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SLS 3D PRINTER HANDBOOK 2024

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SCIENTIFIC PUBLICATIONS

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Selective Recovery of Gold from Electronic Waste Using 3D-Printed Scavenger

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OPEN ARTICLE

ABSTRACT:

Around 10% of the worldwide annual production of gold is used for manufacturing of electronic devices. According to the European Commission, waste electric and electronic equipment is the fastest growing waste stream in the European Union. This has generated the need for an effective method to recover gold from electronic waste. Here, we report a simple, effective, and highly selective nylon-12-based three-dimensional (3D)-printed scavenger objects for gold recovery directly from an aqua regia extract of a printed circuit board waste. Using the easy to handle and reusable 3D printed meshes or columns, gold can be selectively captured both in a batch and continuous flow processes by dipping the scavenger into the solution or passing the gold containing solution through the column. The possibility to optimize the shape, size, and flow properties of scavenger objects with 3D printing enables the gold scavengers to match the requirements of any processing plants.

Scaling up colloidal surface additivation of polymer powders for laser powder bed fusion

Tim Hupfeld, Carlos Doñate-Buendí, Matthias Krause, Alexander Sommereyns, Andreas Wegner, Thorsten Sinnemann Michael Schmidt Bilal Gökce, Stephan Barcikowski

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Institute of Photonic Technologies (LPT), Friedrich-Alexander Universität Erlangen-Nürnberg, Konrad-Zuse-Str.3-5, 91052 Erlangen, Germany
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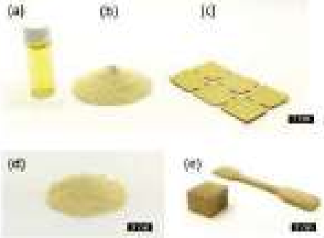
OPEN ARTICLE

ABSTRACT:

Nanoadditivation of polymer materials has high potential to meet the needs of material modification for laser powder bed fusion (PBF-LB/P), e.g. by tuning optical or mechanical properties. Colloidal additivation of polymer powders has proven to avoid aggregation of nanofillers on the polymer surface during additivation. In our study, we demonstrate kg-scale, continuous colloidal surface additivation of polymer powders to generate sufficient amounts for PBF-LB/P process development and manufacturing of test specimens. Furthermore, colloidal additivation achieves a high surface coverage even at low wt% and allows PBF-LB/P with CO2 and diode lasers to form parts preserving the superior nanoparticle dispersion within TPU and PA12.



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On the Development of Polymer Particles for Laser Powder Bed Fusion via Precipitation

OPEN ARTICLE

Maximilian A. Dechet, Jochen Schmidy

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ABSTRACT:

In this contribution, some aspects of the development of powder bed fusion (PBF) feedstock powders via the solution-dissolution process, also known as precipitation, are exemplary addressed based on the authors' own work. The development is based on the selection of an appropriate polymer-solvent system, followed by the investigation of the cloud point diagram. After identification of a polymer-solvent system for precipitation, process-product relations, i.e. the influence of stirring, concentration and thermal regime on particle size distribution and shape, can be assessed. Via thorough product characterization concerning, amongst others, flowability and thermal properties, not only applicable PBF process parameters, but also necessary in-situ additive-enhancement with thermal stabilizers or post-processing with flow aids can be derived.

Manufacturing Porous Alumina Ceramics Using Selective Laser Sintering

OPEN ARTICLE

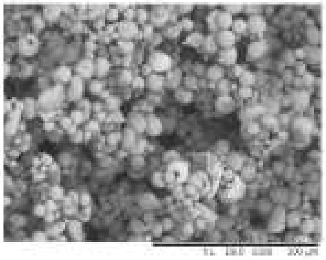
Student: Andrew Bryce Lynch
Supervisors: Dr. Mingyuan Lu and Professor Han Huang

Faculty of Engineering, Architecture and Information Technology (EAIT), University of Queensland

ABSTRACT:

The Production of complex shaped Alumina ceramics has historically been labor intensive and costly. Recent advancements in 3D printing technologies have allowed for desktop indirect Selective Laser Sintering (iSLS) machines to become commercially available to consumers. These machines allow for complex 3D geometry alumina 'green' parts to be printed from a powder base mixture of PA12 polymer binder and a eutectic mixture of titanium oxide (TiO_2) and alumina (Al_3O_2).

This study aims to optimise binder burnout and sintering temperature profiles in order to produce dense Alumina ceramics. The binder burnout and sintering temperature profile contain three key variables: rate of temperature change, maximum temperature and maximum temperature hold time.



Interfacial stereocomplexation in heterogeneous polymer powder formulations for reinforcing (laser) sintered welds

Varun Srinivas, Francesca Bertella, Catharina S. J. van Hooy-Corstjens, Bas van Leeuwen, E.G.M.Craenmehr, Dario Cavallo, Sanjay Rastogi, Jules A. W. Harings

Aachen-Maastricht Institute for Biobased Materials, Maastricht University, P.O. Box 616, 6200 MD Maastricht, The Netherlands
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Corbion Purac Biomaterials, P.O. Box 21, 4200 AA Gorinchem, The Netherlands
Brightlands Materials Center, Urmonderbaan 22, 6167 RD Geleen, The Netherlands

OPEN ARTICLE

ABSTRACT:

To understand the relation of molecular design of powder formulations in the realization of effective stress transfer at sintered polymer – polymer interfaces by the concept of interfacial stereocomplex crystallization in a broad temperature range, the effect of temperature and molar mass ratio are studied in heterogeneous poly(lactide) melt-states. Whereas the stereocomplex crystallization rate is dictated by supercooling and relative viscosities, the length-scales depend on the formation of crystalline stereocomplex domains connected via amorphous regions resulting in network formation, gelation. Upon gelation, further diffusion is impeded, which is supported by rheometry, DSC and FTIR imaging. [...]

In-situ synthesis of Metal Organic Frameworks (MOFs)-PA12 powders and their laser sintering into hierarchical porous lattice structures

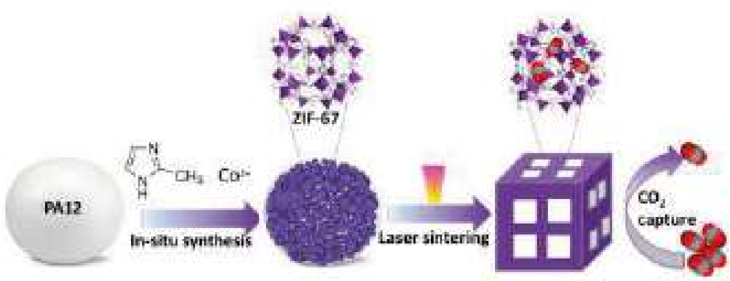
Binling Chen, Richard Davies, Hong Chang, Yongde Xia, Yanqiu Zhu, Oana Ghita

College of Engineering, Mathematics and Physical Sciences, University of Exeter, Exeter EX4 4QF, UK

OPEN ARTICLE

ABSTRACT:

This paper demonstrates the utilisation of in-situ synthesised novel metal organic framework (MOF)-polymer nanocomposite laser-sintered parts with enhanced CO_2 adsorption properties. Making use of polyamide PA12, one of the most common materials in powder bed fusion process as the base polymer, an in-situ synthesis of nanofiller ZIF-67 crystals on the surface of polyamide polymer particles was proposed to allow the fabrication of a nanocomposite powder with a good dispersion, reducing any health and safety handling issue arising from use of loose nanoparticles. [...]



Gold Nanoparticles on 3D-Printed Filters: From Waste to Catalysts

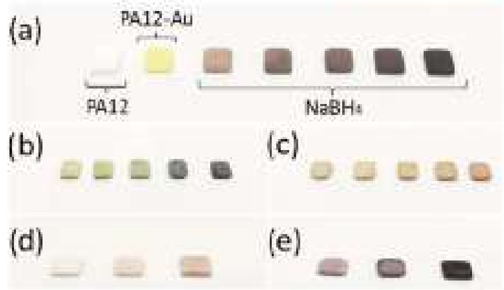
Elmeri Lahtinen, Esa Kukkonen, Virva Kinnunen, Manu Lahtinen, Kimmo Kinnunen, Sari Suvanto, Ari Väisänen, and Matti Haukka

Department of Chemistry and Department of Physics, Nanoscience Center, University of Jyväskylä, P.O. Box 35, Jyväskylä FI-40014, Finland
Department of Chemistry, University of Eastern Finland, P.O. Box 111, Joensuu FI-80101, Finland

OPEN ARTICLE

ABSTRACT:

Three-dimensionally printed solid but highly porous polyamide-12 (PA12) plate-like filters were used as selective adsorbents for capturing tetrachloroaurate from acidic solutions and leachates to prepare PA12–Au composite catalysts. The polyamide-adsorbed tetrachloroaurate can be readily reduced to gold nanoparticles by using sodium borohydride, ascorbic acid, hydrogen peroxide, UV light, or by heating. All reduction methods led to polyamide-anchored nanoparticles with an even size distribution and high dispersion. The particle sizes were somewhat dependent on the reduction method, but the average diameters were typically about 20 nm. Particle sizes were determined by using a combination of single-particle inductively coupled plasma mass spectrometry, helium ion microscopy, and powder X-ray diffraction. [...]



Development of Polyoxymethylene Particles via the Solution-Dissolution Process and Application to the Powder Bed Fusion of Polymers

Maximilian A. Dechet, Ina Baumeister and Jochen Schmidt

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Interdisciplinary Center for Functional Particle Systems, Friedrich-Alexander-Universität, Erlangen-Nürnberg, Haberstraße 9a, D-91058 Erlangen, Germany

OPEN ARTICLE

ABSTRACT:

In this study, the development of a polyoxymethylene (POM) feedstock material for the powder bed fusion (PBF) of polymers is outlined. POM particles are obtained via liquid-liquid phase separation (LLPS) and precipitation, also known as the solution-dissolution process. In order to identify suitable POM solvent systems for LLPS and precipitation, in the first step, a solvent screening based on solubility parameters was performed, and acetophenone and triacetin were identified as the most promising suitable moderate solvents for POM. Cloud point curves were measured for both solvents to derive suitable temperature profiles and polymer concentrations for the solution-dissolution process. In the next step, important process parameters, namely POM concentration and stirring conditions, were studied to elucidate their e ect on the product's properties. The product particles obtained from both aforementioned solvents were characterized with regard to their morphology and size distribution, as well as their thermal properties (cf. the PBF processing window) and compared to a cryo-milled POM PBF feedstock. [...]

Selective laser sintering of polyamide 12/flame retardant compositions

Marcos Batistella, Arnaud Regazzi, Monica Francesca Pucci, José-Marie Lopez-Cuesta
Ouassila Kadri, David Bordeaux, Florence Ayme

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LMGC, IMT Mines Ales, Univ Montpellier, CNRS, Ales, France
SD Tech, Ales, France

OPEN ARTICLE

ABSTRACT:
In this work, various flame retardants (FR) and clays were added to polyamide 12 (PA12). The processability by Selective Laser Sintering (SLS), thermal behaviour and flame retardancy of these compounds were evaluated. The observations show an important impact on powder flowability of some formulations containing melamine cyanurate and melamine polyphosphate leading to difficulties during SLS process. The incorporation of FRs also leads to changes in melting and crystallization temperatures of polyamide as a function of the FR type. Furthermore, in order to evaluate the influence of the process on thermal properties of samples, a comparison between thermocompression (TC) and SLS techniques was performed for the formulations containing the flame retardants alone. The addition of flame retardants impacts the porosity of the SLS samples as a function of the FR type. For the additives which are able to melt during SLS process, a lower porosity was observed. [...]

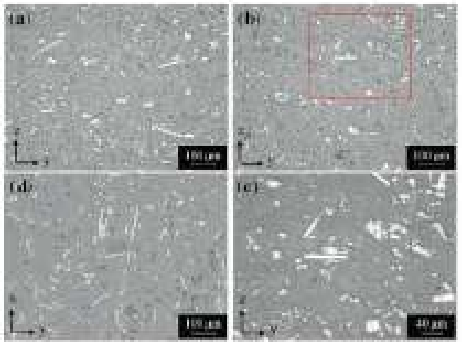
Innovative approach to the development of conductive hybrid composites for Selective Laser Sintering

Federico Lupone, Elisa Padovano, Oxana Ostrovskaya, Alessandro Russo, Claudio Badini

Politecnico di Torino, Department of Applied Science and Technology, Corso Duca degli Abruzzi 24, 10129 Torino, Italy

OPEN ARTICLE

ABSTRACT:
Selective Laser Sintering (SLS) was used to manufacture electrically conductive polymer composites made of polyamide 12 reinforced with carbon fibres and graphite (PA12/CF/GP). Since material design is critical in developing conductive polymer composites, an innovative experimental technique is proposed to preliminary evaluate the electrical behaviour of the powders before SLS processing and select the most performing hybrid compositions. The properties of starting powders and the microstructure, mechanical and electrical behaviour of PA12/CF/GP composites were studied. Results reveal that the addition of graphite lowers the flowability and mechanical properties of the composites compared to the carbon fibres reinforced counterparts. Hybrid composites display great enhancements in the electrical conductivity with respect to the neat PA12 up to anti-static and conductive range; however, no synergistic effect between the two fillers was observed.



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3D Printed Palladium Catalyst for Suzuki-Miyaura Cross-coupling Reactions

Evgeny Bulatov, Elmeri Lahtinen, Lauri Kivijärvi, Evamarie Hey-Hawkins and Matti Haukka

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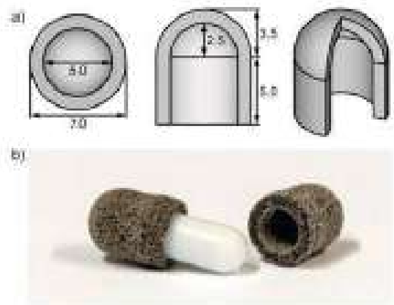
Department of Chemistry, University of Helsinki, A.I. Virtasen aukio 1, P.O. Box 55 00014 Helsinki (Finland)
Faculty of Chemistry and Mineralogy, Institute of Inorganic Chemistry, Leipzig University, Johannisallee 29 04103 Leipzig (Germany)

OPEN ARTICLE

ABSTRACT:

Selective laser sintering (SLS) 3d printing was utilized to manufacture a solid catalyst for Suzuki-Miyaura cross-coupling reactions from polypropylene as a base material and palladium nanoparticles on silica (SilicaCat Pd R815-100 by SiliCycle) as the catalytically active additive. The 3d printed catalyst showed similar activity to that of the pristine powdery commercial catalyst, but with improved practical recoverability and reduced leaching of palladium into solution. Recycling of the printed catalyst led to increase of the induction period of the reactions, attributed to the pseudo-homogeneous catalysis. The reaction is initiated by oxidative addition of aryl iodide to palladium nanoparticles, resulting in formation of soluble molecular species, which then act as the homogeneous catalyst. SLS 3d printing improves handling, overall practicality and recyclability of the catalyst without altering the chemical behaviour of the active component.



Considering lithium-ion battery 3D-printing via thermoplastic material extrusion and polymer powder bed fusion

AlexisMaurel, Matti Haukka, Eric MacDonald, Lauri Kivijärvi, Elmeri Lahtinen, Hyeonseok Kim
Michel Armand, Aurélie Cayla, Arash Jamali, Sylvie Grugeon, Loic Dupont, Stéphane Panier

Laboratoire de Réactivité et de Chimie des Solides, UMR CNRS 7314, Hub de l'Énergie, Université de Picardie Jules Verne, 33 rue Saint Leu, 80039, Amiens Cedex, France
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OPEN ARTICLE

ABSTRACT:

In this paper, the ability to 3D print lithium-ion batteries through Pmnbspace thermoplastic material extrusion and polymer powder bed fusion is considered. Focused on the formulation of positive electrodes composed of polypropylene, $LiFePO_4$ as active material, and conductive additives, advantages and drawbacks of both additive manufacturing technologies, are thoroughly discussed from the electrochemical, electrical, morphological and mechanical perspectives. Based on these preliminary results, strategies to further optimize the electrochemical performances are proposed. Through a comprehensive modeling study, the enhanced electrochemical suitability at high current densities of various complex three-dimensional lithium-ion battery architectures, in comparison with classical two-dimensional planar design, is highlighted. Finally, the direct printing capability of the complete lithium-ion battery by means of multi-materials printing options processes is examined.

Optimization of selective laser sintering process conditions using stable sintering region approach

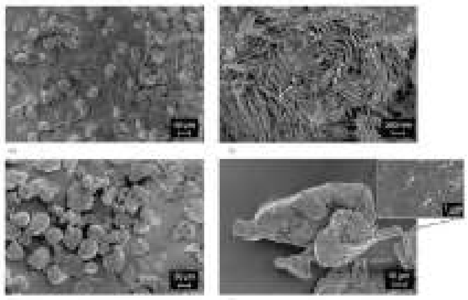
F. Lupone, E. Padovano, M. Pietroluongo, S. Giudice, O. Ostrovskaya, C. Badini

OPEN ARTICLE

Politecnico di Torino, Department of Applied Science and Technology, Corso Duca degli Abruzzi 24, 10129 Torino, Italy

ABSTRACT:

The optimization of process parameters represents one of the major drawbacks of selective laser sintering (SLS) technology since it is largely empirical and based on performing a series of trial-and-error builds. This approach is time consuming, costly, and it ignores the properties of starting powders. This paper provides new results into the prediction of processing conditions starting from the material properties. The stable sintering region (SSR) approach has been applied to two different polymer-based powders: a polyamide 12 filled with chopped carbon fibers and polypropylene. This study shows that the laser exposure parameters suitable for successful sintering are in a range that is significantly smaller than the SSR. For both powders, the best combination of mechanical properties, dimensional accuracy, and porosity level are in fact, achieved by using laser energy density values placed in the middle of the SSR.



3D Printing of magnetic parts by Laser Powder Bed Fusion of iron oxide nanoparticle functionalized polyamide powders

Tim Hupfeld, Soma Salamon, Joachim Landers, Alexander Sommereyns, Carlos Doñate-Buendía
Jochen Schmidt, Heiko Wende, Michael Schmidt, Stephan Barcikowski, Bilal Gökce

OPEN ARTICLE

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Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen, Lotharstr. 1, 47057 Duisburg, Germany
Institute of Photonic Technologies (LPT), Friedrich-Alexander Universität Erlangen-Nürnberg, Konrad-Zuse-Str.3-5, 91052 Erlangen, Germany
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Institute of Particle Technology (LFG), Friedrich-Alexander Universität Erlangen-Nürnberg, Cauerstr. 4, 91058 Erlangen, Germany

ABSTRACT:

The development of new feedstock materials is a central prerequisite for advances in Additive Manufacturing (AM). To increase the breadth of potential applications for 3D and 4D printing of polymers, micro- and nano-additives incorporated into the feedstock material play an important role. In this context, magnetic materials are of great interest. Our study describes a way to fabricate polymer powders for laser powder bed fusion (PBF-LB) with a homogeneous, well-dispersed coating of iron oxide nanoparticles. Without the addition of chemical precursors, spherical superparamagnetic FeOx nanoparticles with monomodal size distribution below 10 nm are generated from FeOx micropowder by laser fragmentation in liquid. The adsorption of the nanoparticles on polyamide (PA12) powder is conducted directly in an aqueous dispersion after laser fragmentation, followed by drying, powder analysis and PBF-LB processing. Via Mössbauer spectroscopy and magnetometry, we determined that the saturation magnetization and structure of the iron oxide nanoparticles were not influenced by PBFLB processing, and the magnetic properties were successfully transferred to the final 3D-printed magnetic part.

UNIVERSITÉ DE MONTPELLIER pharmaceutics CHU NÎMES MDPI

Selective Laser Sintering of Solid Oral Dosage Forms with Copovidone and Paracetamol Using a CO2 Laser

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ICGM, University Montpellier, CNRS, ENSCM, 34000 Montpellier, France
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Department of Pharmacy, Nîmes University Hospital, 30900 Nimes, France

ABSTRACT:

Material suitability needs to be considered for the 3D printing of solid oral dosage forms (SODFs). This work aims to assess the suitability of a CO2 laser (λ = 10.6 μm) for selective laser sintering of SODFs containing copovidone and paracetamol. First, physicochemical characterization of powders (two grades of copovidone, two grades of paracetamol and their mixtures at various proportions) was conducted: particle size distribution, morphology, infrared absorbance, flowability, and compactness. Then, printing was launched, and printability of the powders was linked to their physicochemical characteristics. The properties of the sintered SODFs were evaluated (solid state, general aspect, porosity, hardness, drug content and release). Hence, it was found that as copovidone absorbs at the laser's wavelength, sintering was feasible without using an absorbance enhancer. [...]

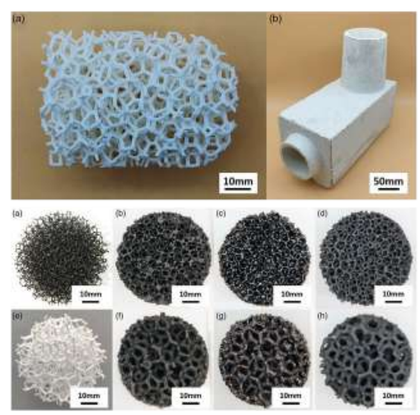
ADVANCED ENGINEERING MATERIALS

Rapid Prototyping of Carbon-Bonded Alumina Filters with Flame-Sprayed Alumina Coating for Bottom-Teeming Steel Ingot Casting

Tony Wetzig, Marc Neumann, Matthias Schwarz, Leandro Schöttler, Martin Abendroth, Christos G. Aneziris

ABSTRACT:

Although continuous casting is the state-of-the-art casting method in steelmaking, ingot casting by bottom teeming has kept its relevance, for example, in the area of specialty steels. The main challenge is to meet the ever-increasing quality requirements demanded by the customers. Regarding high-performance steel applications, the purity with respect to the content of nonmetallic inclusions thereby is of special interest. Herein, foam templates with tailored geometry are designed and manufactured by selective laser sintering. Different coating techniques based on carbon-bonded alumina slurries are applied to replicate foam structures with miniature cube geometry and cylindrical geometry. The techniques are evaluated regarding the porosity, pore size distribution, bulk density, mechanical strength, and shrinkage of the resulting filters. Suitable processing routes are selected to manufacture prototype batches with near-net-shape geometry. Finally, the feasibility of applying a flame spray coating is tested. First samples of the prototype batch are tested in industrial bottom-teeming ingot casting.



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Mary Ann Liebert, Inc. publishers

Recovery of 17β-Estradiol Using 3D Printed Polyamide-12 Scavengers

Janne Frimodig, Aino Autio, Elmeri Lahtinen, and Matti Haukka

ABSTRACT:

Over the past decades, endocrine-disrupting compounds have been under active studies due to their potential environmental impact and increased usage. The actual hormones, especially estrogens, have shown to be one of the major contributors to hormonal waste in wastewater. Wastewater treatment facilities have variable capabilities to handle hormonal compounds and, therefore, different quantities of harmful compounds may end up in the environment. We introduce a simple technique to remove estrogens, such as 17β-estradiol (E2) from wastewater by using 3D printed polyamide-12 (PA12) filters. A selective laser sintering 3D printing was used to manufacture porous PA12 filters with accessible functional groups. Adsorption and desorption properties were studied using gas chromatography with flame ionization detector. The results showed that near quantitative removal of E2 was achieved. The 3D printed filters could also be regenerated and reused without losing their efficiency. During regeneration, E2 could be extracted from the filter without destroying the compound. This opens up possibilities to use the hormone scavenger filters also as concentration tools enabling accurate analyses of sources with trace concentrations of E2.

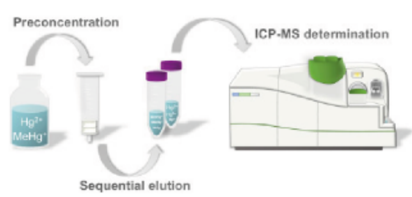
ELSEVIER

Preconcentration and speciation analysis of mercury: 3D printed metal scavenger-based solid-phase extraction followed by analysis with inductively coupled plasma mass spectrometry

Tony Wetzig, Marc Neumann, Matthias Schwarz, Leandro Schöttler, Martin Abendroth, Christos G. Aneziris

ABSTRACT:

A selective method for preconcentration and determination of methylmercury (MeHg) and inorganic mercury (iHg) in natural water samples at the ng L−1 level has been developed. The method involves adsorption of Hg species into a 3D printed metal scavenger and sequential elution with acidic thiourea solutions before ICP-MS determination. Experimental parameters affecting the preconcentration of MeHg and iHg such as the sample matrix, effect of the flow rate on adsorption, eluent composition, and elution mode have been studied in detail. The obtained method detection limits, considering the preconcentration factors of 42 and 93, were found to be 0.05 ng L−1 and 0.08 ng L−1 for MeHg and iHg, respectively. The accuracy of the method was assessed with a certified groundwater reference material ERM-CA615 (certified total iHg concentration 37 ± 4 ng L−1). The determined MeHg concentration was below MDL while iHg concentration was determined to be 41.2 ± 0.5 ng L−1. Both MeHg and iHg were also spiked to natural water samples at 5 ng L−1 concentration and favorable spiking recoveries of 88–97% were obtained. The speciation procedure was successfully applied to two lake water samples where MeHg and iHg concentrations ranged from 0.18 to 0.24 ng L−1 and 0.50–0.62 ng L−1, respectively. The results obtained demonstrate that the developed 3D printed metal scavenger-based method for preconcentration and speciation of Hg is simple and sensitive for the determination of Hg species at an ultra-trace level in water samples.



Springer Link

Laser sintering of coated polyamide 12: a new way to improve flammability

Marcos Batistella, Ouassila Kadri, Arnaud Regazzi, Monica Francesca Pucci, José-Marie Lopez-Cuesta, Florence Ayme & David Bordeaux

ABSTRACT:

In this study coatings of kaolin and talc particles were successfully applied on the surface of polyamide 12 powder intended for laser sintering (LS). Microscopic observations revealed that using carboxymethyl cellulose (CMC) as surface modifier for fillers led to a better coverage of polymer grains with a surface coverage between 6 and 16% as a function of filler type and content. Differential scanning calorimetry measurements showed that the addition of talc and kaolin led to an increase in the crystallization temperature of PA12, but at the expense of processability. Process parameters were optimized in order to manufacture LS samples with the different coated powders. Fire behavior assessed by cone calorimetry showed that the use of CMC resulted in a significant decrease in the peak of heat release rate depending on the filler type and content. This behavior can be partially explained by an interaction between CMC, fillers and polymer, with the formation of amide linkage between carboxyl part of CMC and amine end groups of polyamide, resulting in an increase in the complex viscosity of materials.

MDPI

Fire Behavior of Polyamide 12/Rubber Formulations Made by Laser Sintering

Marcos Batistella 1,, Monica Francesca Pucci 2, Arnaud Regazzi 2, José-Marie Lopez-Cuesta 1ORCID, Ouassila Kadri 3, David Bordeaux 3 and Florence Ayme*

Polymers Composites and Hybrids (PCH), IMT Mines Ales, 30319 Ales, France
LMGC, IMT Mines Ales, University Montpellier, CNRS, 30319 Ales, France
SDTech, 30100 Ales, France

ABSTRACT:

In the present work, the processability and fire behavior of parts made by the laser sintering (LS) of polyamide 12/rubber powder blends is studied. In order to evaluate some of the interactions that could take place during LS, three acrylonitrile butadiene rubbers (NBRs) were used, which included two that had different acrylonitrile (AN) contents, and one that had carboxylated rubber. The results show that the flowability of the powders is strongly dependent on the rubber used. For the carboxylated rubber, a good flowability of the blend was observed, whereas the use of rubbers with different AN contents led to significant changes in the powder flowability, with a heterogeneous powder bed, and differences in the porosity as a function of the AN content. Furthermore, the addition of rubbers to polyamide 12 (PA12) entails an increase in the sintering window and, in particular, a change in the melting temperature of PA12 is noticed. Even though some changes in the crystallization and melting temperatures are observed, formulations containing 10 and 20 wt.% of rubbers could be processed using the same process parameters as PA12. Furthermore, the formulations containing carboxylated rubber show improved fire behavior, which is measured by a cone calorimeter, with reductions of about 45 and 65% in the peak of the heat release rate, compared to the PA12. Moreover, almost all of the samples evaluated in this study are classed as “Good” by the Flame Retardancy Index. This result can be partially explained by the formation of an amide linkage between the polyamide and NBR during processing, which could result in increases in the melt viscosities of these samples.

PATENTS DEVELOPED
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SHAREBOT

A POROUS BODY, METHOD FOR MANUFACTURING IT AND ITS USE FOR CATALYSIS

Applicants:
Weefiner OY

Publication:
WO2020109658A1

Inventors:
Elmeri Lahtinen, Lauri Kivijärvi, Rissanen Kari, Väisänen Ari and Matti Haukka

ABSTRACT:
Simple, versatile and reusable catalyst based on laser 3D printed porous body has been invented. The shape, porosity and active component of the objects can be easily tuned to generate an efficient catalyst for various reactions such as hydrogenation and C-C bond formation.

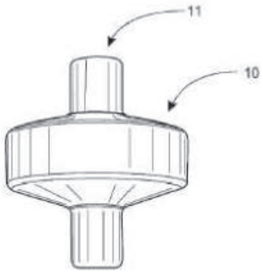


Fig. 1a

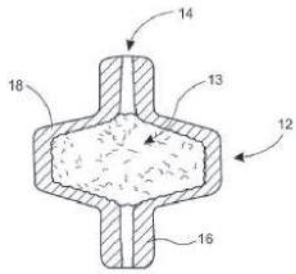


Fig. 1b

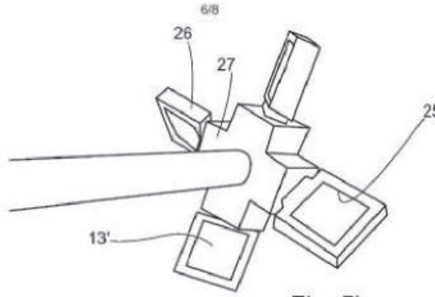


Fig. 5b

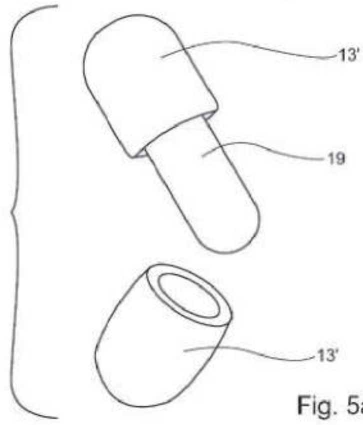


Fig. 5a

A POROUS BODY, METHOD FOR MANUFACTURING IT AND ITS USE FOR COLLECTING SUBSTANCE FROM SOURCE MATERIAL

Applicants:
Weefiner OY

Publication:
WO2019008232A1

Inventors:
Elmeri Lahtinen, Lauri Kivijärvi, Rissanen Kari, Väisänen Ari and Matti Haukka

ABSTRACT:
Limitations of existing metal recovery processes have raised a need to develop more efficient methods. To answer these needs, we present a simple, effective and selective hydrometallurgic precious metal recovery method based on laser 3D printed collectors. The objects collected from 99-80 % of desired metals (for example Pd, Pt and Au) in both batch or flow systems despite having hundreds of times higher concentrations of other metals. The chosen metals can be collected to separate objects depending on the chemically active species. Using different solutions, the metal ions are stripped from the collectors which can be then reused.

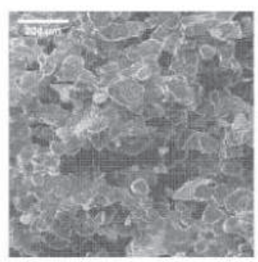


Fig. 2a

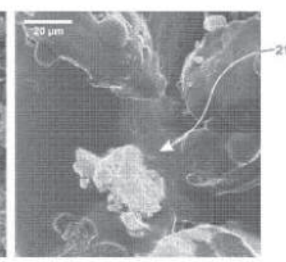


Fig. 2b

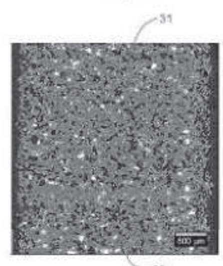


Fig. 3a

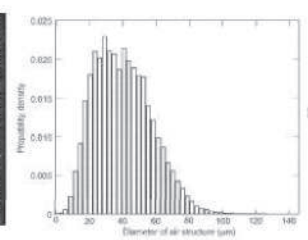


Fig. 3b

POWDER-BASED ADDITIVE MANUFACTURING PROCESS AT LOW TEMPERATURES

Applicants:
COVESTRO DEUTSCHLAND AG

Publication:
US10926459B2

Inventors:
Achten Dirk, Akbas Levent, Arndt Wolfgang, Büchner Jörg, Büsgen Thomas, Degiorgio Nicolas, Dijkstra Dirk, Reichert Peter, Wagner Roland

ABSTRACT:
A process for manufacturing an article comprises the steps of: applying a layer that consists of particles to a target area; allowing, in a chamber, energy to act on a selected portion of the layer, according to a cross-section of the article, so that the particles in the selected portion are bonded, and repeating the steps of applying and allowing energy to act for a plurality of layers so that the bonded portions of the adjacent layers are bonded to form the article, at least part of the particles comprising a fusible polymer. The fusible polymer has a fusion range (DSC, differential scanning calorimetry; 2nd heating at a heating rate of 5 K/min.) of ≥20° C. to ≤100° C. The fusible polymer further has a complex viscosity \η*\ (determined by viscosity measurement in the melt using a plate-plate oscillating viscometer according to ISO 6721-10 at 100° C. and a shear rate of 1/s) of ≥10 Pas to ≤1000000 Pas. Finally, the temperature inside the chamber is ≤50° C. The invention also relates to an article manufactured by the process according to the invention, to an article having a substrate and to an article bonded to the substrate, the article being in the form of an adhesive joint or varnish region, and to the use of a particular polyurethane in powder-based additive manufacturing processes.

PROCESS FOR PRODUCING 3D STRUCTURES FROM POWDERED RUBBER MATERIAL AND ITS PRODUCTS

Applicants:
COVESTRO DEUTSCHLAND AG

Publication:
CN109689340A

Inventors:
Achten Dirk, Akbas Levent, Busgen Thomas, Dijkstra Dirk, Kessler Michael, Mettmann Bettina, Wagner Roland

ABSTRACT:
A process is described for producing a three dimensional structure, the process including the following steps a) applying of at least a first material M1 onto a substrate to build a first layer L1 onthe substrate; b) layering of at least one further layer Ly of the first material M1 or of a further material Mx onto the first layer L1, wherein the at least one further layer Ly covers the first layer L1 and/or previous layer Ly-1 at least partially to build a precursor of the three dimensional structure; c) curing the precursor to achieve the three dimensional structure; wherein at least one ofthe materials M1 or Mx provides a Mooney viscosity of > 10 ME at 60 degrees centigrade and of < 200 ME at 100 degrees centigrade before curing and wherein at least one of the first material Mi or ofthe further material Mx is a powder. Also, a three dimensional structure is described which is available according to the process according to the invention.

METHOD FOR PRODUCING AN AT LEAST PARTIALLY COATED OBJECT

Applicants:
COVESTRO DEUTSCHLAND AG

Publication:
CN109963898A

Inventors:
Achten Dirk, Akbas Levent, Busgen Thomas, Guedou Arnaud, Hittig Jurgen, Mettmann Bettina, Michaelis Thomas, Wagner Roland

ABSTRACT:
The invention relates to a method for producing an at least partially coated object, comprising the step of producing the object from a construction material by means of an additive manufacturing method, the construction material comprising a thermoplastic polyurethane material. Following the production of the object, the method comprises the step of at least partially bringing a preparation intocontact with the object, the preparation being selected from: an aqueous polyurethane dispersion; an aqueous dispersion of a polymer comprising OH groups, this dispersion also containing a compound comprising NCO groups; an aqueous preparation of a compound containing NCO groups, but not containing any polymers comprising OH groups; or a combination of at least two thereof. The invention also relates to an at least partially coated object that was obtained by a method according to the invention.

POWDER OF SPHERICAL CROSSLINKABLE POLYAMIDE PARTICLES, PREPARATION PROCESS AND USE WITH THE SELECTIVE LASER SINTERING TECHNIQUE

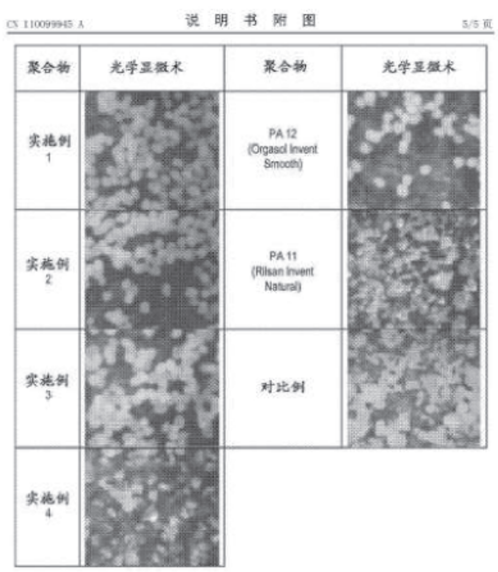
Applicants:
SETUP PERFORMANCE

Publication:
CN110099945A

Inventors:
Gimenez Jerome

ABSTRACT **EN:**
The present invention relates to a powder of crosslinkable polyamide spherical particles, which is suitable for selective laser sintering (SLS) technology, and a method for preparing the powder of such crosslinkable polyamide spherical particles. The present invention also relates to the production of articles by performing SLS starting from the powder of the crosslinkable polyamide spherical particles, and then performing a crosslinking step.

ABSTRACT ZH:
本发明涉及可交联性聚酰胺球形粒子的粉末，其适用于选择性激光烧结(SLS)技术，和涉及制备这种可交联性聚酰胺球形粒子的粉末的方法。本发明也涉及通过从所述可交联性聚酰胺球形粒子的粉末开始进行SLS、然后进行交联步骤以生产制品。



POWDERS FOR LASER SINTERING

Applicants:
XEROX CORP

Publication:
US10577458B2

Inventors:
Farrugia Valerie, Gardner Sandra J., Zwartz Edward G.

ABSTRACT:
Provided herein is a powder composition comprising a silica-infused crystalline polyester particle for laser sintering comprising at least one crystalline polyester resin and silica nanoparticles present in the particle an amount ranging from about 10 wt % to about 60 wt % relative to the total weight of the particle. Further provided herein are methods of preparing silica-infused crystalline polyester particles.

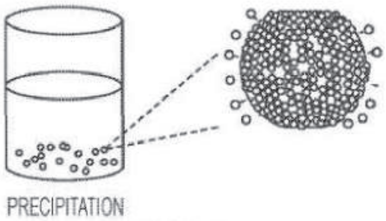


FIG. 1

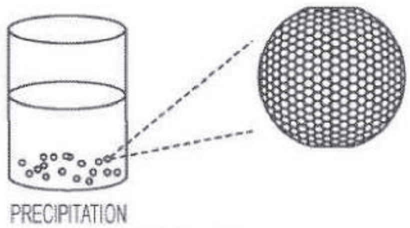


FIG. 2

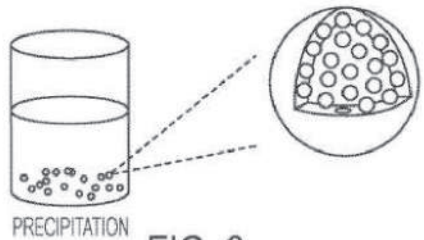


FIG. 3

CURABLE UNSATURATED CRYSTALLINE POLYESTER POWDER AND METHODS OF MAKING THE SAME

Applicants:
XEROX CORP

Publication:
EP3569634A1

Inventors:
Farrugia Valerie M., Hawkins Michael S., Sacripante Guerino G., Zwartz Edward G.

ABSTRACT:
A process for producing unsaturated polyester microparticles comprising: melt-mixing an unsaturated polyester and an oil in an extruder; washing the microparticles with an organic solvent to reduce the amount of oil; and removing the organic solvent to form the microparticles.

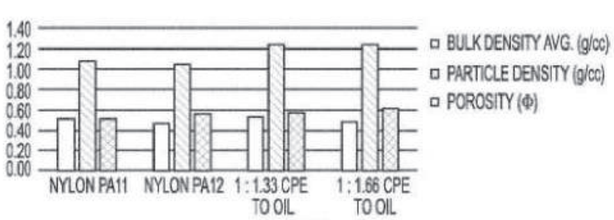


FIG. 7

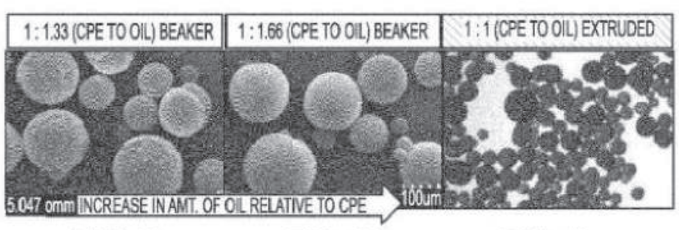


FIG. 8a FIG. 8b FIG. 8c

SHAREBOT

COMPOSITIONS COMPRISING UNSATURATED CRYSTALLINE POLYESTER FOR 3D PRINTING

Applicants:
XEROX CORP

Publication:
EP3569633A1

Inventors:
Farrugia Valerie M., Sacripante Guerino G., Sriskandha Shivanthi E., Zwartz Edward G.

ABSTRACT:
A composition for use in 3D printing includes an unsaturated polyester resin including an ethylenically unsaturated monomer, a first diol monomer and a second diol monomer.

FIG. 5A FIG. 5C FIG. 5E FIG. 5G

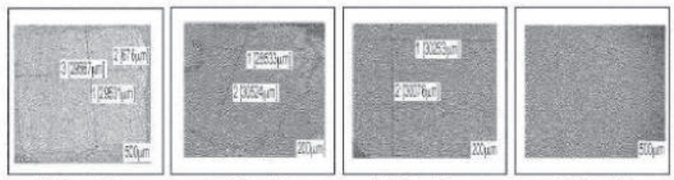


FIG. 5B FIG. 5D FIG. 5F FIG. 5H

PRECIPITATION PROCESS FOR PREPARING POLYSTYRENE MICROPARTICLES

Applicants:
XEROX CORP

Publication:
US2020102427A1

Inventors:
Farrugia Valerie M., Gardner Sandra J., Zwartz Edward G.

ABSTRACT:
A process including combining polystyrene and a first solvent to form a polystyrene solution; heating the polystyrene solution; adding a second solvent to the polystyrene solution with optional stirring whereby polystyrene microparticles are formed via microprecipitation; optionally, cooling the formed polystyrene microparticles in solution; and optionally, removing the first solvent and second solvent. A polystyrene microparticle formed by a microprecipitation process, wherein the polystyrene particle has a spherical morphology, a particle diameter of greater than about 10 micrometers, and a weight average molecular weight of from about 38,000 to about 200,000 Daltons. A method of selective laser sintering including providing polystyrene microparticles formed by a microprecipitation process; and exposing the microparticles to a laser to fuse the microparticles.

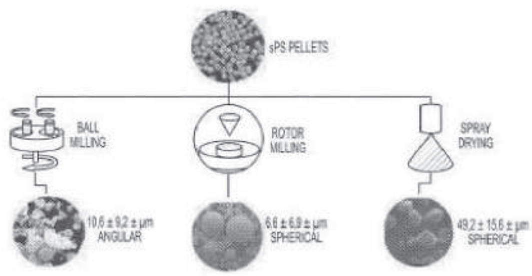


FIG. 2

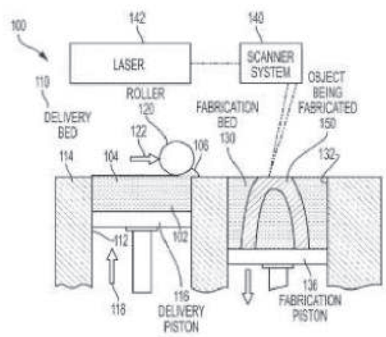


FIG. 5

THERMOPLASTIC POLYESTER PARTICLES AND METHODS OF PRODUCTION AND USES THEREOF

Applicants:
XEROX CORP

Publication:
US2021070954A1

Inventors:
Farrugia Valerie M., Jamali Hojjat Seyed

ABSTRACT:
A method of producing thermoplastic particles may comprise: mixing a melt emulsion comprising (a) a continuous phase that comprises a carrier fluid having a polarity Hansen solubility parameter (dP) of about 7 MPa0.5 or less, (b) a dispersed phase that comprises a dispersing fluid having a dP of about 8 MPa0.5 or more, and (c) an inner phase that comprises a thermoplastic polyester at a temperature greater than a melting point or softening temperature of the thermoplastic polyester and at a shear rate sufficiently high to disperse the thermoplastic polyester in the dispersed phase; and cooling the melt emulsion to below the melting point or softening temperature of the thermoplastic polyester to form solidified particles comprising the thermoplastic polyester.

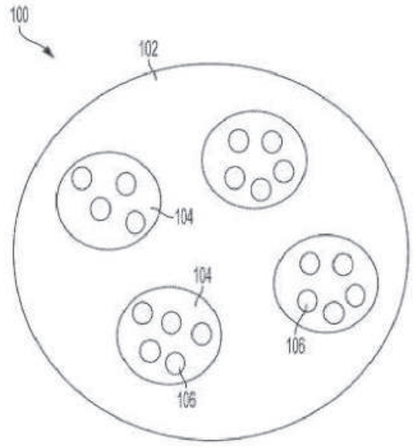


FIG. 1

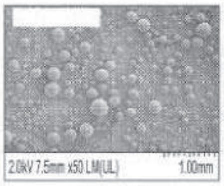


FIG. 12A

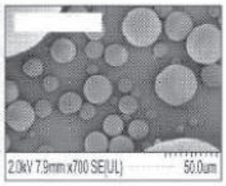


FIG. 12B

NANOPARTICLE-COATED ELASTOMERIC PARTICULATES AND SURFACTANT-PROMOTED METHODS FOR PRODUCTION AND USE THEREOF

Applicants:
XEROX CORP

Publication:
EP3789443A1

Inventors:
Claridge Robert, Farrugia Valerie M., Resetco Cristina, Sriskandha Shivanthi Easwari, Zwartz Edward G.

ABSTRACT:
Melt emulsification may be employed to form elastomeric particulates in a narrow size range when nanoparticles and a sulfonate surfactant are included as emulsion stabilizers. Such processes may comprise combining a polyurethane polymer, a sulfonate surfactant, and nanoparticles with a carrier fluid at a heating temperature at or above a melting point or softening temperature of the polyurethane polymer, applying sufficient shear to disperse the polyurethane polymer as liquefied droplets in the presence of the nanoparticles in the carrier fluid at the heating temperature, cooling the carrier fluid at least until elastomeric particulates in a solidified state form, and separating the elastomeric particulates from the carrier fluid. The polyurethane polymer defines a core and an outer surface of the elastomeric particulates, and the nanoparticles are associated with the outer surface. The elastomeric particulates may have a span of about 0.9 or less.

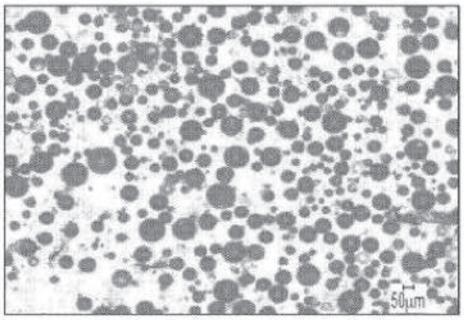


FIG. 4

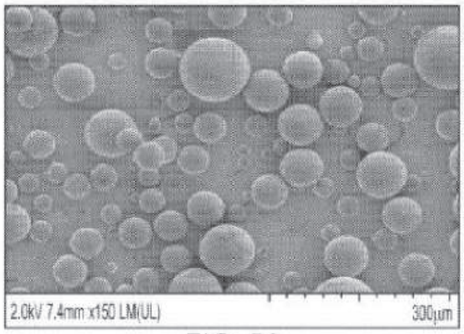


FIG. 5A

NANOPARTICLE-COATED ELASTOMERIC PARTICULATES AND METHODS FOR PRODUCTION AND USE THEREOF

Applicants:
XEROX CORP

Publication:
EP3789442A1

Inventors:
Farrugia Valerie M., Hawkins Michael S., Resetco Cristina, Sriskandha Shivanthi Easwari, Zwartz Edward G.

ABSTRACT:
Melt emulsification may be employed to form elastomeric particulates in a narrow size range when nanoparticles are included as an emulsion stabilizer. Such processes may comprise combining a polyurethane polymer and nanoparticles with a carrier fluid at a heating temperature at or above a melting point or a softening temperature of the polyurethane polymer, applying sufficient shear to disperse the polyurethane polymer as liquefied droplets in the presence of the nanoparticles in the carrier fluid at the heating temperature, cooling the carrier fluid at least until elastomeric particulates in a solidified state form, and separating the elastomeric particulates from the carrier fluid. In the elastomeric particulates, the polyurethane polymer defines a core and an outer surface of the elastomeric particulates and the nanoparticles are associated with the outer surface. The elastomeric particulates may have a D50 of about 1 µm to about 1,000 µm.

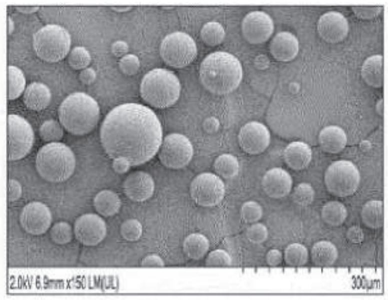


FIG. 16A

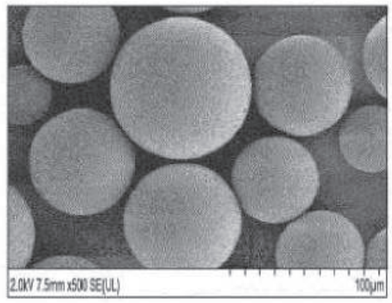


FIG. 16B

THERMOPLASTIC POLYESTER PARTICLES AND METHODS OF PRODUCTION AND USES THEREOF

Applicants:
XEROX CORP

Publication:
US2021070993A1

Inventors:
Claridge Robert, Farrugia Valerie M., Hawkins Michael S., Moorlag Carolyn Patricia, Resetco Cristina, Sriskandha Shivanthi Easwari

ABSTRACT:
Thermoplastic polymer particles can be produced that comprise a thermoplastic polymer and an emulsion stabilizer (e.g., nanoparticles and/or surfactant) associated with an outer surface of the particles. The nanoparticles may be embedded in the outer surface of the particles. Melt emulsification can be used to produce said particles. For example, a method may include: mixing a mixture comprising a thermoplastic polymer, an carrier fluid that is immiscible with the thermoplastic polymer, and the emulsion stabilizer at a temperature greater than a melting point or softening temperature of the thermoplastic polymer and at a shear rate sufficiently high to disperse the thermoplastic polymer in the carrier fluid; cooling the mixture to below the melting point or softening temperature of the thermoplastic polymer to form the thermoplastic polymer particles; and separating the thermoplastic polymer particles from the carrier fluid.

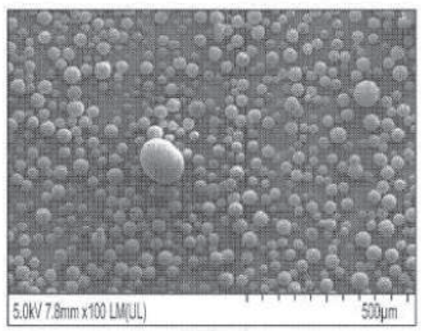


FIG. 4

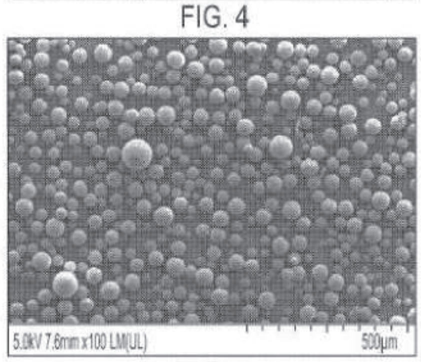


FIG. 5

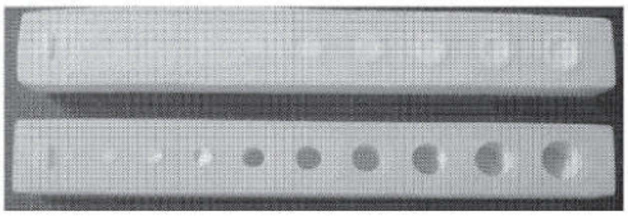
PARTICLES OF POLYAMIDE POWDERS AND USE THEREOF IN POWDER AGGLOMERATION PROCESSES

Applicants:
ARKEMA FRANCE

Publication:
WO2020212662A1

Inventors:
Cammage Geoffroy, Lemaitre Arnaud, Soares Latour Emilie-Marie

ABSTRACT:
The invention relates to a seeded particle (PA) of polyamide powder, consisting of: - a polyamide core with a d50 value ranging from 15 to 60 µm, and - a polyamide shell, characterised in that the shell has a higher inherent viscosity in solution and a higher melting point than the core.



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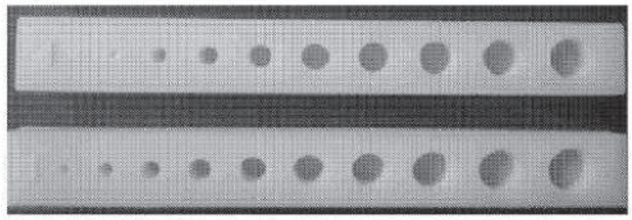

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10/10

Powder composition for additive process and printed articles thereof

Applicants:
Basf Se

Inventors:
Florian A. DEMEJérôme GIMENEZ

Publication:
WO2022023195A1

ABSTRACT:
The invention relates to 3D printable powders comprising 75-98 wt% of a polymeric matrix containing at least 90 wt% of polyolefin(s) and 2-25 wt% of at least one olefinic thermoplastic elastomer chosen from ethylene acetate elastomers, ethylene acrylate elastomers, ethylene propylene elastomers and ethylene alpha-olefin elastomers. The invention further relates to the preparation of these 3D printable powders and to their use in an additive process.

Thermoplastic polyester for the manufacture of 3D printing objects

Applicants:
Roquette Freres SA

Inventors:
Helene Amedro, Rene Saint Loup

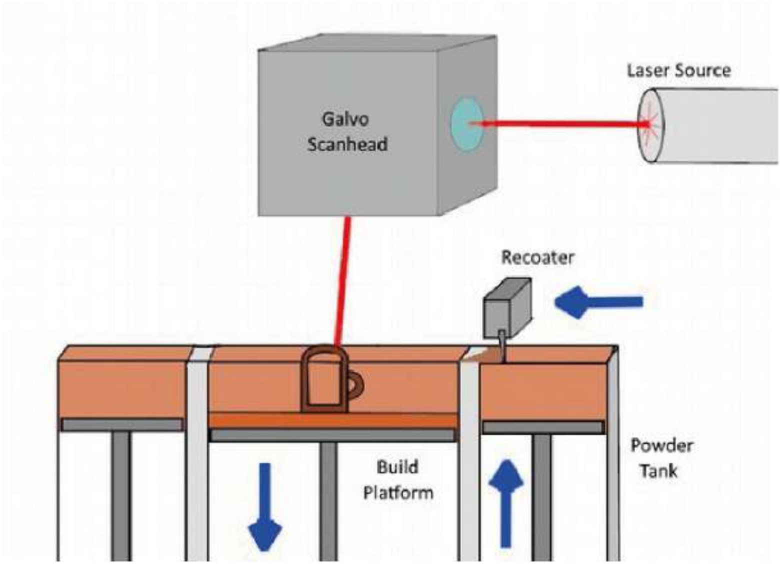
Publication:
FR3112305A1

ABSTRACT:
Use of a thermoplastic polyester for manufacturing 3D printed objects, said polyester comprising: at least one 1,4:3,6-dianhydrohexitol (A) unit; at least one butanediol unit (B); at least one terephthalic acid unit (C); wherein the ratio (A)/[(A)+(B)] being at least 0.01 and at most 0.60; said polyester being free of alicyclic diol units or comprising a molar quantity of alicyclic diol units, relative to all of the monomer units of the polyester, of less than 5%, and whose reduced viscosity in solution (35°C; orthochlorophenol; 5 g /L of polyester) is greater than 40 mL/g.

SHAREBOT CASE STUDY

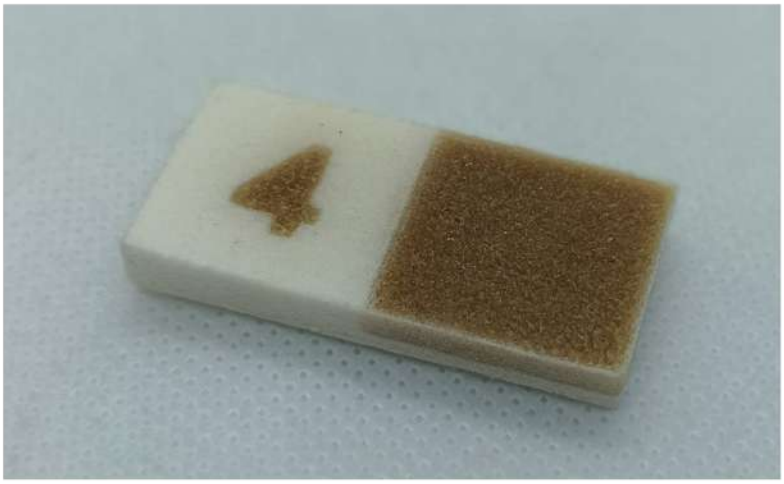
Development of dual-color 3D printing powder for SLS Machines, utilizing SnowWhite2

Rapid prototyping technologies represent innovative manufacturing methods used to fabricate objects based on three-dimensional Computer-Aided Design (CAD) models. This process involves slicing the CAD model into multiple layers, with each layer being transformed into a physical entity and then fused onto the preceding layers until the final product is achieved. Since the mid-1980s, a variety of rapid prototyping techniques have emerged, including Stereolithography (SLA) (Charles, 1986), Selective Laser Sintering (SLS) (Deckard, 1986), Fused Deposition Modeling (FDM) (Crump, 1988), Laminated Objects Manufacturing (LOM) (Feygin, 1988), and Three-dimensional printing (Pham and Gault, 1998; Rochus et al., 2007).



Selective Laser Sintering (SLS) represents a powder-based rapid prototyping (RP) process that utilizes a laser beam to sinter powdered raw materials, pioneeringly developed by C. R. Dechard at the University of Texas in 1989. This innovative technique constructs solid components directly from three-dimensional CAD models by selectively sintering successive layers of powder. SLS technology has evolved rapidly and is now widely employed not only for rapid prototyping but also for the direct manufacturing of components, leading to a shift in its application definition to Additive Manufacturing (AM). SLS technology offers the advantage of producing solid parts with intricate geometries, as the unsintered powder remains in place to support the structure of the sintered powder, eliminating the need for support systems during construction. A diverse range of materials can be utilized with SLS machinery, including Polyamides, Polycarbonate, HIPS, Polypropylene, Thermoplastic Polyurethane, Polyesters, and other thermoplastic or composite materials. Composite materials for SLS comprise high melting point and low melting point powder materials, with the former enhancing mechanical properties or technical characteristics and reducing costs. Additionally, the incorporation of high-melting powdered materials sourced from industrial, agricultural, or recycled waste allows for further advantages. The process involves laser radiation melting of the low melting point powder, which binds the high melting point powder and solidifies upon cooling, facilitating consolidation and part formation. Additive components can be introduced to enhance the performance of SLS powder materials during the 3D construction process. For instance, light stabilizers are added to mitigate oxidation from the laser beam and infrared heaters, while lubricating components improve flow capacity during powder layer deposition. Coupling agents are also included to enhance bonding between different materials present in the powder. However, a significant drawback of SLS systems and materials is the uniformity in color of the produced parts, typically determined by the color of the starting material, which is often limited to shades of white, black, or gray. While post-production techniques can be employed to apply different colors to 3D printed parts, they often result in uniform coloration across the entire surface.

To address this limitation, a new class of powder materials or powder composite materials suitable for processing in SLS machines, featuring the ability to selectively change color through thermal activation during the construction process, was developed with Snowwhite2. These innovative materials enable the alteration of color or hue in specific portions of the fabricated parts. Notably, the color change can be achieved on the external surface, internal portions, or both, offering versatility in design possibilities. Furthermore, the color change is permanent even after the object cools to room temperature, and it can be gradual, allowing for the creation of various shades within a defined temperature range. Importantly, these materials facilitate the printing of objects with multiple colors using standard SLS machines, potentially without requiring any modifications to the existing equipment. This remarkable characteristic is achieved through the incorporation of a coloring additive that initiates color change at a predefined temperature.



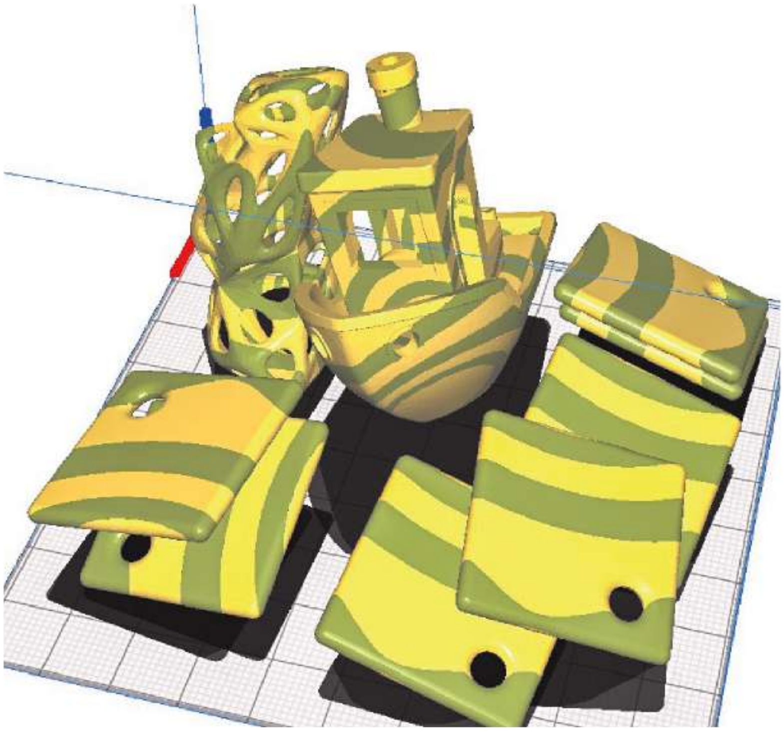
An excellent application arises with the use of the following powder: a biomimetic composite material inspired by wood, crafted from wood waste. This innovative material transforms into beautiful objects when processed in SLS additive manufacturing system.

Unlike other composite wood products, this powder enables the production of 3D printed parts with a digital grain, not just a simple texture, that flows across the entire part, faithfully reproducing the grain of the original 3D mapped tree. These 3D printed parts can be sanded, treated with wood stain or wood varnish, and refinished just like real wood. Additive manufacturing enables the creation of complex structures that are impossible to produce with other technologies.

In advance this formulation is designed to require low energy during the printing process and can be used in older industrial SLS systems that may no longer be capable of sintering typical polymers. This powder material, derived from wood waste, makes the additive production cost-effective with a 0% refresh ratio.

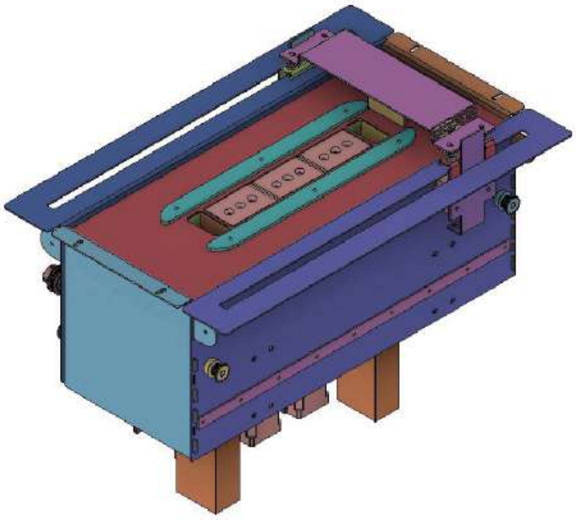
Snowwhite2 is equipped with the capability to heat the surface of the powder bed and maintain the entire processed powder at temperature. Additionally, it features a laser source capable of selectively irradiating the surface of the powder bed with a wavelength of 10640nm. The printer is configured with a powder bed temperature of 110°C, and scanning power and speed settings designed to achieve an energy density of $26mJ/mm^2$.

Under these conditions, the surface of the powder, heated to 110°C, reaches a temperature of 130°C when scanned by the laser, which is sufficient to melt the thermoplastic material binding the wood powder and other substances, thereby forming a single layer of a solid object. To achieve a different color in specific areas, the density of energy transferred to the powder by the laser can be increased to 40mJ/mm^2. This can be accomplished by either increasing the laser power or decreasing the scanning speed.



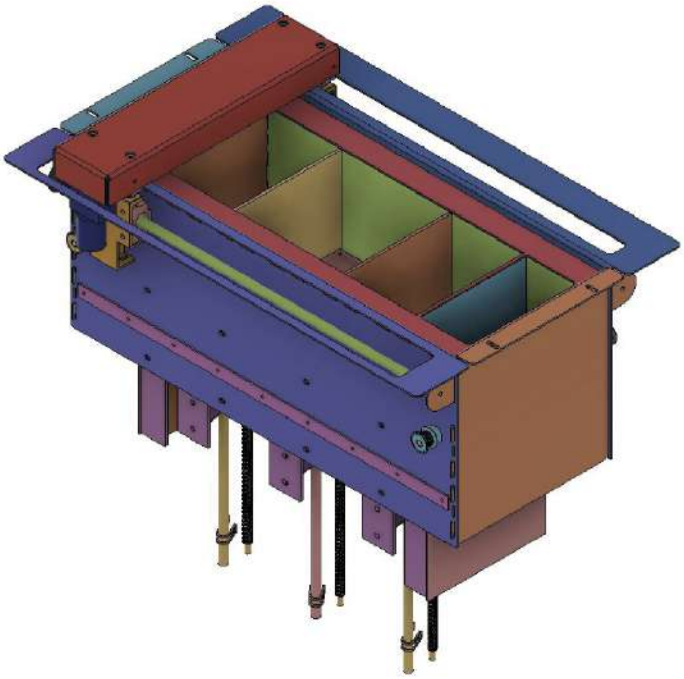
With 40mJ/mm2 of energy, the irradiated powder will reach a temperature of 160°C. At this temperature, the constituents of the powder are below the decomposition temperature, but it's adequate to induce browning of the coloring agent, resulting in black coloration in those portions of the layer. The wood powder, being outside its temperature range, remains bound to the melted mixture and essentially unchanged. Functional additives play their roles; Calcium Stearate enhances the flowability of the composition, aiding in the deposition of dust layers during the process, while Maleic Anhydride improves compatibility between lignin fibers, coloring agent, and thermoplastic material. By gradually adjusting the energy density transmitted with the laser to the powder bed from $26 mJ/mm^2$ to $40 mJ/mm^2$, it's possible to modulate the color gradation from the original light ocher color of the powder to black.

The formulation of this wood dust-based powder material, capable of changing color based on the added energy during the 3D printing process, was carried out using Snowwhite2. Initially, the Reduced Area Powder Distributor, with its printing area of 20x40x40 mm, enabled the laboratory to prepare and test over 50 formulations of powder, each time producing only a few grams of powder.



This approach allowed the developers to find the perfect combination of the different engineering compounds used, evaluating the color change capability and mechanical characteristics of the printed samples. They could iterate through different powder formulations in a single day.

Once the right formula was identified, it was scaled up to produce a few kilograms of powder.



Mounted in Snowwhite2, the standard powder distributor (printing size 100x100x100mm) was utilized, and the printing process parameters were adjusted. Several samples were then printed to demonstrate the powder's capabilities and conduct more real-world application tests. Now, the powder is ready for bulk production and printing in industrial machines.

Printing parameters will vary depending on the additive manufacturing system used, but a basic profile is already prepared for fine-tuning according to the specific SLS 3D printer employed.

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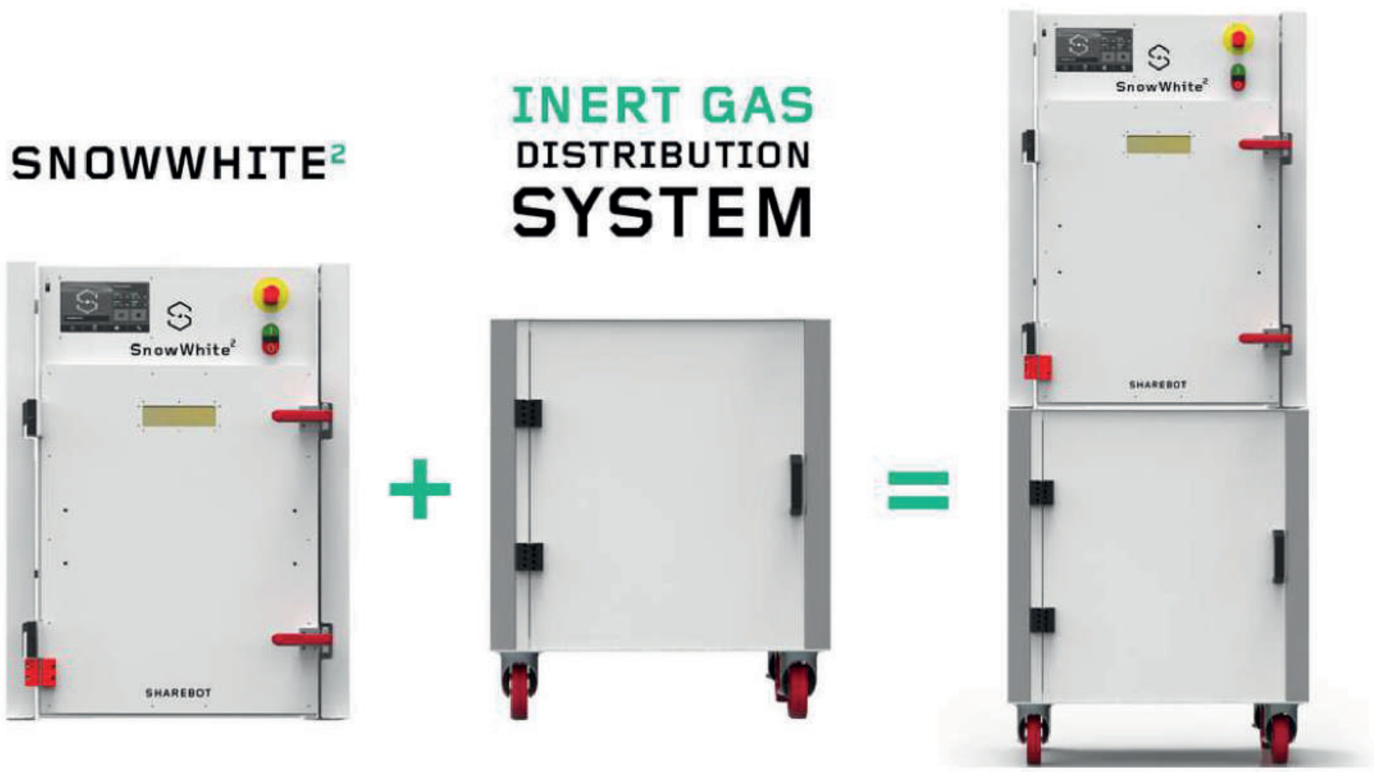
Powder distributor exchangeable

As the powder distributor can be changed following the instructions on the maintenance manual.

When you buy a machine you can choose to have more than a single distributor.
Example if you want to test your powders for the various kind of industrial machines you can buy a standard distributor (with blade) and a roller distributor.

We will mount the machine with a powder distributor (usually the standard one) then you will receive the machine with the other ones in a separated package.

TECHNICAL SPECIFICATIONS:



DIMENSIONS	1500 X 600 X 520 mm
WEIGHT	ca. 120 Kg
PRINTING VOLUME	100 X 100 X 100 mm
Z RESOLUTION	50 Micron
XY RESOLUTION	100 Micron
LASER	CO_2 – 14 Watt
SPOT DIMENSION	0.2 mm
SPEED (Z-AXIS)	35 mm/h
SCAN SPEED	up to 3500 mm/s
HEATED BUILD CHAMBER / MAX T°	up to 190°C
CONNECTIVITY	Ethernet- Sharebox

DIMENSIONS	59 X 23.6 X 20.5 in
WEIGHT	approx. 264.55 lb
PRINTING VOLUME	3.93 X 3.93 X 3.93 in
Z RESOLUTION	50 Micron (0.002 in)
XY RESOLUTION	100 Micron (0.004 in)
LASER	CO_2 – 14 Watt
SPOT DIMENSION	20 Micron (0.0008 in)
SPEED (Z-AXIS)	35 mm/h (1.37 in/h)
SCAN SPEED	up to 3500 mm/s (11.48 [illegible]/s)
HEATED BUILD CHAMBER / MAX T°	up to 190°C (374 °F)
CONNECTIVITY	Ethernet- Sharebox

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