approaches have used additives such as surfactants to form silane emulsions prior to the reaction with an aqueous clay suspension. The silane is first emulsified into water containing surfactant, which acts as a wetting agent and emulsifier. Then, the emulsified silanes are mixed with the clay silicates. Accordingly, the surfactant used in this case is limited to a specific range of hydrophilic/lipophilic balance values. In addition, the surfactant concentration and pH at which the silane/surfactant emulsion is prepared are very important to the resulting silane emulsion stability. By using this method, it is very difficult to mix different types of silanes into one pot of aqueous clay suspension in a one-step process, because there a reaction may occur between the two silanes before reacting with clay silicates, which will result in reduced surface treatment of clay and bonding strength to the polymer matrix. Moreover, the presence of residual surfactants in the finished silane modified clay product may influence the properties of barrier layer even though its concentration is low. All these parameters limit the efficacy of the process and productivity in their preparation.

[0005] Another known method is directed to dissolving or dispersing silanes into aqueous clay suspension via a solvent exchange technique. In this method, the clay silicate aqueous suspension may be subjected to a solvent exchange whereby the solvent is capable of dissolving the silane compound. The solvent may be an organic solvent selected from methanol, ethanol, propanol, butanol, or pentanol or ketone, propanone or 2-butanone. The solvent exchange method involves washing and filtration steps. After silane-clay reaction, the solvent is removed and the silane modified clay is re-dispersed in aqueous solution. This modification process is cumbersome and may increase manufacturing cost. It further involves the use of organic solvent which makes it less environmentally acceptable.

[0006] In summary, it is found that the barrier films known from the prior art are not fully satisfying with regard to bonding strength to plastic films or do not show the desired high transparency. Others are very cumbersome to prepare and require the use of emulsifier/surfactant or organic solvent during the preparation.

[0007] Therefore, there is still a need to provide more cost effective, time saving and environmentally friendly methods to produce clay/polymer composite films with good oxygen and moisture barrier property combined with good bonding strength that overcome, or at least ameliorate, one or more of the disadvantages described above.

Summary

[0008] According to a first aspect, there is provided a one-step process for making a polymer composite suspension for coating plastic films characterized in that a poly (acrylic acid) (PAA) copolymer is synthesized in-situ optionally in the presence of other polymers and in the presence of clay. Advantageously, the invention provides a poly

improve the bonding strength and adhesion to the polymer, thereby forming a strong composite layer.

[0013] According to a second aspect, there is provided the respective polymeric coating suspension obtainable according to the process as defined above.

[0014] According to a third aspect, there is provided a respective polymeric coating suspension comprising

a) 1.0 to 11.0 wt% of clay or silane modified clay,
b) 0.1 to 10.0 wt% of poly (acrylic acid) copolymer, which is a copolymer of acrylic acid (AA) with at least one other monomer selected from 2-ethylhexyl acrylate (EHA), β-carboxyethyl acrylate (β-CEA), methacrylamidoethyl ethylene urea (WAM II) and ethoxylated behenyl methacrylate (β-EM),
c) 1.0 to 15.0 wt% of other polymers and
d) 70 to 97 wt% of water or mixture of water with of 2-propanol.

[0015] These suspensions advantageously show good bonding to plastic films, high transparency and flexibility combined with high water vapour and oxygen protection when being coated on plastic films. In one embodiment the other polymers in this suspension are selected from poly (vinyl alcohol) and block copolymers of ethylene and vinyl alcohol.

[0016] According to a fourth aspect, there is provided a method for making the silane modified clay by dispersing the clay in an aqueous solution and adding a silane or a mixture of silanes at a slow injection speed under high homogenization speed. Preferably the silane or silane mixture is added by injection with a flow rate of 0.1 to 3.0 ml/min and the speed of homogenization is in the range of 15,000 to 20,000 rpm of a turrax. Advantageously, this allows to uniformly intercalate silanes into clay sheet suspension in the high speed homogenization process. The silane is directly dispersed into aqueous clay suspension without using surfactants or organic solvent. With the present invention, it is feasible to prepare silane mixture modified clay product in a one-step process.

[0017] According to a fifth aspect, there is provided the use of silane modified clay obtained in a process for making a polymeric coating suspension for forming a barrier film on plastic films which comprises a polymer that has at least a hydroxyl functional group, a polymer that has a carboxyl functional group or mixtures thereof. Advantageously, the silane modified clay can be used in such a broad range of processes for making such polymer matrices including the in-situ polymerisation process mentioned above.

[0018] According to a sixth aspect, there is provided a polymeric coating suspension obtained by using the silane modified clay made according to the above described method.

[0019] According to a seventh aspect, there is provided the use of a polymer composite suspension as defined above for producing a laminated film on a plastic film. According to an eighth aspect, there is provided the use of the tri or more layer film obtained as defined above for making packaging films. According to a ninth aspect, there is provided a poly (acrylic acid) copolymer that is derived from a monomer mixture that comprises a) 50 to 90 wt% of acrylic acid, b) 5 to 30 wt% of 2-ethylhexyl acrylate, c) 0.5 to 10 wt% of β-carboxyethyl acrylate, d) 0.5 to 10 wt% of methacrylamidoethyl ethylene urea, e) 0.5 to 10 wt% of ethoxylated behenyl methacrylate. According to the present disclosure, the polymeric coating suspensions made according to the various inventive processes and methods can be used for producing a laminated film on a plastic substrate. In one embodiment the use comprises the following steps: a) applying an inventive polymer composite suspension on a plastic film via blade coating, b) drying the obtained barrier layer on the plastic film, and c) coating the obtained bi-layer film with at least another plastic substrate with adhesive. The resulting three or more layer film obtained can be used for making packaging films. Advantageously, the packing films show the improved moisture and oxygen barrier capabilities.

Definitions

[0020] The following words and terms used herein shall have the meaning indicated:

[0021] Those skilled in the art will appreciate that the invention described herein is susceptible to variations and modifications other than those specifically described. It is to be understood that the invention includes all such variations and modifications. The invention also includes all of the steps, features, compositions and compounds referred to or indicated in this specification, individually or collectively, and any and all combinations or any two or more of said steps or features.

[0022] The term "clay" refers to both naturally occurring clay materials and to synthetic clay materials. Clay refers to phyllosilicate minerals and to minerals which impart plasticity and which harden upon drying or firing. See generally, Guggenheim, S. & Martin, R. T., "Definition of Clay and Clay Mineral: Joint Report of the AIPEA Nomenclature and CMS Nomenclature Committees," Clays and Clay Minerals 43: 255-256 (1995). Materials composed of clay are characterized by having a mineral structure formed by the arrangement of octahedral units and tetrahedral units or by stacked layers formed by an octahedral sheet and one or more tetrahedral sheets of the atoms that constitute the clay structure. Illustrations are the two groups of naturally occurring clay minerals. First is the hormite group, defined here as including palygorskite and sepiolite, which have channels formed by octahedral units and tetrahedral units of the clay mineral structure. Second is the smectite group including montmorillonites and saponite, which are constituted by stacked layers formed by an octahedral sheet and more than one tetrahedral sheet, and mixtures of the foregoing. Smectite is a generic term that refers to a variety of related minerals also found in some clay deposits. Smectite is composed of units made of two silica tetrahedral sheets with a central alumina octahedral sheet. Each of the tetrahedra has a tip that points to

the center of the smectite unit. The tetrahedral and octahedral sheets are combined so that the tips of the tetrahedra of each silica sheet and one of the hydroxyl layers of the octahedral sheet form a common layer. In particular, the smectite family of clay minerals includes the various mineral species montmorillonite, beidellite, nontronite, hectorite and saponite, all of which can