SUMMARY

[004a] In a first aspect of the present disclosure, there is provided a composition comprising:

a first portion of a poly(hydroxyalkanoate) and a second portion of the poly(hydroxyalkanoate),

wherein the first portion of the poly(hydroxyalkanoate) has a first weight average molecular weight and the second portion of the poly(hydroxyalkanoate) has a second weight average molecular weight which is at least 50 percent less than the first weight average molecular weight and

wherein the poly(hydroxyalkanoate) comprises at least 10 mole percent monomer repeat units of 3-hydroxypropionate.

[004b] In another aspect of the present disclosure, there is provided a film comprising the composition as disclosed herein.

[004c] In yet another aspect of the present disclosure, there is provided a fiber comprising the composition as disclosed herein.

[004d] In a further aspect of the present disclosure, there is provided a method for making a composition having a first portion of a poly(hydroxyalkanoate) and a second portion of the poly(hydroxyalkanoate), the method comprising the steps of:

polymerizing a first charge of at least one substituted lactone to produce a first portion of a poly(hydroxyalkanoate) having a first weight average molecular weight;

polymerizing a second charge of the at least one substituted lactone to produce a second portion of the poly(hydroxyalkanoate) having a second weight average molecular weight; and

blending the first portion and the second portion to produce a final poly(hydroxyalkanoate),

wherein the at least one substituted lactone comprises beta-propiolactone and the poly(hydroxyalkanoate) comprises monomer repeat units of 3-hydroxypropionate, and

wherein the second weight average molecular weight is at least 50 percent less than the first weight average molecular weight.

[005] In response to the above and other needs, the present disclosure provides a poly(hydroxyalkanoate) composition having a bimodal molecular weight distribution. In other words, the molecular weight distribution of the poly(hydroxyalkanoate) in the composition exhibits two distinct molecular weight peaks.

[006] In general, the composition comprises a first portion of a poly(hydroxyalkanoate) and a second portion of the poly(hydroxyalkanoate). Each of the first portion and the second portion has its own distinct weight average molecular weight. Thus, the first portion of the poly(hydroxyalkanoate) has a first weight average molecular weight and the second portion of the poly(hydroxyalkanoate) has a second weight average molecular weight. According to the present disclosure, the second weight average molecular weight which is at least 50 percent less than the first weight average molecular weight.

[007] More particularly, the first weight average molecular weight is typically at least 100,000 daltons, as determined by ASTM D5296. Preferably, the first weight average molecular weight is at least 200,000 daltons, as determined by ASTM D5296. Even more preferably, the first weight average molecular weight is at least 300,000 daltons, as determined by ASTM D5296.

[008] By contrast, the second weight average molecular weight is preferably less than about 25,000 daltons, as determined by ASTM D5296.

[009] With this difference in molecular weights, the composition typically has a polydispersity of at least 1.9, as determined by ASTM D5296. More preferably, the composition typically has a polydispersity from about 1.9 to about 3.5 as determined by ASTM D5296

[010] Typically, the composition includes from about 90 to about 50 weight percent of the first portion of the poly(hydroxyalkanoate) and from about 50 to about 10 weight percent of the second portion of the poly(hydroxyalkanoate). More preferably, the composition includes from about 85 to about 60 weight percent of the first portion of the poly(hydroxyalkanoate) and from about 40 to about 15 weight percent of the second portion of the poly(hydroxyalkanoate).

[011] In some examples, the weight ratio of the first portion of the poly(hydroxyalkanoate) to the second portion of the poly(hydroxyalkanoate) from about 1:1 to about 9:1

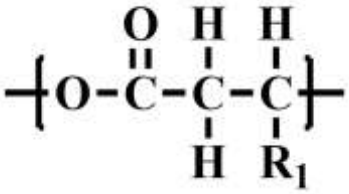
[012] The poly(hydroxyalkanoate) of the present composition comprises at least 10 mole percent monomer repeat units of 3-hydroxypropionate. In certain examples, the poly(hydroxyalkanoate) may comprise at least 25, at least 50, or at least 75 mole percent monomer repeat units of 3-hydroxypropionate.

[013] In broad terms, the poly(hydroxyalkanoate) of the composition may be a homopolymer, a copolymer, or a terpolymer. Thus, in certain examples, the poly(hydroxyalkanoate) comprises a homopolymer, namely, poly(3-hydroxypropionate).

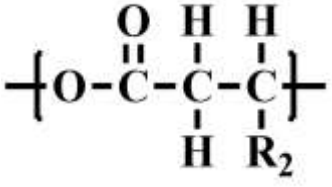
[014] In other examples, the poly(hydroxyalkanoate) comprises a copolymer or a terpolymer which includes

[015] a first repeat unit which is (3-hydroxypropionate),

[016] a second repeat unit according to Formula I

	Formula I ; and

[017] optionally, a third repeat unit according to Formula II,

	Formula II

[018] wherein R_1 and R_2 are each independently selected from the group consisting of linear or branched alkyl groups having from 1 to 22 carbon atoms.

[019] In some examples, this poly(hydroxyalkanoate) is more preferably a copolymer and R_1 is methyl. In such examples, the poly(hydroxyalkanoate) copolymer preferably comprises from about 10 to about 90 mole percent of the first repeat unit and from about 90 to about 10 mole percent of the second repeat unit.

[020] In other examples, the poly(hydroxyalkanoate) is more preferably a terpolymer, in which R_1 is methyl and R_2 is propyl. In such examples, the poly(hydroxyalkanoate) terpolymer preferably comprises from about 15 to about 75 mole percent of the first repeat unit, from about 75 to about 15 mole percent of the second repeat unit, and from about 1 to about 5 mole percent of the third repeat unit.

[021] Advantageously, this bimodal poly(hydroxyalkanoate) composition has been found to provide good physical properties associated with higher molecular weights while also having a reduced melt viscosity.

[022] The present disclosure also provides various articles which incorporate the aforementioned poly(hydroxyalkanoate) composition. In one example, the disclosure provides a film which is made up of a poly(hydroxyalkanoate) composition having a bimodal molecular weight distribution. In another example, the disclosure provides a fiber which is made up of a poly(hydroxyalkanoate) composition having a bimodal molecular weight distribution.

[023] In a further example, the present disclosure provides a method for making a composition having a first portion of a poly(hydroxyalkanoate) and a second portion of the poly(hydroxyalkanoate). According to one example, the method includes a step of polymerizing a first charge of at least one substituted lactone to produce a first portion of a poly(hydroxyalkanoate) having a first weight average molecular weight. The method also includes a step of polymerizing a second charge of the at least one substituted lactone to produce a second portion of the poly(hydroxyalkanoate) having a second weight average molecular weight. The second weight average molecular weight is at least 50 percent less than the first weight average molecular weight.

[024] The method further includes a step of blending the first portion and the second portion to produce a final poly(hydroxyalkanoate).

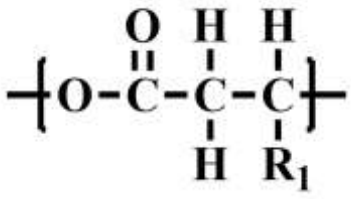
[025] According to the present disclosure, the at least one substituted lactone includes beta-propiolactone and the poly(hydroxyalkanoate) includes monomer repeat units of 3-hydroxypropionate.

[026] In accordance with certain examples of the method, the poly(hydroxyalkanoate) is a homopolymer, namely, poly(3-hydroxypropionate).

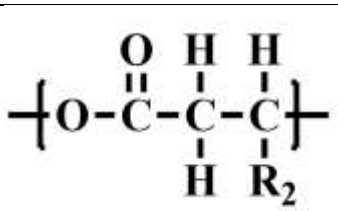
[027] In other examples of the method, the poly(hydroxyalkanoate) is a copolymer or a terpolymer which is made up of

[028] a first repeat unit which is (3-hydroxypropionate),

[029] a second repeat unit according to Formula I

	Formula I ; and

[030] optionally, a third repeat unit according to Formula II,

	Formula II

[031] wherein R_1 and R_2 are each independently selected from the group consisting of linear or branched alkyl groups having from 1 to 22 carbon atoms.

[032] In some examples of the method, the first charge is preferably polymerized in a first loop reactor. In some instances, the second charge is also preferably polymerized in a second loop reactor.

[033] In accordance with some examples of the method, the step of blending the first portion and the second portion is carried out by polymerizing the second charge to form the second portion in the presence of the first portion.