Innovations in Advanced Materials Processing Enabled By ResonantAcoustic® Mixing

Testimonials • Published Articles • Patents & Patent Applications

December 2024

This document is a portfolio of user testimonials, articles, and patents/patents pending that reference Resodyn's ResonantAcoustic® Mixing (RAM) technology in a variety of advanced material applications. This collection of 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 materials such as nanomaterials, graphenes, ceramics and polymers.

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Advanced Materials Processing

The category of advanced materials generally includes **technical ceramics**, **polymers**, semiconductors, biomaterials and **nanomaterials**. Nanomaterials are generally defined as material having at least one dimension less than 100 nanometers, and offer uniquely beneficial qualities for optical, electronic, mechanical and thermo-physical types of applications. **Graphenes** are a class of nanomaterial that is rapidly being adopted due to its exceptional tensile strength, electrical conductivity, transparency, and being the thinnest two-dimensional material known to man. Technical ceramics enable innovations in aerospace, defense, energy production, and industrial processing industries by expanding on the unique thermal, wear and corrosion resistance of conventional ceramics. Synthetic polymers include elastomers, polymer fibers and thermoplastics.

RAM technology allows for the discovery of new materials and innovative methods to create old materials. In this folio, there is a tool to scale up formerly prohibitively expensive carbon capture technology, an option to create more efficient formaldehyde, and a way to cut down production of materials by hours.

Developers of leading-edge products enabled by advanced materials rely upon ResonantAcoustic® Mixing technology to conceive and deliver innovative new products across a wide spectrum of industries.

= Locations of customers of ResonantAcoustic® Mixers

What advanced material processors are saying about RAM

"ResonantAcoustic® mixers from Resodyn have proven to be extremely valuable in graphene development for our clients. It is critical for nanotechnologies such as graphene to be processed with the level of exacting consistency and particle distribution, especially at low loadings, that RAM has proven to consistently achieve."

- Dr. Arun Prakash Aranga Raju, Graphene Engineering Innovation Centre
The University of Manchester, Manchester, England

"RAM has given us the ability to increase solids loading in our ceramic slurries to levels not possible with bladed mixers. RAM can also mix thixotropic materials that bladed mixers can't."

- U.S.-based Advanced Ceramics Materials Company

"…ResonantAcoustic® mixing allows for large-scale synthesis of nanoparticle solutions and the formation of nanoparticles of desirable sizes...We believe this new technique will facilitate the development of lyotropic mesophase materials and new methodologies for the fabrication of nanoparticles. The technique will have a significant impact in shaping the future of nanoscience..."

- Australian Government Science Research Organization

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

Number of RAM systems sold for advanced materials mixing: **>50**
Number of RAM advanced materials customers worldwide: **>43**
Number of RAM systems sold worldwide (38 countries): **>1,000**

PUBLISHED ARTICLES

Icon Legend

- RAM testing, evaluation
- Material/chemical properties
- Powder/powder
- Liquid/powder
- Materials processing
- Materials/product quality
- Polymers, ceramics
- Nanomaterial
- Graphene

Icons	Publication Title (Live Links)*	RAM Application Summary	Year
	Preparation of thiol-decorated Ag nanoparticles on N-doped carbon through resonant acoustic mixing for electrochemical CO2 reduction	However, the practical production of these supported metal NPs necessitates a facile and scalable approach. Addressing this challenge, the present study introduces a novel method for solid-state synthesis of Ag/C using **resonant acoustic mixing (RAM)**. The **RAM** technique successfully facilitated the deposition of Ag nanoparticles onto n-doped carbon support, forming Ag/N-C catalysts.	2024
	Extreme Temperature Additively Manufactured GRX-810 Alloy Development and Hot-fire Testing for Liquid Rocket Engines	… coated with sub 100nm Y2O3 particles using the **resonant acoustic mixing process** [16]. Lot 2 … In fact, there appears to be a slightly higher frequency of oxides nanoparticles in the Lot 2 …	2024
	A new ternary high-energy composite based on nano titanium powder with low sensitivity and stable combustion	For solving the low combustion efficiency caused by aggregation and further promoting the application of nano titanium powder (n-Ti), a new ternary composite high-substitute nitrochitosan/nano titanium/graphene oxide (NCh/n-Ti/GO) was prepared by a r**esonant acoustic mixing** method.	2023
	Tailoring Vibrational Signature and Functionality of 2D-Ordered Linear-Chain Carbon-Based Nanocarriers for Predictive Performance Enhancement of High-End Energetic Materials	The technological chain of the transformative energetic materials (TEM) preprocessing and synthesis includes the following main stages... the **resonant acoustic mixing (RAM)** of the EM composition, leading to changes in the material properties.	2022
	Resonant Acoustic Mixing Method to Produce Lipid-Based Liquid-Crystal Nanoparticles	We have found that when compared to traditional sonication-based methods, the use of **resonant acoustic mixing** allows for large-scale synthesis of nanoparticle solutions and the formation of LLC nanoparticles of desirable sizes.	2021

PUBLISHED ARTICLES (cont.)

Icons	Publication Title (Live Links)*	RAM Application Summary	Year
	3D-printed nanoporous ceramics: Tunable feedstock for direct ink write and projection microstereolithography	The [ceramic additive manufacturing] ink was mixed with spherical zirconia grinding beads (4 mm diameter) in a LabRAM II acoustic mixer for 3 h at 70 g-force to break up agglomerates and disperse the particles. The **LabRAM II** mixing time was determined by SEM images of the inks at different time points to ensure homogeneous dispersion...	2021
	Investigation of the impact of particle size on properties and applications of a ceramic slurry	To make the ceramic slurry, 3YZrO2 nanoparticles were mixed with polyethylene glycol diacrylate (PEGDA Mn 575, Sigma Aldrich) and zirconia grinding media and mixed for 3 hours in a Resodyn™ **LabRAM II acoustic mixer.**	2019
	Investigating High Energy Mixing in Cement-based Materials	**RAM** mixing does not use a tool [e.g., impeller] that directly interacts with the mixing medium. This makes it an attractive mixing device as it reduces the cost of wear and tear of the mixing device...A 30% increase in 3-day and 20% increase in 28-day mechanical properties were observed in UHPC specimens mixed with **RAM**. The improved mechanical properties support there is more uniform mixing energy transmitted to the system during mixing which enhances cement hydration and reduces air voids.	2015
	Final Report on creation of the Energetic Materials Laboratory, Univ. of Texas at El Paso	The objective of this project was to acquire equipment and instrumentation for research and education on energetic materials that would enhance the University's capabilities in materials preparation, materials characterization, and combustion experiments...The [**Resodyn Acoustic Mixers LabRAM**] will enhance the academic experience for students and help prepare them for productive work in advanced areas of engineering important for the U.S. Department of Defense.	2014
	A new and improved method for the preparation of drug nanosuspension formulations using acoustic mixing technology	[We used] low shear **acoustic mixing** to rapidly identify optimized nanosuspension formulations for a wide range of compounds with dramatically improved material and time efficiencies.	2014

* Article links may be limited by copyright restrictions. Detailed links on following pages.
^ Results excerpted/paraphrased from articles.

PUBLISHED ARTICLES (cont.)

Icons	Publication Title (Live Links)*	RAM Application Summary	Year
	Preparation of an energetic-energetic cocrystal using resonant acoustic mixing	**Resonant acoustic mixing (RAM)** was applied to the preparation of an energetic-energetic cocrystal comprised of CL-20 and HMX in a 2:1 mol ratio. We have prepared the cocrystal using the **RAM** technology in a resource-efficient manner providing near quantitative yield. The cocrystalline product from the **RAM** preparation is consistent with the product from solution crystallization.	2014
	Preparation and characterization of aqueous nanothermite inks for direct deposition on SCB initiators	...[**RAM**] uses an environmentally friendly mixing medium, can result in a higher density final material, and allows safe one-step mixing and deposition.	2014
	Nano-aluminum thermite formulations: characterizing the fate properties of a nanotechnology during use	The thermite formulations were prepared using a one-step mixing process in a **Resodyn LabRAM** mixer as opposed to typical ultrasonication.	2013
	Feasibility study and demonstration of an aluminum and ice solid propellant	Although this current propellant formulation is far from optimized, improvements in the mixing procedure [using **RAM**] have produced a consistent and homogeneous propellant. While the performance of ALICE is too low for practical use, the knowledge gained through formulating and experimenting with nanoscale particles in a simple mixture is of great interest for ongoing research activities on advanced propellants.	2012
	The Effect of Varied Amounts of LiF Sintering Aid on the Transparency of Alumina Rich Spinel Ceramic with the Composition MgO	Starting powders are prepared from combinations of high purity Mg(OH)2 and γ-Al2O3 thoroughly mixed in an aqueous slurry, and the solids are collected, dried, calcined, mixed with LiF sintering aid, and sieved...mixing was performed using a **Resodyn Acoustic Mixer.**	2012
	Graphene–aluminum nanocomposites	Aluminum–graphene composite powders were fabricated by initially blending the constituent precursory powders of Valimet Al and graphene. Blending was conducted using a **Resodyn LabRAM acoustic mixer** for approximately 5 minutes.	2011

PUBLISHED ARTICLES (cont.)

Icons	Publication Title (Live Links)*	RAM Application Summary	Year
	Preparation morphology and properties of reduced graphene oxide/natural rubber nanocomposites	Two routes for exfoliation of graphite oxide (GO) to graphene oxide yield different aspect ratio platelets... **Resodyn Acoustic Mixer** and Ultrasonication. Both methods exfoliate to single-layer graphene oxide but prolonged exfoliation times lead to smaller platelets, thus a smaller Af [aspect ratio].	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," "nanomaterials," "ceramics," "polymers," and "advanced materials."

Preparation of thiol-decorated Ag nanoparticles on N-doped carbon through resonant acoustic mixing for electrochemical CO2 reduction

Jinho Hyun, Mokyeon Cho, Jaeyoung Lee, Taewon Kim, Chanho Pak

In this work, we designed and fabricated thiol-decorated Ag nanoparticles on N-doped carbon support through **resonant acoustic mixing (RAM)**... At this time, the **RAM** is used to generate the Ag-supported electrocatalysts in a very short time without any additional capping agent and/or surfactant using the Ag precursor, n-doped carbon support, and reductant mixture without solvents. The as-prepared Ag/N-C electrocatalyst has good dispersion and uniformity in particle size compared to the Ag/C catalyst.

Extreme Temperature Additively Manufactured GRX-810 Alloy Development and Hot-fire Testing for Liquid Rocket Engines

Paul R. Gradl, Timothy M. Smith, Darren C. Tinker, Benjamin Williams and Christopher Kantzos

… coated with sub 100nm Y2O3 particles using the **resonant acoustic mixing process** [16]. Lot 2 … In fact, there appears to be a slightly higher frequency of oxides nanoparticles in the Lot 2 …

A new ternary high-energy composite based on nano titanium powder with low sensitivity and stable combustion

Chong Wan, Zhaoqi Guo, Wenzhen Zhang, Suhang Chen, Zhao Qin & Kangzhen Xu

For solving the low combustion efficiency caused by aggregation and further promoting the application of nano titanium powder (n-Ti), a new ternary composite high-substitute nitrochitosan/nano titanium/graphene oxide (NCh/n-Ti/GO) was prepared by a r**esonant acoustic mixing** method. Herein the high-substitute nitrochitosan (NCh) was used as binder and oxidant to modify the surface of n-Ti powder, and GO was introduced as stabilizer and carrier. The energy release rate, laser ignition, combustion performance and sensitivity of NCh/n-Ti/GO were systematically studied in this work.

Tailoring Vibrational Signature and Functionality of 2D-Ordered Linear-Chain Carbon-Based Nanocarriers for Predictive Performance Enhancement of High-End Energetic Materials

Alexander Lukin & Oğuz Gülseren

The technological chain of the transformative energetic materials (TEM) preprocessing and synthesis includes the following main stages: preprocessing the EM components with the material properties, changing at the conversion into the nanoscale; the **resonant acoustic mixing** (**RAM**) of the EM composition, leading to changes in the material properties; the final 3D printing (additive manufacturing) of the blended EM composition into the high-end EM elements and solid propellant charges.

Resonant Acoustic Mixing Method to Produce Lipid-Based Liquid-Crystal Nanoparticles

Dilek Yalcin, Sarigama Rajesh, Jacinta White, Shaun C. Howard, Paul J. Pigram, Nhiem Tran & Benjamin W. Muir

In this study, we report for the first time a fast and easily scalable methodology for the fabrication of lipid-based liquid-crystal (LLC) nanoparticles. We have shown that large volume solutions of cubosomes, liposomes, and hexosomes can be produced (500 mL at 60 mg/mL lipid concentration) in a matter of minutes without the need for any cosolvents. Straightforward synthesis from 5 to 500 mL has been exemplified using **resonant acoustic mixing** to produce these LLC nanoparticles.

PUBLISHED ARTICLES

3D-printed nanoporous ceramics: Tunable feedstock for direct ink write and projection microstereolithography
Alyssa L. Troksa, Hannah V. Eshelman, Swetha Chandrasekaran, Nicholas Rodriguez, Samantha Ruelas, Eric B. Duoss, James P. Kelly, Maira R. Cerón & Patrick G. Campbell
… Common methods for making porous ceramics make use of sacrificial pore formers, direct foaming …beads (4 mm diameter) in an **acoustic mixer** (**LabRAM II**, **Resodyn Acoustic Mixers** … Once the initiator was added, the ceramic ink was ready for subsequent characterization and …

Investigation of the impact of particle size on properties and applications of a ceramic slurry
Hannah Eshelman
...and zirconia grinding media and mixed for 3 hours in a **Resodyn™ LabRAM II** … Based on a few simple tests, we determined that the different sized zirconia nanoparticles created slurries that behaved differently both during processing and once they were sintered.

Final Report on creation of the Energetic Materials Laboratory, Univ. of Texas at El Paso
Evgeny Shafirovich
The objective of this project was to acquire equipment and instrumentation for research and education on energetic materials that would enhance the University s capabilities in materials preparation, materials characterization, and combustion experiments... They include a glovebox isolator Terra Universal Series 300, an **acoustic mixer Resodyn LabRAM**...

A new and improved method for preparation of drug nanosuspension formulation using acoustic mixing technology
Dennis H. Leung, David J. Lamberto, Lina Liu, Elizabeth Kwong, Todd Nelson, Timothy Rhodes & Annette Bak
… In addition, the **acoustic mixer** agitates the entire container and does not contact the components of … This drug slurry is then acoustically mixed in the presence of zirconia grinding media, resulting …Herein we report this new **acoustic milling process** in detail as well as advantages …

Preparation of an energetic-energetic cocrystal using resonant acoustic mixing
Stephen R. Anderson, David J. am Ende, Jerry S. Salan & Philip Samuels
Resonant acoustic mixing (**RAM**) was applied to the preparation of an energetic-energetic cocrystal comprised of CL-20 and HMX in a 2:1 mol ratio. We have prepared the cocrystal using the **RAM** technology in a resource-efficient manner providing near quantitative yield. The cocrystalline product from the **RAM** preparation is consistent with the product from solution crystallization.

Nano-Aluminum Thermite Formulations: Characterizing the Fate Properties of a Nanotechnology during Use
Aimee R. Poda, Robert D. Moser, Michael F. Cuddy, Zac Doorenbos, Brandon J. Lafferty, Charles A. Weiss Jr., Ashley Harmon, Mark A. Chappell & Jeffery A. Steevens
The thermite formulations were prepared using a one-step mixing process in a **Resodyn LabRAM mixer** as opposed to typical ultrasonication.

Investigating High Energy Mixing in Cement-based Materials
Kay Wille, Nicolas Roussel, Hela Bessaies-Bey & Michael Accorsi
RAM mixing does not use a tool [e.g., impeller] that directly interacts with the mixing medium. This makes it an attractive mixing device as it reduces the cost of wear and tear of the mixing device...A 30% increase in 3-day and 20% increase in 28-day mechanical properties were observed in UHPC specimens mixed with **RAM**. The improved mechanical properties support there is more

uniform mixing energy transmitted to the system during mixing which enhances cement hydration and reduces air voids.

Feasibility study and demonstration of an aluminum and ice solid propellant
Timothee L. Pourpoint, Tyler D. Wood, Mark A. Pfeil, John Tsohas & Steven F. Son
"Although this current propellant formulation is far from optimized, improvements in the mixing procedure [using **RAM**] have produced a consistent and homogeneous propellant. While the performance of ALICE is too low for practical use, the knowledge gained through formulating and experimenting with nanoscale particles in a simple mixture is of great interest for ongoing research activities on advanced propellants."

The Effect of Varied Amounts of LiF Sintering Aid on the Transparency of Alumina Rich Spinel Ceramic with the Composition MgO
Anthony C. Sutorik, Gary Gilde, Christopher Cooper, Jared Wright & Corydon Hilton
Starting powders are prepared from combinations of high purity Mg(OH)2 and γ-Al2O3 thoroughly mixed in an aqueous slurry, and the solids are collected, dried, calcined, mixed with LiF sintering aid, and sieved...mixing was performed using a **Resodyn Acoustic Mixer.**

Graphene–aluminum nanocomposites
Anthony C. Sutorik, Gary Gilde, Christopher Cooper, Jared Wright &Corydon Hilton
Aluminum–graphene composite powders were fabricated by initially blending the constituent precursory powders of Valimet Al and graphene. Blending was conducted using a **Resodyn LabRAM acoustic mixer** for approximately 5 minutes.

Preparation and characterization of aqueous nanothermite inks for direct deposition on SCB initiators
R. Ross Nellums, Steven F. Son, Lori J. Groven
… polytetrafluoroethylene (PTFE) fixture 18, clamped in a **LabRAM resonant mixer** (**Resodyn Acoustic Mixers** … 30 mg increments to mitigate dangers presented by inadvertent reaction of material …Additional materials and powders used for stability verification included iron(III) oxide …

Preparation morphology and properties of reduced graphene oxide/natural rubber nanocomposites
Boyle, Timothy J.; Potts, Jeff; Shankar, Om; Ruoff, Rodney & Lambert, Timothy N.
Two routes for exfoliation of graphite oxide (GO) to graphene oxide yield different aspect ratio platelets...**Resodyn Acoustic Mixer** and Ultrasonication. Both methods exfoliate to single-layer graphene oxide but prolonged exfoliation times lead to smaller platelets, thus a smaller Af [aspect ratio].

Relevant Patents

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

*Including patents with RAM as the preferred embodiment

System and method for producing superalloys utilizing electrometallurgy

US EP EP4428271A2 Rahbar Nasserrafi, JR Gerald Eugene HICKS, Paul Ray TOIVONEN, Ni Yen LUU & Shawn Douglas Vierthaler Spirit AeroSystems inc.

Filed 2024-02-19 • Published 2024-09-11

A system and method for producing a rigid, heat-resistant part, such as a superalloy, via electrodeposition. The method can include the steps of coating a secondary alloy particulate with a superior alloy, forming a pre-coated particulate, dispensing a quantity of the pre-coated particulate into a container of an electrolytic solution, and applying a charge to the electrolytic solution such that the pre-coated particulate is electrodeposited onto a cathode or an external casing of the cathode. The pre-coated particulate can include particulate of non-uniform size and/or shape. The secondary alloy particulate is protected in the catalytic solution by the superior alloy coated thereon, such as nickel, iron, cobalt, and/or copper. The method also includes a step of vibrating or agitating the electrolytic solution before and/or during applying the charge to the electrolytic solution for even distribution of the pre-coated particulate onto the cathode or an external casing thereof.

Highlighted Use: RAM disperses coated powders and perform in-situ stress relief of electrodeposited layers.

High molecular weight zwitterion-containing polymers

WO EP US CN JP KR AU BR CA CL CO DK ES IL LT MX PT SI US20240293585A1 Stephen A. Charles Kodiak Sciences Inc.

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

Highlighted Use: RAM technology allows for efficient mixing over 1,000 cP.

Methanol oxidation catalyst

GB WO WO2024170881A1 Sonia Garcia Lopez, Robert Haggblad & Maitham Majeed

Filed 2024-02-13 • Published 2024-08-22

The present invention provides a catalyst composition comprising: i) a catalytic material comprising iron molybdate (Fe2(MoO4)3) and molybdenum trioxide (MoO3); and ii) a metal oxide A, wherein the metal oxide A is an alkaline earth metal oxide or zirconium oxide or a combination of zirconium oxide and cerium oxide.

Highlighted Use: A LabRAM II mixed a catalyst necessary for more efficient formaldehyde.

Process for preparing a dispersion hardened precious metal article

GB WO WO2024165866A1 John Richard Davenport, David Daniel Joseph, Maria Elena Rivas-Velazco & Jayasheelan Vaithilingam

Filed 2024-02-09 • Published 2024-08-15

A process is described for preparing a dispersion hardened article, comprising the steps of: (i) mixing a metal oxide powder comprising particles of one or more metal oxide(s), and a metal powder comprising particles of a precious metal or

Patents, cont'd.

precious metal-based alloy, by **resonant acoustic mixing (RAM)** to produce a **RAM-mixed** powder; and (ii) converting the **RAM-mixed powder** from step (i) into the desired article.
Highlighted Use: RAM dispersed a metal oxide powder across powdered precsious metals more efficiently than currently methods.

Dark catalytic material for decomposition of a volatile organic compound and filter containing the sam
WO WO2023147438A1 Shahzahan Mia, Ekambaram Sambandan, Bin Zhang, Shinya Kotake & Yoshie Satomi Nitto Denko Corporation
Priority 2022-01-26 • Filed 2023-01-26 • Published 2023-08-03
The present disclosure relates to deactivation resistant catalytic materials for decomposing volatile organic compounds in the presence or absence of visible light or ultraviolet light. The catalytic materials comprise an active catalyst comprising a noble metal and a single-phase metal oxide and/or a single-phase metal oxide hydroxide disposed on a supporting material comprising multiple catalytic action sites. Filters comprising the catalytic materials are also described.
Highlighted Use: RAM equipment "which creates good contact of single-phase TiO2: Fe(OH)s and Halloysite."

Solution Masterbatch With Resonant Acoustic Mixing
US US20230203255A1 Piotr Kozminski Bridgestone Corp
Filed 2022-12-29 • Assigned 2023-01-04 • Published 2023-06-29
Methods for producing an uncured masterbatch material from a solution masterbatch that includes an uncured polymer, for example a polydiene such as present in a guayule cement, a diluting liquid and a particulate filler. The solution masterbatch is subjected to resonant acoustic mixing which provides excellent dispersion of the solution components and leads to a masterbatch material having desirable properties. After **resonant acoustic mixing**, the solution masterbatch can be dried and further processed with other components and a curative to prepare a vulcanized composition.
Highlighted Use: "While mixing times for typical shear force mixers such as Brabenders may extend several hours, resonant acoustic mixing takes much less time for equal size batches."

Integral 3D graphene-carbon hybrid foam
US US10189006B2 Aruna Zhamu Nanotek Instruments, Inc.
Priority 2015-12-28 • Filed 2018-06-01 • Granted 2019-01-29 • Published 2019-01-29
Provided is an integral 3D graphene-carbon hybrid foam composed of multiple pores and pore walls, wherein the pore walls contain single-layer or few-layer graphene sheets chemically bonded by a carbon material having a carbon material-to-graphene weight ratio from 1/100 to 1/2, wherein the few-layer graphene sheets have 2-10 layers of stacked graphene planes having an inter-plane spacing d002 from 0.3354 nm to 0.40 nm and the graphene sheets contain a pristine graphene material having essentially zero % of non-carbon elements, or a non-pristine graphene material having 0.01% to 25% by weight of non-carbon elements wherein said non-pristine graphene is selected from graphene oxide, reduced graphene oxide, graphene fluoride, graphene chloride, graphene bromide, graphene iodide, hydrogenated graphene, nitrogenated graphene, doped graphene, chemically functionalized graphene, or a combination thereof. Also provided are a process for producing the hybrid form, products containing the hybrid foam, and its applications.
Highlighted Use: A RAM mixer processed expanded graphite with ABS pellets for 30 minutes to create graphite.

Patents, cont'd.

Supercapacitor with integrated 3D graphene-carbon hybrid foam-based electrode

JP JP2019506736A Arjuna Tsar & Zed. Chang, Boa, Nanotek Instruments, Inc.

Filed 2017-01-03 •Published 2019-03-07

A supercapacitor having an anode, a cathode, a porous separator / electrolyte, wherein at least one electrode comprises an integral 3D graphene-carbon hybrid foam composed of a plurality of pores and pore walls, Includes a single-layer or several-layer graphene sheet chemically bonded by a carbon material having a carbon material to graphene weight ratio of 1/100 to 1/2, and the several-layer graphene sheet has an interplanar spacing of 0.3354 nm to 0.40 nm a pure graphene material having 2 to 10 layers of graphene surfaces with d002, wherein the graphene sheet has substantially 0% non-carbon elements, or 0.01 wt% to 25 wt% non-carbon elements An impure graphene material, wherein the impure graphene includes graphene oxide, reduced graphene oxide, graphene fluoride, salt Graphene bromide graphene iodide graphene, hydrogenated graphene, nitrogen graphene, doped graphene, are selected from the chemical functionalization graphene, or a combination thereof, the super capacitor is provided.

Highlighted Use: A RAM mixer processed expanded graphite with ABS pellets for 30 minutes to create graphite.

Chemical-free production of graphene-wrapped electrode active material particles for battery applicati

US US20180183062A1 Aruna Zhamu & Bor Z. Jang Nanotek Instruments, Inc.

Priority 2016-05-17 • Filed 2018-02-19 • Published 2018-06-28

Provided is a simple, fast, scalable, and environmentally benign method of producing graphene-embraced or encapsulated particles of a battery electrode active material directly from a graphitic material, the method comprising: a) mixing graphitic material particles, multiple particles of an electrode active material, and non-polymeric particles of milling media to form a mixture in an impacting chamber, wherein the graphitic material has never been intercalated, oxidized, or exfoliated and the chamber contains therein no previously produced graphene sheets; 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 graphene sheets to surfaces of electrode active material particles to produce graphene-embraced active material particles; and c) recovering the graphene-embraced particles from the impacting chamber. Also provided is a mass of the graphene-embraced particles, electrode containing such particles, and battery containing this electrode.

Highlighted Use: RAM mixers coated SnO_2 with graphene using highly oriented pyrolytic graphite.

Thermoelectric polymer composite, method of making and use of same

US US10497849B2 Sayantan Roy, David Peter Gerrard & Oleksandr V. Kuznetsov Baker Hughes Holdings LLC

Priority 2013-05-21 • Filed 2017-01-31 • Granted 2019-12-03 • Published 2019-12-03

A thermoelectric composite includes a plurality of particles comprising a crosslinked polymer having a heat deflection temperature greater than or equal to 200° F. and a segregated network comprising a first filler material which is disposed between the particles to produce a thermoelectric response in response to application of a voltage difference or temperature difference across the thermoelectric composite. The first filler material includes a carbon material, a metal, a metal disposed on a carbon material, or a combination thereof. A process for preparing a thermoelectric article includes combining a first filler material and a plurality of particles comprising a polymer to form a composition and molding the composition to form a thermoelectric article, wherein the thermoelectric article is configured to produce a

Patents, cont'd.

thermoelectric response in response to application of a voltage difference or temperature difference across the article.
Highlighted Use: A RAM mixer dry blended a filler material and polymer.

Method for producing a cemented carbide or ceramic metal powder using a resonant acoustic mixer
KR CN WO JP ES EP US WO2013057136A2 Carl-Johans Maderud, Tommy Flygare, Michael Carpenter & Jane Smith
Filed 2012-10-17 • Priority 20212-10-17 • Publication 2013-08-15
The present invention relates to a method of making a cemented carbide or a cermet body comprising the steps of first forming a powder blend comprising powders forming hard constituents and metal binder. The powder blend is then subjected to a mixing operation using a non-contact mixer wherein **acoustic waves** achieving resonance conditions to form a mixed powder blend and then subjecting said mixed powder blend to a pressing and sintering operation. The method makes it possible to maintain the grain size, the grain size distribution and the morphology of the WC grains.
Highlighted Use: A RAM mixer combined powders ahead of the pressing and sintering.

The electrode active material particles that graphene for battery applications is encapsulated are produced without chemicals formula
US CN JP KR WO CN109155399A Arjuna Zam & Zhang Bozeng Nanotek Instruments Inc.
Filed 2017-05-09 • Published 2019-01-04
Provide a kind of battery electrode active material particle directly being surrounded from graphite material production graphene or encapsulating it is simple, quick, can scale and environmental-friendly method; the described method includes: graphite material particle and multiple solid electrode active material particles a) are mixed to form mixture in the impact room of energy impact device; wherein the graphite material never carries out intercalation, oxidation or extruding, and the room is wherein without containing the graphene film generated in advance and without containing ball-milling medium; B) the energy impact device is run with certain frequency and intensity and generates the electrode active material particles of graphene encirclement so that graphene film is transferred to the surface of electrode active material particles from the graphite material; And the particle c) is recycled from the impact room. Additionally provide block, the electrode containing such particle and the battery containing this electrode of a kind of particle that the graphene surrounds.
Highlighted Use: A RAM machine ground stannic oxide powder and height-oriented pyrolysis graphite together.

ResonantAcoustic mixing (RAM) of an explosive composition
EP AU CA WO AU ES CA WO US EP US CA3058701A1 Andy Oden Burn & Rebecca Elizabeth Stevens BAE Systems PLC
Priority 2017-04-03 • Filed 2018-03-28 • Published 2018-10-11
The invention relates to a cast explosive composition, particularly to a pre-cure castable explosive composition comprising an explosive material, a polymerisable binder, a microencapsulated cross linking reagent, said microencapsulated cross linking reagent, comprising a cross linking agent encapsulated in a microcapsule. Providing a process for formulating a homogenous crosslinked polymer bonded explosive composition comprising the steps of: i) forming an admixture of pre-cure castable explosive composition, said composition comprising an explosive material, a polymerisable binder, a microencapsulated cross linking reagent, said microencapsulated cross linking reagent, comprising a cross linking re-

Patents, cont'd.

agent encapsulated in a microcapsule; wherein the microcapsule, comprises at least one shell wall polymer, wherein the microcapsule's shell wall polymer comprises at least one **resonant acoustic stimulus** labile linkage, ii) applying **resonant acoustic stimulus** to the admixture, causing the microcapsule to rupture and release said cross linking reagent, to cause the cure process to start.

Highlighted Use: RAM mixers are used extensively to produce polymer-bonded explosives.

Acoustic mixing for flocculant addition to mineral suspensions

WO WO2018022352A1 Carole E. Mohler, Michael K. Poindexter, Thomas L. Sanders & Cole A. Witham
Filed 2017-07-18 • Priority 2017-07-18 • Published 2018-02-01

The present invention relates to a process for mixing a flocculant composition with mineral suspensions, especially waste mineral slurries, using an **acoustic mixer**. Preferably the flocculant composition is a polymeric flocculant composition preferably comprising a poly(ethylene oxide) homopolymer or copolymer. The process of the present invention is particularly suitable for the treatment of tailings and other waste material resulting from mineral processing, in particular, processing of oil sands tailings.

Highlighted Use: A RAM system combined flocculant and a mineral suspension to extract solids and liquids.

Solvent-free emulsion process using acoustic mixing

US US8435714B2 Zhen Lai, Chieh-Min Cheng, Shigang Qiu, Emily L. Moore & Tie Hwee Ng Xerox Corp
Priority 2009-04-20 • Filed 2010-06-25 • Published 2013-05-08 • Granted 2013-05-08

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.

Highlighted Use: A RAM mixer combined amorphous resin, crystalline resin, pigment and a surfactant.

Continuous acoustic chemical microreactor

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Priority 2012-05-31 • Filed 2023-01-30 • Published 2023-06-08

A continuous **acoustic chemical microreactor** system is disclosed. The system includes a continuous process vessel (CPV) and an acoustic agitator coupled to the CPV and configured to agitate the CPV along an oscillation axis. The CPV includes a reactant inlet configured to receive one or more reactants into the CPV, an elongated tube coupled at a first end to the reactant inlet and configured to receive the reactants from the reactant inlet, and a product outlet coupled to a second end of the elongated tube and configured to discharge a product of a chemical reaction among the reactants from the CPV. The acoustic agitator is configured to agitate the CPV along the oscillation axis such that the inner surface of the elongated tube accelerates the one or more reactants in alternating upward and downward directions along the oscillation axis.

Highlighted Use: A RAM system can be used without stopping production.

RAM 5

RAM 5 Continuous

RAM 55

OmniRAM Continuous

OmniRAM H

RAM 5 H

RAM 55 H

OmniRAM

LabRAM II LabRAM I

PharmaRAM I PharmaRAM II

LabRAM II H

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