number of strokes to end point.

[00256] Duplicate tests provide greater reliability. Indicate if end point is a single result or the average of several results.

[00257] Record the description of the coating, the film thickness, and the substrate and surface preparation.

[00258] If the test is conducted to a specific number of strokes, record the number of strokes. Record a description of the amount of wear, such as percent of substrate exposed, or number of strokes to first substrate exposure. Optionally, record the film thickness and/or weight before and after testing.

[00259] If the test is performed at elevated temperature, record the temperature of the test. If performed with a liquid, record the specifics of the liquid.

[00260] Comments/Precautions.

[00261] Both sides of a Scotch-Brite pad may be used. Pads must be cut precisely to fit the "foot." Ragged edges or rough spots on the pad will give false results. Test pieces must be flat and free from dirt or other particles. This test method is similar to the abrasion test described in BS 7069:1988, Appendix A1. When tested according to BS 7069, test pieces are immersed in 50 cm^3 of a 5 g/liter solution of household dish washing detergent in water. The test runs for 250 cycles with pads changed every 50 cycles.

Example 3C

Taber reciprocating abrasion test

[00262] A Taber reciprocating abrasion test was conducted according to ASTM D3389 under the following conditions: (1) the test was completed on a Taber 5135 Abraser using the weight loss method; (2) resilient Calibrase wheels H-18 were used with a 250 g load on each abraser arm, and the wheels were resurfaced every 1000 cycles; and (3) the Taber Wear Index was calculated as:

$$TWI = Wt(loss)\ mg / \#\ of\ cycles$$

[00263] Taber tests generally involve mounting a specimen (typically less than 12.5 mm thickness) to a turntable platform that rotates at a fixed speed. Two abrasive wheels, which are applied at a specific pressure, are lowered onto the specimen surface. As the turntable rotates, the wheels are driven by the sample in opposite directions about a horizontal axis displaced tangentially from the axis of the sample. One abrading wheel rubs the specimen outward toward the periphery and the other, inward toward the centre while a vacuum system removes loose debris during testing.

[00264] The results are set forth in Table 16 below:

Table 16

Taber reciprocating abrasion test

Formula	TWI 1000	TWI 2000	TWI 3000
F(Control A)	21	20	23
F(Control B)	11	10.5	10
F(Control C)	16	13.5	12.3
F(Control D)	27	20	18.3
F(1)	11	16.5	15.3
F(2)	8	15.5	16.3
F(3)	10	15.5	17.3
F(4)	20	23.5	19.3
F(5)	48	41.3	39
F(6)	33	48	47.1
F(7)	41	42.5	53.1
F(8)	23	29.5	28.7
F(9)	15	12.5	15.3
F(10)	26	28	31.3
F(11)	24	25	27
F(12)	50	27	24.3
F(13)	19	28	36
F(14)	20	23	30
F(15)	29	46.5	38.3
F(16)	24	26	35.3
F(17)	24	28	40.7
F(18)	25	23	32.7
F(19)	20	23	29.7
F(20)	23	22.5	29.7
F(21)	25	24	34
F(22)	30	20	26.3
F(23)	18	17	26.7

Formula	TWI 1000	TWI 2000	TWI 3000
F(24)	20	16.5	28.7
F(25)	23	16.5	28
F(26)	16	16	27
F(27)	17	19.5	29.7
F(28)	37	22	27
F(29)	36	20	26.7
F(30)	46	24.5	30
F(31)	31	19.5	28
F(32)	138	107	.
F(33)	24	26	27.7
F(34)	13	21	24.7
F(35)	11	20.5	18
F(36)	39	24	24.3
F(37)	49	28	22
F(38)	15	25	24
F(39)	15	23	22
F(40)	15	22.5	20.3
F(41)	23	24.5	20
F(42)	25	27	24.7
F(43)	32	27	25
F(44)	31	34	30.7

[00265] The results in Table 16 above show that there is a reduction in the Taber Wear Index with the topcoats made in accordance with the first and second embodiments of the present invention when applied to flexible glass substrates, indicating an improvement in cross directional abrasion resistance over the control topcoats.

Example 3D

Cooking release tests

[00266] Cooking release tests were conducted in accordance with the protocols below for cookie dough, pizza dough, chicken leg, and egg. The results were graded from 1–5 (1-cannot remove, 5-excellent release with no residue and no staining).

[00267] Cookie dough. Small round piece (approximately 5cm diameter) of dough placed centrally on coated substrate and cooked for 12 mins at 160°C, allowed to cool for 5 mins. Release evaluated including ease of release, residue and staining.

[00268] Pizza Dough. Small round piece (approximately 5cm diameter) of dough placed centrally on coated substrate and cooked for 12 mins at 160°C, allowed to cool for 5 mins. Release evaluated including ease of release, residue and staining.

[00269] Chicken Leg. One chicken leg placed centrally on coated substrate and cooked for 30 mins at 225°C, allowed to cool for 5 mins. Release evaluated including ease of release, residue and staining.

[00270] The results are set forth in Table 17 below:

Table 17

Cooking Release Tests

Formula	Release Cookie	Release Pizza	Release Chicken
F(Control A)	3	3	2
F(Control B)	3	3	2
F(Control C)	3	3	3
F(Control D)	3	3	3
F(1)	4	4	3
F(2)	3	3	3
F(3)	3	3	3
F(4)	5	5	4
F(5)	4	5	4
F(6)	5	5	5
F(7)	5	5	5
F(8)	4	5	4
F(9)	4	4	4
F(10)	4	5	4
F(11)	5	5	5
F(12)	4	5	4
F(13)	5	5	5
F(14)	5	5	5
F(15)	4	4	3
F(16)	4	4	4
F(17)	5	5	4
F(18)	4	5	4
F(19)	4	5	4
F(20)	3	3	3
F(21)	4	4	3
F(22)	3	4	3

Formula	Release Cookie	Release Pizza	Release Chicken
F(23)	3	4	3
F(24)	3	4	3
F(25)	3	3	2
F(26)	4	5	5
F(27)	3	4	4
F(28)	4	5	4
F(29)	5	5	5
F(30)	5	5	5
F(31)	3	3	2
F(32)	4	4	4
F(33)	3	4	3
F(34)	3	3	3
F(35)	4	5	5
F(36)	3	4	4
F(37)	3	3	3
F(38)	4	4	4
F(39)	4	4	3
F(40)	4	4	4
F(41)	3	4	3
F(42)	4	4	4
F(43)	4	3	3
F(44)	4	4	4

[00271] The results in the table above show that there is an improvement in the release, reduction in staining, and ease of cleaning characteristics for all types of food tested over the control topcoats with the topcoats made in accordance with the first and second embodiments of the present invention when applied to flexible glass substrates.

Example 3E

Light Transmission Test

[00272] A light transmission test was conducted using a TES 1334 light meter, available from TES Electronic Corp. of Taipei, Taiwan. Units of measurement are lux (lx).

[00273] Samples were secured on a frame 2 inches in front of a light box and the peak reading was measured. Light transmission is expressed as a percent (%) obtained by dividing the measured lx value for a coated sample by the measured lx value for an uncoated sample.

[00274] The results are set forth in Table 18 below:

Table 18

Light Transmission Test

Formula	Reading - LUX
F(Control A)	1.47
F(Control B)	0.31
F(Control C)	1.41
F(Control D)	1.97
F(1)	1.85
F(2)	1.88
F(3)	2.03
F(4)	1.98
F(5)	2.44
F(6)	1.64
F(7)	1.94
F(8)	1.85
F(9)	1.92
F(10)	1.78
F(11)	2.04
F(12)	1.97
F(13)	2.07
F(14)	2.12
F(15)	2.64
F(16)	1.78
F(17)	2.03
F(18)	2.74
F(19)	2.28
F(20)	1.99
F(21)	2.08
F(22)	1.92
F(23)	1.78
F(24)	1.97
F(25)	2.05
F(26)	1.99
F(27)	2.15
F(28)	2.14
F(29)	1.91
F(30)	2.12
F(31)	1.84
F(32)	2.09
F(33)	1.84
F(34)	2.21
F(35)	2.04
F(36)	2.51

Formula	Reading - LUX
F(37)	2.13
F(38)	2.24
F(39)	1.92
F(40)	1.89
F(41)	2.01
F(42)	2.16
F(43)	1.88
F(44)	2.32

[00275] Table 18 shows that there is an increase in light transmission versus the control topcoats with the topcoats made in accordance with the first and second embodiments of the present invention when applied to flexible glass substrates.

Example 3F

Adhesion test

[00276] Adhesion tests were conducted under the following conditions: (1) the test was completed on a Lloyd LRX Tensometer; (2) Samples 25mm wide, 200mm in length are prepared by sealing 2 strips of fabric with PFA film (temperature 375°C, 25 seconds).

[00277] The test is conducted at a speed of 100mm/min for a distance of 25mm. An average reading of 3 measurements are quoted, and the units of measurement are lbs/f.

[00278] The results are set forth in Table 19 below:

Table 19

Adhesion test

Formula	Instantaneous Force (lbf)	Kinetic Force (lbf)
F(Control A)	4.32	2.29
F(Control B)	5.93	4.77
F(Control C)	5.09	4.23
F(Control D)	4.48	4.32
F(1)	.	.
F(2)	.	.
F(3)	6.05	2.81
F(4)	5.07	2.26
F(5)	5.34	4.75
F(6)	5.17	3.72
F(7)	5.21	3.68

Formula	Instantaneous Force (lbf)	Kinetic Force (lbf)
F(8)	4.61	4.63
F(9)	5.49	2.38
F(10)	5.17	2.78
F(11)	5.57	4.87
F(12)	3.51	3.53
F(13)	4.85	4.69
F(14)	5.15	4.96
F(15)	5.25	4.44
F(16)	3.53	3.96
F(17)	2.96	3.32
F(18)	3.03	5.64
F(19)	5.03	3.91
F(20)	2.44	4.11
F(21)	3.21	1.69
F(22)	5.21	3.2
F(23)	4.47	4.6
F(24)	6.02	4.13
F(25)	5.57	3.07
F(26)	4.79	4.19
F(27)	3.51	3.64
F(28)	3.42	3.74
F(29)	3.33	2.74
F(30)	2.65	4.03
F(31)	5.23	2.96
F(32)	4.91	5.2
F(33)	5.51	1.68
F(34)	4.74	4.12
F(35)	2.32	2.45
F(36)	3.31	4.02
F(37)	5.43	3.23
F(38)	5.79	5.48
F(39)	5.46	3.1
F(40)	3.03	3.14
F(41)	4.38	5.13
F(42)	4.5	4.19
F(43)	4.06	3.61
F(44)	4.03	2.65

[00279] The results in Table 19 show that the adhesion properties of the control topcoats are either maintained or show a slight improvement in the present coating

compositions when applied to flexible glass substrates, indicating that the addition of the coating compositions does not interfere with the adhesion of the coating to the substrate.

[00280] Finally Table 20 summarizes the 10 compositions which yielded desirable overall properties as glasscloth topcoats they are ordered from best to worst, the four controls are also listed; they have significantly worse overall properties.

Table 20

Selected 4-Component Glasscloth Coating Topcoat Formulations with Desirable Properties

Run #	HPTFE	PFA	FEP	LPTFE	Norm abrasion	norm release	norm surface properties	Reading - LUX	norm adhesion	norm all
F(11)	0.6	0.04	0.13	0.23	0.74	1	0.74	2.04	0.84	0.83
F(13)	0.64	0.04	0.02	0.3	0.64	1	0.66	2.07	0.72	0.76
F(14)	0.666	0.04	0.07	0.224	0.55	1	0.68	2.12	0.79	0.75
F(4)	0.6	0.12	0.12	0.16	0.62	1	0.89	1.98	0.44	0.74
F(8)	0.84	0.1	0.02	0.04	0.82	0.75	0.68	1.85	0.68	0.73
F(5)	0.74	0.04	0.18	0.04	0.45	0.75	0.9	2.44	0.79	0.72
F(28)	0.84	0.04	0.08	0.04	0.71	0.75	1	2.14	0.41	0.72
F(30)	0.774	0.113	0.073	0.04	0.58	1	0.94	2.12	0.34	0.71
F(38)	0.64	0.04	0.02	0.3	0.52	0.5	0.82	2.24	0.94	0.7
F(1)	0.6	0.08	0.08	0.24	0.75	0.5	0.82	1.85		0.69
F(Control C)	0	0	0	1	0.63	0.17	0.55	1.97	0.62	0.49
F(Control B)	1	0	0	0	0.61	0	0.39	0.31	0.87	0.47
F(Control D)	0	1	0	0	0.78	0.17	0	1.41	0.69	0.41
F(Control A)	1	0	0	0	0.51	0	0.22	1.47	0.35	0.27

[00281] From Table 20 it is apparent that these selected 4-Component Fluropolymer blends for glasscloth coating contain 60-84% HPTFE, 4-12% PFA, 2-18% FEP and 4-30% LPFFE yield the most desirable properties.

Example 4

Multiple component blends with engineering resins

[00282] In this example, coil topcoats were made and applied over conventional coil base coatings ("basecoats") to rigid substrates in the form of ECCS (Hi-Top Steel) panels.

Topcoats formulated in accordance with the present invention were evaluated against control topcoats.

[00283] A. Description of the basecoat.

[00284] It is well known in the art that the solvent based systems of polyether sulphone can be prepared by the dissolution of a granular PES polymer, such as RADEL A-704P, available from Advanced Polymers LLC in an NMP/solvent blend. The PES solution can then be formulated into a basecoat by the addition of various compositions.

[00285] The topcoat formulations were coated onto one of four basecoats (Basecoat A, Basecoat B, Basecoat C or Basecoat D), which were prepared as described above and formulated as set further in Table 21 below.

Table 21

Basecoat formulations

COMPONENT	BASECOAT A	BASECOAT B	BASECOAT C	BASECOAT D
	%	%	%	%
RESIN	15	15	14	1.8
SOLVENT	66	67	74	98.2
ADDITIVES	16	14	4	0
PTFE	3	4	8	0

[00286] Test samples were prepared by drawing down Basecoat A, Basecoat B and Basecoat C onto pre-cleaned ECCS (Hi-Top Steel) panels, followed by heating in an oven at 400oC for 30 seconds. Basecoat D was applied onto a cleaned rubber substrate through a spray application and left to air dry for 1 minute.

[00287] Topcoats E(control)1 through E(control)11, E1-E17, E19, E21-E51, E62, E64, E66-E75, E101 and E133 were applied over Basecoat A, Topcoats E18, E20, E76-E100, E102-E116, E131-E132 were applied over Basecoat B, Topcoats E52-E61, E63, E65, E117-E130, E134 and E135 over basecoat C, and Topcoats E136 and E137 were applied over Basecoat D.

[00288] B. Application of Topcoats.

[00289] Topcoats formulated as described below were applied to the test samples by drawing down with relevant K Bar (draw down bar). Typically, the coated panels were then cured for 90 seconds in an oven at 420°C. As applied, the dry film thickness (DFT) of the

basecoat was approximately 6 microns, and that of the topcoats were approximately 6 microns.

[00290] Example topcoats were made using combinations of fluoropolymer dispersions and a topcoat base. The fluoropolymer components of the topcoats included one or more of the following: one or more high molecular weight PTFE (HPTFE) dispersions, one or more melt processible fluoropolymer dispersions (MPF), and one or more low molecular weight PTFE (LPTFE) dispersions.

[00291] As defined in this Example, a "4-component" blend contains all of the following components as described above: at least one HPTFE, at least one LPTFE, and at least two chemically different MPFs. In this Example, the two MPFs employed are FEP and PFA. The blends in this Example were made by mixing aqueous dispersions of the components, and adding to a formulated "topcoat base" containing the engineering resin. The resulting "formulations" were then drawn down or sprayed as films, as indicated in Table 24 below, over a basecoat and tested for gloss, surface roughness, steak release, chicken release and stain resistance.

[00292] The formula for the topcoat base, used in each topcoat formulations of the present Example, is set forth below in Table 22:

Table 22

Topcoat Base

Component	Weight %
Engineering resin	38.00
Deionized water	30.00
Monoetheylene glycol	30.00
TX-100	1.4
Foam Blast	0.6

[00293] Per Table 23 below, a first set of topcoats, designated Topcoats "E Control 1" through "E Control 11", were formulated as controls using a Topcoat base and each fluoropolymer in dispersion form, as produced by dispersion polymerization or emulsion polymerization and which was not thereafter not agglomerated, irradiated, or thermally degraded. Additionally, both LPTFE dispersions and LPTFE micropowders have been evaluated. A second set of topcoats, designated Topcoats E1through E137 below, were

formulated as above using the Topcoat base described above and fluoropolymer dispersion blends formulated as set forth in Table 23 below.

Table 23

Topcoat Blends

ID	EN. POLYMER	POLYMER SOLID %	HPTFE SOLIDS	PFA SOLIDS	FEP SOLIDS	LPTFE SOLIDS	SFN-D SOLIDS	9205 Dyneon PTFE
EControl1	PES	32.90	7.63	0.00	0.00	0.00	0.00	0.00
EControl2	PES	32.90	0.00	7.63	0.00	0.00	0.00	0.00
EControl3	PES	32.90	0.00	0.00	7.63	0.00	0.00	0.00
EControl4	PES	32.90	0.00	0.00	0.00	7.63	0.00	0.00
EControl5	PES	32.90	0.00	0.00	0.00	0.00	0.00	7.63
EControl6	PES	32.90	0.00	0.00	0.00	0.00	7.63	0.00
EControl7	PES	32.90	0.00	0.00	0.00	0.00	7.63	0.00
EControl8	PES	35.62	0.00	0.00	0.00	0.00	0.00	0.00
EControl9	PES	32.90	4.62	0.92	0.84	0.00	0.00	1.22
EControl10	PEEK	36.81	0.00	0.00	0.00	0.00	0.00	0.00
EControl11	PAI	34.72	0.00	0.00	0.00	0.00	0.00	0.00
E1	PPS	26.59	3.59	0.20	0.00	0.20	0.00	0.00
E2	PPS	26.59	3.59	0.20	0.00	0.20	0.00	0.00
E3	PPS	27.21	2.45	0.14	0.00	0.14	0.00	0.00
E4	PPS	27.21	2.45	0.14	0.00	0.14	0.00	0.00
E5	PPS	27.21	2.18	0.27	0.00	0.27	0.00	0.00
E6	PPS	27.21	2.18	0.27	0.00	0.27	0.00	0.00
E7	PPS	26.54	3.59	0.20	0.00	0.20	0.00	0.00
E8	PPS	26.59	3.59	0.20	0.00	0.20	0.00	0.00
E9	PPS	26.59	3.20	0.40	0.00	0.40	0.00	0.00
E10	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E11	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E12	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E13	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E14	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E15	PPS	29.98	3.56	0.44	0.00	0.44	0.00	0.00
E16	PPS	27.63	3.29	0.41	0.00	0.41	0.00	0.00
E17	PPS	27.63	3.29	0.41	0.00	0.41	0.00	0.00
E18	PPS	27.63	3.29	0.41	0.00	0.41	0.00	0.00
E19	PPS	27.63	3.29	0.41	0.00	0.41	0.00	0.00
E20	PPS	27.63	3.29	0.41	0.00	0.41	0.00	0.00
E21	PPS	29.19	3.47	0.43	0.00	0.43	0.00	0.00
E22	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E23	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00

ID	EN. POLYMER	POLYMER SOLID %	HPTFE SOLIDS	PFA SOLIDS	FEP SOLIDS	LPTFE SOLIDS	SFN-D SOLIDS	9205 Dyneon PTFE
E24	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E25	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E26	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E27	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E28	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E29	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E30	PPS	29.98	3.57	0.45	0.00	0.45	0.00	0.00
E31	PPS	29.98	3.57	0.45	0.00	0.45	0.00	0.00
E32	PPS	29.98	3.57	0.45	0.00	0.45	0.00	0.00
E33	PPS	29.98	3.57	0.45	0.00	0.45	0.00	0.00
E34	PPS	29.98	3.57	0.45	0.00	0.45	0.00	0.00
E35	PPS	29.98	3.57	0.45	0.00	0.45	0.00	0.00
E36	PPS	29.98	3.57	0.45	0.00	0.45	0.00	0.00
E37	PPS	29.98	3.57	0.45	0.00	0.45	0.00	0.00
E38	PPS	29.98	3.57	0.45	0.00	0.45	0.00	0.00
E39	PPS	29.98	3.57	0.45	0.00	0.45	0.00	0.00
E40	PPS	29.98	3.57	0.45	0.00	0.45	0.00	0.00
E41	PPS	29.98	3.57	0.45	0.00	0.45	0.00	0.00
E42	PPS	29.98	3.57	0.45	0.00	0.45	0.00	0.00
E43	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E44	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E45	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E46	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E47	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E48	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E49	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E50	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E51	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E52	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E53	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E54	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E55	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E56	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E57	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E58	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E59	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E60	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E61	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E62	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E63	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00

ID	EN. POLYMER	POLYMER SOLID %	HPTFE SOLIDS	PFA SOLIDS	FEP SOLIDS	LPTFE SOLIDS	SFN-D SOLIDS	9205 Dyneon PTFE
E64	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E65	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E66	PPS	28.99	3.45	0.43	0.00	0.43	0.00	0.00
E67	PPS	28.24	3.45	0.43	0.00	0.43	0.00	0.00
E68	PPS	26.35	6.44	0.81	0.00	0.81	0.00	0.00
E69	PPS	28.10	3.43	0.43	0.00	0.43	0.00	0.00
E70	PPS	28.10	3.43	0.43	0.00	0.43	0.00	0.00
E71	PPS	28.10	3.43	0.43	0.00	0.43	0.00	0.00
E72	PPS	28.10	3.43	0.43	0.00	0.43	0.00	0.00
E73	PPS	28.85	1.37	0.17	0.00	0.17	0.00	4.29
E74	PPS	30.26	3.70	0.46	0.00	0.46	0.00	0.00
E75	PPS	29.97	1.85	0.23	0.00	0.23	0.00	0.00
E76	PES	32.90	3.66	0.46	0.00	0.46	0.00	0.00
E77	PES	32.71	3.64	0.45	0.00	0.45	0.00	0.00
E78	PES	32.39	3.61	0.45	0.00	0.45	0.00	0.00
E79	PES	32.74	3.64	0.45	0.00	0.45	0.00	0.00
E80	PES	34.09	3.79	0.47	0.00	0.47	0.00	0.00
E81	PES	33.88	3.77	0.47	0.00	0.47	0.00	0.00
E82	PES	33.55	3.73	0.46	0.00	0.46	0.00	0.00
E83	PES	33.92	3.78	0.47	0.00	0.47	0.00	0.00
E84	PES	32.90	3.66	0.46	0.00	0.46	0.00	0.00
E85	PES	33.52	3.73	0.46	0.00	0.46	0.00	0.00
E86	PES	33.52	3.73	0.46	0.00	0.46	0.00	0.00
E87	PES	32.09	5.62	0.70	0.00	0.70	0.00	0.00
E88	PES	32.09	5.62	0.70	0.00	0.70	0.00	0.00
E89	PES	28.97	5.07	0.63	0.00	0.63	0.00	0.00
E90	PES	29.36	5.14	0.64	0.00	0.64	0.00	0.00
E91	PES	29.36	3.86	0.51	0.46	1.54	0.00	0.00
E92	PES	29.36	2.57	1.16	1.04	1.54	0.00	0.00
E93	PES	29.36	2.57	0.77	0.69	2.31	0.00	0.00
E94	PES	31.59	1.75	0.52	0.47	1.57	0.00	0.00
E95	PES	33.61	1.87	0.56	0.51	1.69	0.00	0.00
E96	PES	33.61	2.80	0.56	0.50	0.75	0.00	0.00
E97	PES	33.30	1.85	0.56	0.50	1.67	0.00	0.00
E98	PES	33.30	2.78	0.55	0.50	0.74	0.00	0.00
E99	PES	33.38	2.79	0.56	0.50	0.74	0.00	0.00
E100	PES	33.71	2.81	0.56	0.51	0.75	0.00	0.00
E101	PES	33.71	2.81	0.56	0.51	0.75	0.00	0.00
E102	PEEK	33.92	2.83	0.56	0.51	0.76	0.00	0.00
E103	PEEK	33.92	2.83	0.56	0.51	0.76	0.00	0.00

ID	EN. POLYMER	POLYMER SOLID %	HPTFE SOLIDS	PFA SOLIDS	FEP SOLIDS	LPTFE SOLIDS	SFN-D SOLIDS	9205 Dyneon PTFE
E104	PPS	28.99	2.59	0.52	0.46	0.69	0.00	0.00
E105	PPS	28.99	2.59	0.52	0.46	0.69	0.00	0.00
E106	PPS	30.77	2.75	0.55	0.50	0.73	0.00	0.00
E107	PPS	30.77	2.75	0.55	0.50	0.73	0.00	0.00
E108	PPS	32.90	2.75	0.55	0.50	0.73	0.00	0.00
E109	PPS	32.90	1.83	0.55	0.50	1.65	0.00	0.00
E110	PPS	28.99	1.73	0.52	0.46	1.55	0.00	0.00
E111	PPS	28.99	1.73	0.52	0.46	1.55	0.00	0.00
E112	PPS	30.77	1.83	0.55	0.50	1.65	0.00	0.00
E113	PPS	30.77	1.83	0.55	0.50	1.65	0.00	0.00
E114	PEEK	33.92	1.89	0.57	0.51	1.70	0.00	0.00
E115	PAI	57.60	1.89	0.57	0.51	1.70	0.00	0.00
E116	PAI	57.60	2.83	0.56	0.51	0.76	0.00	0.00
E117	PAI	62.52	0.00	0.00	0.00	0.00	0.00	0.00
E118	PES	33.37	2.78	0.55	0.50	0.74	0.00	0.00
E119	PES	31.43	2.62	0.52	0.47	0.70	0.00	0.00
E120	PES	32.37	2.70	0.54	0.48	0.72	0.00	0.00
E121	PES	32.37	2.70	0.54	0.48	0.72	0.00	0.00
E122	PES	34.02	3.40	0.62	0.56	0.57	0.00	0.00
E123	PES	32.72	2.73	0.54	0.49	0.73	0.00	0.00
E124	PES	32.03	2.78	0.55	0.50	0.74	0.00	0.00
E125	PES	32.03	3.11	0.62	0.56	0.82	0.00	0.00
E126	PES	32.30	2.83	0.56	0.51	0.76	0.00	0.00
E127	PES	32.07	3.09	0.61	0.55	0.82	0.00	0.00
E128	PES	31.75	3.06	0.61	0.55	0.81	0.00	0.00
E129	PES	32.07	3.09	0.61	0.55	0.82	0.00	0.00
E130	PES	31.92	3.07	0.61	0.55	0.81	0.00	0.00
E131	PAI	32.03	2.78	0.55	0.50	0.00	0.00	0.00
E132	PAI	33.37	2.78	0.55	0.50	0.00	0.00	0.00
E133	PES	31.36	2.72	0.54	0.49	0.00	0.00	0.00
E134	PES	30.70	2.66	0.53	0.48	0.00	0.00	0.00
E135	PES	30.31	2.32	0.46	0.41	0.00	0.00	0.00
E136	FKM	0.00	4.93	0.62	0.00	0.62	0.00	0.00
E137	FKM	0.00	3.70	0.74	0.66	0.98	0.00	0.00

[00294] The fluoropolymer components of the Topcoats were as follows:

[00295] PTFE (HPTFE) - Daikin D310 (solids = 60%).

[00296] PFA - du Pont PFA TE7224 (Lot# 0804330005, solids = 58.6%).

[00297] FEP - du Pont FEP TE9568 (solids = 54.0%).

[00298] LPTFE - DuPont TE3887N (solids = 55%, except that topcoats E(control)6 and E(control)7 were made with SFN-D, Chenguang (solids = 25%) and topcoat E(control)5, E(control)9 and F73 was made with Dyneon 9205 PTFE micropowder).

[00299] Although not set forth in Table 23 above, Topcoat E75 additionally included 3.57 wt.% TF-1750, a granular HPTFE available from Dyneon LLC.

[00300] Test samples were prepared using the engineering polymer ratios and fluoropolymer dispersion blends as set forth above in Table 23, and were coated over the respective basecoat using the given cure schedules as given in Table 24 below. The topcoats E(control)1 through E(control)11 and E1-E135 were then "quenched" by passing the panel under a flowing tap of cold water until the panel is fully cooled to room temperature. The topcoats using E136 and E137 were spray applied, cured as per the coating schedule given in Table 24 below and allowed to cool to room temperature without any water quench.

Table 24

Preparation of test samples

ID	BASE COAT	K Bar B/C	K Bar T/C	Cure temp (oC)	T/C cure time (s)
EControl1	A	K4	K4	420	90
EControl2	A	K4	K4	420	90
EControl3	A	K4	K4	420	90
EControl4	A	K4	K4	420	90
EControl5	A	K4	K4	420	90
EControl6	A	K4	K4	420	90
EControl7	A	K4	K4	420	90
EControl8	A	K4	K4	420	90
EControl9	A	K4	K4	420	90
EControl10	A	K4	K4	420	90
EControl11	A	K4	K4	420	90
E1	A	K4	K4	420	90
E2	A	K4	K4	400	90
E3	A	K4	K4	400	90
E4	A	K4	K4	420	90
E5	A	K4	K4	400	90
E6	A	K4	K4	400	90
E7	A	K4	K4	400	90
E8	A	K4	K4	420	90

ID	BASE COAT	K Bar B/C	K Bar T/C	Cure temp (oC)	T/C cure time (s)
E9	A	K4	K4	420	90
E10	A	K4	K5?	420	90
E11	A	K4	K4	420	90
E12	A	K4	K4	420	120
E13	A	K4	K5	420	90
E14	A	K4	K5	420	120
E15	A	K4	K5?	420	90
E16	A	K4	K4	420	90
E17	A	K4	K4	420	90
E18	B	K4	K4	420	90
E19	A	K4	K4	420	90
E20	B	K4	K4	420	90
E21	A	K4	K4	420	90
E22	A	K4	K4	420	90
E23	A	K4	K4	420	120
E24	A	K4	K4	420	90
E25	A	K4	K4	420	120
E26	A	K4	K4	420	90
E27	A	K4	K4	420	120
E28	A	K4	K5	420	90
E29	A	K4	K5	420	120
E30	A	K4	K2	420	90
E31	A	K4	K2	420	120
E32	A	K4	K2	420	180
E33	A	K4	K3	420	90
E34	A	K4	K3	420	120
E35	A	K4	K3	420	180
E36	A	K4	K4	420	90
E37	A	K4	K4	420	120
E38	A	K4	K4	420	180
E39	A	K4	K5	420	90
E40	A	K4	K5	420	120
E41	A	K4	K5	420	180
E42	A	K4	K4	420	90
E43	A	K4	K2	420	90
E44	A	K4	K2	420	120
E45	A	K4	K2	420	180
E46	A	K4	K3	420	90
E47	A	K4	K3	420	120
E48	A	K4	K3	420	180
E49	A	K4	K4	420	90

ID	BASE COAT	K Bar B/C	K Bar T/C	Cure temp (oC)	T/C cure time (s)
E50	A	K4	K4	420	120
E51	A	K4	K4	420	180
E52	C	K4	K2	420	90
E53	C	K4	K2	420	120
E54	C	K4	K2	420	180
E55	C	K4	K3	420	90
E56	C	K4	K3	420	120
E57	C	K4	K3	420	180
E58	C	K4	K4	420	90
E59	C	K4	K4	420	120
E60	C	K4	K4	420	180
E61	C	K4	K4	420	90
E62	A	K4	K4	420	90
E63	C	K4	K4	420	90
E64	A	K4	K4	420	90
E65	C	K4	K4	420	90
E66	A	K4	K4	420	90
E67	A	K4	K4	420	90
E68	A	K4	K4	420	90
E69	A	K4	K4	420	90
E70	A	K4	K4	420	90
E71	A	K4	K4	420	90
E72	A	K4	K4	420	90
E73	A	K4	K4	420	90
E74	A	K4	K4	420	90
E75	A	K4	K4	420	90
E76	B	K4	K4	420	90
E77	B	K4	K4	420	90
E78	B	K4	K4	420	90
E79	B	K4	K4	420	90
E80	B	K4	K4	420	90
E81	B	K4	K4	420	90
E82	B	K4	K4	420	90
E83	B	K4	K4	420	90
E84	B	K4	K4	420	90
E85	B	K4	K4	420	90
E86	B	K4	K4	420	90
E87	B	K4	K4	420	90
E88	B	K4	K4	420	90
E89	B	K4	K4	420	90
E90	B	K4	K4	420	90

ID	BASE COAT	K Bar B/C	K Bar T/C	Cure temp (oC)	T/C cure time (s)
E91	B	K4	K4	420	90
E92	B	K4	K4	420	90
E93	B	K4	K4	420	90
E94	B	K4	K4	420	90
E95	B	K4	K4	420	90
E96	B	K4	K4	420	90
E97	B	K4	K4	420	90
E98	B	K4	K4	420	90
E99	B	K4	K4	420	90
E100	B	K4	K4	420	90
E101	A	K4	K4	420	90
E102	B	K4	K4	420	90
E103	B	K4	K4	420	90
E104	B	K4	K4	420	90
E105	B	K4	K4	420	90
E106	B	K4	K4	420	90
E107	B	K4	K4	420	90
E108	B	K4	K4	420	90
E109	B	K4	K4	420	90
E110	B	K4	K4	420	90
E111	B	K4	K4	420	90
E112	B	K4	K4	420	90
E113	B	K4	K4	420	90
E114	B	K4	K4	420	90
E115	B	K4	K4	420	90
E116	B	K4	K4	420	90
E117	A	K4	K4	420	90
E118	A	K4	K4	420	90
E119	A	K4	K4	420	90
E120	A	K4	K4	420	90
E121	A	K4	K4	420	90
E122	A	K4	K4	420	90
E123	A	K4	K4	420	90
E124	A	K4	K4	420	90
E125	A	K4	K4	420	90
E126	A	K4	K4	420	90
E127	A	K4	K4	420	90
E128	A	K4	K4	420	90
E129	A	K4	K4	420	90
E130	A	K4	K4	420	90
E131	B	K4	K4	420	90

ID	BASE COAT	K Bar B/C	K Bar T/C	Cure temp (oC)	T/C cure time (s)
E132	B	K4	K4	420	90
E133	A	K4	K4	420	90
E134	B	K4	K4	420	90
E135	B	K4	K4	420	90
E136	D	spray	spray	165	180
E137	D	spray	spray	165	180

Example 4A

Roughness and Gloss

[00301] In this Example, roughness and gloss of the coatings were determined. The test protocols are as follows.

[00302] Roughness. A stylus type surface roughness detector equipped with an analyzer that provides a tracing of the surface was used according to EN ISO 13565, such as the following: Mitutoyo Surftest 402 surface roughness detector and analyzer, available from Mitutoyo Canada, 2121 Meadowvale Blvd, Mississauga, Toronto, Ontaria, ON L5N 5N1, and Perthometer M2P / M3P / M4P surface roughness detector and analyzer (Mahr GmbH - Carl-Mahr-Str.1, D-37073 Göttingen, Germany). These instruments measure Ra (arithmetic mean deviation of the roughness profile, measured in microns) and Pc (peak count). The procedure is as follows. First, prepare the sample to be measured. Due to the configuration of most detectors this may require cutting the sample to obtain a flat surface accessible to the detector. Set the detector roughness range to the level just higher than the expected roughness to be measured. Set the length of trace, scale magnification and measurement units (English or metric). Calibrate the detector according to the manufacturer's instructions using a known reference standard. In the same manner, measure the roughness of the sample surface. Make at least 6 measurements.

[00303] Gloss. Gloss measurements were attained using a Miniglossmeter 110V 20°-60°, available from Sheen Instruments, at an angle of 60°. The gloss meter conformed to the following standards: BS3900/D5, DIN EN ISO 2813, DIN 67530, EN ISO 7668, ASTM D523, ASTM D1455, ASTM C346, ASTM C584, ASTM D2457, JIS Z 8741, MFT 30064, TAPPI T 480. Units of measurement are expressed as % reflectance.

[00304] The results are set forth in Table 25 below:

Table 25

Roughness and Gloss

ID	ENGINEERING POLYMER	Gloss (60°)	Smoothness (R_a mean)
EControl1	PES	2.2	1.25
EControl2	PES	8.2	1
EControl3	PES	12	0.66
EControl4	PES	16.5	0.9
EControl5	PES	8.2	2.6
EControl6	PES	23	1.5
EControl7	PES	5.6	1.84
EControl8	PES	19.7	1.42
EControl9	PES	4.7	1.3
EControl10	PEEK	19.1	2.32
EControl11	PAI	1.6	2.9
E1	PPS	14	2.76
E2	PPS	18	2.53
E3	PPS	42	2.88
E4	PPS	19	2.8
E5	PPS	23	3.12
E6	PPS	22	2.16
E7	PPS	16	2.4
E8	PPS	20	.
E9	PPS	15	3.637
E10	PPS	10	2.1
E11	PPS	13.8	1.16
E12	PPS	12	1.01
E13	PPS	14.1	0.9
E14	PPS	9.8	1.37
E15	PPS	5	2.55
E16	PPS	10.2	2.51
E17	PPS	13.3	2
E18	PPS	12	2.46
E19	PPS	12.2	2.3
E20	PPS	3.7	1.9
E21	PPS	18	4
E22	PPS	11.8	1.16
E23	PPS	13	0.88
E24	PPS	12	1.27
E25	PPS	10.2	1.48
E26	PPS	21	0.74
E27	PPS	19	0.71
E28	PPS	21	0.96
E29	PPS	17	0.9
E30	PPS	7	1.04
E31	PPS	7.7	1.15
E32	PPS	3.3	1.57
E33	PPS	8.9	1.28

ID	ENGINEERING POLYMER	Gloss (60°)	Smoothness (R_a mean)
E34	PPS	10.9	1.06
E35	PPS	10.3	1.2
E36	PPS	10.8	1.22
E37	PPS	15	1.01
E38	PPS	11.5	1.15
E39	PPS	11.1	1.09
E40	PPS	12.6	1.07
E41	PPS	12	1.1
E42	PPS	8.2	1.04
E43	PPS	1.7	1.2
E44	PPS	1.9	1.23
E45	PPS	1.8	1.3
E46	PPS	3.2	1.36
E47	PPS	3.2	1.25
E48	PPS	2.9	1.27
E49	PPS	2.8	1.18
E50	PPS	3.8	1.07
E51	PPS	3.7	1.24
E52	PPS	1.9	1.3
E53	PPS	1.7	1.27
E54	PPS	2.2	1.15
E55	PPS	2.4	1.35
E56	PPS	2.9	1.27
E57	PPS	4	1.372
E58	PPS	4	1.45
E59	PPS	4	1.3
E60	PPS	4.2	1.18
E61	PPS	4.0	1.45
E62	PPS	2.8	1.18
E63	PPS	5.1	2.51
E64	PPS	3.2	2.72
E65	PPS	5.1	2.51
E66	PPS	3.2	2.72
E67	PPS	4	2.65
E68	PPS	1.7	2.82
E69	PPS	4.6	1.04
E70	PPS	5	0.98
E71	PPS	4.2	0.99
E72	PPS	7.5	1.71
E73	PPS	9.3	2.06
E74	PPS	33	1.15
E75	PPS	.	.
E76	PES	3.5	2.37
E77	PES	1.9	2.47
E78	PES	2.6	2.81
E79	PES	2.5	3.62
E80	PES	2	2.23

ID	ENGINEERING POLYMER	Gloss (60°)	Smoothness (R_a mean)
E81	PES	2.7	2.47
E82	PES	2.7	2.33
E83	PES	2.4	2.76
E84	PES	0.8	1.97
E85	PES	4.3	1.89
E86	PES	3.9	1.68
E87	PES	2.5	2.4
E88	PES	2.4	1.59
E89	PES	0.5	1.81
E90	PES	1.7	1.69
E91	PES	2.5	1.86
E92	PES	3	1.9
E93	PES	2.7	2.11
E94	PES	3.8	3.16
E95	PES	4.6	3.178
E96	PES	3.4	3.1
E97	PES	4.2	4.01
E98	PES	6	5.7
E99	PES	3.2	3.76
E100	PES	3.1	2.48
E101	PES	7.8	1.27
E102	PEEK	3	0.67
E103	PEEK	6	overflow
E104	PPS	5.8	0.89
E105	PPS	5.2	1.14
E106	PPS	5	3.09
E107	PPS	7	1.03
E108	PPS	9.8	0.82
E109	PPS	8.9	1.07
E110	PPS	4.6	1.28
E111	PPS	5.5	1.05
E112	PPS	6	0.78
E113	PPS	6	1.108
E114	PEEK	4.1	0.64
E115	PAI	6.6	4.76
E116	PAI	5.5	4.25
E117	PAI	23	overflow
E118	PES	6	4.09
E119	PES	6	1.22
E120	PES	5.9	1.54
E121	PES	5.7	1.37
E122	PES	9.5	2.76
E123	PES	6.6	2.39
E124	PES	5.1	1.89
E125	PES	4.8	1.1
E126	PES	6.3	1.93
E127	PES	6	1.62

ID	ENGINEERING POLYMER	Gloss (60°)	Smoothness (R_a mean)
E128	PES	5.2	1.74
E129	PES	5.5	1.5
E130	PES	6.4	1.35
E131	PAI	0.3	4.78
E132	PAI	0.5	2.54
E133	PES	6.8	0.87
E134	PES	5.2	0.77
E135	PES	4.2	1.6
E136	FKM		
E137	FKM		

Example 4B

Reciprocating abrasion test

[00305] A reciprocating abrasion test (RAT) was conducted on certain of the coatings under the test protocol set forth in Example 3B. The results are set forth in Table 26 below:

Table 26

Reciprocating abrasion test (RAT)

ID	EN. POLYMER	BASE COAT	Abrasion / RAT Cycles
EControl1	PES	A	900
EControl2	PES	A	367
EControl3	PES	A	440
EControl4	PES	A	230
EControl5	PES	A	450
EControl6	PES	A	275
EControl7	PES	A	80
EControl8	PES	A	400
EControl9	PES	A	165
EControl10	PEEK	A	200
EControl11	PAI	A	160
E1	PPS	A	60
E2	PPS	A	110
E3	PPS	A	220
E4	PPS	A	125
E5	PPS	A	220

ID	EN. POLYMER	BASE COAT	Abrasion / RAT Cycles
E6	PPS	A	200
E7	PPS	A	90
E8	PPS	A	60
E9	PPS	A	60
E10	PPS	A	220
E11	PPS	A	180
E12	PPS	A	150
E13	PPS	A	220
E14	PPS	A	200
E15	PPS	A	220
E16	PPS	A	180
E17	PPS	A	180
E18	PPS	B	290
E19	PPS	A	180
E20	PPS	B	3000
E21	PPS	A	330
E22	PPS	A	298
E23	PPS	A	105
E24	PPS	A	298
E25	PPS	A	105
E26	PPS	A	298
E27	PPS	A	105
E28	PPS	A	275
E29	PPS	A	140
E30	PPS	A	165
E31	PPS	A	100
E32	PPS	A	54
E33	PPS	A	194
E34	PPS	A	300
E35	PPS	A	180
E36	PPS	A	335
E37	PPS	A	170
E38	PPS	A	300
E39	PPS	A	356
E40	PPS	A	212
E41	PPS	A	335
E42	PPS	A	180
E43	PPS	A	50

ID	EN. POLYMER	BASE COAT	Abrasion / RAT Cycles
E44	PPS	A	64
E45	PPS	A	61
E46	PPS	A	150
E47	PPS	A	200
E48	PPS	A	100
E49	PPS	A	200
E50	PPS	A	200
E51	PPS	A	150
E52	PPS	C	40000
E53	PPS	C	71000
E54	PPS	C	60000
E55	PPS	C	42000
E56	PPS	C	100000
E57	PPS	C	85000
E58	PPS	C	93000
E59	PPS	C	91000
E60	PPS	C	80000
E61	PPS	C	93000
E62	PPS	A	200
E63	PPS	C	38000
E64	PPS	A	394
E65	PPS	C	38000
E66	PPS	A	394
E67	PPS	A	445
E68	PPS	A	330
E69	PPS	A	620
E70	PPS	A	220
E71	PPS	A	190
E72	PPS	A	90
E73	PPS	A	390
E74	PPS	A	475
E75	PPS	A	.
E76	PES	B	21000
E77	PES	B	7000
E78	PES	B	7000
E79	PES	B	7000
E80	PES	B	7000
E81	PES	B	22000

ID	EN. POLYMER	BASE COAT	Abrasion / RAT Cycles
E82	PES	B	100000
E83	PES	B	33000
E84	PES	B	100000
E85	PES	B	42000
E86	PES	B	33000
E87	PES	B	26000
E88	PES	B	26000
E89	PES	B	17000
E90	PES	B	18000
E91	PES	B	33000
E92	PES	B	28000
E93	PES	B	27000
E94	PES	B	8000
E95	PES	B	36000
E96	PES	B	31000
E97	PES	B	20000
E98	PES	B	20000
E99	PES	B	65000
E100	PES	B	19000
E101	PES	A	570
E102	PEEK	B	19000
E103	PEEK	B	.
E104	PPS	B	14000
E105	PPS	B	25000
E106	PPS	B	25000
E107	PPS	B	26000
E108	PPS	B	19000
E109	PPS	B	25000
E110	PPS	B	25000
E111	PPS	B	38000
E112	PPS	B	3000
E113	PPS	B	40000
E114	PEEK	B	35000
E115	PAI	B	85000
E116	PAI	B	18000
E117	PAI	A	620
E118	PES	A	403
E119	PES	A	370

ID	EN. POLYMER	BASE COAT	Abrasion / RAT Cycles
E120	PES	A	440
E121	PES	A	400
E122	PES	A	350
E123	PES	A	403
E124	PES	A	700
E125	PES	A	370
E126	PES	A	400
E127	PES	A	800
E128	PES	A	320
E129	PES	A	320
E130	PES	A	330
E131	PAI	B	32000
E132	PAI	B	23000
E133	PES	A	450
E134	PES	B	31000
E135	PES	B	27000
E136	FKM	D	.
E137	FKM	D	.

[00306] The results in the table above show that there is improvement in linear abrasion resistance over the control topcoats with the topcoats made in accordance with the first and second embodiments of the present invention.

Example 4C

Cooking release tests

[00307] Cooking release tests were conducted in accordance with the protocols below for chicken leg, and steak. For the chicken leg and steak testing, the results were determined by whether or not the surface of the coating appeared to be clean after washing without containing meat still stuck to the surface. This would then determine the end point of the testing and the number of cycles completed to achieve the end point then recorded.

[00308] Chicken Leg. One chicken leg placed centrally on coated substrate and cooked for 40 mins at 230°C. Clean coated substrate in a warm solution of water and washing up liquid. Dry and evaluate coated surface for signs of meat residues. Signs of meat residues

indicate the endpoint of the testing. The number of cycles of chicken leg cooked to reach endpoint is then recorded, however, 5 cycles of testing are required for a test "pass".

[00309] Steak. Place a piece of raw rump steak visibly free from the fat around the outside of the meat into the sample to be tested (marble does not need removing). Surface area is important and the size of steak being used is approx. 22.5 cm^2 by 12.5 cm^2 to give a surface area of 200cm^2 ± 25 cm^2. The weight of the pieces should be ~0.6kg. Cook for 1 hour at 180°C. Soak coated substrate in 60°C solution of water and washing up liquid for 15 mins. Dry and evaluate coated surface for signs of meat residues. Signs of meat residues and any staining whatsoever indicated the endpoint of the testing. The number of cycles of steak cooked to reach endpoint is then recorded, however, 5 cycles of testing are required for a test "pass".

[00310] The results are set forth in Table 27 below:

Table 27

Cooking release tests

ID	ENGINEERING POLYMER	Steak clean up (Fail = 0, Pass = 1)	Number of Steak Cycles (5 CYCLES IS STANDARD PASS)	Chicken
EControl1	PES	0	2	3
EControl2	PES	0	2	5
EControl3	PES	0	2	4
EControl4	PES	0	4	5
EControl5	PES	1	4	4
EControl6	PES	1	4	5
EControl7	PES	1	4	3
EControl8	PES	0	3	1
EControl9	PES	0	3	3
EControl10	PEEK	0	1	1
EControl11	PAI	0	0	1
E1	PPS	1	2	3
E2	PPS	1	2	2
E3	PPS	0	1	5
E4	PPS	1	2	1
E5	PPS	1	2	2
E6	PPS	0	1	2
E7	PPS	0	1	1
E8	PPS	0	1	3
E9	PPS	0	1	5
E10	PPS	1	20	1
E11	PPS	0	1	1

ID	ENGINEERING POLYMER	Steak clean up (Fail = 0, Pass = 1)	Number of Steak Cycles (5 CYCLES IS STANDARD PASS)	Chicken
E12	PPS	1	3	1
E13	PPS	0	1	0
E14	PPS	0	3	1
E15	PPS	1	2	1
E16	PPS	0	1	1
E17	PPS	1	1	1
E18	PPS	1	1	1
E19	PPS	1	1	1
E20	PPS	0	1	1
E21	PPS	0	1	5
E22	PPS	0	3	5
E23	PPS	0	3	5
E24	PPS	0	3	5
E25	PPS	0	3	5
E26	PPS	0	3	5
E27	PPS	0	3	5
E28	PPS	0	3	3
E29	PPS	0	3	3
E30	PPS	0	1	1
E31	PPS	0	1	1
E32	PPS	0	1	4
E33	PPS	0	1	1
E34	PPS	0	1	1
E35	PPS	0	1	1
E36	PPS	0	1	1
E37	PPS	0	1	1
E38	PPS	0	1	1
E39	PPS	0	1	1
E40	PPS	0	1	1
E41	PPS	0	1	1
E42	PPS	0	5	5
E43	PPS	0	2	5
E44	PPS	0	1	2
E45	PPS	1	5	5
E46	PPS	0	1	5
E47	PPS	0	1	5
E48	PPS	0	1	4
E49	PPS	0	1	5
E50	PPS	0	1	2
E51	PPS	1	5	5
E52	PPS	0	1	5
E53	PPS	0	1	5
E54	PPS	1	5	5
E55	PPS	0	1	5
E56	PPS	1	5	5

ID	ENGINEERING POLYMER	Steak clean up (Fail = 0, Pass = 1)	Number of Steak Cycles (5 CYCLES IS STANDARD PASS)	Chicken
E57	PPS	0	1	5
E58	PPS	0	1	5
E59	PPS	0	1	5
E60	PPS	0	1	5
E61	PPS	0	1	5
E62	PPS	0	1	5
E63	PPS	0	1	1
E64	PPS	0	1	4
E65	PPS	0	1	1
E66	PPS	0	1	4
E67	PPS	0	5	1
E68	PPS	0	5	5
E69	PPS	0	5	5
E70	PPS	0	5	0
E71	PPS	0	5	5
E72	PPS	0	5	5
E73	PPS	1	5	5
E74	PPS	0	1	0
E75	PPS	.	.	.
E76	PES	0	1	1
E77	PES	0	1	5
E78	PES	0	5	5
E79	PES	0	3	1
E80	PES	0	1	2
E81	PES	0	4	5
E82	PES	1	5	5
E83	PES	0	2	2
E84	PES	0	1	5
E85	PES	1	5	5
E86	PES	0	1	2
E87	PES	0	5	5
E88	PES	0	1	2
E89	PES	0	1	1
E90	PES	0	1	5
E91	PES	0	1	5
E92	PES	0	1	3
E93	PES	1	5	5
E94	PES	1	5	3
E95	PES	1	5	2
E96	PES	1	2	5
E97	PES	1	5	5
E98	PES	1	5	0
E99	PES	1	5	5
E100	PES	1	30	2
E101	PES	1	30	5

ID	ENGINEERING POLYMER	Steak clean up (Fail = 0, Pass = 1)	Number of Steak Cycles (5 CYCLES IS STANDARD PASS)	Chicken
E102	PEEK	0	5	5
E103	PEEK	.	.	.
E104	PPS	0	5	5
E105	PPS	0	1	1
E106	PPS	0	1	1
E107	PPS	0	1	1
E108	PPS	0	1	1
E109	PPS	0	1	1
E110	PPS	0	5	5
E111	PPS	0	1	1
E112	PPS	0	1	1
E113	PPS	0	1	3
E114	PEEK	0	5	5
E115	PAI	0	1	1
E116	PAI	0	1	0
E117	PAI	0	1	1
E118	PES	1	5	3
E119	PES	1	1	5
E120	PES	1	1	5
E121	PES	1	1	5
E122	PES	1	1	5
E123	PES	1	1	4
E124	PES	1	1	5
E125	PES	1	1	5
E126	PES	1	1	5
E127	PES	1	1	5
E128	PES	1	1	5
E129	PES	1	1	5
E130	PES	1	1	5
E131	PAI	0	1	1
E132	PAI	0	1	1
E133	PES	1	1	5
E134	PES	0	5	5
E135	PES	0	5	5
E136	FKM			
E137	FKM			

[00311] The results in the table above show that there is an improvement in the release and ease of cleaning characteristics for all types of food tested over the control topcoats with the topcoats made in accordance with the first and second embodiments of the present invention.

Example 4D

Adhesion and 0T bend tests for formable coatings

[00312] In this Example, an adhesion test was conducted in accordance with the procedures described below to determine the adhesion strength of a coating to its substrate by trying to remove the coating with adhesive tape. A 0T bend test was also conducted.

[00313] The procedure for the adhesion test, referred to as "Test 2" below, is as follows, with initial reference to "Test 1" below. For ECCS substratre BOTH Test 2 and 0T must pass.

Test 1

[00314] 1. Scope.

[00315] This procedure is to be used to determine the adhesion of a coating to its substrate by trying to remove the coating with adhesive tape.

[00316] 2. Equipment and Materials.

[00317] 2.1. Metal ruler divided in millimetres or special template with appropriate spacing of cuts.

[00318] 2.2. Single edge razor blade, scalpel, knife or other cutting instrument with a fine, sharp edge.

[00319] 2.3. As an alternative to 2.1 and 2.2, a multi-bladed cutting tool with the proper blade spacing may be used.

[00320] 2.4. Adhesive tape, such as 3M Scotch Brand No. 897 Strapping Tape or No. 898 Filament tape or its equivalent.

[00321] 2.5. Low power (3 - 5X) magnifying glass.

[00322] 3. Procedure.

[00323] 3.1. Lay the test piece on a flat firm surface.

[00324] 3.2. With the metal rule, mark off eleven (11) spaces separated by the required distance. This may be 1, 1.5 or 2 mm. Markings may be made by nicking the coating with the cutting tool.

[00325] 3.3. Hold the ruler or other metal straight edge firmly on the test piece at the first marking. Scribe a line 2 to 4 cm long with the cutting tool. Continue making cuts for the remaining marks. The cuts should be evenly spaced and parallel to one another. The cuts should penetrate the coating completely through to the substrate, but should not gouge the substrate.

[00326] 3.4. Rotate the test piece 90°, and repeat steps 3.2 and 3.3, making a second set of cuts perpendicular to and superimposed on the first set of cuts. The completed cuts will form a grid of 100 squares with sides of the required dimension. Brush away any flakes or ribbons of the coating from the grid.

[00327] 3.5. If a multi-bladed cutting tool is used, steps 3.2, 3.3 and 3.4 can be eliminated. Use the multi-bladed cutting tool to produce the grid as required. Make sure that the cuts are clean and completely through to the substrate.

[00328] 3.6. Cut a 15 cm length of adhesive tape. Apply the tape over the grid. Press down firmly. A rubber eraser may be used to rub the tape to remove air pockets and ensure a good bond.

[00329] 3.7. Within 90 ± 30 seconds of application, remove the tape by grasping one end and pulling rapidly at a peeling angle of 180°. Pull rapidly but do not jerk.

[00330] 3.8. Repeat steps 3.6 and 3.7 over the same grid for the required number of times. Usually 5 pulls are used.

[00331] 4. Evaluation.

[00332] 4.1. Inspect the grid with the magnifying glass for removal of the coating from the substrate. In the case of a multicoat system or in the case of a recoatability test, inspect the grid for removal of one coat from another.

[00333] 4.2. Report the amount of coating remaining on the grid, e.g., 100% means no coating removed. Typically this is reported as number of squares remaining compared to number of squares produced. For perfect adhesion over 100 squares, the rating would be 100/100. Note any adhesion failures to the substrate or between coats.

[00334] 5. Precautions.

[00335] 5.1. Inspect the cutting tool before each test. Dress the tool with fine abrasive paper or a sharpening stone, if needed. Replace multibladed tools or single edged tools when they become too badly damaged to use.

[00336] 6. References.

[00337] 6.1. ASTM D-3359 Method B, Measuring Adhesion by Tape Test

[00338] 6.2. DIN 53 151

[00339] 6.3. JIS K 5400 - Section 6.15 Cross Cut Adhesion

[00340] 6.4. BS EN 24624 : 1992

Test 2

[00341] 1. Scope.

[00342] 1.1. This procedure measures the adhesion of coatings to a substrate by the cross hatch and indent adhesion method after exposure to boiling water. This method is an extension of Test 1 above. It is applicable to formable coatings.

[00343] 2. Equipment and Materials.

[00344] 2.1. Container large enough to hold test items, normally coated sheet metal, with a lid to cover the container after inserting the items.

[00345] 2.2. Electric hot plate or gas burner stove.

[00346] 2.3. Timer.

[00347] 2.4. Water (deionised water is preferred, but not required).

[00348] 2.5. Cloth or paper towels.

[00349] 2.6. Falling weight/Impact tester or Erikson tester (a press which produces a hemisphirical protrusion in the panel).

[00350] 2.7. Other equipment and materials required as per Test 1.

[00351] 3. Procedure.

[00352] 3.1. Fill container with sufficient water to cover most of the article to be tested. Place container on stove or hot plate and bring to the boil. Reduce heat to maintain a constant simmer. Keep covered.

[00353] 3.2. Immerse article in the boiling water. Set timer for required time. The usual time is fifteen (15) minutes unless otherwise specified.

[00354] 3.3. Remove article after the required time. Dry immediately with paper towel.

[00355] 3.4. Scribe a crosshatch pattern on the article to be tested according to the procedure outlined in Test 1.

[00356] 3.5. Apply reverse impact or Erikson to rear of article directly behind crosshatch.

[00357] 3.6. Apply tape to crosshatch area and check adhesion as described in Test 1.

[00358] 4. Evaluation.

[00359] 4.1. Evaluate and report as describe in Test 1.

[00360] 5. Precautions/Comments.

[00361] 5.1. Conduct initial tape test by Test 1 within 5 minutes of removal from water.

[00362] 5.2. If a series of tests are being conducted, maintain a constant water level. Also, replace water periodically to avoid a build up of salts or other debris, especially if using tap water.

[00363] 6. References.

[00364] 6.1. BS 7069 : 1988

[00365] 6.2. BS 3900 Part E3

0T Bend test

[00366] The procedure for the 0T bent test is as follows.

[00367] 1. Scope.

[00368] 1.1 This procedure is used to determine the adhesion and flexibility of coatings when subjected to a 180o bend.

[00369] 2. Equipment and Materials.

[00370] 2.1 A five inch bench vise permanently mounted to work table or metal brake form machine.

[00371] 2.2 Scotch #160 Transparent tape 3/4" wide, or equivalent.

[00372] 3. Procedure.

[00373] 3.1 Prepare test panels using agreed upon substrate and following the application recommendations for the coating. Alternately, cut panels from production coated metal. Panels should be 2" to 3" wide by length necessary to make the test.

[00374] 3.2 Insert one end of the panel 1/2 inch into the vise. Bend the panel to 90o with coating on outside of bend. Remove from vise and bend to greater than 90o by hand. Reinsert into vise and compress until flat. This is a zero "T" bend. Use the same procedure for each successive "T" bend. One thickness to be 1 "T", two thicknesses to be 2 "T", etc. Apply the tape firmly over the entire length of the bend.

[00375] 3.3 Remove the tape with a single rapid pull. Repeat with fresh tape for the number of pulls specified.

[00376] 4. Evaluation.

[00377] 4.1 Examine each "T" bend visually before applying tape. Report lowest "T" bend at which no cracking of the coating is visible.

[00378] 4.2 Examine each "T" bend visually after taping. Report lowest "T" bend at which no coating is removed.

[00379] 5. Comments/Precautions.

[00380] 5.1 Avoid scratching of the coating when crimping panel in the vise. If necessary, protect the coating with paper while bending.

[00381] 5.2 Results may vary depending upon the direction of the bend in relation to the grain of the metal (across grain or with grain).

[00382] 5.3 Coatings become more flexible with increasing temperature. Specify temperature at which bend is to be made.

[00383] 5.4 Hard, high temper metals will fracture when bent 180°. The "T" bend test cannot be run on these metals.

[00384] 6. References.

[00385] 6.1 ASTM D3794-79 Section 9.5.5

[00386] The results are set forth in Table 28 below:

Table 28

Adhesion and 0T bend tests

ID	ENGINEERING POLYMER	0T Bend Test (PASS = 1, FAIL = 0)	Adhesion Test 2 (crosshatch tape peel) (PASS = 1, FAIL = 0)	% Fluoropolymer solids
EControl1	PES	0	0	7.63
EControl2	PES	1	1	7.63
EControl3	PES	1	1	7.63
EControl4	PES	1	1	7.63
EControl5	PES	1	1	7.63
EControl6	PES	1	1	7.63
EControl7	PES	1	1	7.63
EControl8	PES	1	1	0
EControl9	PES	1	1	7.63
EControl10	PEEK	1	1	0
EControl11	PAI	1	1	0
E1	PPS	1	1	3.99
E2	PPS	1	1	3.99
E3	PPS	1	1	2.73
E4	PPS	1	1	2.73
E5	PPS	1	1	2.73
E6	PPS	1	1	2.73
E7	PPS	1	1	3.98
E8	PPS	1	1	3.99
E9	PPS	1	1	4
E10	PPS	1	1	4.31
E11	PPS	1	1	4.31

ID	ENGINEERING POLYMER	0T Bend Test (PASS = 1, FAIL = 0)	Adhesion Test 2 (crosshatch tape peel) (PASS = 1, FAIL = 0)	% Fluoropolymer solids
E12	PPS	1	1	4.31
E13	PPS	1	1	4.31
E14	PPS	1	1	4.31
E15	PPS	1	1	4.45
E16	PPS	1	1	4.12
E17	PPS	1	1	4.12
E18	PPS	1	1	4.12
E19	PPS	1	1	4.12
E20	PPS	1	1	4.12
E21	PPS	1	1	4.34
E22	PPS	1	1	4.31
E23	PPS	1	1	4.31
E24	PPS	1	1	4.31
E25	PPS	1	1	4.31
E26	PPS	1	1	4.31
E27	PPS	1	1	4.31
E28	PPS	1	1	4.31
E29	PPS	1	1	4.31
E30	PPS	0	0	4.46
E31	PPS	0	0	4.46
E32	PPS	0	0	4.46
E33	PPS	1	1	4.46
E34	PPS	0	0	4.46
E35	PPS	0	0	4.46
E36	PPS	0	1	4.46
E37	PPS	1	1	4.46
E38	PPS	0	0	4.46
E39	PPS	0	0	4.46
E40	PPS	0	1	4.46
E41	PPS	0	0	4.46
E42	PPS	1	1	4.46
E43	PPS	0	0	4.31
E44	PPS	0	0	4.31
E45	PPS	0	0	4.31
E46	PPS	0	1	4.31
E47	PPS	0	0	4.31
E48	PPS	0	0	4.31
E49	PPS	0	0	4.31
E50	PPS	0	0	4.31
E51	PPS	0	0	4.31
E52	PPS	1	1	4.31
E53	PPS	1	1	4.31
E54	PPS			4.31
E55	PPS	1	1	4.31

ID	ENGINEERING POLYMER	0T Bend Test (PASS = 1, FAIL = 0)	Adhesion Test 2 (crosshatch tape peel) (PASS = 1, FAIL = 0)	% Fluoropolymer solids
E56	PPS	1	1	4.31
E57	PPS	0	1	4.31
E58	PPS	1	1	4.31
E59	PPS	0	1	4.31
E60	PPS	0	1	4.31
E61	PPS	1	1	4.31
E62	PPS	0	0	4.31
E63	PPS	1	1	4.31
E64	PPS	1	1	4.31
E65	PPS	1	1	4.31
E66	PPS	1	1	4.31
E67	PPS	0	0	4.31
E68	PPS	1	0	8.05
E69	PPS	1	1	4.29
E70	PPS	1	1	4.29
E71	PPS	0	0	4.29
E72	PPS	0	1	4.29
E73	PPS	0	1	6.01
E74	PPS	0	1	4.62
E75	PPS			5.88
E76	PES	0	1	4.57
E77	PES	1	1	4.55
E78	PES	1	1	4.5
E79	PES	1	1	4.55
E80	PES	1	1	4.74
E81	PES	1	1	4.71
E82	PES	1	1	4.66
E83	PES	1	1	4.72
E84	PES	1	1	4.57
E85	PES	1	1	4.66
E86	PES	1	1	4.66
E87	PES	1	1	7.02
E88	PES	1	1	7.02
E89	PES	1	1	6.34
E90	PES	1	1	6.43
E91	PES	1	1	6.37
E92	PES	1	1	6.31
E93	PES	1	1	6.35
E94	PES	1	1	4.31
E95	PES	1	1	4.63
E96	PES	1	1	4.61
E97	PES	1	1	4.59
E98	PES	1	1	4.57
E99	PES	1	1	4.59

ID	ENGINEERING POLYMER	0T Bend Test (PASS = 1, FAIL = 0)	Adhesion Test 2 (crosshatch tape peel) (PASS = 1, FAIL = 0)	% Fluoropolymer solids
E100	PES	1	1	4.64
E101	PES	1	1	4.64
E102	PEEK	1	1	4.65
E103	PEEK			4.65
E104	PPS	0	0	4.26
E105	PPS	0	1	4.26
E106	PPS	1	0	4.53
E107	PPS	0	0	4.53
E108	PPS	1	1	4.53
E109	PPS	1	1	4.53
E110	PPS	1	0	4.26
E111	PPS	1	1	4.26
E112	PPS	0	1	4.53
E113	PPS	1	1	4.53
E114	PEEK	1	1	4.67
E115	PAI	1	1	4.67
E116	PAI	1	1	4.65
E117	PAI	0	0	0
E118	PES	1	1	4.58
E119	PES	1	1	4.31
E120	PES	1	1	4.44
E121	PES	1	1	4.44
E122	PES	1	1	5.16
E123	PES	1	1	4.49
E124	PES	1	1	4.58
E125	PES	1	1	5.11
E126	PES	1	1	4.66
E127	PES	1	1	5.07
E128	PES	1	1	5.02
E129	PES	1	1	5.07
E130	PES	1	1	5.04
E131	PAI	1	1	3.83
E132	PAI	1	1	3.83
E133	PES	1	1	3.75
E134	PES	1	1	3.67
E135	PES	1	1	3.2
E136	FKM			6.16
E137	FKM			6.08

[00387] The results in Table 28 show that the adhesion properties of the control topcoats are either maintained or show a slight improvement in the present coating compositions, indicating that the addition of the coating compositions at the tested percentage solids of fluoropolymers does not interfere with the adhesion of the coating to the substrate

when the topcoats have been made in accordance with the first and second embodiments of the present invention.

[00388] Nomalized properties are used to combine the results of several tests and determine selected formulations which are set out in Table 29. Normalized data are calculated as follows:

[00389] NORM SURFACE = Mean((Col Maximum(:Ra) - :Ra) / (Col Maximum(:Ra) - Col Minimum(:Ra)),(("Gloss (60o)") - Col Minimum(("Gloss (60o)"))) / (Col Maximum(("Gloss (60o)")) - Col Minimum(("Gloss (60o)")))

[00390] NORM (RAT, CHICK, STEAK) = Mean((("Number of Steak Cycles (5 CYCLES IS STANDARD PASS)") -Col Minimum(("Number of Steak Cycles (5 CYCLES IS STANDARD PASS)"))) /(Col Maximum(("Number of Steak Cycles (5 CYCLES IS STANDARD PASS)")) -Col Minimum(("Number of Steak Cycles (5 CYCLES IS STANDARD PASS)"))),(:Chicken - Col Minimum(:Chicken)) / (Col Maximum(:Chicken) -Col Minimum(:Chicken)),(:RAT - Col Minimum(:RAT)) / (Col Maximum(:RAT) - Col Minimum(:RAT)))

[00391] NORM ENG ALL = Mean((("Number of Steak Cycles (5 CYCLES IS STANDARD PASS)") -Col Minimum(("Number of Steak Cycles (5 CYCLES IS STANDARD PASS)"))) /(Col Maximum(("Number of Steak Cycles (5 CYCLES IS STANDARD PASS)")) -Col Minimum(("Number of Steak Cycles (5 CYCLES IS STANDARD PASS)"))),(:Chicken - Col Minimum(:Chicken)) / (Col Maximum(:Chicken) -Col Minimum(:Chicken)),(:RAT - Col Minimum(:RAT)) / (Col Maximum(:RAT) - Col Minimum(:RAT)), ((Col Maximum(:Ra) - :Ra) / (Col Maximum(:Ra) - Col Minimum(:Ra)),(("Gloss (60o)") - Col Minimum(("Gloss (60o)"))) / (Col Maximum(("Gloss (60o)")) - Col Minimum(("Gloss (60o)")))

Table 29

Selected Coating Formulations for Topcoats on Rigid Substrates

ID	POLYMER SOLID %	%HPTFE	%PFA	%FEP	%LPTFE	norm Surface	norm all eng	norm RAT Chick Steak
E56	28.99	0.8	0.1	0	0.1	0.47	0.62	0.71
E101	33.71	0.61	0.12	0.11	0.16	0.53	0.61	0.67
E59	28.99	0.8	0.1	0	0.1	0.48	0.57	0.64
E82	33.55	0.8	0.1	0	0.1	0.36	0.57	0.71
E58	28.99	0.8	0.1	0	0.1	0.46	0.57	0.64

ID	POLYMER SOLID %	%HPTFE	%PFA	%FEP	%LPTFE	norm Surface	norm all eng	norm RAT Chick Steak
E57	28.99	0.8	0.1	0	0.1	0.47	0.56	0.62
E60	28.99	0.8	0.1	0	0.1	0.49	0.56	0.6
E84	32.9	0.8	0.1	0	0.1	0.37	0.55	0.67
E53	28.99	0.8	0.1	0	0.1	0.45	0.52	0.57
E114	33.92	0.4	0.12	0.11	0.36	0.55	0.52	0.5
EControl6	32.9	0	0	0	1	0.69	0.5	0.37
EControl4	32.9	0	0	0	1	0.67	0.49	0.37
EControl2	32.9	0	1	0	0	0.56	0.43	0.35
EControl5	32.9	0	0	0	1	0.4	0.43	0.45
EControl3	32.9	0	0	1	0	0.64	0.42	0.28
EControl9	32.9	0.52	0.1	0.1	0.28	0.49	0.33	0.22
EControl7	32.9	0	0	0	1	0.44	0.32	0.23
EControl1	32.9	1	0	0	0	0.46	0.31	0.21

[00392] As can be seen from Table 29, the 3-Component formula 80% HPTFE, 10% PFA and 10% LPTFE yields desirable properties. In addition the 4-Component formula with 40-61% HPTFE, 12% PFA 11% FEP and 16-36% LPTFE also delivers desirable properties.

[00393] Even ignoring RAT performance, the best performing formulations are as listed above.

[00394] While this invention has been described as having a preferred design, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.

WHAT IS CLAIMED IS:

1. A fluoropolymer composition, comprising:

at least one low molecular weight polytetrafluoroethylene (LPTFE) having a first melt temperature (T_m) of 335° C or less; and

at least two melt processible fluoropolymers, comprising:

a first melt-processible fluoropolymer (MPF); and

a second melt-processible fluoropolymer (MPF), said second melt-processible fluoropolymer (MPF) chemically different from said first melt-processible fluoropolymer (MPF).

2. The fluoropolymer composition of Claim 1, wherein said composition lacks high molecular weight polytetrafluoroethylene (HLPTFE) having a number average molecular weight (M_n) of at least 500,000.

3. The fluoropolymer composition of Claim 2, wherein said at least one LPTFE is present in an amount of between 10 wt.% and 70 wt.%, and said at least two MPFs are together present in an amount of between 30 wt.% and 90 wt.%, based on the total solids weight of said at least one LPTFE and said at least two MPFs.

4. The fluoropolymer composition of Claim 2, wherein said at least one LPTFE is present in an amount of between 40 wt.% and 60 wt.%, and said at least two MPFs are together present in an amount of between 40 wt.% and 60 wt.%, based on the total solids weight of said at least one LPTFE and said at least two MPFs.

5. The fluoropolymer composition of Claim 1, wherein said composition further comprises at least one high molecular weight polytetrafluoroethylene (HPTFE) having a number average molecular weight (M_n) of at least 500,000.

6. The fluoropolymer composition of Claim 5, wherein said at least one HPTFE is present in an amount of between 1 wt.% and 89 wt.%, based on the total solids weight of said at least one HPTFE, said at least one LPTFE, and said at least two MPFs.

7. The fluoropolymer composition of Claim 5, wherein said at least one LPTFE is present in an amount of between 16 wt.% and 60 wt.%, said HPTFE is present in an amount of between 1 wt.% and 60 wt.%, and said at least two MPFs are together present in an amount of between 1 wt.% and 60 wt.%, based on the total solids weight of said at least one HPTFE, said at least one LPTFE, and said at least two MPFs.

8. The fluoropolymer composition of Claim 7, wherein said at least two MPFs are each present in an amount of between 1 wt.% and 30 wt.%, based on the total solids weight of said at least one HPTFE, said at least one LPTFE, and said at least two MPFs.

9. The fluoropolymer composition of Claim 1, wherein said at least one LPTFE has a first melt temperature (T_m) selected from the group consisting of 332° C or less, 330° C or less, 329° C or less, 328° C or less, 327° C or less, 326° C or less, and 325° C or less.

10. The fluoropolymer composition of Claim 1, wherein said at least one LPTFE is obtained via emulsion polymerization without being subjected to agglomeration, thermal degradation, or irradiation.

11. The fluoropolymer composition of Claim 1, wherein said composition is in the form of an aqueous dispersion.

12. A coating applied to a substrate, said coating comprising the fluoropolymer composition of Claim 1.

13. A method of coating a substrate, said method comprising the steps of:

providing a substrate;

applying a coating composition to the substrate, the coating composition comprising:

at least one low molecular weight polytetrafluoroethylene (LPTFE) having a first melt temperature (T_m) of 335° C or less; and

at least two melt processible fluoropolymers, comprising:

a first melt-processible fluoropolymer (MPF); and

a second melt-processible fluoropolymer (MPF), the second

melt-processible fluoropolymer (MPF) chemically different from the first melt-processible fluoropolymer (MPF); and

curing the composition to form a coating.

14. The method of Claim 13, further comprising the additional steps, prior to said applying a coating composition step, of:

applying a primer to the substrate, the primer including at least one fluoropolymer; and

optionally, at least partially curing the primer.

15. The method of Claim 14, further comprising the additional steps, following said applying a primer step and prior to said applying a coating composition step, of:

applying a midcoat to the substrate, the midcoat including at least one fluoropolymer; and

optionally, at least partially curing the midcoat.

16. The method of Claim 13, wherein the coating composition lacks high molecular weight polytetrafluoroethylene (HLPTFE) having a number average molecular weight (M_n) of at least 500,000.

17. The method of Claim 16, wherein the at least one LPTFE is present in an amount of between 10 wt.% and 70 wt.%, and the at least two MPFs are together present in an amount of between 30 wt.% and 90 wt.%, based on the total solids weight of the at least one LPTFE and the at least two MPFs in the coating composition.

18. The method of Claim 13, wherein the coating composition further comprises at least one high molecular weight polytetrafluoroethylene (HPTFE) having a number average molecular weight (M_n) of at least 500,000.

19. The method of Claim 18, wherein the at least one HPTFE is present in an amount of between 1 wt.% and 89 wt.%, based on the total solids weight of the at least one HPTFE, the at least one LPTFE, and the at least two MPFs in the coating composition.

20. The method of Claim 13, wherein the substrate is selected from the group consisting of:

a rigid substrate; and

a flexible substrate.

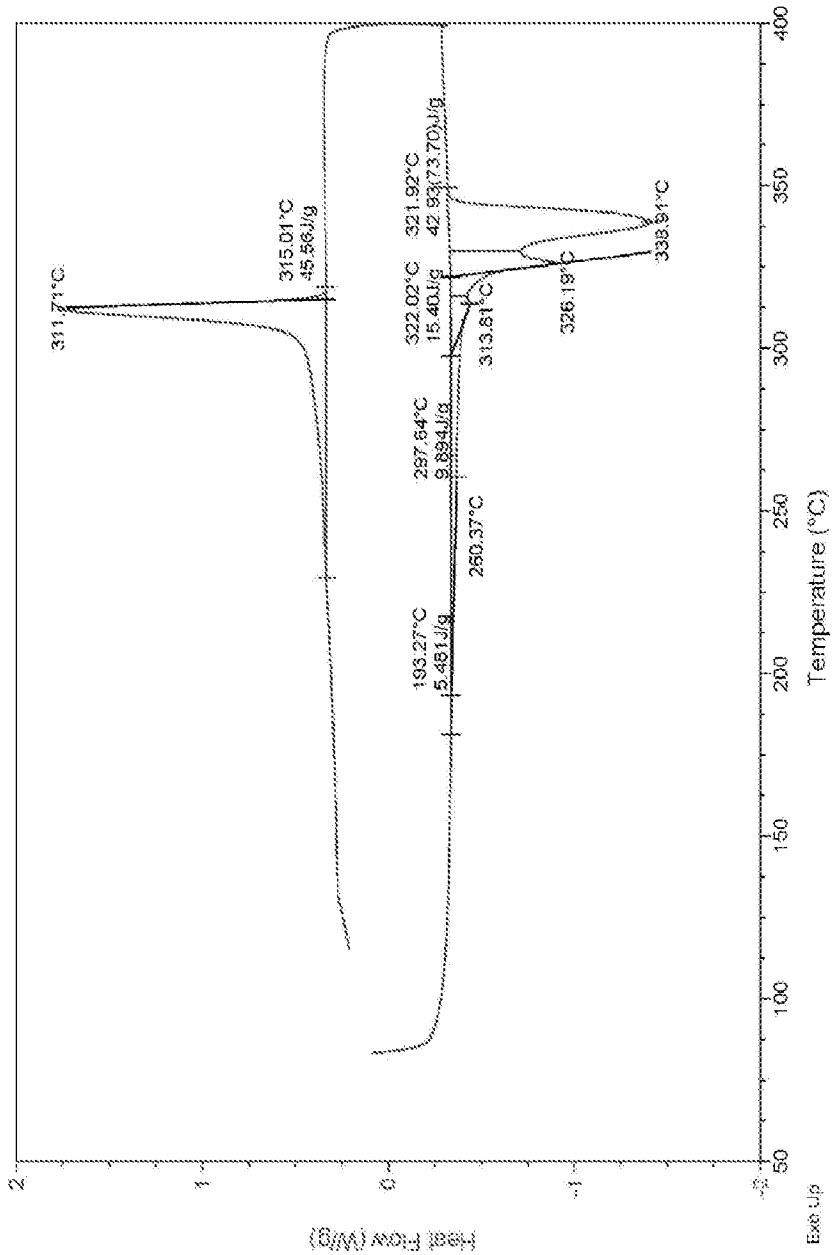


Fig. 1: Run 31 DSC first melt peaks and Fusion peak

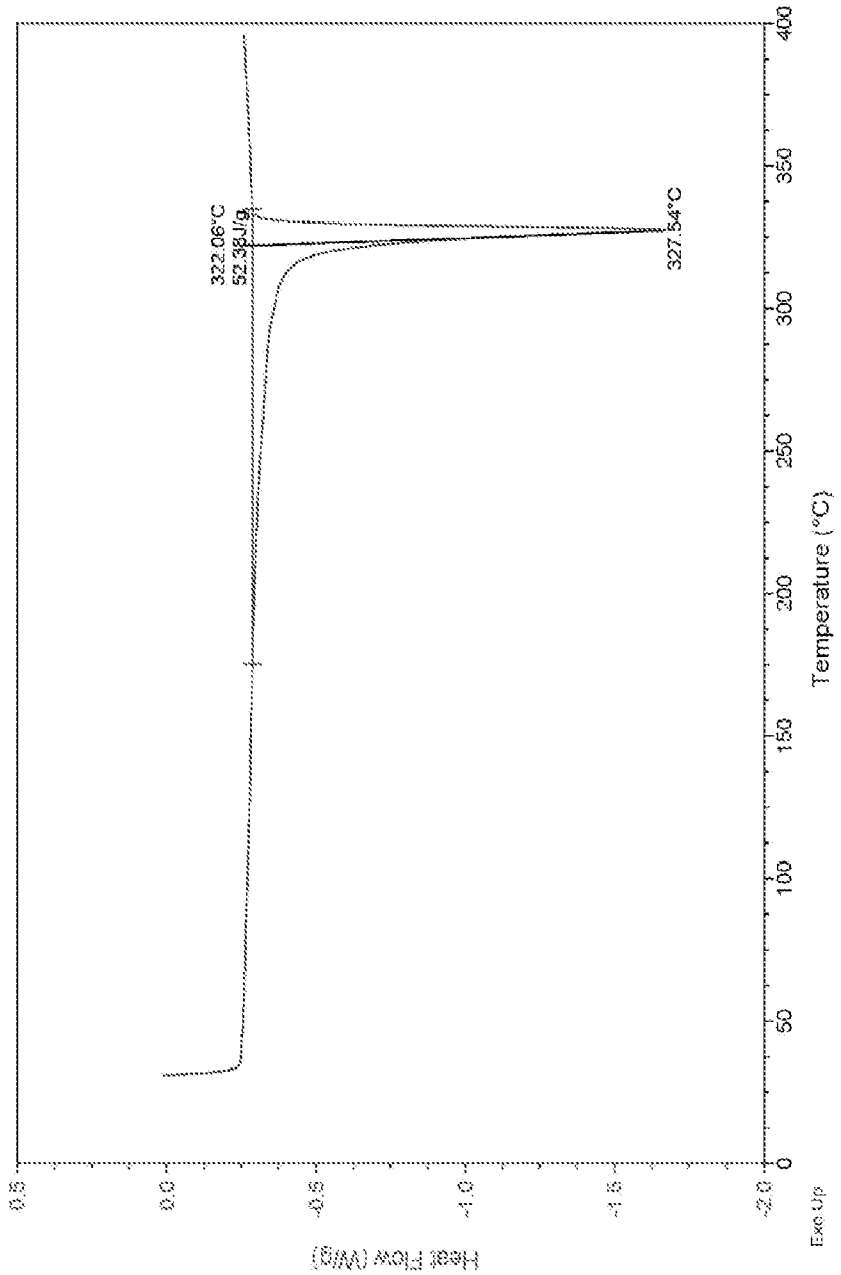


Fig. 2: Run 31 DSC Remelt Peak

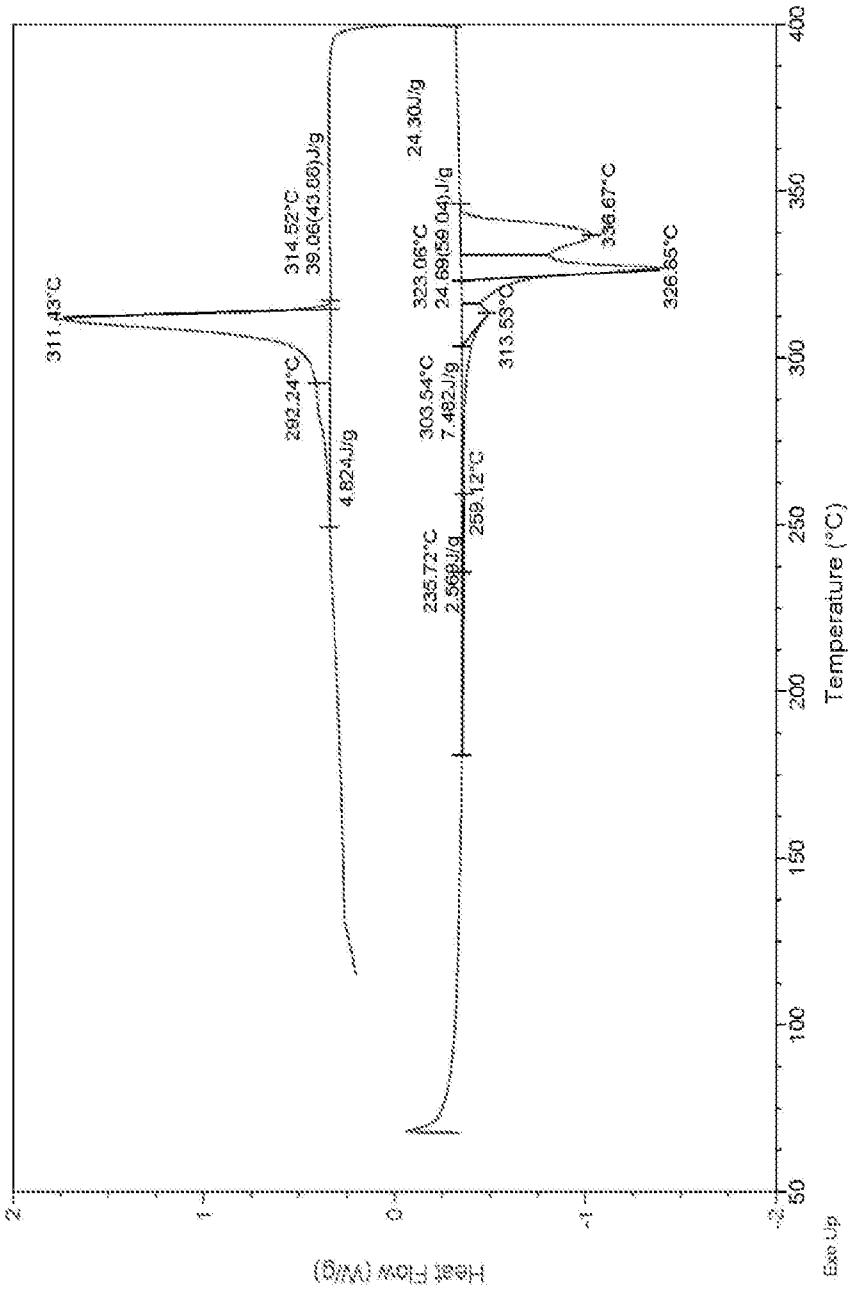


Fig. 3: Run 23 DSC first melt peaks and Fusion peak

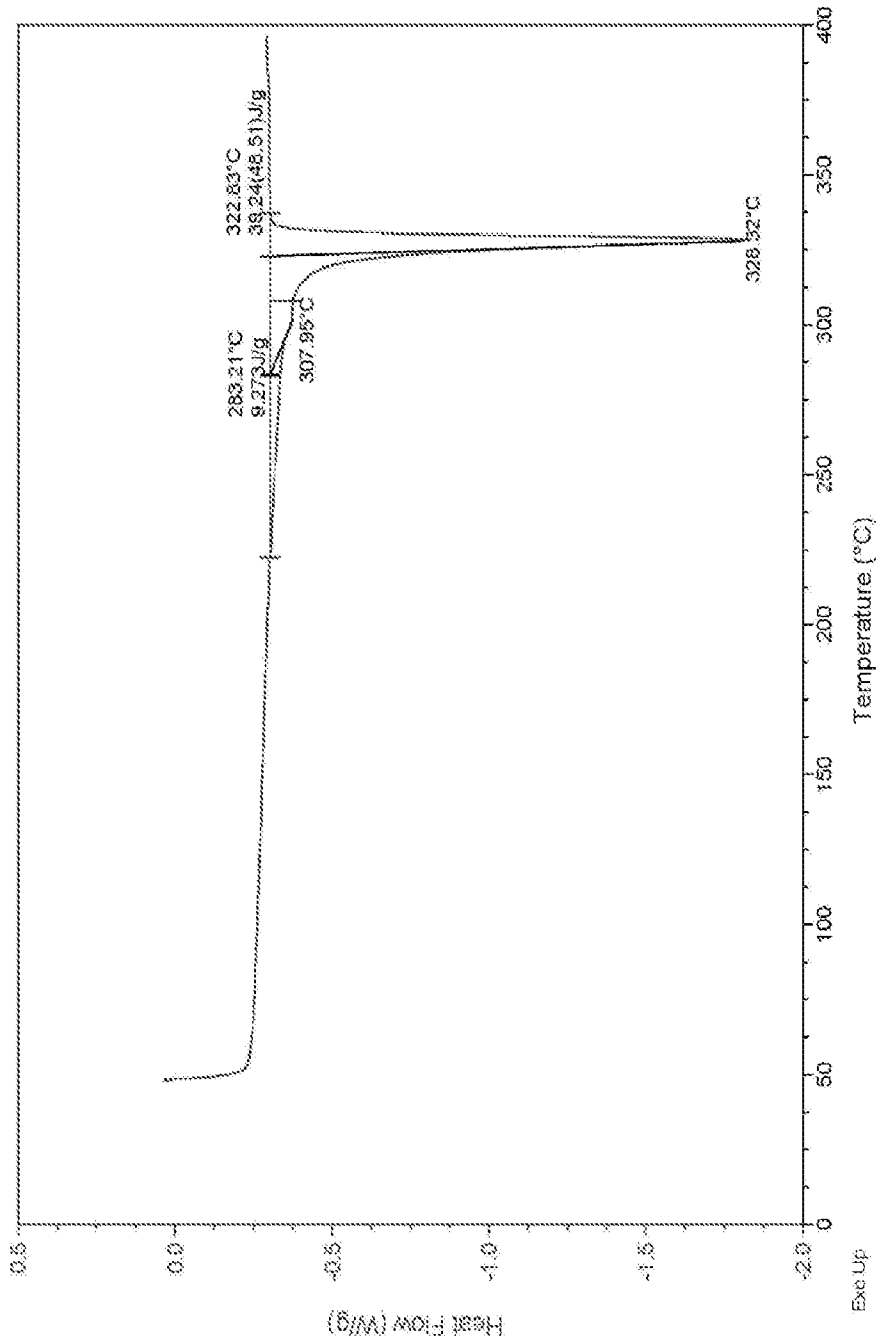


Fig. 4: Run 23 DSC first Remelt peak

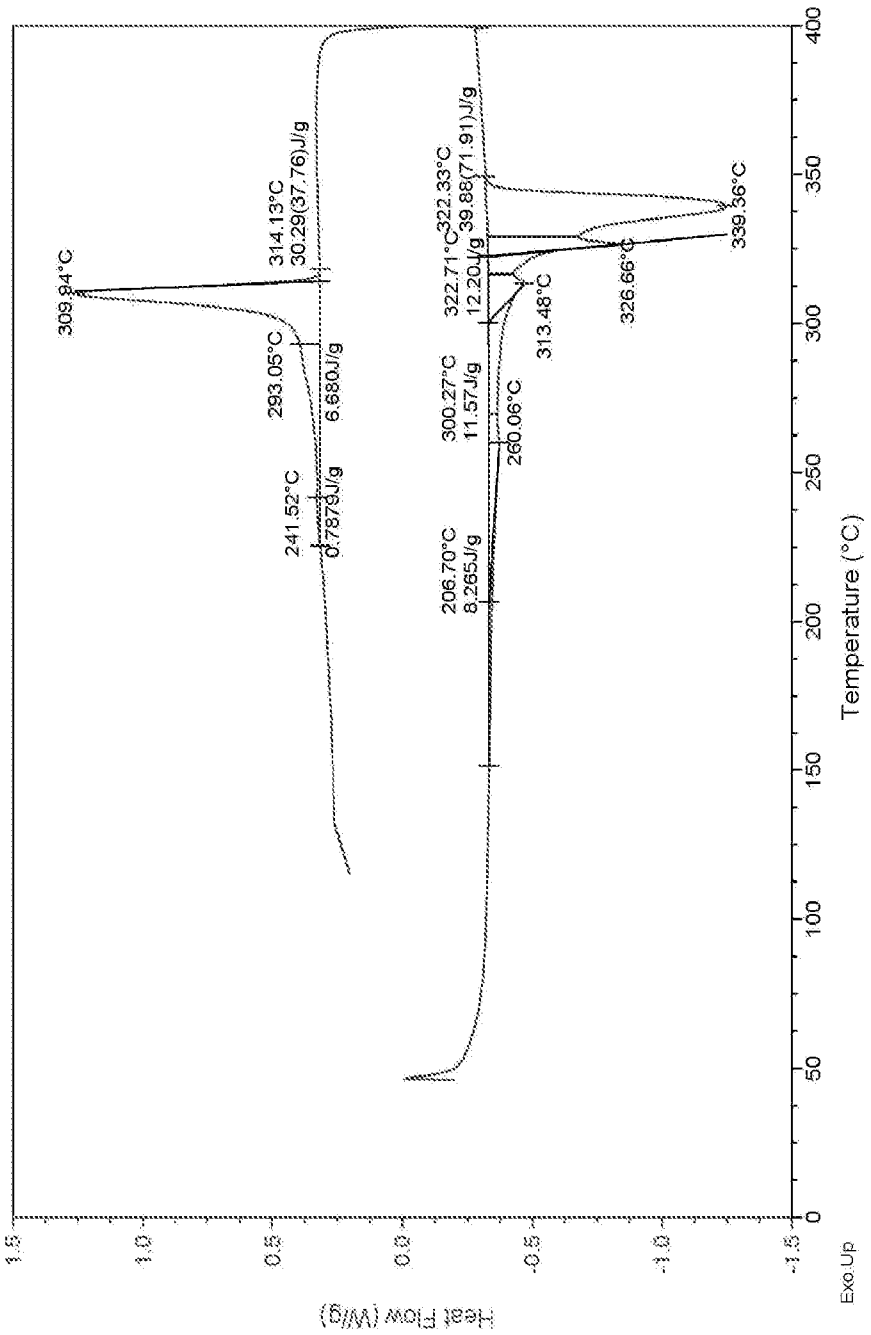


Fig. 5: Run 30 DSC first melt peaks and Fusion peak

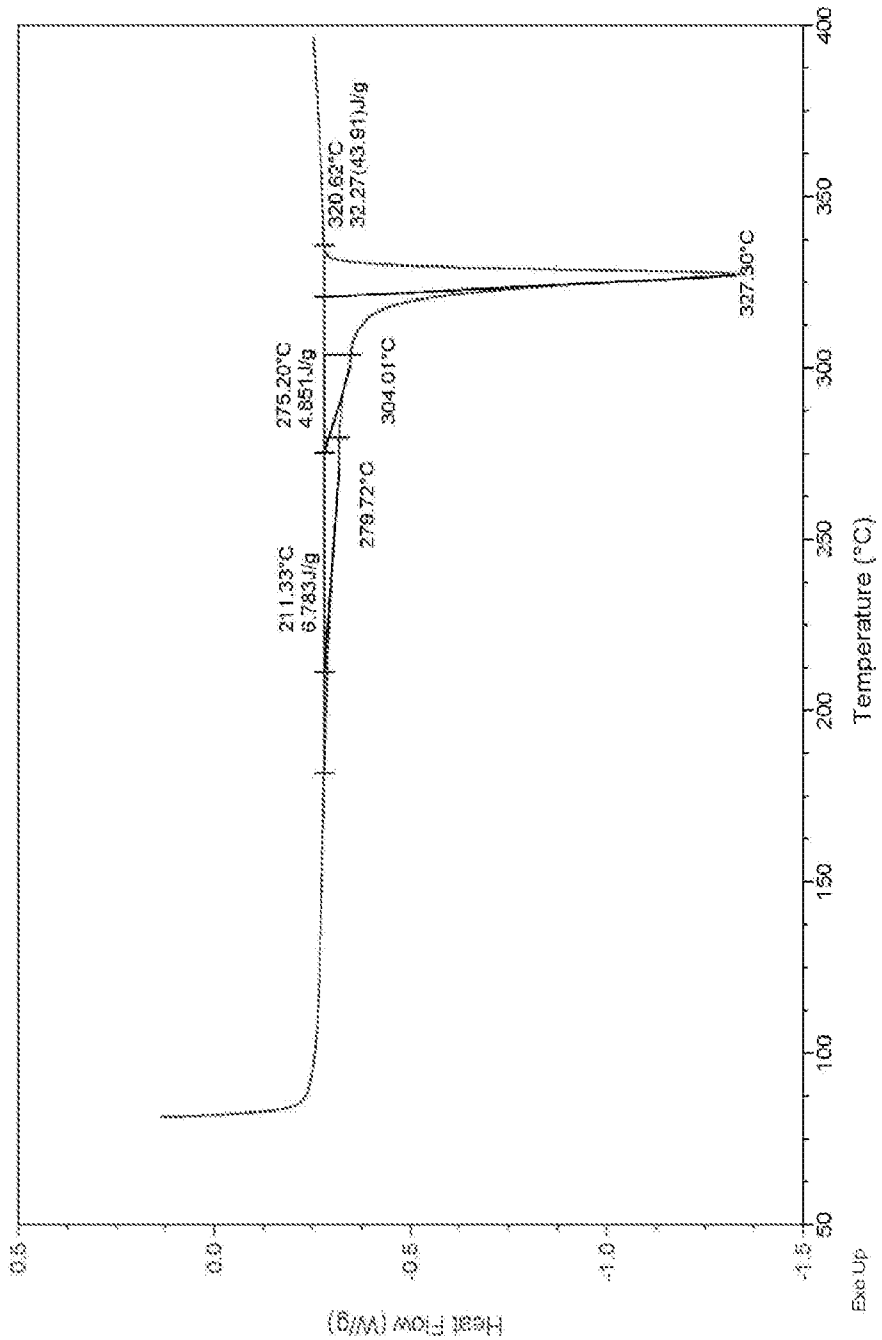


Fig. 6: Run 30 DSC Remelt Peak

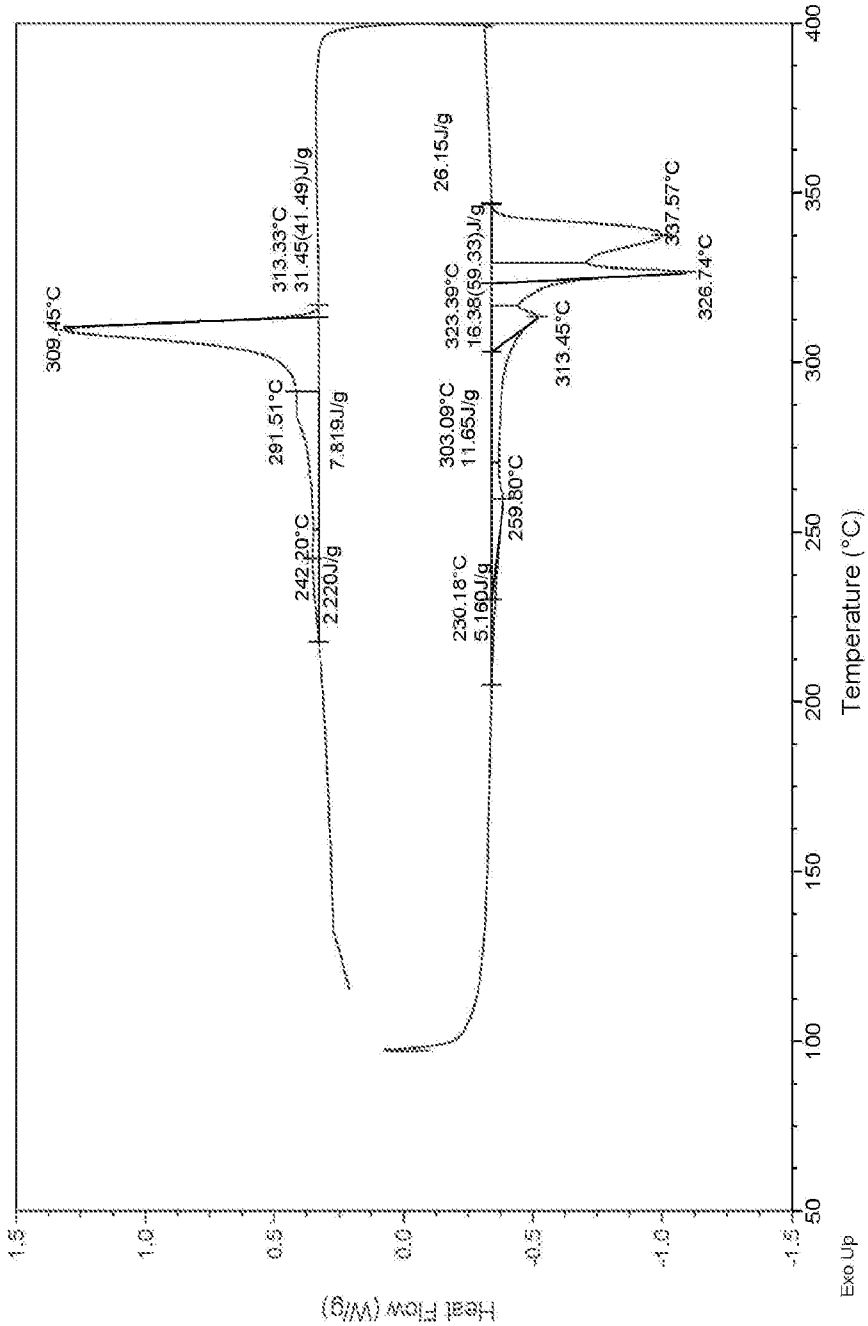


Fig. 7: Run 22 DSC first melt peaks and Fusion peaks

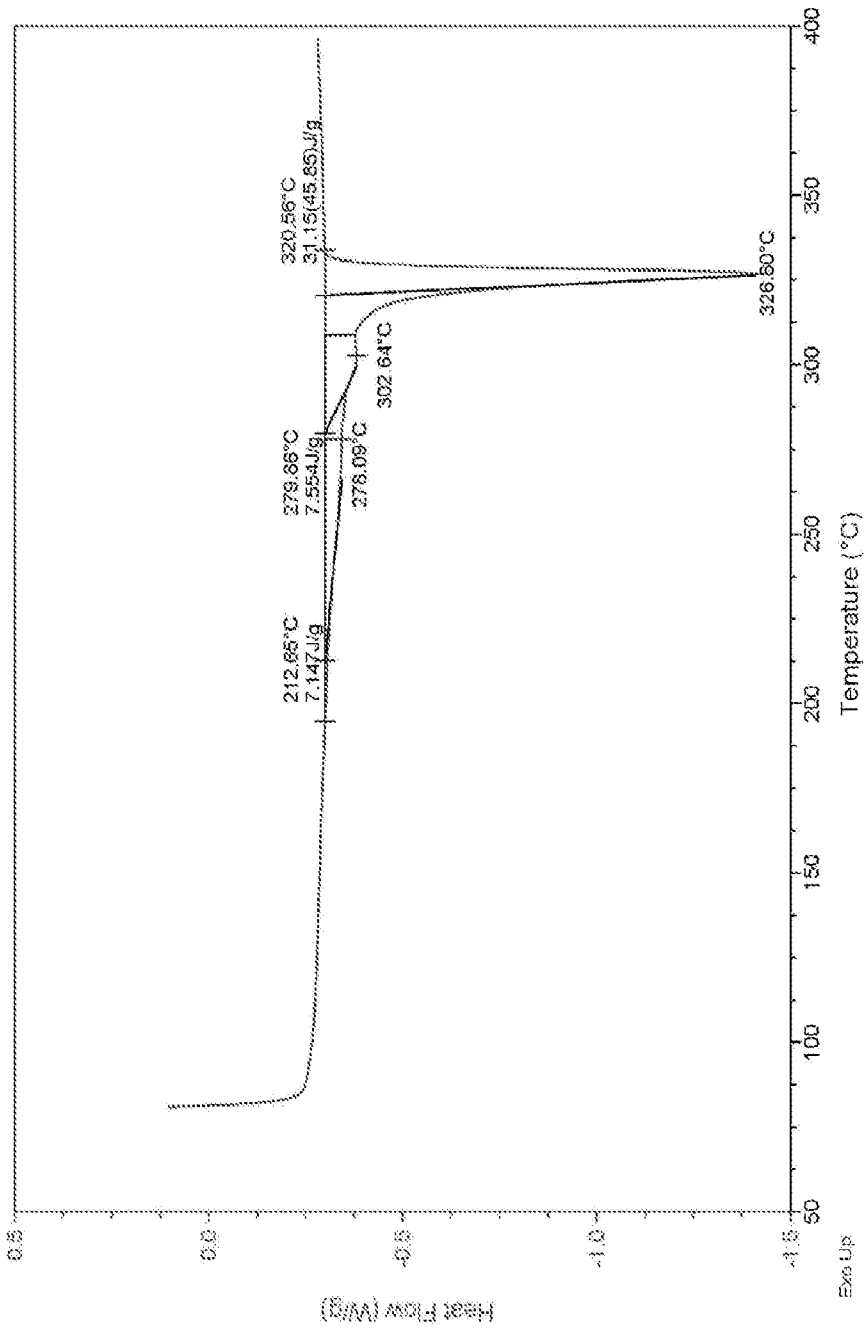


Fig. 8: Run 22 DSC Remelt Peaks

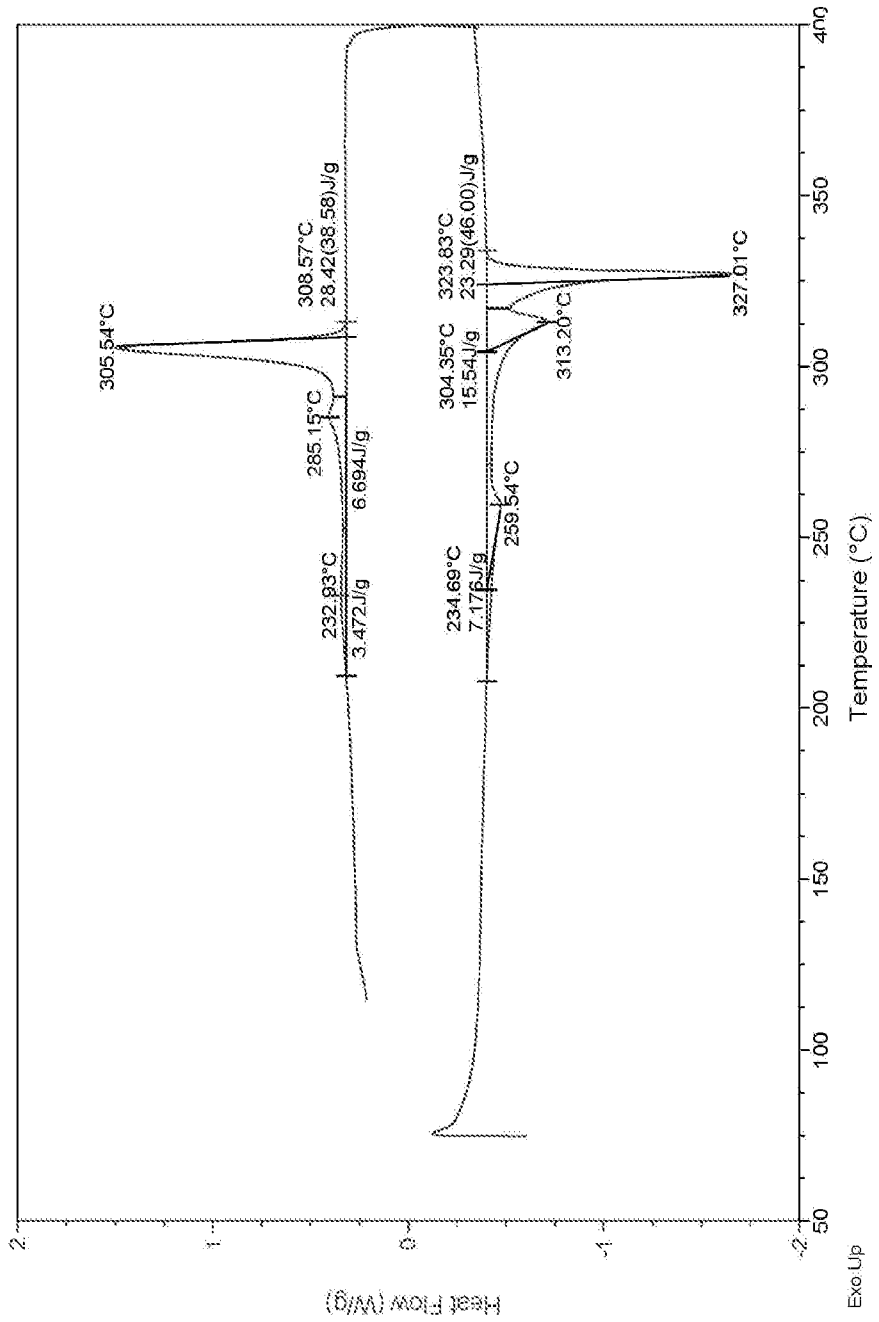


Fig. 9: Run 03 DSC first melt peaks and Fusion peaks

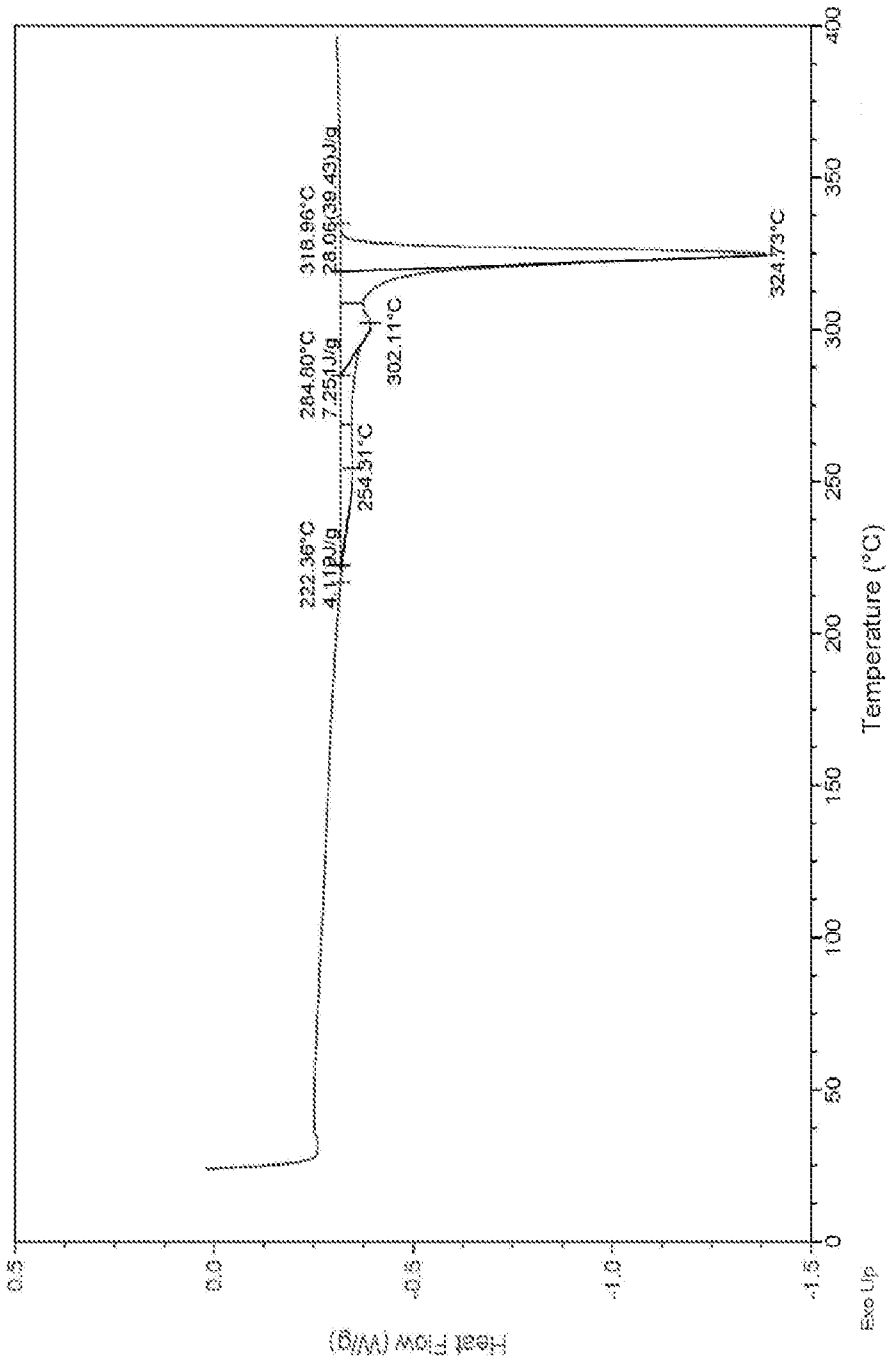


Fig. 10: Run 03 DSC Remelt peaks

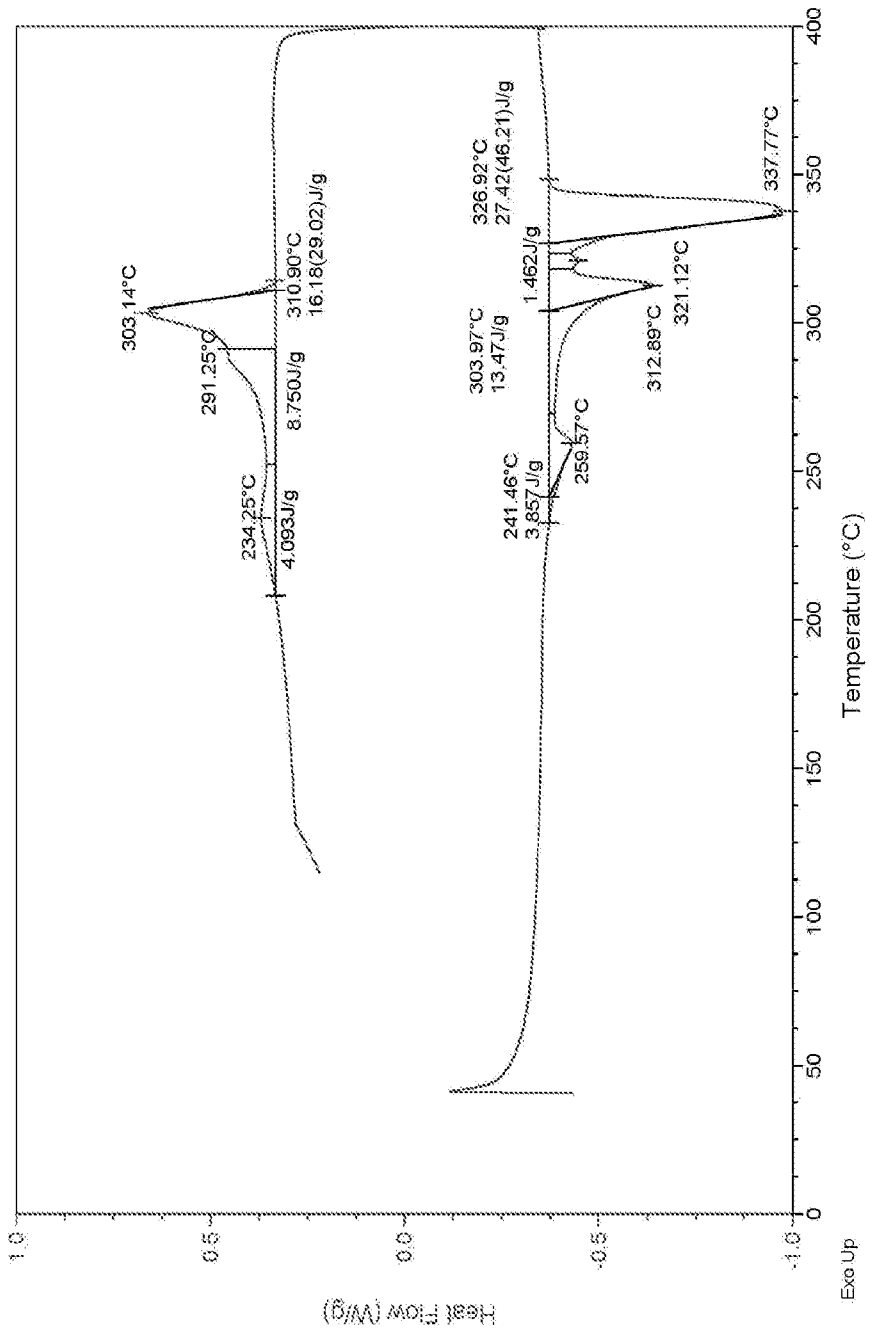


Fig. 11: Run 41 DSC first melt peaks and Fusion peaks

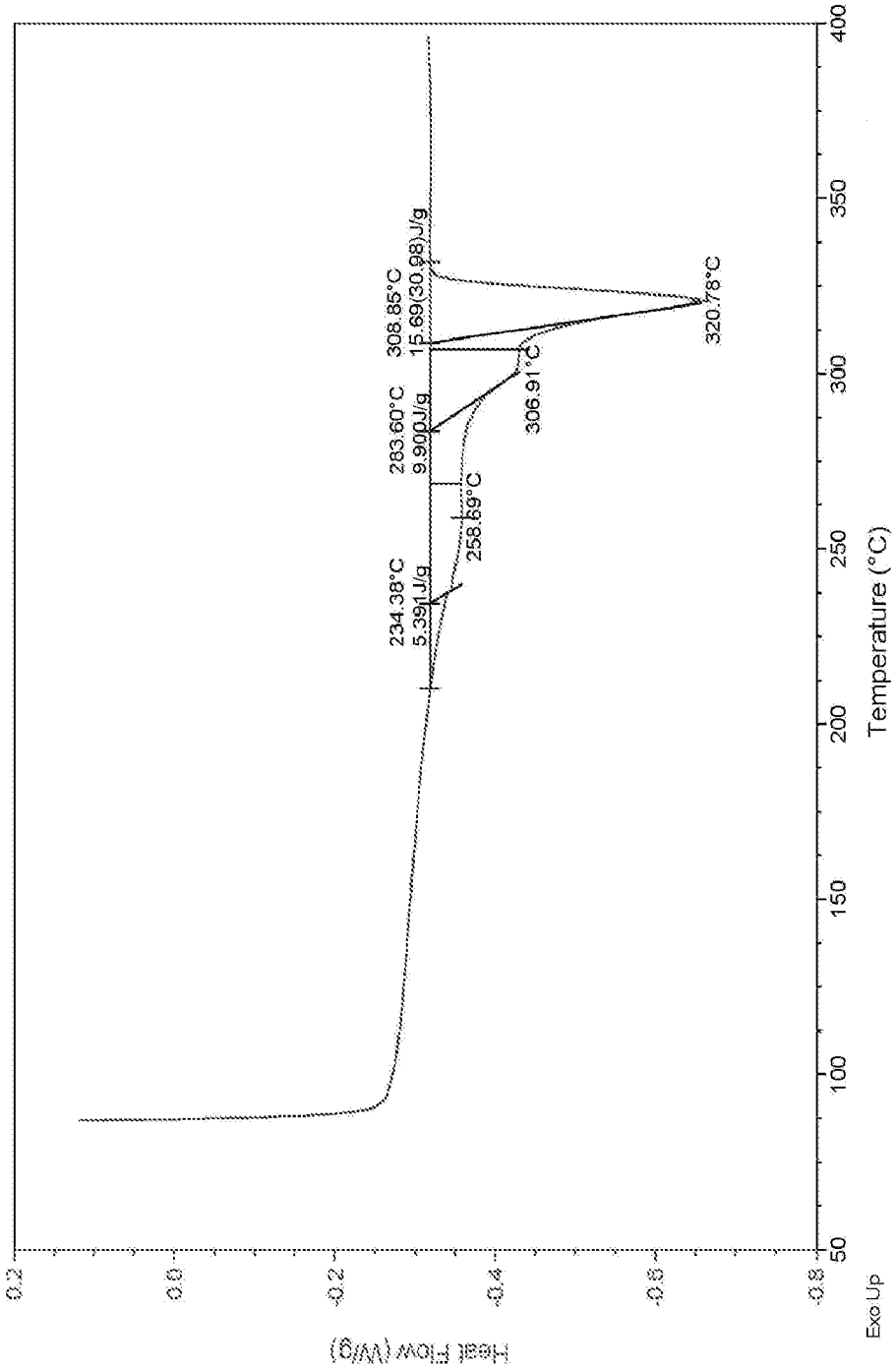


Fig. 12: Run 41 DSC Remelt peaks

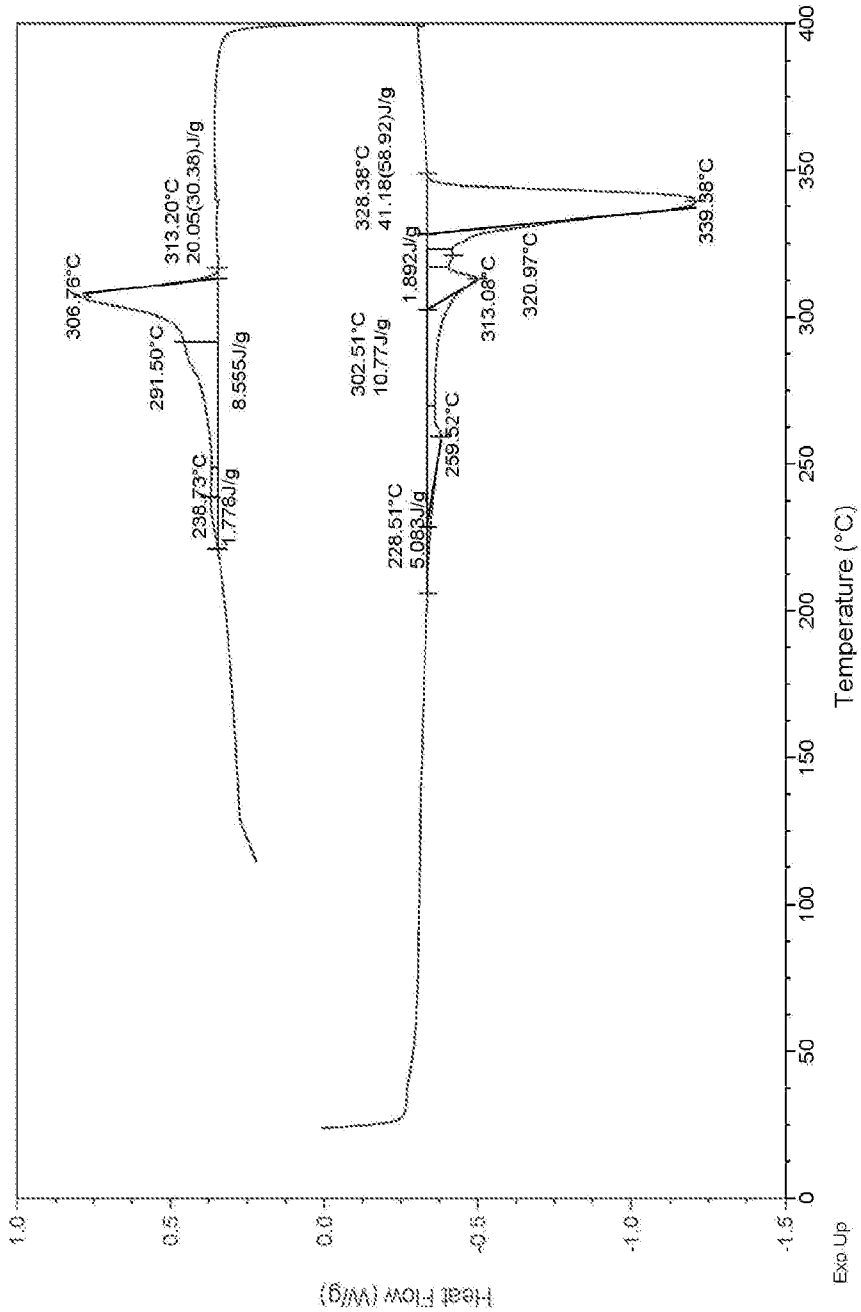


Fig. 13: Run 29 DSC first melt peaks and Fusion peaks

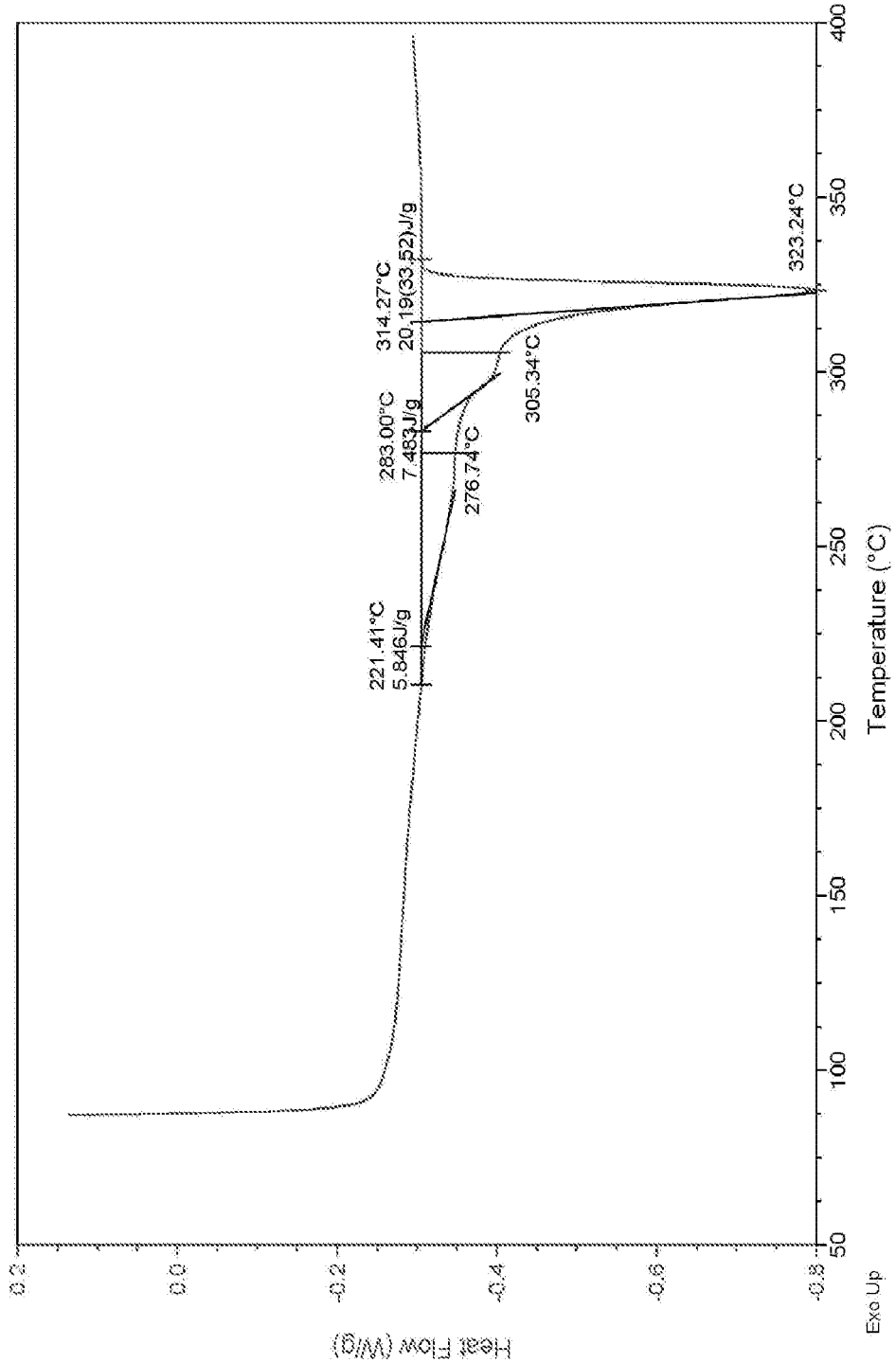


Fig. 14: Run 29 DSC Remelt peaks

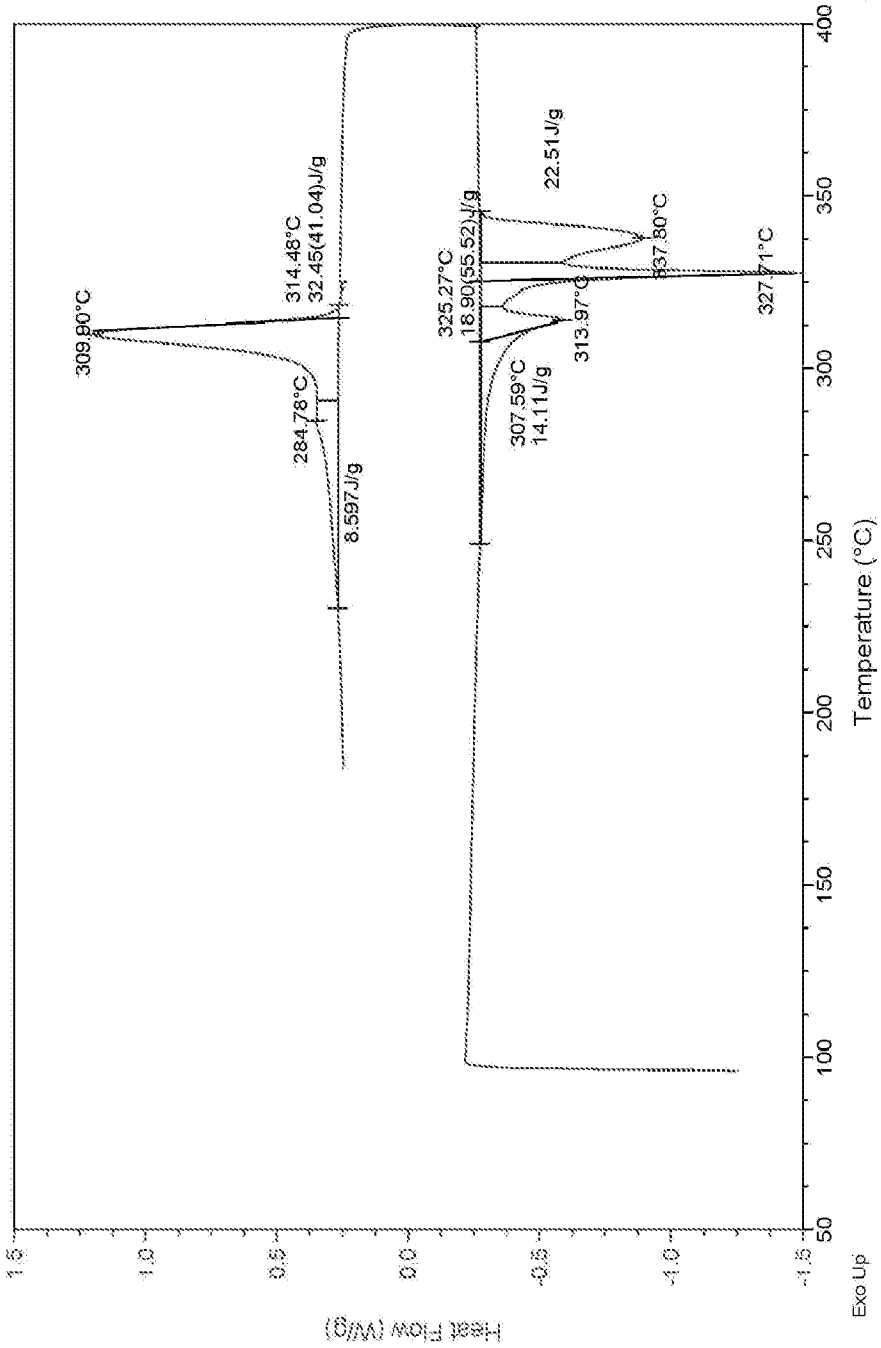


Fig. 15: Run 38 DSC first melt peaks and Fusion peaks

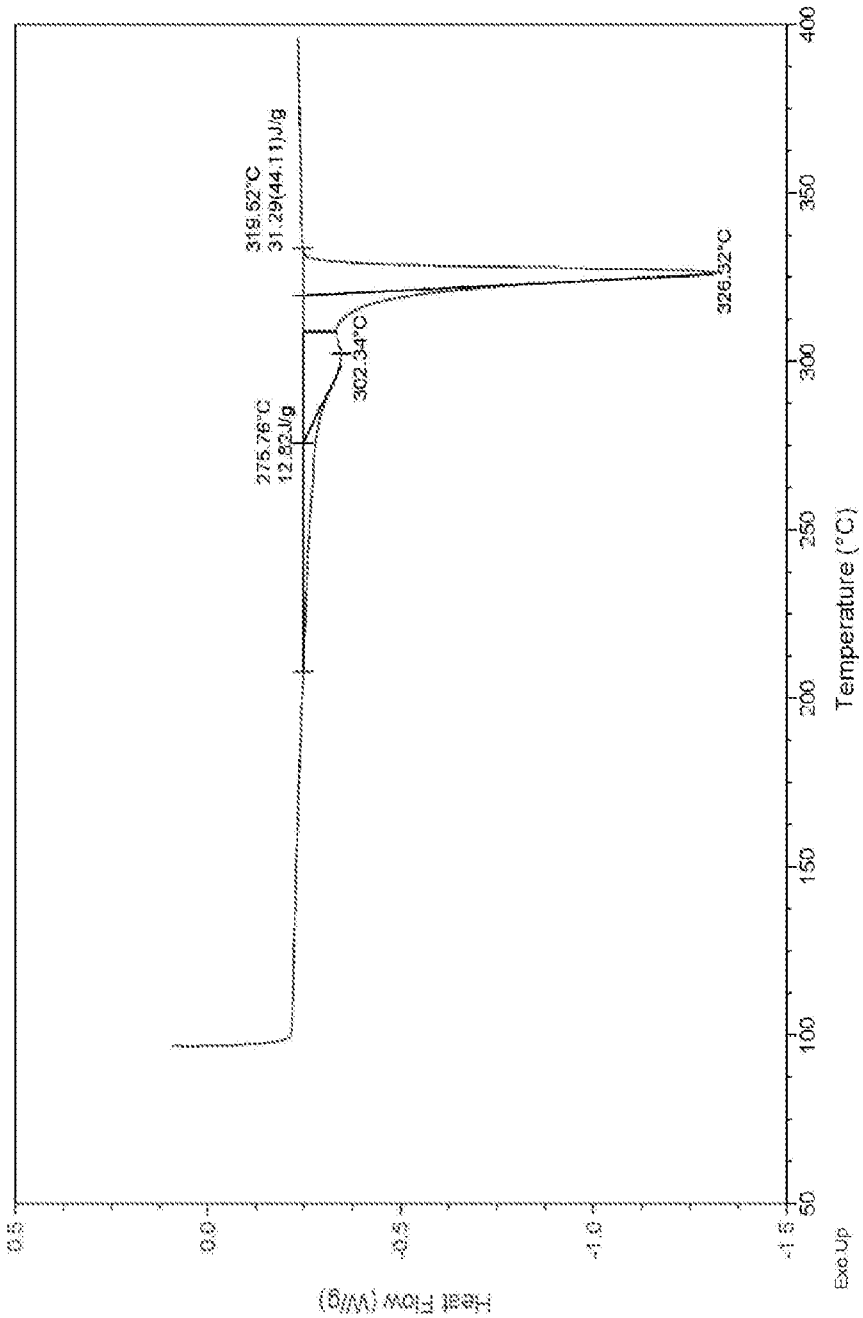


Fig. 16: Run 38 DSC Remelt peaks

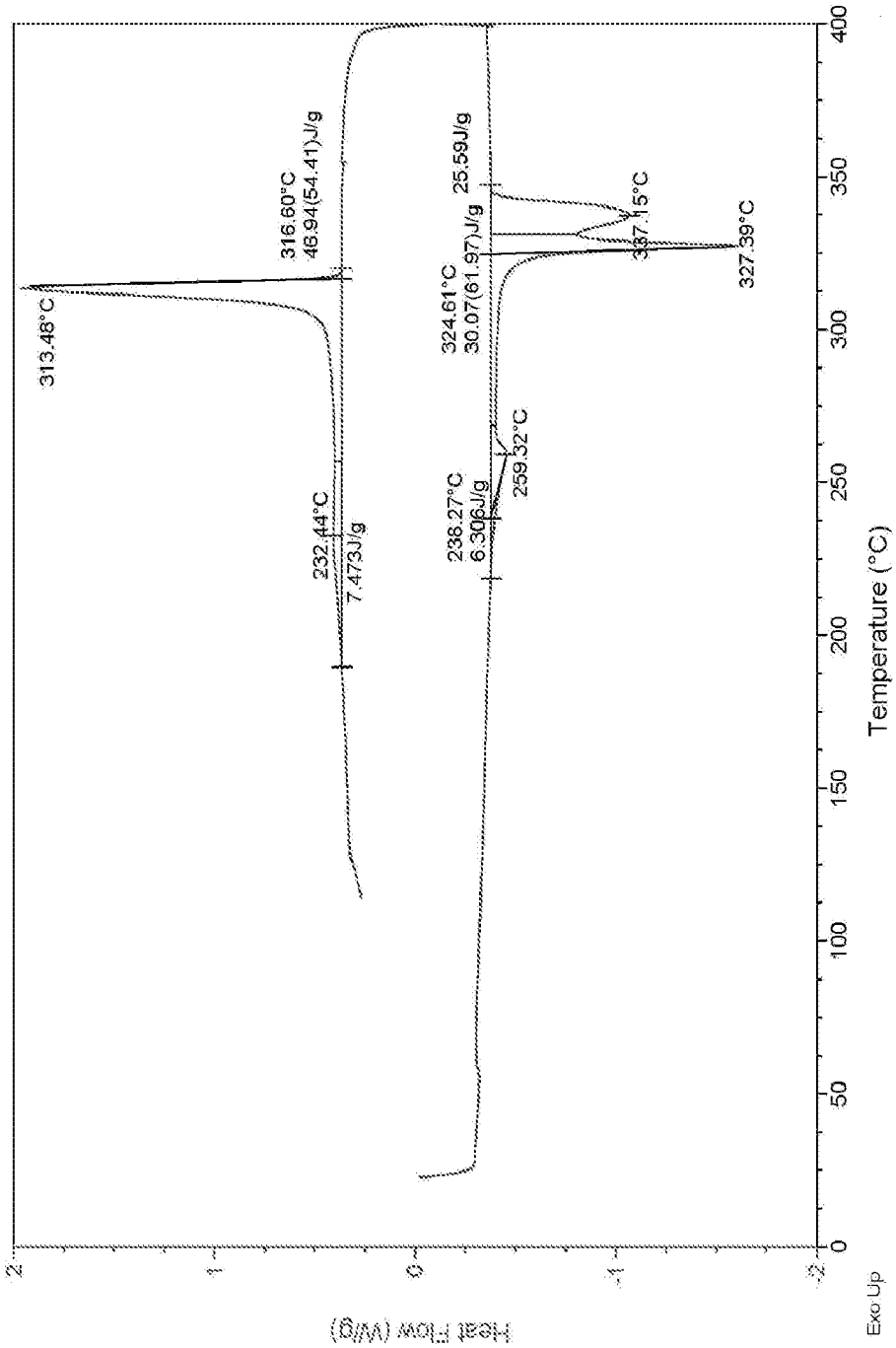


Fig. 17: Run 39 DSC first melt peaks and Fusion peaks

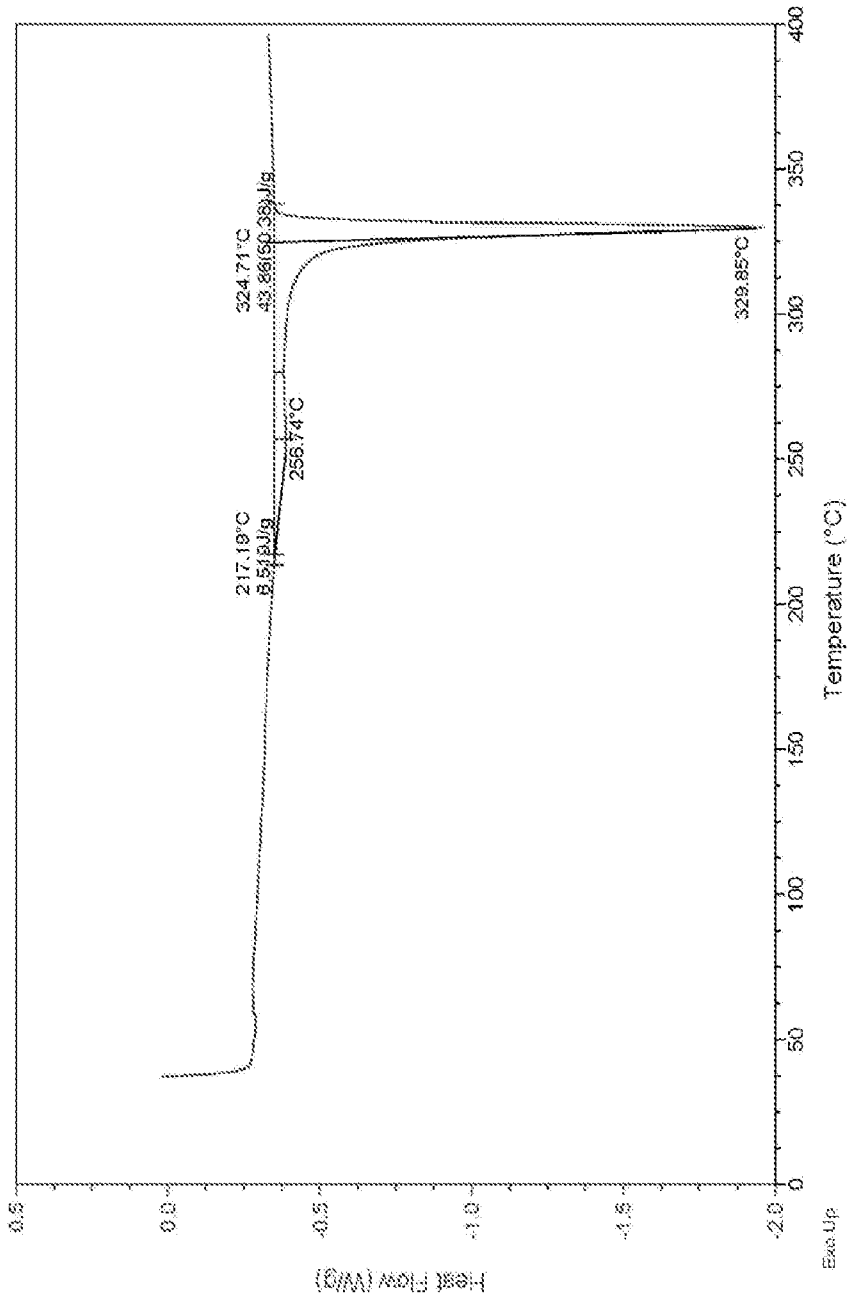


Fig. 18: Run 39 DSC Remelt peaks

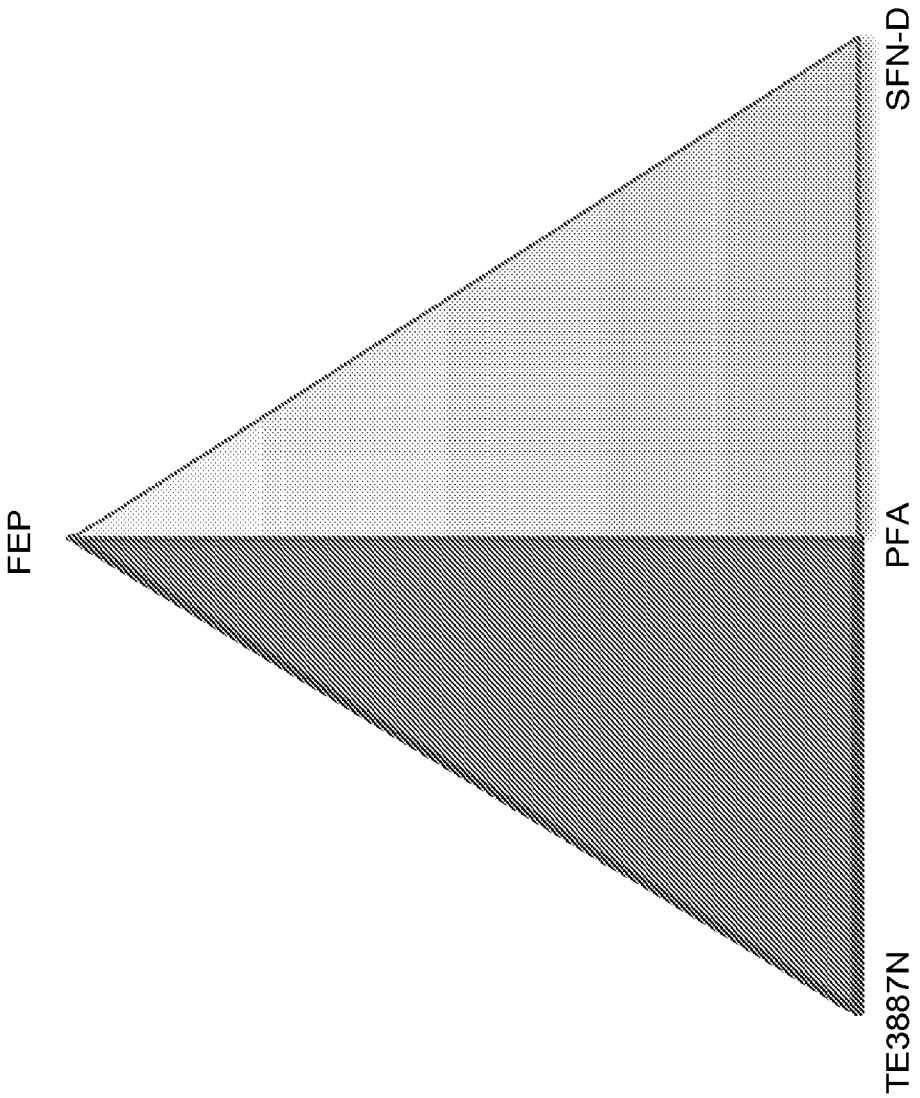


Fig. 19

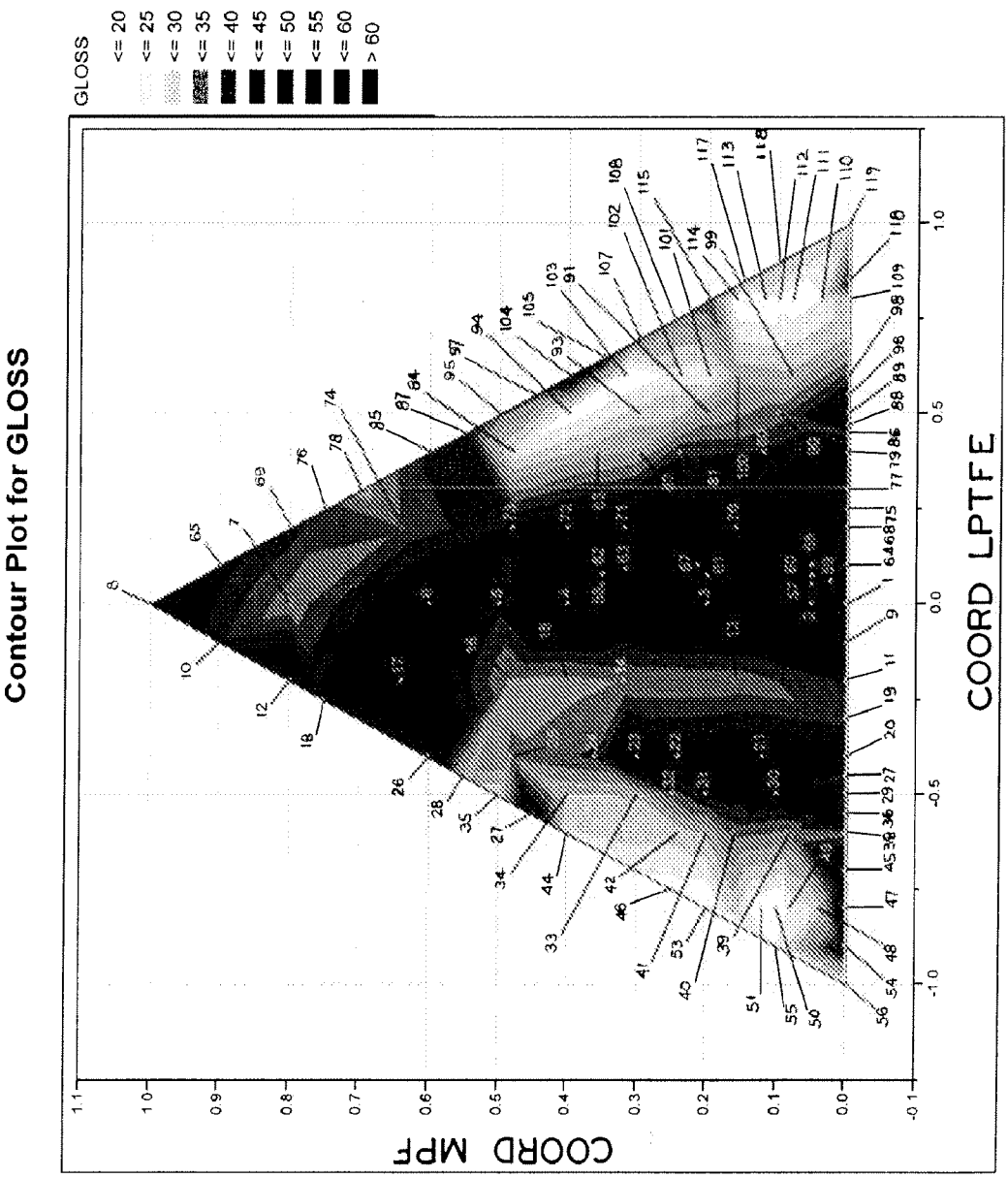

Contour Plot for GLOSS
GLOSS
<= 20
<= 25
<= 30
<= 35
<= 40
<= 45
<= 50
<= 55
<= 60
> 60
COORD MPF
COORD LPTFE

Fig. 20

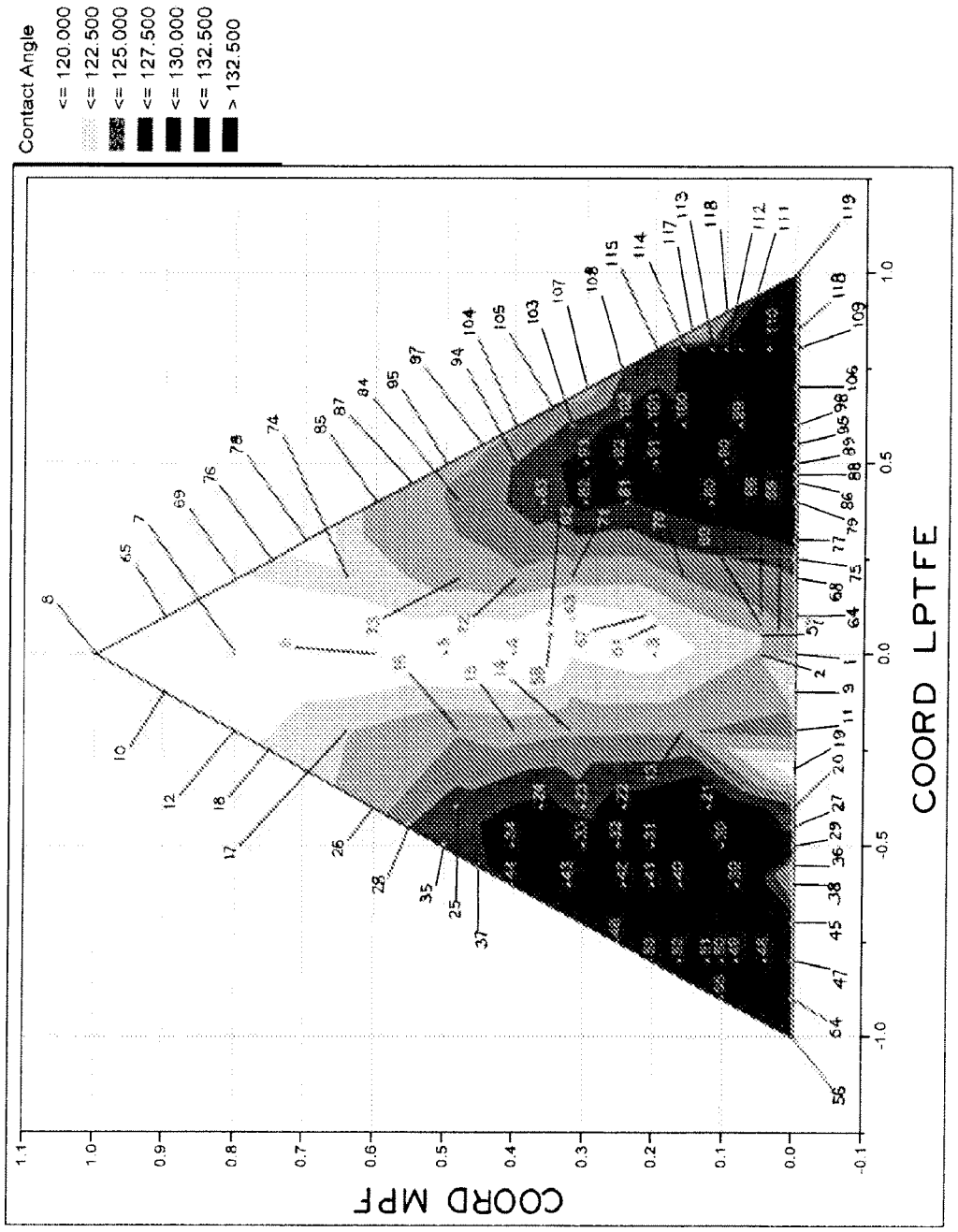

Contour Plot for Contact Angle
Contact Angle
<= 120.000
<= 122.500
<= 125.000
<= 127.500
<= 130.000
<= 132.500
> 132.500
COORD MPF
COORD LPTFE

Fig. 21

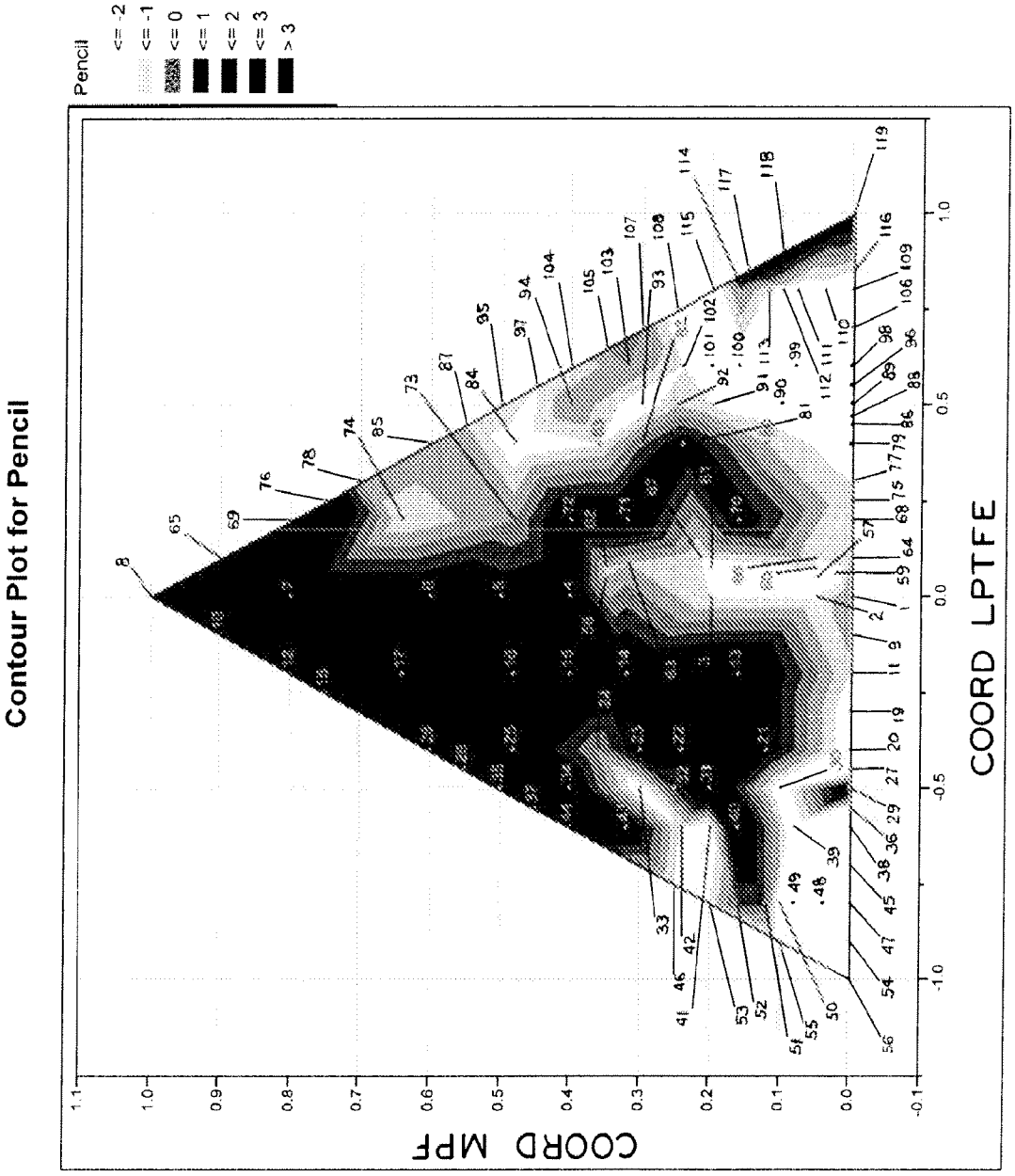

Contour Plot for Pencil
Pencil
<= -2
<= -1
<= 0
<= 1
<= 2
<= 3
> 3
COORD MPF
COORD LPTFE

Fig. 22

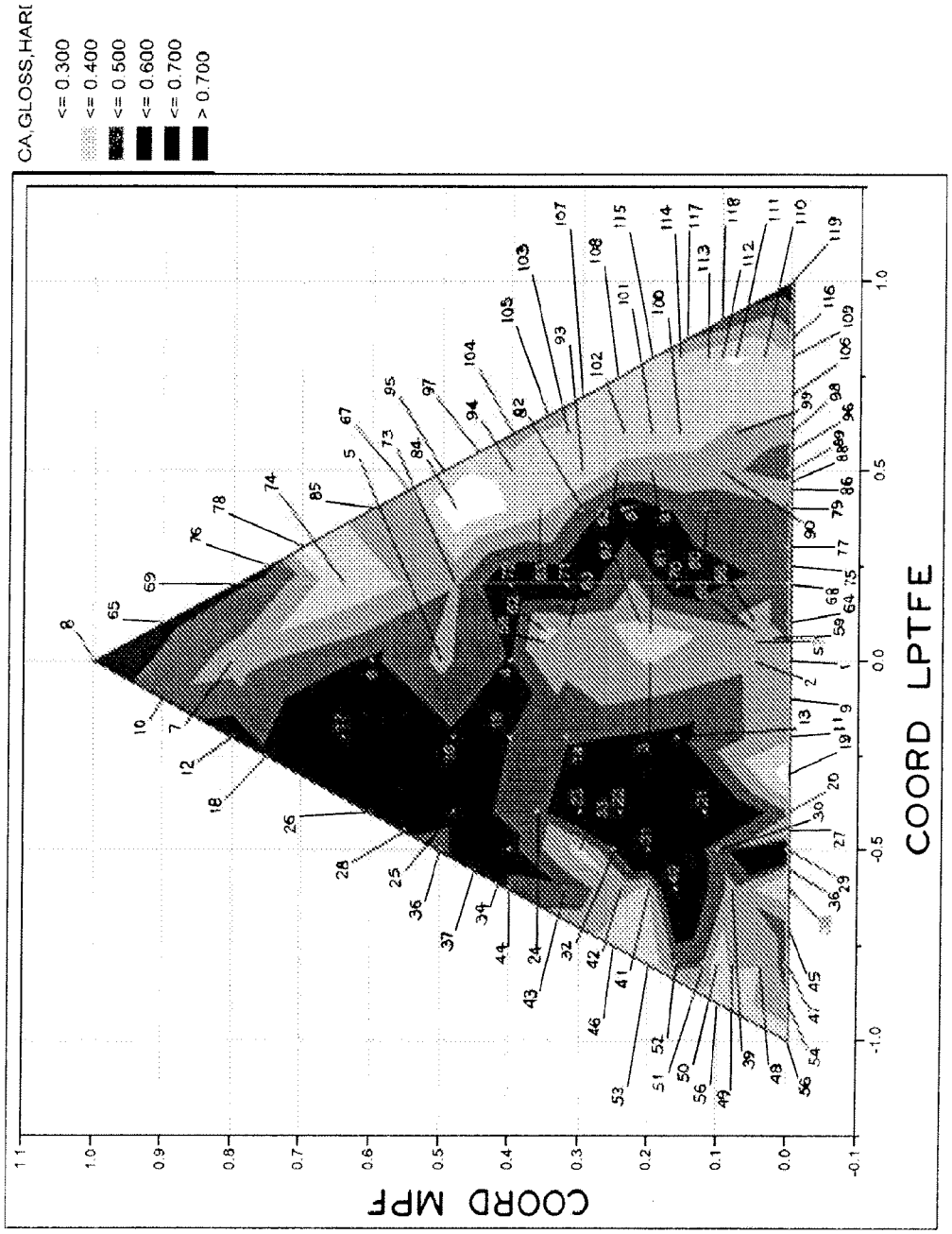

Contour Plot for CA,GLOSS,HARD
CA,GLOSS,HARI
<= 0.300
<= 0.400
<= 0.500
<= 0.600
<= 0.700
> 0.700
COORD MPF
COORD LPTFE

Fig. 23

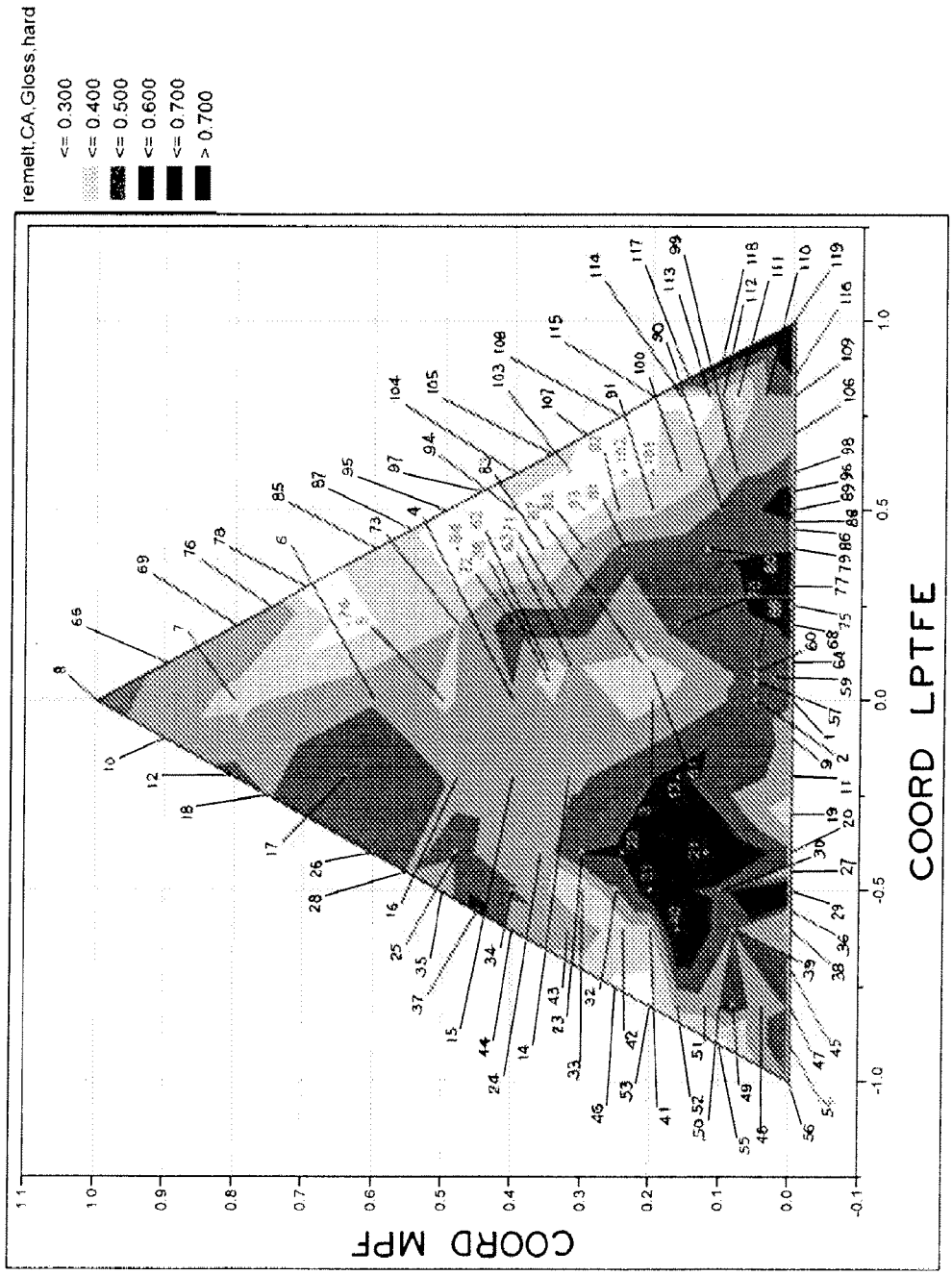

Contour Plot for remelt,CA,Gloss,hard
remelt,CA,Gloss,hard
<= 0.300
<= 0.400
<= 0.500
<= 0.600
<= 0.700
> 0.700
COORD MPF
COORD LPTFE

Fig. 24

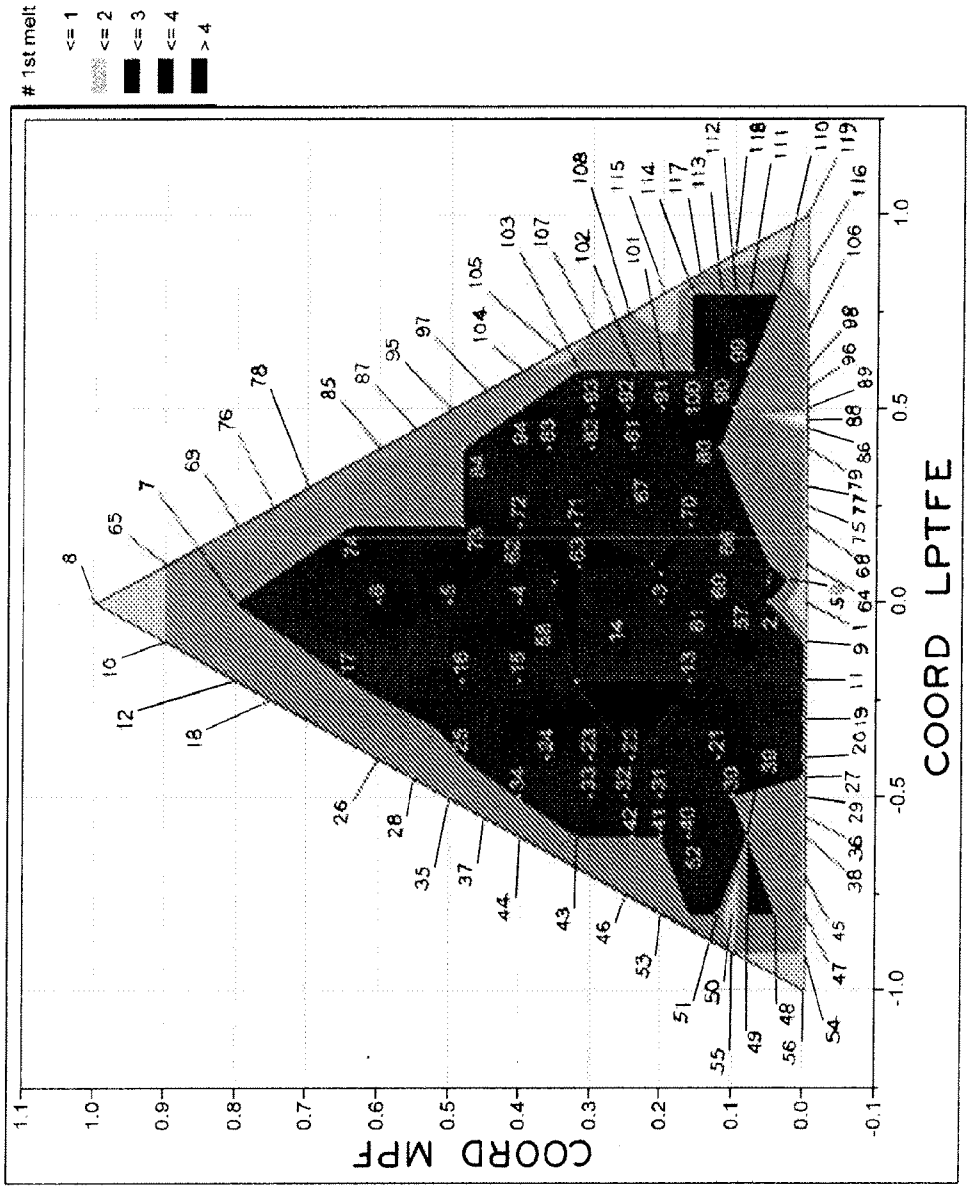

Contour Plot for # 1st melt
1st melt
<= 1
<= 2
<= 3
<= 4
> 4
COORD MPF
COORD LPTFE

Fig. 25a

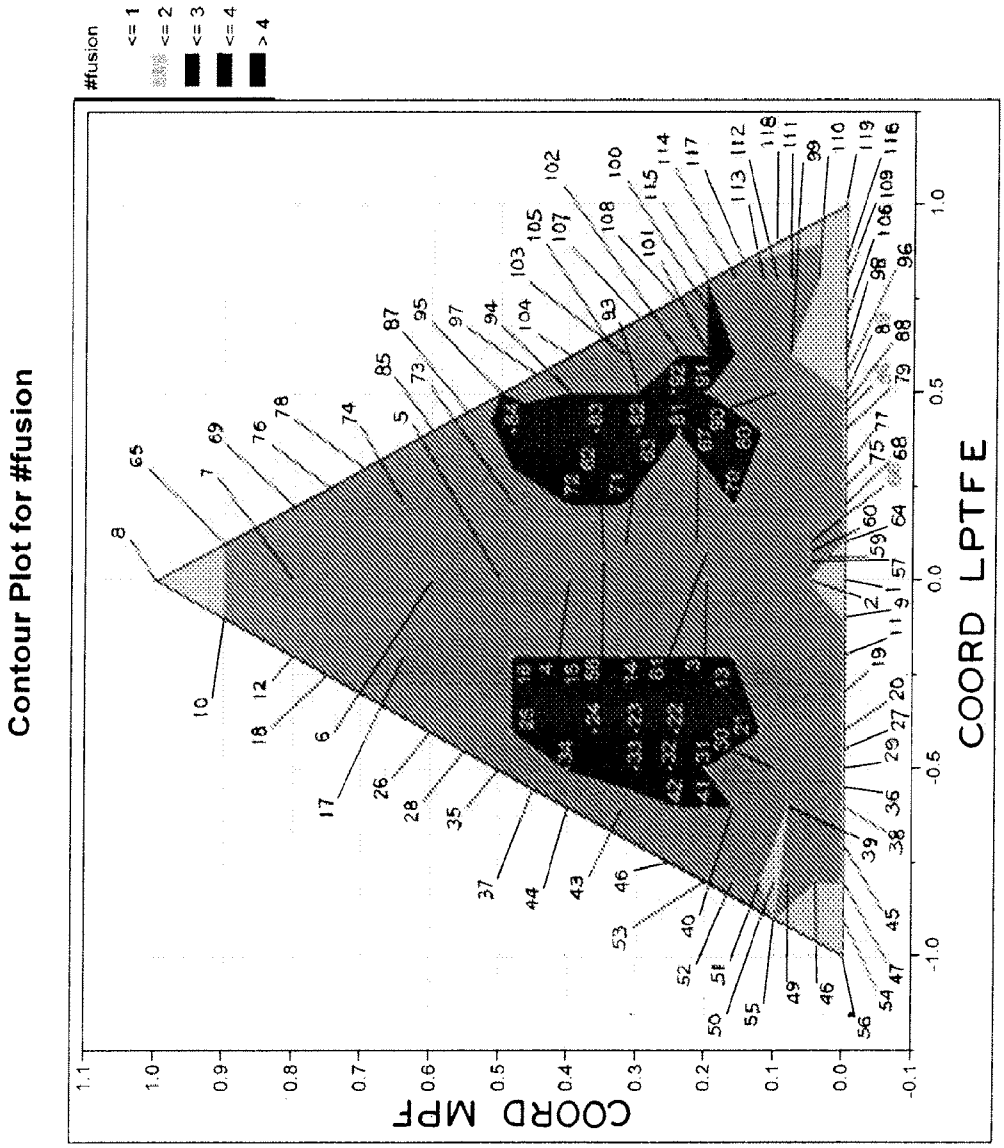


Fig. 25b

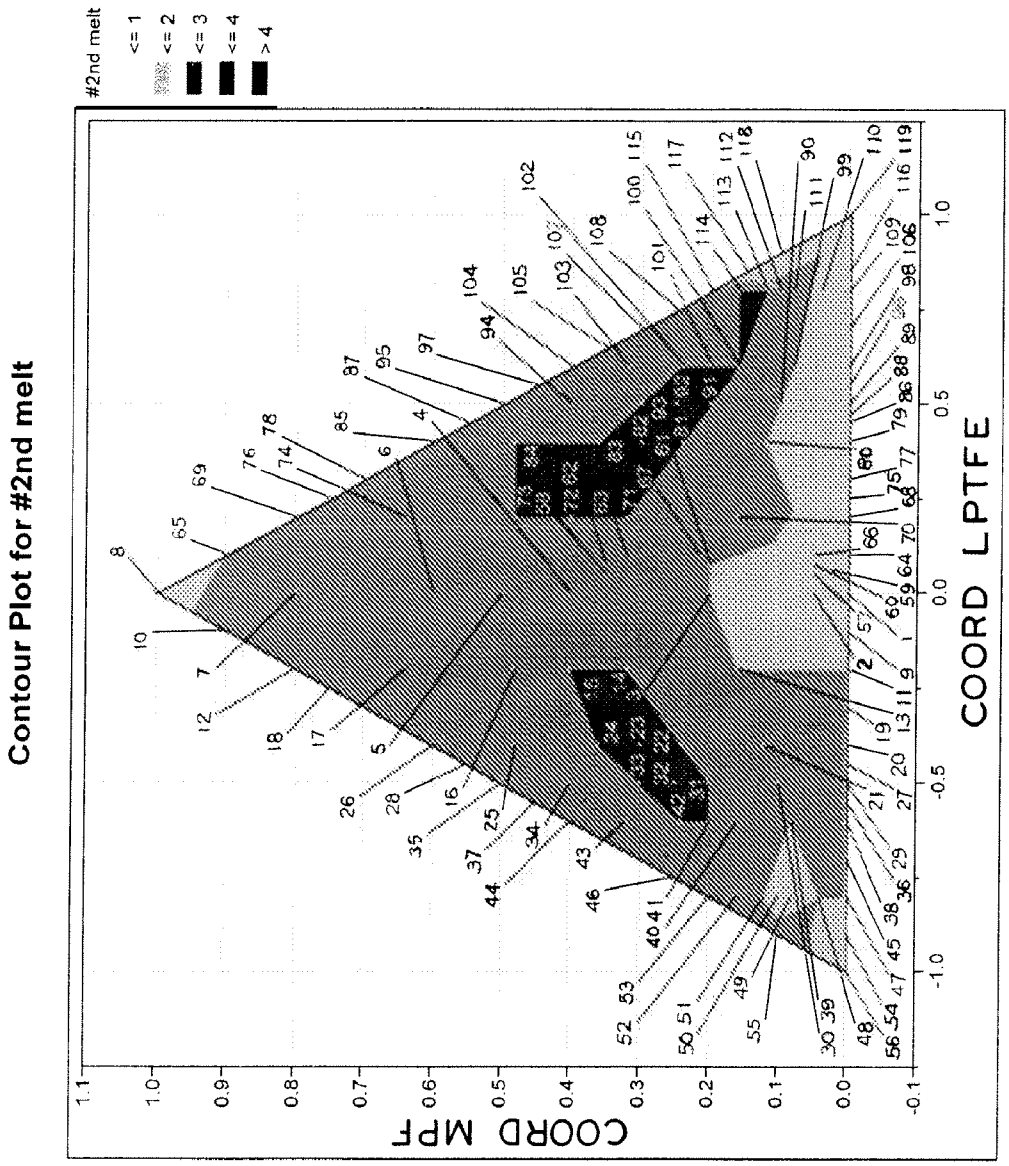

Contour Plot for #2nd melt
#2nd melt
<= 1
<= 2
<= 3
<= 4
> 4
COORD MPF
COORD LPTFE

Fig. 25c

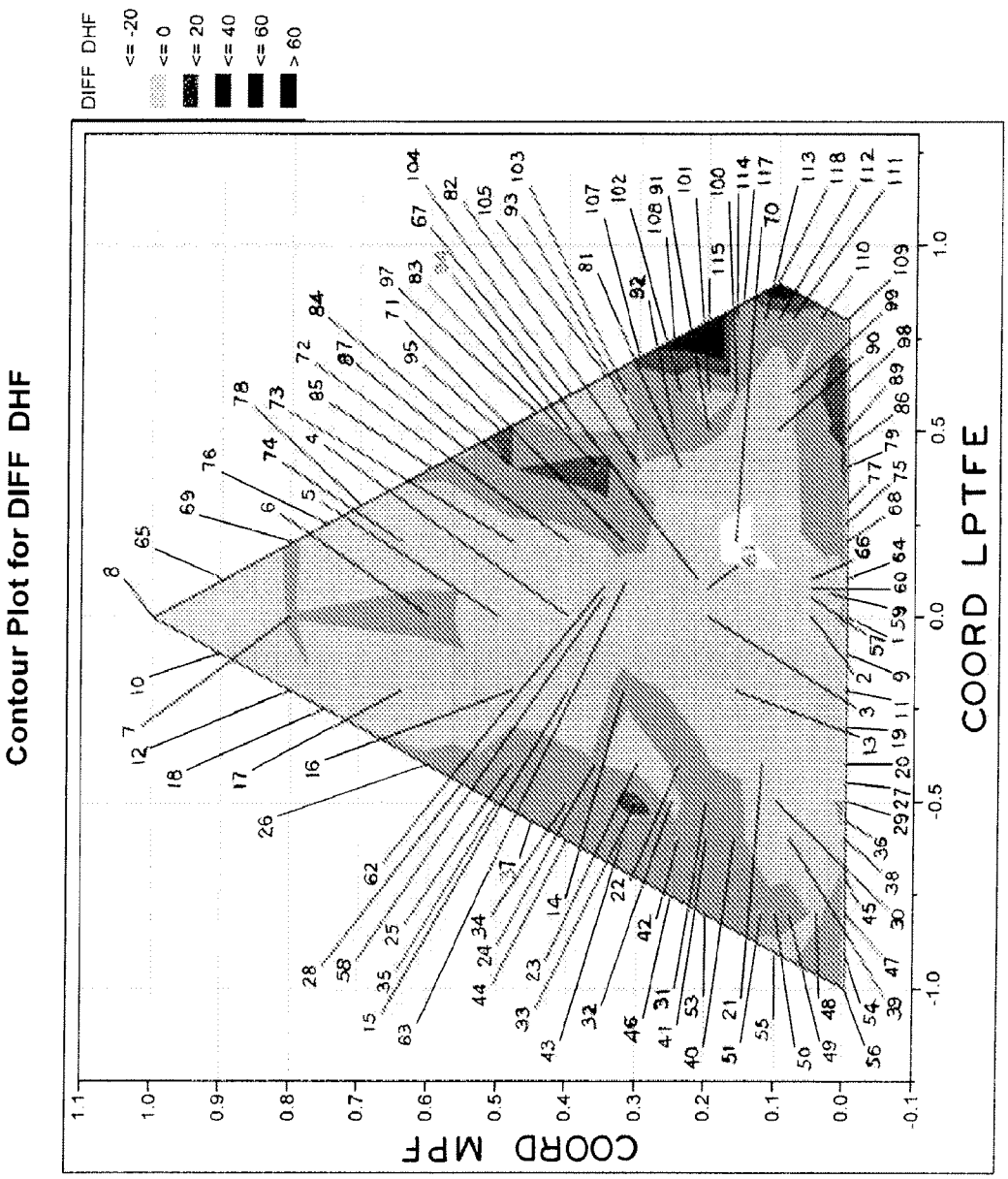

Contour Plot for DIFF DHF
DIFF DHF
<= -20
<= 0
<= 20
<= 40
<= 60
> 60
COORD MPF
COORD LPTFE

Fig. 26

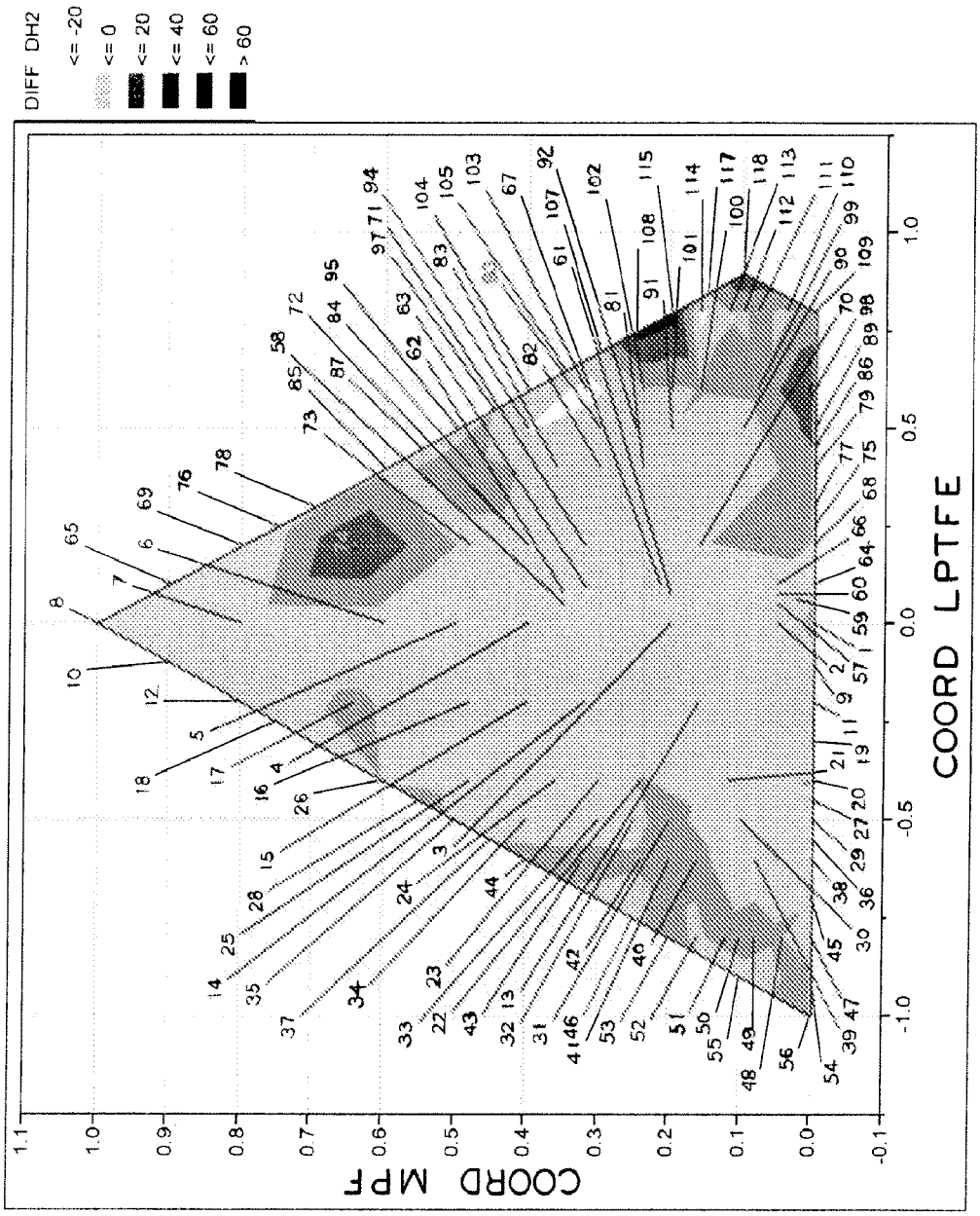

Contour Plot for DIFF DH2
DIFF DH2
<= -20
<= 0
<= 20
<= 40
<= 60
> 60
COORD MPF
COORD LPTFE

Fig. 27

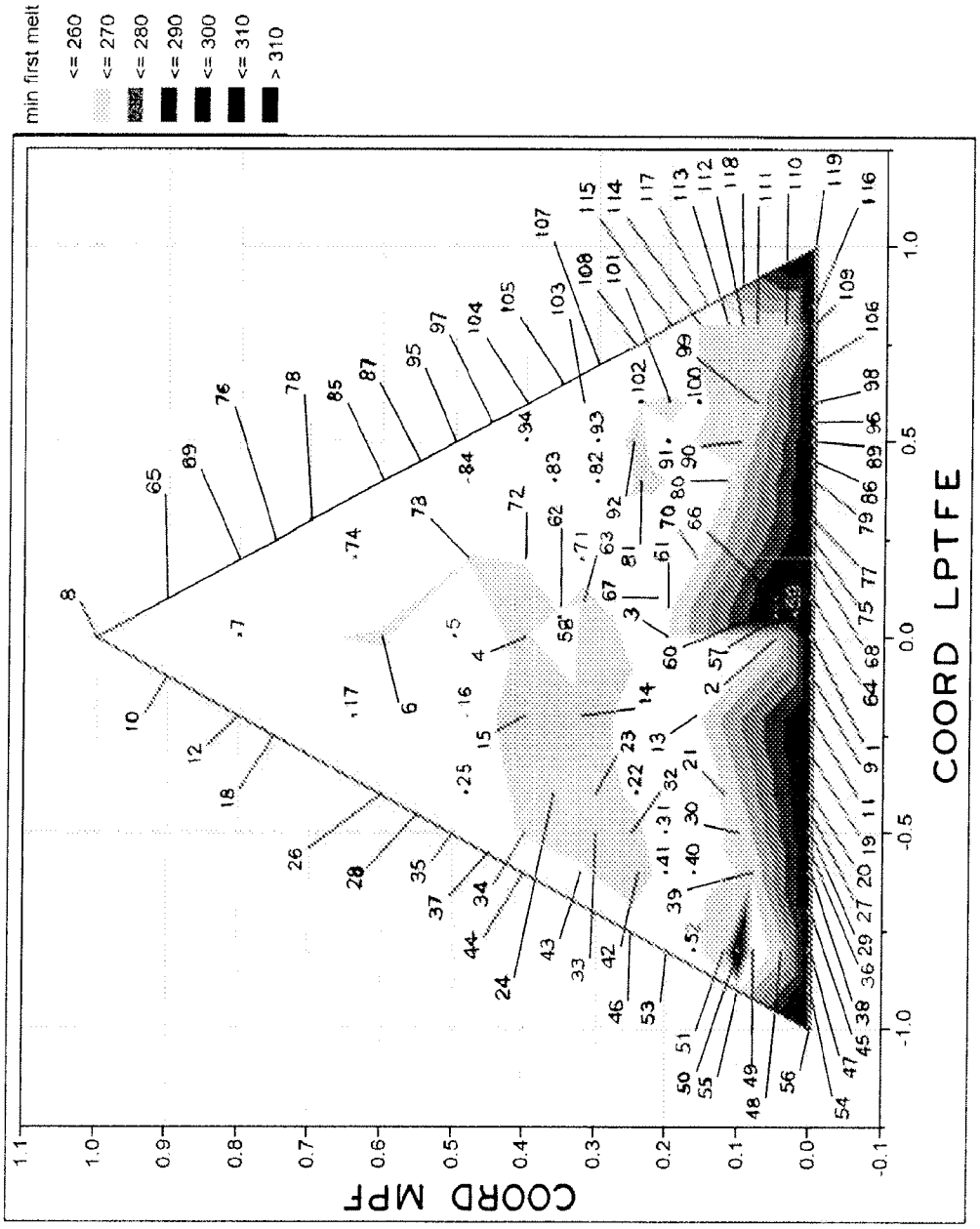

Contour Plot for min first melt
min first melt
<= 260
<= 270
<= 280
<= 290
<= 300
<= 310
> 310
COORD MPF
COORD LPTFE

Fig. 28

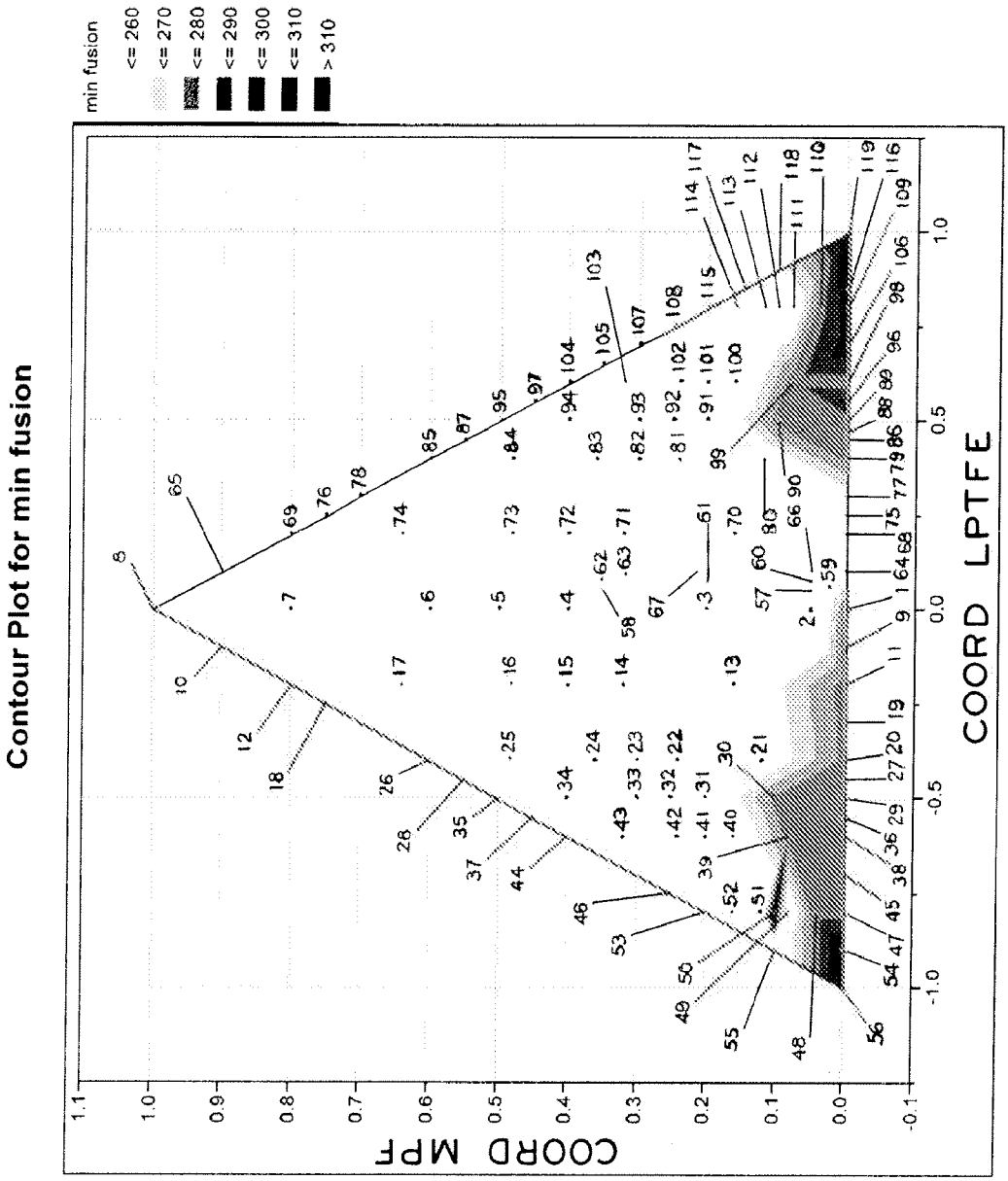

Contour Plot for min fusion
min fusion
<= 260
<= 270
<= 280
<= 290
<= 300
<= 310
> 310
COORD MPF
COORD LPTFE

Fig. 29

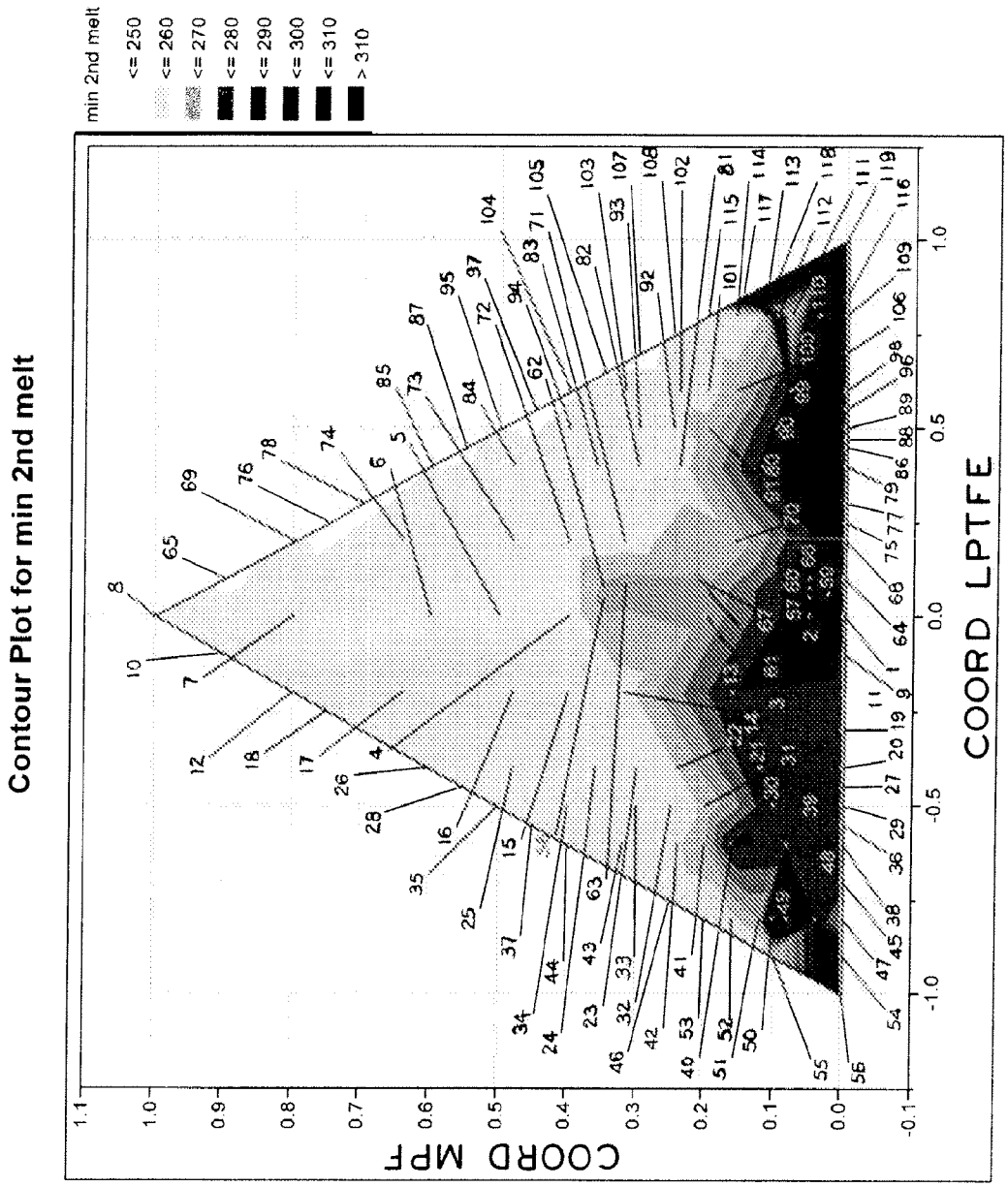

Contour Plot for min 2nd melt
min 2nd melt
<= 250
<= 260
<= 270
<= 280
<= 290
<= 300
<= 310
> 310
COORD MPF
COORD LPTFE

Fig. 30

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/059368

A. CLASSIFICATION OF SUBJECT MATTER
INV. C08L27/18 C09D127/18
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C09D C08L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, CHEM ABS Data, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	WO 2010/036935 A1 (WHITFORD CORP [US]; HARVEY LEONARD W [US]; BRAIN HELEN L [GB]) 1 April 2010 (2010-04-01) page 38, line 31; examples; tables 3c-12	1-20
X,P	WO 2010/036911 A1 (WHITFORD CORP [US]; HARVEY LEONARD W [US]; LEECH LAWRENCE D [US]) 1 April 2010 (2010-04-01) claims; examples 1,9; tables 6,9,11,12,18	1-20
X	WO 2007/056350 A1 (DU PONT [US]; MITSUI DU PONT FLUORCHEMICAL [JP]; NAMURA SHINICHI [JP]) 18 May 2007 (2007-05-18) claims; example 3	1,3,5,6, 9

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 March 2011	29/03/2011

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Enrique de Los Arcos

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/059368

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 1-20(partially)
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/059368

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1 840 165 A1 (EIDGENOESS TECH HOCHSCHULE [CH]) 3 October 2007 (2007-10-03) claims; example 9; tables V,VI	1,3,4,8, 9
A	WO 2009/146277 A1 (WHITFORD CORP [US]; HARVEY LEONARD W [US]; COATES MICHAEL [US]; WRIGHT) 3 December 2009 (2009-12-03) claims; examples	1-20

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FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 1-20(partially)

I) The subject-matter of the claims is unclear for the following reasons: 1. It is clear from the description para. 73-79 and 109-11 that the following features are essential to the definition of the invention: a) The LPTFE is typically a dispersion, have a mean particle size of 0.1 micro.m (as measured therein) and a Mn of less than 500.000 (as measured therein). b) The MPF has typically a MFR of greater than 0.5 g/10' (as measured therein) and a co-monomer content, other than TFE, of 3.0 wt-% or greater. Since the independent claims do not contain these features they do not meet the requirement following from Article 6 PCT taken in combination with Rule 6.3(b) PCT that any independent claim must contain all the technical features essential to the definition of the invention. 1.1 It should be noted that the application as filed does not specify the particular, standard method, used for the calculation of value Mn (weight-average molecular weight), the value being thus unclear. The different methods available for calculating the Mn are known to lead to different Mn values (Art. 6 PCT). 1.2 Further, the expression 'low molecular weight' in claims 1 and 13 and the expression 'high molecular weight' in claims 2, 5, 16 and 18, include relative, vague and indefinite terms (low, resp., high) that introduce unclarity into the claims, since the claims do not include a basis for its calculation (Art. 6 PCT). Cf description, para 75. 2. The subject-matter of independent claims 1, 12 and 13 is unclear, since the definition of the components do not clearly exclude the possibility that the components LPTFE and first or second MPF are actually one and the same. The claims should be redrafted in order to clearly identify the individual components forming the subject-matter of the claims (Art. 6 PCT). 2.1 It is also unclear whether the 'further' component of claims 5, 18 actually is or may be one of the LPTFE and/or MPF components already present in the independent claims 1 and 13, or, at least, this possibility is not excluded (Art. 6 PCT). 3. The claims should include standard methods permitting the calculation of the parameters Tm, Mn (Art. 6 PCT). 4. The expression 'chemically different' in claims 1 and 13 includes a relative, vague and indefinite term (different) that introduces unclarity into the claims, since the claims do not include a basis for its calculation (Art. 6 PCT). Cf description, para. 102. 5. The expression used in claims 3, 4, 6, 7, 8, 17 and 19 'of total solids' is unclear, since the previous claims to which said claims refer do not mention and/or are not limited by any particular state (Art 6 PCT). 6. The process feature in claim 10 that the LPTFE 'is obtained via emulsion polymerization without being subjected to agglomeration, thermal degradation, or irradiation' is unclear, since claim 10 claims a product per se (a composition) that should be defined in terms of the technical features of the product, disregarding the method used (or not used) for its obtention. II) The lack of clarity of the claims is of such an extent, that a complete search report may not be established (Art. 17(2)(a)(ii) and (b) PCT). The present International Search Report has been established based on the particular components used in the examples on file and on the present claims, in which the unclear, objected subject-matter has been clarified based in the description.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.2), should the problems which led to the Article 17(2) declaration be overcome.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2010/059368

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2010036935 A1	01-04-2010	US 2010080959 A1	01-04-2010
WO 2010036911 A1	01-04-2010	AR 073682 A1	24-11-2010
		US 2010080955 A1	01-04-2010
WO 2007056350 A1	18-05-2007	CN 101365750 A	11-02-2009
		EP 1948733 A1	30-07-2008
		JP 2007133007 A	31-05-2007
EP 1840165 A1	03-10-2007	NONE	
WO 2009146277 A1	03-12-2009	AR 071934 A1	28-07-2010
		CA 2725349 A1	03-12-2009
		EP 2291452 A1	09-03-2011
		US 2009317553 A1	24-12-2009