application by jetting technology. Stable, colloidal dispersions of organic color pigments have been prepared using this technology. These dispersions have been used to prepare inks with excellent jetting properties, although the invention is not limited to this application. Other uses of the novel, stable colloidal dispersions of the present invention include, but are not limited to, other types of inks and coatings; preparation of stable colloids of electronic materials such as conductors, insulators, semiconductors, and the like, particularly those useful for devices or manufacturing as by jetting; preparation of stable dispersions of organic and ceramic materials for various other applications; preparation of stable dispersions for biotechnology, pharmaceutical, drug delivery, medical diagnostics or bioassays, or imaging applications; and nano-fabrication of devices. Other uses will be evident to one skilled in the art.

[0018] The novel, stable colloidal dispersions of the invention have comparable particle size and comparable or better stability than those produced by traditional competitive processes and have demonstrated utility in jetting applications.

[0019] It is an object of the invention to provide a simple, one step method for reducing the particle size of a large variety of solids to nanostructured particles.

[0020] It is a further object of the invention to provide stabilized colloidal dispersions of nanoparticles from a wide variety of selected solids.

[0021] It is yet another object of the invention to provide commercially viable techniques for producing stabilized colloidal dispersions of nanoparticles of a wide variety of selected solids, which are simple, safe, cost effective and environmentally friendly to perform.

SUMMARY ~~OF THE INVENTION~~

[0022] The ~~invention~~present disclosure is directed to novel nano-structured particles and stable colloidal dispersions thereof, novel methods to reduce the particle size of a solid to nanoparticle dimensions by formation in a clathrate structure, and novel methods to prepare clathrate-based structured fluids useful for reducing particle size of a solid and producing stable colloidal dispersions of nanoparticles, without the need for conventional stabilization techniques. In contrast to conventional particle size reduction

techniques, the inventive techniques allow for reduction in the particle size of the selected solid to nanoparticles and stabilization of a colloidal dispersion of the nanoparticles so formed in a single step – by annealing

in a gel comprising native or modified polysaccharides, cavitands, or other similarly structured molecules known to be useful host vessels in a fluid. The viscoelastic or semi-solid gel resulting from the dispersion of the host vessel in an acid or other solvent is a "structured" fluid matrix that acts as a template for reducing the particle size of an added solid or limiting the growth of particles of compounds that are synthesized within the gel. The colloidal dispersions formed are useful in a number of applications, including but not limited to inkjet applications and other applications discussed above.

[0022a] In one aspect, there is provided a nanoparticle-based clathrate, comprising: a solid guest particle, and a host compound comprising a native or modified polysaccharide, cavitand, simple sugar, simple polyol, or other similarly structured host compound mixed in an acid or other solvent medium to form a gel.

[0022b] In another aspect, there is provided a colloidal dispersion of nanoparticle-based clathrates as described herein.

[0022c] In another aspect, there is provided a nanoparticle formed by the process of: heating an acid medium with agitation, adding a host vessel comprising a native or modified polysaccharide, cavitand, simple sugar, simple polyol, or other similarly structured molecule, with agitation, to the acid medium to form a gel, adding a solid guest particle, with agitation, to the gel to form a mixture, stirring the mixture at an elevated temperature for a set time for particle size reduction and annealing, and quenching the mixture.

[0023] In one ~~embodiment~~example, ~~the invention~~disclosed herein is a novel structured fluid matrix comprising host vessels formed from native or modified polysaccharides, cavitands, simple sugars, such as dextrose, fructose and glucose, simple (linear, branched, or cyclic) polyols, such as ethylene glycol, propylene glycol, or glycerin, crown ethers, aza crowns, cryptands, cyclophanes, oligo- and poly-peptides, proteins, oligo- and poly-nucleotides, or other similarly structured molecules, dispersed in an acid or other solvent medium.

[0024] In a ~~second embodiment~~further example, ~~the invention is~~there is disclosed a colloidal dispersion of nano-structured particles formed through the addition of selected guest solids to the novel structured fluid matrix.

[0025] In a ~~third embodiment~~further example, ~~the invention~~disclosed herein is a process for converting native or modified polysaccharides, cavitands, simple sugars, such as dextrose, fructose or glucose, simple (linear, branched, or cyclic) polyols, such as ethylene glycol, propylene glycol, or glycerin, crown ethers, aza crowns, cryptands, cyclophanes, oligo- and poly-peptides, proteins, oligo- and poly-nucleotides, and other similarly structured molecules into a structured fluid matrix and preparing nano-structured particles by adding selected guest solids to the structured fluid matrix to yield colloidal dispersions thereof.

[0026] In a further ~~embodiment~~example, ~~the invention~~disclosed herein is a process for creating a stable nanoparticle colloidal dispersion by fusing small, supra-molecular host molecules into a clathrate cage encompassing the entire nanoparticle, e.g., by caramelizing cyclodextrins or other carbohydrates at the surface of the nanoparticle.

[0027] In another ~~embodiment~~example, ~~the invention~~disclosed herein is a process for attaching useful moieties to a nanoparticle through the clathrate cage, e.g. through acetal or hydrazone linkages. This may include moieties that stabilize colloidal dispersions,

for example by attaching charged groups that increase the zeta potential of the nanoparticles.

[0027a] In one aspect, there is provided a process for generating a stable colloidal dispersion of nanoparticles, useful for jetting, comprising: heating an acid solution with agitation, adding a host vessel molecule comprising a native or modified polysaccharide, cavitand, simple sugar, simple polyol or other similarly structured molecule to the acid solution with agitation to form a gel, adding a solid guest particle to the gel at temperature ranging between 40° C and 100° C, with agitation, to form a mixture, stirring the mixture at a set temperature for a set time for particle size reduction and annealing, quenching the mixture, and separating the unreacted host vessel component from the mixture to obtain a stabilized colloidal dispersion of nanoparticles within the gel.

[0027b] In another aspect, there is provided a method for reducing the particle size of a solid to nanoparticle dimensions, comprising: adding the solid as a guest particle to a structured fluid matrix of host vessel molecules formed by dispersing a native or modified polysaccharide, cavitand, simple sugar, simple polyol, or other similarly structured molecules, in an acid medium, and excluding any reduction of the particle size of the solid prior to adding to the structured fluid matrix, wherein the particle size achieved by the solid is limited by the structural constraints of the gel and is in nanoparticle dimensions.

[0027c] In another aspect, there is provided a method for preparing a stable colloidal dispersion of nanoparticles for jetting comprising the steps of: initiating cavitation of a solid guest particle in a high viscosity fluid matrix formed by dispersing a modified polysaccharide, cavitand, simple sugar, simple polyol or other similarly structured molecules in an acid medium, wherein a colloidal dispersion of nanoparticles results, and stabilizing the resulting colloidal dispersion by caramelizing cyclodextrins, polysaccharides, or other carbohydrates onto the surface of the nanoparticles.

[0027d] In one aspect, there is provided a high viscosity structured fluid matrix useful for reducing the particle size of a guest solid, comprising host vessel molecules selected

from the group of native or modified polysaccharides, cavitands, simple sugars, simple polyols, other similarly structured molecules, and mixtures thereof, dispersed in an acid medium to form a gel, wherein the particle size of the solid is reduced or limited upon incorporation into the gel.

[0028] In yet a further ~~embodiment~~example, ~~the invention~~disclosed herein is a distinctive process technology useful to prepare dispersions for jetting and other stable colloidal dispersions of nanoparticles, by initiating cavitation to reduce the size of solid guest particles in a high viscosity structured fluid.

[0029] The structured fluids ~~of the invention~~disclosed herein are prepared by mixing components that are easily removed by membrane filtration. These components include, but are not limited to cavitands, modified polysaccharides, native polysaccharides, simple sugars, such as dextrose, fructose or glucose, simple polyols, such as ethylene glycol, propylene, glycerin, sorbitol, xylitol and the like, polyphosphoric acids, mixtures of two or more of these components, and combinations of the mixture with aldehydes or polyaldehydes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] FIG. 1 shows the helical structure of amylose from starch;

[0031] FIG. 2 is a chemical structure of β-cyclodextrin;

[0032] FIG. 2a is a schematic representing structures and dimensions for α, β, and γ - cyclodextrins; and

[0033] FIG. 3 shows a computer generated space filled model of β-cyclodextrin.

DETAILED DESCRIPTION OF THE INVENTION

[0034] Before describing the inventive compositions and processes in detail, it should be understood that the invention is not limited to the specific components, amounts of components, or applications for use set forth herein. The inventions may include other embodiments and may be practiced in various ways, as one skilled in the art would understand from the description.

[0035] Terminology used herein is not intended to be limiting. The use of "including", "containing", "constituting", "comprising" or "having" and any other variations thereof is not limited to the items recited or listed and is intended to encompass equivalents and additional items. Use of singular terms are intended to include the plural form.

[0036] Numerical ranges described herein include all values from the lowest value to the highest value.