(12) UK Patent Application (19) GB (11) 2 294 050 (13) A

(43) Date of A Publication 17.04.1996

(21) Application No 9420665.3

(22) Date of Filing 13.10.1994

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(51) INT CL^6
C09J 123/02 , B22F 1/00 , C09J 125/06 133/10 153/00 // C09J 123/06 123/12

(52) UK CL (Edition O)
C3M MXAM M129A M133A M139 M139A M140 M140A M145 M146 M146A M152 M165 M167 M170 M203
U1S S1369 S1638 S1658 S3052

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GB 1421583 A **GB 1348836 A** **GB 1252607 A** **GB 1252604 A** **EP 0444446 A2**

(58) Field of Search
UK CL (Edition M) **C3M MXAH MXAL MXAM MXAP MXAS MXAT MXZ**
INT CL^5 **C09J**
Online databases : WPI

(54) High performance binder compound composition for making precision metal part by powder injection molding

(57) A binder composition for use in making metal parts through a metal powder injection molding process comprises: (a) a first C_2-C_8 olefin polymer with a relatively low solubility parameter; (b) a second polymer (polyvinyl aromatic, polymethacrylate) with a relatively high solubility parameter; and (c) a block copolymer containing blocks of the repeating units of the first and second polymers, or of the repeating units whose structures are similar to those of the repeating units of the first and second polymers. Also provided are a metal powder injection composition comprising the blend composition and a process for making metal parts from the metal powder injection composition.

GB 2 294 050 A

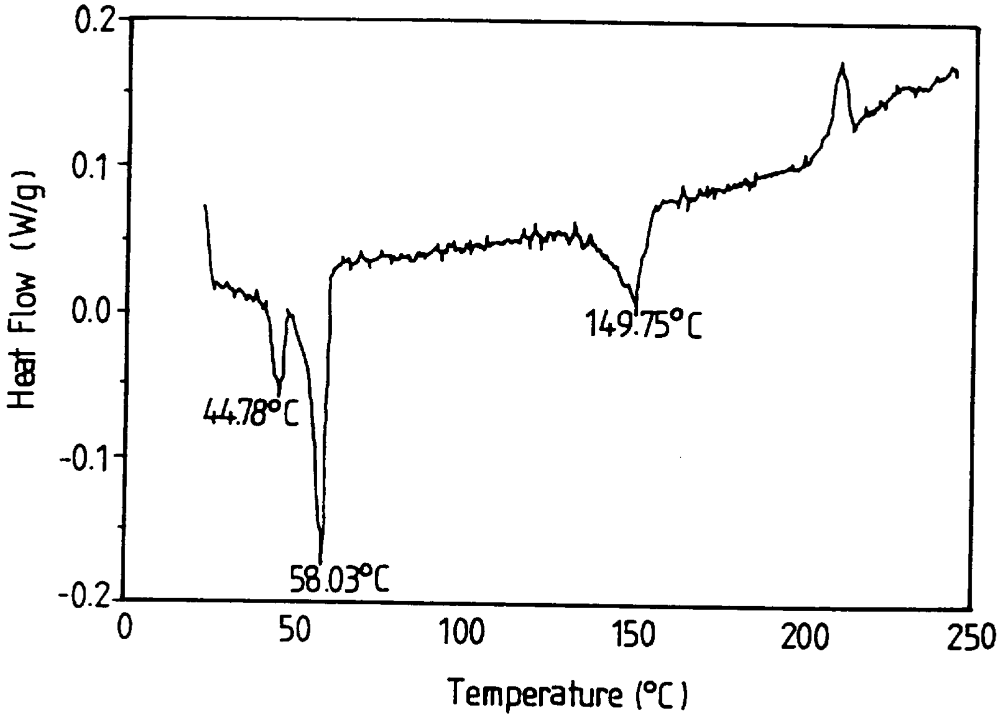

0.2
0.1
0.0
-0.1
-0.2
Heat Flow (W/g)
44.78°C
58.03°C
149.75°C
0
50
100
150
200
250
Temperature (°C)

Fig. 1

2/5

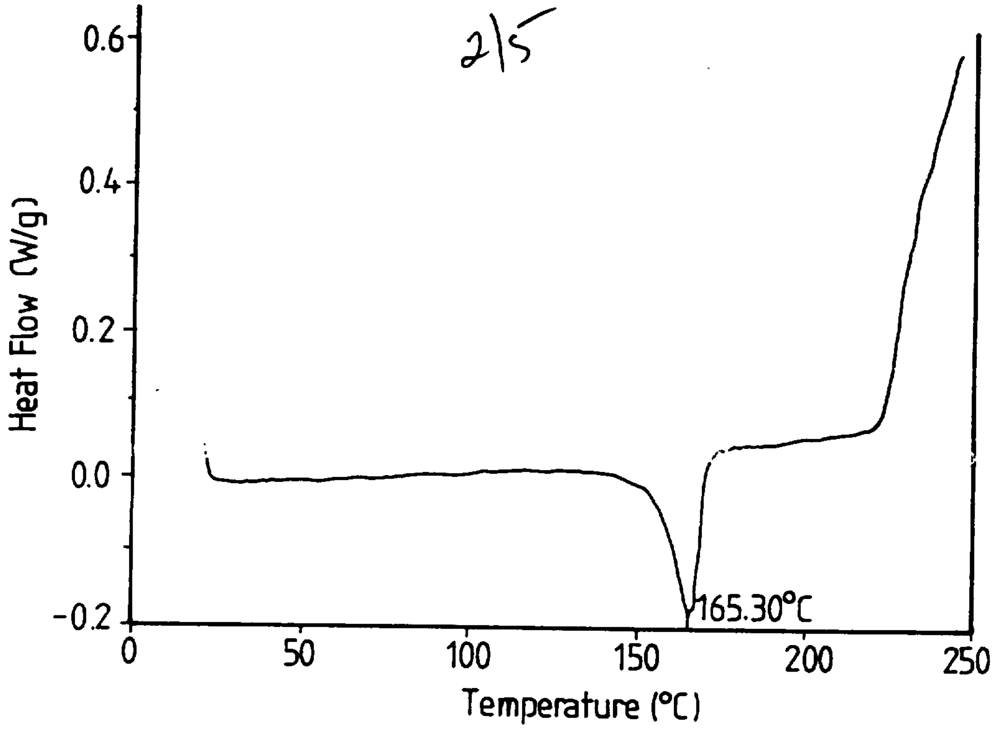


Fig. 2A

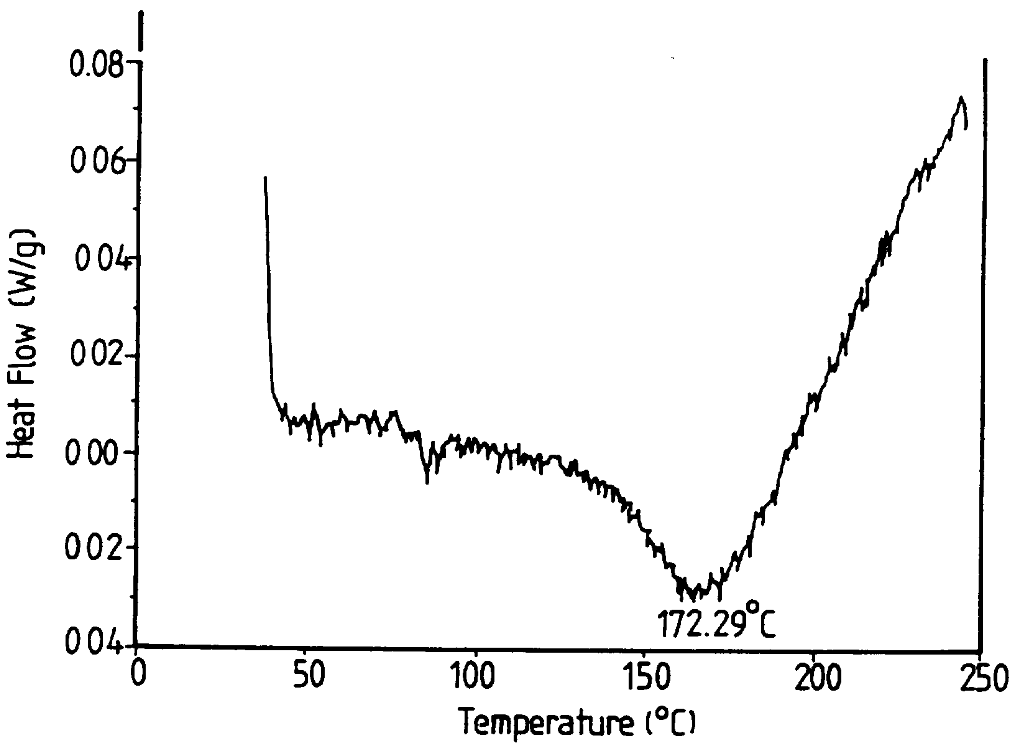
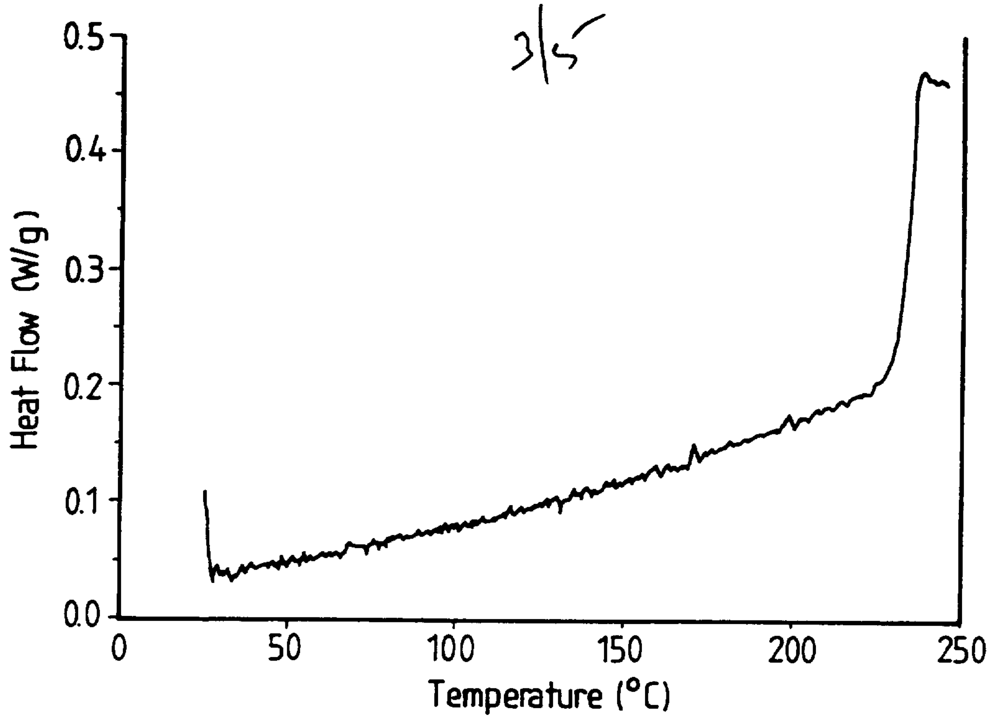
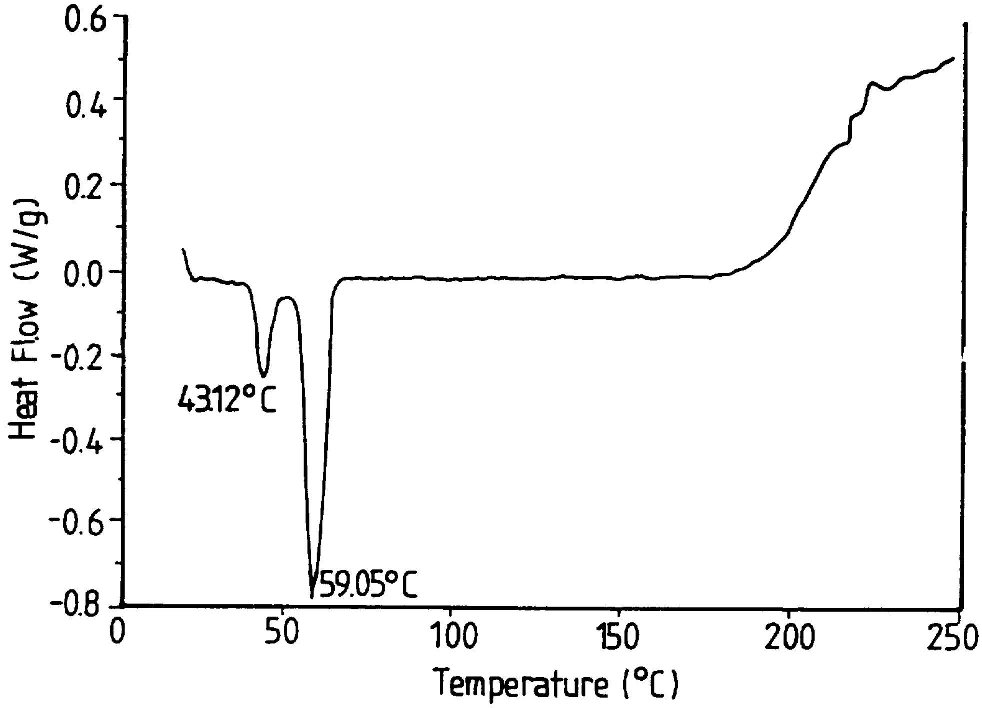


Fig. 2B



Heat Flow (W/g)
0.5
0.4
0.3
0.2
0.1
0.0
0
50
100
150
200
250
Temperature (°C)

Fig. 2C



Heat Flow (W/g)
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
43.12°C
59.05°C
0
50
100
150
200
250
Temperature (°C)

Fig. 2D

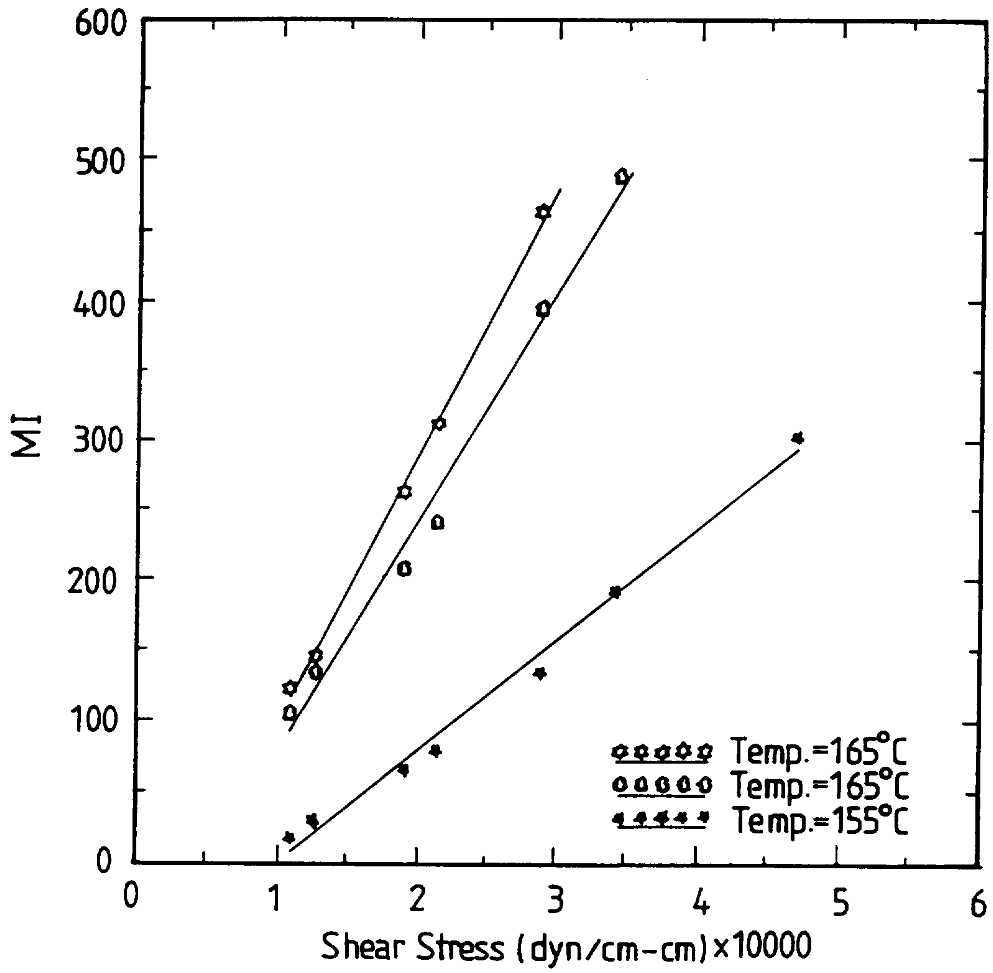

600
500
400
300
200
100
0
MI
0
1
2
3
4
5
6
Shear Stress (dyn/cm-cm)×10000
Temp.=165°C
Temp.=165°C
Temp.=155°C

Fig. 3

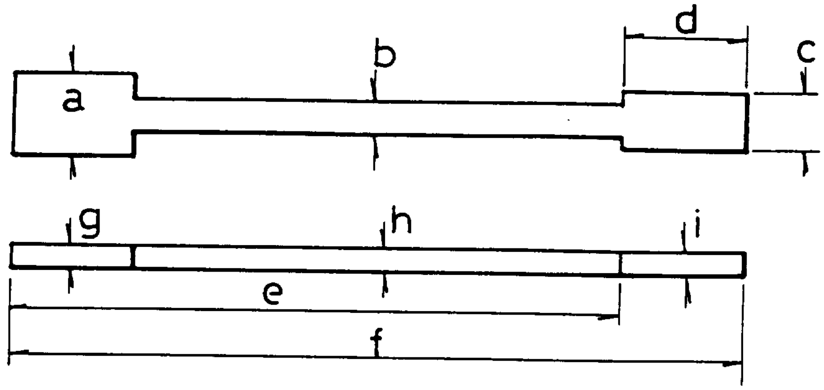


Fig. 4

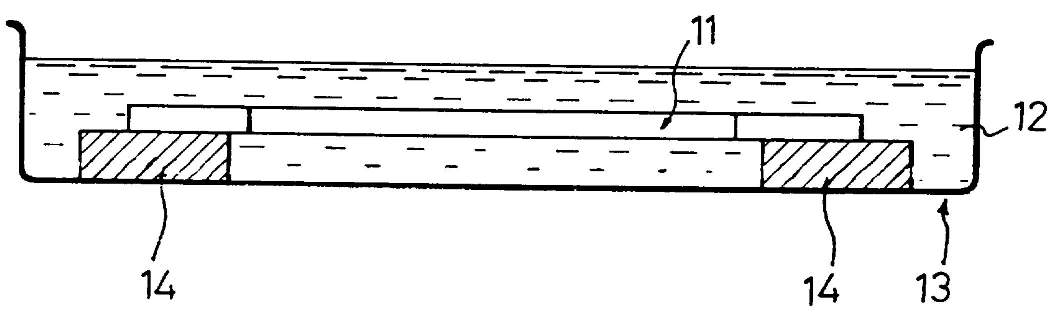


Fig. 5

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TITLE

HIGH PERFORMANCE BINDER COMPOUND COMPOSITION FOR MAKING PRECISION METAL PART BY POWDER INJECTION MOLDING

BACKGROUND OF THE INVENTION

The present invention relates to a binder composition for use in making metal parts through a metal powder injection molding process. The present invention also relates to a use of the binder composition.

Powder injection molding is an emerging technology for making metal parts. One of the main advantages of using the powder injection molding method is that it provides a quick and relatively simple way to fabricate small, high-precision three-dimensional parts with relatively complicated external features. Typically, the powder injection molding process involves the steps of first mixing a metal powder with a multi-component binder composition, and then forming a green compact from the metal powder/binder mixture via an injection molding process. The green compact is then subjected to debinding (by firing) and sintering steps until the sintered body has taken its permanent predetermined form. The use of multiple components in binder compositions allows various components to be sacrificed at different stages to avoid deformation or collapse of the green compact during the debinding step, thus ensuring the dimensional integrity of the final sintered product.

The most commonly used binder composition for metal powder injection molding typically contains two or more polymeric components and an appropriate amount of oil or wax. Fatty acids are conventionally added to the binder composition as a surface active agent and/or plasticizer. The binder composition then blends with metallic powder to form an injection molding composition. The polymeric components of the binder composition typically include non-crystalline polymers such as polystyrene, and crystalline polymers such as polypropylene. Because of the different properties among the various polymeric components in the binder composition, compatibility often becomes a problem. The incompatibility between or among the polymeric components can result in heterogeneity in the binder composition and adversely affects the dimensional integrity as well as the precise shape of the sintered parts, and thus makes the precision control of the final dimension and shape of the final products difficult.

US Patent No. 4,158,688 discloses a sacrificial binder composition for molding particulate solids, including powders of lithium-modified beta-alumina, into sintered products. The binder composition disclosed in the '688 patent comprises a block copolymer and a plasticizer. The block copolymer is represented by the following formula: X-[B(AB) A] , wherein "A" is a liner or branched polymer that is glassy or crystalline at room temperature, "B" is a polymer that behaves as an elastomer at processing temperature, " " is 0 or a positive integer, " " is a positive integer greater than 2, and "X" is either "A" or "B". The plasticizer may be an oil, a wax, or a mixture thereof. The '688 does not address any compatibility problem when multiple polymeric binder components are used.

US Patent No. 4,283,360 discloses a process for producing a molded ceramic metal, wherein a solvent-soluble resin and a solvent-insoluble resin, a ceramic or metallic powder and a plasticizer are blended and molded. The molded product is treated with an organic solvent to dissolve the solvent-soluble resin. Then the treated product is fired to obtain a molded ceramic or metal product. Again, the '360 patent does not address the potential incompatibility problem between the solvent-soluble and solvent-insoluble resins. Nevertheless, the dimensional integrity of the sintered product can be adversely affected as a result of such incompatibility.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an improved binder composition for use in a powder injection molding of metal parts. It is another object of the present invention to provide a binder composition comprising a first polymer with a relatively low solubility parameter, a second polymer with a relatively high solubility parameter, and a block copolymer containing blocks of the constituting monomers of the first and second polymers, or of monomers of respectively similar structures. The block copolymer serves as a solubilization aid which causes the first and the second polymers to be mutually miscible to thereby form a homogeneous liquid mixture exhibiting high flowability.

It is yet another object of the present invention to provide a metal powder injection composition for making metal parts through a metal powder injection process.

It is a further object of the present invention to provide a process for making metal parts through a metal powder injection molding process.

In accordance with the present invention, an improved binder composition is mixed with metallic powders to fabricate high-precision metal parts, wherein the mixture of the binder composition and the metallic powders is molded by a powder injection molding process into a green compact and the green compact is then debinded and sintered to obtain the high-precision metal parts. The binder composition of the present invention exhibits excellent compatibility and is uniformly distributed in a green compact in a very homogeneous manner, thus allowing the green compact to exhibit excellent physical and dimensional integrity both before and during the subsequent sintering stage to thereby ensure the required precision of the final products.

These and other objects, advantages and features of the present invention will be more fully understood and appreciated by reference to the written specification.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be described in detail with reference to the annexed drawings, wherein:

Fig.1 is a plot of the DSC thermal analysis of the binder composition prepared in Example 3.

Fig.2A to 2D are plots of DSC thermal analyses of polypropylene, polystyrene, ethylene/styrene block copolymer, and paraffin wax, which were used to prepare the binder composition in Example 3.

Fig.3 shows the relationship between melt index and shear stress at various temperatures measured for the binder composition prepared in Example 3.

Fig.4 is a schematic drawing showing a test specimen of a green compact suspended on top of two supports for measuring its tendency to warp, wherein a= 7mm, b= 3mm, c= 5mm, d= ,e = , f= 50 mm and g=h=i= 2mm.

Fig.5 shows the various portions of a sintered metal powder product as described in Table 4 for reporting the dimensional stability of sintered product prepared using the binder composition of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

While this specification concludes with claims particularly pointing out and distinctly claiming that which is considered to be the invention, it is believed that the invention can be better understood from a reading of the following detailed description of the invention.

The present invention relates to a binder composition, which comprises (1) a first polymer with a relative low solubility parameter, (2) a second polymer with a relatively high solubility parameter, and (3) a block copolymer containing blocks of the repeating units of the first and second polymers, or of monomers with respectively similar structures. More specifically, the present invention relates to a binder composition comprising (1) a first polymer having a relative high crystallinity and low solubility parameter, (2) a second polymer having a relative low crystallinity and high solubility parameter and (3) a block copolymer containing blocks of the repeating units of the first and second polymers, or of monomers with respectively similar structures.

The definition of solubility parameter can be found in many polymer textbooks, such as Polymer Chemistry, 2nd. ed., by Raymond B. Seymour and Charles E. Carraher, Jr., Marcel Dekker, Inc. (1988).

It is preferred that the first polymer of the present invention is a polyolefine. More preferably, the first polymer is a polymer of C_{1-8} alpha-olefine, and most preferably, the first polymer is polyethylene or especially polypropylene.

The second polymer of the present invention is a polymer with, as compared with the first polymer, a lower crystallinity and higher solubility parameter. It is preferred that the second polymer is a polyester or a polymer of vinyl aromatic. More preferably, the second polymer is poly(methyl methacrylate) or especially polystyrene.

The block copolymer of the present invention generally contains blocks of the repeating units of the first and second polymers. The copolymer containing blocks of monomers whose structures are similar to the repeating units of the first and second polymers, e.g. an isoprene/styrene block copolymer is also useful as a block copolymer of the present invention. The block copolymer of the present invention exhibits thermoplastic characteristic at elevated temperatures. After being cooled down, it possesses excellent adhesive characteristics. In the binder composition of the present invention, the block copolymer serves as a solubilization aid causing the first and second polymers to be mutually miscible to thereby form a homogeneous liquid mixture.

The binder composition of the present invention exhibits a melt index (MI) ranging from 0-100g/10 min at a test temperature of 200^{o}C under a load of 6.2Kg. The uniformity and homogeneity of the binder composition can be examined by spreading a thin layer of the binder composition on a glass plate and visually inspecting the uniformity and homogeneity of the coating layer.

The preferred combinations of the first polymer/ second polymer/ copolymer for the binder composition of the present invention include, but not limit to, polypropylene/polystyrene/a styrene-ethylene copolymer or a styrene-propylene copolymer. Other examples for the first/second polymers combinations are, but not limit to: polyethylene/polystyrene, polypropylene/ poly(methyl methacrylate), polyethylene/ poly(methyl methacrylate) and the likes.

The present invention also relates to the use of the binder composition. Namely, the present invention further relates to a metal powder injection composition comprising the binder composition and to a process for making metal parts by use of the binder composition.

Therefore, the present invention relates to a metal powder injection composition comprising the binder composition of the present invention and a dispersant and a metal powder. It is preferred that the dispersant for the metal powder injection composition comprises an oil, a wax, or a mixture thereof. Further, it is preferred that the metal powder comprises a carbonyl iron powder, a stainless steel powder or a mixture thereof.

The present invention further relates to a process for making metal parts through a metal powder injection molding process. For making metal parts, a first polymer, a second polymer and a block copolymer are blended to form a white gellish mixture. The gellish mixture is then uniformly dispersed in a plasticizer to form an injection molding binder. The injection molding binder so prepared is then mixed with a metal powder to form an injection molding composition, which is subsequently subjected to an injection molding to form a green compact. The green compact is sintered to form the final metal parts of predetermined shape and dimension. Since the block copolymer of the present invention exhibits thermoplastic characteristic at elevated temperatures and after being cooled down, it possesses excellent adhesive characteristics, it provides the required characteristics to enable the injection molded green compact prepared from the metal powder/binder mixture to retain the required dimensional integrity and strength.

The present invention will now be described more specifically with reference to the following examples. It is to be noted that the following descriptions of examples including preferred embodiment of this invention are presented herein for purpose of illustration and description; it is not intended to be exhaustive or to limit the invention to the precise form disclosed.

EXAMPLES

EXAMPLE 1:

Polypropylene, polystyrene, and a block copolymer of ethylene and styrene were mixed in accordance with various proportions as shown in Table 1 to form fifteen homogeneous blends (Blend 15 contained the copolymer only). These blends were respectively blended at 175°C for 40 minutes. The units of the components shown in Table 1 are in grams. The melt indexes (MI) of polypropylene, polystyrene, and the ethylene/styrene block copolymer are: 35 g/10min, 22 g/10min, and 12 g/10min, respectively, at a test condition of 180°C and 6.2 Kg. Test results are summarized in Table 1. It was observed that the blends without the ethylene/styrene block copolymer were heterogeneous and opaque. The light transparency of the blend generally increases as the amount of the ethylene/styrene block copolymer increases.

Table 1

Component/ Tests	Blends														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
polypropylene	30	29.5	29	28.5	28	27.5	25	22.5	20	17.5	5	12.5	10	5	0
polystyrene	30	29.5	29	28.5	28	27.5	25	22.5	20	17.5	15	12.5	10	5	0
copolymer	0	1	2	3	4	5	10	15	20	25	30	35	40	50	60
MI	51	58	48	48	46	44	28	24	21	17	14	12	8	6	12
appearance **	*	Homogeneous phase, <== Increasing milkiness, increasing transparence ==>													
light-transparency	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

* heterogeneous, phase separation

** transparent

EXAMPLE 2:

The blends 2-15 prepared in Example 1 were dispersed in a paraffin wax dispersant to form corresponding binder compositions 2-15.

EXAMPLE 3:

A binder composition containing polypropylene, polystyrene, paraffin wax and ethylene/styrene block copolymer in a weight ratio of 6/6/6/1 was prepared and tested. The melt index measured at 3,8 Kg/155°C was

220 g/10 min. Other test results are summarized in Table 2. The DSC thermal analysis of the binder composition is shown in Fig. 1. And the DSC thermal analyses of the constituting components, i.e., polypropylene, polystyrene, ethylene/styrene block copolymer and paraffin wax, are shown in Figs. 2(A) through 2(D), respectively. Fig. 3 shows the relationship between melt index and shear stress at various temperatures. Table 2 shows the relationship between the measured melt index and test conditions, including test temperature (in ^{o}C) and test load (in Kg).

Table 2

Temp. (^{o}C)	Load (Kg)						
	5.2	3.8	3.2	2.36	2.1	1.4	1.2
165	*	*	463	312	264	147	123
160	*	488	395	242	208	136	106
155	304	220	135	80	67	32	20

* too fast to be accurately measured.

EXAMPLE 4:

A metal powder injection composition was prepared by blending carbonyl iron powder (CIP) with 10% by weight of the binder composition prepared from Example 3 at 190^{o}C for 50 minutes. The resultant injection composition exhibited a high flowability. Its melt index was measured to be 140 g/10 min, at 6.2 Kg/160^{o}C.

EXAMPLE 5:

A binder composition containing polypropylene, poly(methyl methacrylate), paraffin wax and ethylene/styrene block copolymer in a weight ratio of 6/6/6/1 was prepared and tested. The melt index measured at 3.8 Kg/155^{o}C was 660 g/10 min.

EXAMPLE 6:

A metal powder injection composition was prepared by blending carbonyl iron powder with 10% by weight of the binder composition prepared from Example 5 at 190°C for 50 minutes. The resultant injection composition also exhibited a high flowability. Its melt index was measured to be 178 g/10 min, at 6.2 Kg/160°C.

EXAMPLE 7:

A binder composition containing polypropylene, polystyrene, paraffin wax and ethylene/styrene block copolymer in a weight ratio of 6/6/6/1 was prepared and tested. The melt index for polyethylene was measured to be 46 g/10min at 0.325 Kg/125°C. The melt index measured for the binder composition at 3.8 Kg/155°C was 175 g/10 min.

EXAMPLE 8:

A metal powder injection composition was prepared by blending carbonyl iron powder with 10% by weight of the binder composition prepared from Example 7 at 190°C for 50 minutes. The resultant injection composition also exhibited a high flowability. Its melt index was measured to be 190 g/10 min, at 6.2 Kg/160°C.

EXAMPLE 9:

A binder composition containing polypropylene, poly(methyl methacrylate), paraffin wax and ethylene/styrene block copolymer in a weight ratio of 6/6/6/1 was prepared and tested. The melt index for polyethylene was measured to be 46 g/10min at 0.325 Kg/125°C. The melt index of the binder composition measured at 3.8 Kg/100°C was 112 g/10 min.

EXAMPLE 10:

A metal powder injection composition was prepared by blending carbonyl iron powder with 10% by weight of the binder composition prepared from Example 9 at 190°C for 50 minutes. The resultant injection composition also exhibited a high flowability. Its melt index was measured to be 27 g/10 min, at 6.2 Kg/160°C.

EXAMPLE 11:

Several binder compositions were prepared using a procedure similar to that described in Example 3, except that the paraffin wax dispersant used in Example 3 was replaced by one of those dispersants listed in Table 3. Corresponding metal powder injection compositions were then prepared by blending carbonyl iron powder with 10% by weight of the binder compositions so prepared, at 190°C for 50 minutes. The melt indexes of these metal powder injection compositions were measured and summarized in Table 3.

Table 3

Temp. (°C)	Dispersant									
	1	2	3	4	5	6	7	8	9	10
160°C	160	*	93	26	*		23	156	52	90
170°C		*			201					
180°C		12				*				
	11	12	13	14	15	16	17	18	19	20
160°C	119	124	145	257	159	*	140	201	86	186
170°C						*				
180°C						41				

Dispersants: 1: soybean oil; 2: hydrogenated soybean oil; 3: olive oil; 4: peanut oil; 5: sesame oil; 6: linseed oil; 7: corn oil; 8: pork oil; 9: butter; 10: lubricant oil (I); 11: lubricant oil (II); 12: vacuum pump oil (I); 13: vacuum pump oil (II); 14: caoutchouc lubricant; 15: R68 cycling oil; 16: sunflower oil; 17: paraffin wax; 18: fossil resin; 19: Brazil wax (Carnauba wax); 20: microcrystalline wax.

* immobile

EXAMPLE 12:

A metal specimen green compact as shown in Fig. 4 was fabricated from the metal powder injection composition prepared in Example 4 using an injection molding process. The flexural strength of the test specimen was measured to be 4.0 Kg/min^2.

EXAMPLE 13:

The metal test specimen prepared in Example 12 was suspended on the top of two supports and immersed in n-heptane, as shown in Fig. 5, for six hours. No warping was observed from the test metal specimen.

EXAMPLE 14:

A metal powder injection composition was prepared by blending stainless steel 304L powder having an average particle diameter of 9.8 um with 10% by weight of the binder composition prepared from Example 3, at 180^{o}C for 50 minutes. The resultant injection composition exhibited a high flowability. Its melt index was measured to be 300 g/10 min, at 6.2 Kg/170^{o}C. A metal specimen similar to Example 12 was fabricated from this metal powder injection composition using an injection molding process. The transverse rupture strength (TRS) of the test specimen was measured to be 3.0 Kg/min^2. The metal test specimen was suspended on the top of two supports and immersed in n-heptane, as in Example 13, for six hours. No warping was observed from the test metal specimen.

EXAMPLE 15:

A metal powder injection composition was prepared by blending stainless steel 306L powder having an average particle diameter of 9.8 um with 10% by weight of the binder composition prepared from Example 3, at 180°C for 50 minutes. The resultant injection composition exhibited a high flowability. Its melt index was measured to be 265 g/10 min, at 6.2 Kg/170°C. A metal specimen similar to Example 12 was fabricated from this metal powder injection composition using an injection molding process. The TRS of the test specimen was measured to be 3.0 Kg/min^2. The metal test specimen was suspended on the top of two supports and immersed in n-heptane, as in Example 13, for six hours. No warping was observed from the test metal specimen.

EXAMPLE 16:

A metal powder injection composition was prepared by blending carbonyl iron powder having an average particle diameter of 5 um, and carbonyl nickel powder having an average particle diameter of 4 um, in a weight ratio of carbonyl iron powder/carbonyl nickel powder =98/2, with 9% by weight of the binder composition prepared from Example 3, at 180°C for 50 minutes. The resultant injection composition exhibited a high flowability. Its melt index was measured to be 412 g/10 min, a 6.2 Kg/170°C. A metal specimen similar to Example 12 was fabricated from this metal powder injection composition using an injection molding process. The TRS of the test specimen was measured to be 4.1 Kg/mm^2. The metal test specimen was suspended on the top of two supports and immersed in n-heptane, as in Example 13, for six hours. No warping was observed from the test metal specimen.

EXAMPLE 17:

A metal powder injection composition was prepared in a procedure similar to that described in Example 16, except that the weight ratio of carbonyl iron powder/carbonyl nickel powder is 92/8. The resultant injection composition exhibited a high flowability. Its melt index was measured to be 423 g/10 min, at 6.2 Kg/170^{o}C.

EXAMPLE 18:

A binder composition containing polypropylene, polystyrene, paraffin wax and isoamylene/styrene block copolymer in a weight ratio of 6/6/6/1 was prepared and tested. The melt index measured at 3.8 Kg/155^{o}C was 281 g/10 min.

EXAMPLE 19:

A metal powder injection composition was prepared by blending carbonyl iron powder with 10% by weight of the binder composition prepared from Example 18 at 190^{o}C for 50 minutes. The resultant injection composition exhibited a high flowability. Its melt index was measured to be 176 g/10 min, at 6.2 Kg/16^{o}C.

EXAMPLE 20:

A metal powder injection composition was prepared by blending stainless steel 304L powder having an average particle diameter of 9.8 um with 10% by weight of the binder composition prepared from Example 18, at 180°C for 50 minutes. The resultant injection composition exhibited a high flowability. Its melt index was measured to be 285 g/10 min, at 6.2 KG/170°c.

EXAMPLE 21:

The green compacts prepared in the above examples using the metal powder injection molding process were removed-from the mold by a robotic arm. No damage or distortion was observed in any of the green compact test specimens.

EXAMPLE 22:

The metal injection composition prepared in Example 17 was subject to an injection molding machine to form metal objects as shown in Fig. 6. The metal objects were debinded and sintered at 125°C for 75 minutes to form sintered objects. The dimensions of the sintered objects were measured at nine locations as shown in Fig. 6. The results are summarized in Table 4. it is clear from Table 4 that excellent dimensional stability can be obtained by using the binder composition disclosed in the present invention. With the binder composition disclosed in the present invention, the weight of the green compacts can be maintained within ±0.1%, and the dimension of the final sintered can be maintained within ±0.3% of the designed value. Thus the present invention discloses an excellent composition for use as a binder in the metal powder injection molding of precision metal parts.

Table 4

Test	Measured Dimension (mm)								
Specimen	1	2	3	4	5	6	7	8	9
A	5.77	2.47	4.11	8.22	32.9	41.1	1.64	1.64	1.63
B	5.76	2.47	4.11	8.19	32.9	41.2	1.64	1.64	1.63
C	5.76	2.47	4.11	8.19	32.9	41.2	1.63	1.64	1.63
D	5.79	2.47	4.11	8.18	32.9	41.1	1.64	1.63	1.63
E	5.77	2.47	4.11	8.20	32.9	41.1	1.63	1.64	1.63
F	5.77	2.47	4.11	8.17	32.9	41.1	1.64	1.65	1.63
Average:	5.77	2.47	4.11	8.19	32.9	41.1	1.63	1.64	1.63

The foregoing description of the preferred embodiments of this invention has been presented for purposes of illustration and description. Obvious modifications or variations are possible in light of the above teaching. The embodiments were chosen and described to provide the best illustration of the principles of this invention and its practical application to thereby enable those skilled in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. All such modifications and variations are within the scope of the present invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly, legally, and equitably entitled.

CLAIMS

1. In a binder composition for metal parts by powder injection characterized in that the composition comprises:

(a) a first polymer selected from the group consisting of C_{2-8} alpha-olefin;

(b) a second polymer selected from the group consisting of polyesters and poly(vinyl)aromatics; and

(c) a block copolymer containing blocks of the repeating units of the first and second polymers, or of the repeating units whose structures are similar to the repeating units of the first and second polymers.

2. The binder composition as set forth in Claim 1 wherein said block copolymer is selected from the group consisting of ethylene/styrene block copolymers, propylene/styrene block copolymers and isoprene/styrene block copolymers.

3. The binder composition as set forth in Claim 1 wherein said first polymer is polyethylene or polypropylene.

4. The binder composition as set forth in Claim 1 wherein said second polymer is poly(methyl methacrylate) or polystyrene.

5. A binder composition substantially as hereinbefore described in the examples.

6. In a metal powder injection composition characterized in that the composition comprises:

(a) a first polymer selected from the group consisting of C_{2-8} alpha-olefin;

(b) a second polymer selected from the group consisting of polyesters and poly(vinyl)aromatics;

(c) a block copolymer containing blocks of the repeating units of the first and second polymers, or of the repeating units whose structures are similar to the repeating units of the first and second polymers;

(d) a dispersant containing an oil, a wax, or a mixture thereof; and

(e) a metal powder selected from the group consisting of a carbonyl iron powder, a stainless steel powder, or a mixture thereof.

7. A metal powder injection composition substantially as hereinbefore described in the examples.

8. In a process for making metal parts from a metallic powder by powder injection molding process, the improvement which comprises:

(A) preparing a binder composition comprising:

(a) a first polymer selected from the group consisting of C_{2-8} alpha-olefin;

(b) a second polymer selected from the group consisting of polyesters and poly(vinyl)aromatics;

(c) a block copolymer containing blocks of the repeating units of the first and second polymers, or of the repeating units whose structures are similar to the repeating units of the first and second polymers;

(d) a dispersant containing an oil, a wax, or a mixture thereof; and

(e) a metal powder selected from the group consisting of a carbonyl iron powder, a stainless steel powder, or a mixture thereof;

(B) preparing a metal powder injection composition by blending said binder composition with a metal powder;

(C) forming a green compact from said metal powder injection composition using an injection molding machine; and

(D) sintering said green compact to remove said binder composition and form said metal parts.

9. A process for making metal parts substantially as hereinbefore described in the examples.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

Application number
GB 9420665.3

Relevant Technical Fields

(i) UK Cl (Ed.M) C3M (MXAH, MXAL, MXAM, MXAP, MXAS, MXAT, MXZ)

(ii) Int Cl (Ed.6) C09J

Search Examiner
K MacDONALD

Date of completion of Search
20 DECEMBER 1994

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE DATABASES: WPI

Documents considered relevant following a search in respect of Claims :-
1-9

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 1421583	(SHELL) Claims 1, 10	at least Claim 1
X	GB 1348836	(EASTMAN KODAK) Claim 1	at least Claim 1
X	GB 1252607	(FLINTKOTE) Claim 1	at least Claim 1
X	GB 1252604	(FLINTKOTE) Claim 1	at least Claim 1
X	EP 0444446 A2	(HIMONT) Claim 1	at least Claim 1

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).