Resodyn™
ACOUSTIC MIXERS
Innovative Mixing Solutions

Advanced Polymers Enabled By ResonantAcoustic® Mixing

Testimonials • Published Articles • Patents & Patent Applications

January 2022

This is a portfolio of user testimonials, articles, and patents/patents pending that reference Resodyn's ResonantAcoustic® Mixing (RAM) technology in a variety of advanced polymer applications. These abstracts and links to published articles is intended to provide insight into the value of RAM technology as a means of solving challenges, improving quality, and raising productivity in the development and processing of advanced polymers.

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Advanced Polymer Materials

Polymers and polymer-based materials are pervasive throughout industry. Innovations in processing and fabrication techniques have resulted in advanced polymers that enable precision in the design of structures down to the molecular level. This has enabled manufacturers to meet performance requirements of leading-edge and emerging applications. Advanced polymers are used in optoelectronic, aerospace, semiconductor, biomedical, and energy fields, but are increasingly applied in traditional packaging, textiles, consumer goods and automotive industries.

Developers of advanced polymers rely on ResonantAcoustic® Mixing as a foundation technology to conceive and deliver innovative and profitable new products across a wide spectrum of industries.

= Locations of customers of ResonantAcoustic® Mixers

What developers of advanced polymer materials are saying about RAM

"...[ResonantAcoustic mixing] is a fantastic technology. It has revolutionized the way we mix for development of materials for additive manufacturing..."

- R & D Engineer
U.S. Based Ceramic Materials Company

"...Having these LabRAM units has changed our processes in a positive manner. Every process involved with these units has become more stream-lined, yielded higher results, and created more consistent results. "

- Materials Scientist
Biotechnology Company

RAM: 21st Century Mixing Technology for 21st Century Materials

More than a thousand RAM systems are in use in 33 countries around the world. RAM is the world's preferred choice for innovation in materials processing.

PUBLISHED ARTICLES

Icon Legend

RAM testing, evaluation

Liquid/powder

Polymers

Material/chemical properties

Materials processing

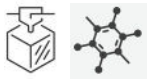
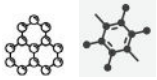
Graphene

Powder/powder

Materials/product quality

Icons	Publication Title (Live Links)*	RAM Application Summary	Year
	A novel method for preparing stabilized amorphous solid dispersion drug formulations using acoustic fusion	"...A diverse set of drug and polymer combinations have been effectively evaluated utilizing a newly developed method called acoustic fusion to form amorphous solid dispersions (ASD) on the mg-scale, indicating that this approach is a general procedure that can be applied for ASD drug formulations...ResonantAcoustic Mixing can be used to homogeneously mix high viscosity materials..."	2021
	Powder Processing and Properties Characterization of Polyamide 11-Graphene anocomposites for Selective Laser Sintering	"...Nano-graphene platelets (NGPs) were added to polyamide 11 (PA11) powder in 1%, 3%, and 5% weight loading in an attempt to create electrostatic dissipative polymer nanocomposites (PNC) using SLS, a rapid manufacturing process. Powder-powder mixing techniques were explored as a potential replacement for twin-screw extrusion for dispersing nano-graphene platelets (NGPs) within a PA11 matrix. The ResodynTM ResonantAcoustic® Mixer [was evaluated for] powder-powder mixing techniques. After mixing, the powder samples were pressed into thin-films for characterization on TGA, SEM, four-probe conductivity, and Raman spectroscopy. Polymer nanocomposites of PA11 and nano-graphene platelets were mixed using powder mixing techniques. The Resodyn ResonantAcoustic® mixer [was] used with the addition of zirconia grinding media to aid in the breaking and exfoliation of graphene clusters..."	2020
	Development of a quantitative method to evaluate the printability of filaments for fused deposition modeling 3D printing	"...Lack of a conventional quantitative method for filament printability has been recognized as a critical barrier to fused deposition modeling (FDM) 3-D printing application. A small molecule drug, indomethacin, was used as a model compound to mix with polymers with various solubility. The indomethacin and polymer excipients with various ratios were mixed using a Resodyn LabRAM II ResonantAcoustic Mixer at 60g for one minute..."	2020

PUBLISHED ARTICLES

Icons	Publication Title (Live Links)*	RAM Application Summary	Year
	Milling of Energetic Crystals with the LabRAM	"...Over the last decade, the Resodyn LabRAM acoustic mixer has been widely used for mixing of powders and for the pharmaceutical industry, yet its use as a vibratory mill has not been published extensively. It has a long history of use for energetic materials processing that includes but is not limited to cocrystal synthesis, dry pyrotechnic powder mixing, rocket propellant mixing, and polymer bound explosives. It was shown that efficient dry vibratory milling could be achieved using the LabRAM acoustic mixer..."	2019
	3D printing of polymer-bonded magnets from highly concentrated, plate-like particle suspensions	"...[a] clear photo polymer resin binder was chosen as the fluid carrier for the NdFeB powder as it yields high NdFeB loading while maintaining sufficiently low viscosity for printing. The resin is composed of methacrylate oligomers and monomers and has a specific gravity of 1.1 g/cm3. According to Zguris [21], a UV curving wavelength of 405 nm would yield the best mechanical strength for the neat binder. For compounding the powder with the UV binder, a Resodyn LabRAM II ResonantAcoustic® mixer was used at a mixing intensity of 100 times gravitation for 5 min to allow thorough and uniform mixing..."	2019
	Surface cross-linking of ZIF-8/polyimide mixed matrix membranes (MMMs) for gas separation	"...remaining polymer was added and the mixture was further stirred and sonicatedfor 4 h and finally stirred for 24 h. Next, the polymer-ZIF dispersion was mixed in a ResodynLabRam Acoustic Mixture for 10 min to break any aggregations..."	2013
	Preparation morphology and properties of reduced graphene oxide/natural rubber nanocomposites	"... [The} research objective is to use graphene to replace carbon black in tire compounds to improve mechanical properties as well as improved electrical conductivity even at high strain (for anti-static purposes) while reducing tire weight. Two routes [mixing technologies: a Resodyn Acoustic Mixer and Ultrasonification] were used for exfoliation of graphite oxide to graphene oxide yield different aspect ratio platelets. Both methods exfoliate to singlelayer graphene oxide but prolonged exfoliation times lead to smaller platelets. The same two methods were used fo assess conductivity...Samples with Resodyn RG-O, which produced greater platelet sizes, revealed substantially lower resistance and conductivity compared to Ultrasonification results..."	2011

PUBLISHED ARTICLES

Partial (edited) selection of searched technical articles using the following search terms (articles are live links): "resonant acoustic," "acoustic mixing" AND/OR: "Resodyn," "polymers," "polymeric nanomaterials," and "advanced materials."

A novel method for preparing stabilized amorphous solid dispersion drug formulations using acoustic fusion
Z Guo, C Boyce, T Rhodes, L Liu, GM Salituro…- International Journal of …, 2021- Elsevier
… benchtop resonant acoustic mixer by Resodyn. The block can hold up to 24 different 4 mL glass vials… one polymer and heating the mixture to a temperature higher than the glass transition or melting point temperatures of at least one of the polymers or the API, the crystalline API and polymers…
Related articles

Powder Processing and Properties Characterization of Polyamide 11-Graphene anocomposites for Selective Laser Sintering
DZ Chen, S Lao, JH Koo…- Proc. 2010 solid …, 2010- utw10945.utweb.utexas.edu
… extend the paradigm of traditional composite materials by introducing fillers in the nano-scale to ceramic, metal, or polymer matrices. … Materials Preparation and Processing The Resodyn ResonantAcoustic® mixer (RAM) was the first method used to mix the PA11 and nano-graphene…
Related articles

Development of a quantitative method to evaluate the printability of filaments for fused deposition modeling 3D printing
P Xu, J Li, A Meda, F Osei-Yeboah, ML Peterson…- International Journal of …, 2020- Elsevier
… Indomethacin and polymer excipients with various ratios were mixed using a Resodyn LabRAM II ResonantAcoustic® mixer at 60G for 1 min. The physical mixtures were then fed into the extruder at 3–5 g/min (depending on the torque) using a magnetic feeder (Model: FTOC, Syntron) and …
Related articles

Milling of Energetic Crystals with the LabRAM
LN Kotter, LJ Groven- Propellants, Explosives, Pyrotechnics, 2019- Wiley Online Library
… Over the last decade, the Resodyn LabRAM acoustic mixer has been widely used for mixing of powders and for the … polymer, anywhere from 5 % to 15 % ethylene is doped within the polymer. This doping of the PP chains by ethylene links randomizes the structure of the polymer …
Related articles

3D printing of polymer-bonded magnets from highly concentrated, plate-like particle suspensions
A Shen, X Peng, CP Bailey, S Dardona, AWK Ma- Materials & Design, 2019- Elsevier
… Recently, 3D printing of polymer-bonded magnets has gained research interest over … In this method, ferromagnetic particles (NdFeB) are first dispersed in a UV curable polymer binder … For compounding the powder with the UV binder, a Resodyn LabRAM II acoustic mixer was …
Related articles

PUBLISHED ARTICLES

Partial (edited) selection of searched technical articles using the following search terms (articles are live links): "resonant acoustic," "acoustic mixing" AND/OR: "Resodyn," "polymers," "polymeric nanomaterials," and "advanced materials."

Surface cross-linking of ZIF-8/polyimide mixed matrix membranes (MMMs) for gas separation
SN Wijenayake, NP Panapitiya…- Industrial & …, 2013- ACS Publications
… Then, the remaining polymer was added and the mixture was further stirred and sonicated or 4 h and finally stirred for 24 h. Next, the polymer-ZIF dispersion was mixed in a Resodyn LabRam Acoustic Mixture for 10 minutes to break any aggregations and was concentrated to about…
Related articles

Preparation morphology and properties of reduced graphene oxide/natural rubber nanocomposites
TJ Boyle, J Potts, O Shankar, R Ruoff, TN Lambert- 2011- osti.gov
… Polymer nanocomposites are polymer-matrix composites with nanoscale filler materials. The high surface areas and physical properties of nanomaterials provide larger performance benefits than conventional polymer fillers. One such filler is carbon black, which is used in tire …
Related articles

Relevant Patents

Approved and pending applications for work involving the use of ResonantAcoustic® mixing technology.*

*Including patents with RAM as the preferred embodiment

Chemical-free production of graphene-reinforced polymer matrix composites

Abstract

Provided is a simple, fast, scalable, and environmentally benign method of producing a graphene-reinforced polymer matrix composite directly from a graphitic material, the method comprising: (a) mixing multiple particles of a graphitic material and multiple particles of a solid polymer carrier material to form a mixture in an impacting chamber of an energy impacting apparatus; (b) operating the energy impacting apparatus with a frequency and an intensity for a length of time sufficient for peeling off graphene sheets from the graphitic material and transferring the graphene sheets to surfaces of solid polymer carrier material particles to produce graphene-coated or graphene-embedded polymer particles inside the impacting chamber; and (c) forming graphene-coated or graphene-embedded polymer particles into the graphene-reinforced polymer matrix composite. Also provided is a mass of the graphene-coated or graphene-embedded polymer particles produced by this method.

Solvent-free emulsion process using acoustic mixing

Abstract

A process for making toner particles is provided. In embodiments, a suitable process includes melt mixing a resin in the absence of an organic solvent, optionally adding a surfactant to the resin, adding to the resin at least one colorant and other optional toner additives, adding to the resin a basic agent and water to form a mixture, and subjecting the mixture to acoustic mixing at a suitable frequency to form to form an emulsion. A phase inversion may then be performed to create a phase inversed emulsion including a disperse phase comprising molten resin and the optional ingredients of the toner composition, at which time toner-sized droplets may be solidified from the disperse phase into toner particles, which can be recovered for use.

Method of making polymer matrix composites

Abstract

Method of making a polymer matrix composite comprising a porous polymeric network structure; and a plurality of particles distributed within the polymeric network structure, the method comprising: combining a thermoplastic polymer, a solvent that the thermoplastic polymer is soluble in, and a plurality of particles to provide a slurry; forming the slurry in to an article; heating the article in an environment to retain at least 90 percent by weight of the solvent, based on the weight of the solvent in the slurry, and inducing phase separation of the thermoplastic polymer from the solvent to provide the polymer matrix composite.

Improvements in or relating to energetic materials

Abstract

Energetic materials comprising active components, a polymer binder matrix and a tackifying resin are useful as propellants, fuels, pyrotechnic materials and explosives; the tackifying resin improves the adhesion and dispersion of the active components throughout the binder resin.

Patents, cont'd.

High molecular weight zwitterion-containing polymers

Abstract

The present invention provides multi-armed high MW polymers containing hydrophilic groups and one or more functional agents, and methods of preparing such polymers.

Dental composite compositions for reduced shrinkage stress

Abstract

A dental composite composition is disclosed that includes a polymerizable resin, filler particles, and at least one polymerizable stable radical. A variety of polymerizable stable radicals may be employed, including those that have a 2,2,6,6-tetramethylpiperidinyl-1-oxyl moiety. Compositions as described herein exhibit excellent mechanical strength, hardness, and flexural modulus, while also significantly decreasing shrinkage stress caused by polymerization.

RAM 5 *Continuous*

RAM 55

*Omni***RAM** *Continuous*

RAM 5H

RAM 5

*Lab***RAM II** *Lab***RAM I**

*Lab***RAM II H**

*Omni***RAM**

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