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SLS 3D PRINTER

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JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

ACS OMEGA

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

OPEN ARTICLE

Elmeri Lahtinen, Lauri Kivijärvi, Rajendhraprasad Tatikonda, Ari Väisänen, Kari Rissanen and Matti Haukka
Department of Chemistry and Nanoscience Center, University of Jyväskylä, P.O. Box 35, FI-40014 Jyväskylä, Finland

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.

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UNIVERSITÄT DUISBURG ESSEN | Fachhochschule Dortmund University of Applied Sciences and Arts | FAU FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG | SAOT erlangen graduate school in advanced optical technologies | Photonische Technologien

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

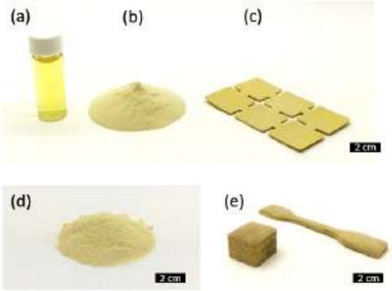
Tim Hupfeld, Carlos Doñate-Buendí, Matthias Krause, Alexander Sommereyns, Andreas Wegner, Thorsten Sinnemann Michael Schmidt Bilal Gökce, Stephan Barcikowski

Technical Chemistry I and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen, Universitaetsstrasse 7, 45141 Essen, Germany
Fachhochschule Dortmund, Department for mechanical engineering, Sonnenstrasse 96, 44139 Dortmund, Germany
Institute of Photonic Technologies (LPT), Friedrich-Alexander Universität Erlangen-Nürnberg, Konrad-Zuse-Str.3-5, 91052 Erlangen, Germany
Erlangen Graduate School in Advanced Optical Technologies (SAOT), Paul Gordan Straße 6, 91052 Erlangen, Germany
Chair for Manufacturing Technology, University of Duisburg-Essen, Lotharstasse 1, 47057 Duisburg, Germany

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.



SNOWWHITE²

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

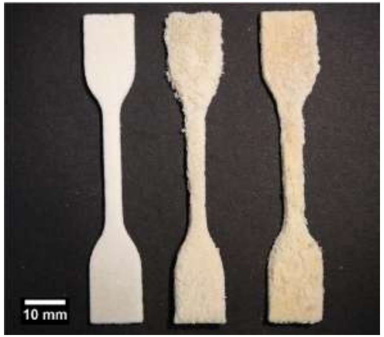
OPEN ARTICLE

Maximilian A. Dechet, Jochen Schmidy

Institute of Particle Technology, Friedrich-Alexander-Universität Erlangen-Nürnberg, Cauerstraße 4, D-91058 Erlangen, Germany
Interdisciplinary Center for Functional Particle Systems, Friedrich-Alexander-Universität Erlangen-Nürnberg, Haberstraße 9a, D-91058 Erlangen, Germany

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.



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THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Manufacturing Porous Alumina Ceramics Using Selective Laser Sintering

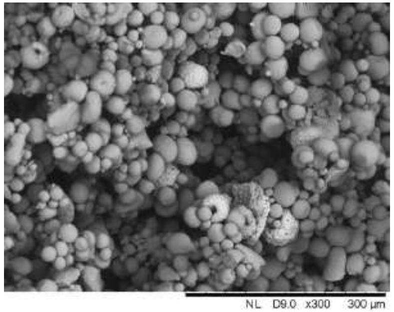
Student: Andrew Bryce Lynch
Supervisors: Dr. Mingyuan Lu and Professor Han Huang

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

OPEN ARTICLE

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.



SNOWWHITE²

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
Zuyd University of Applied Sciences, P.O. Box 550, 6400 AN Heerlen, The Netherlands
University of Genova, Department of Chemistry and Chemical Engineering, Via Docecaneso 31, I-16146 Genova, Italy
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. [...]

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

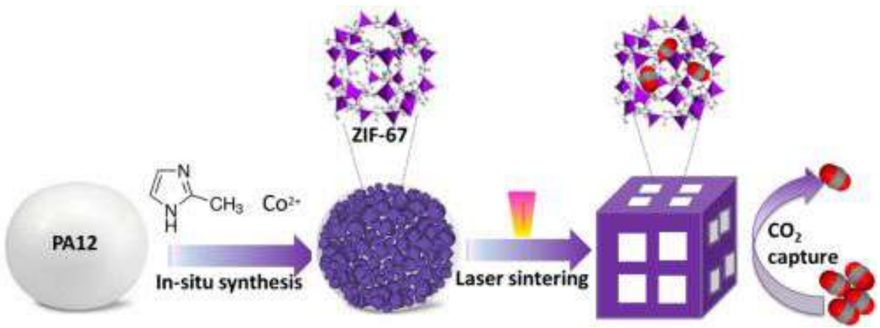
Binling Chen, Richard Davies, Hong Chang, Yongde Xia, Yanqiu Zhu, Oana Ghita

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. [...]



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UNIVERSITY OF JYVÄSKYLÄ

UNIVERSITY OF EASTERN FINLAND

ACS OMEGA

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

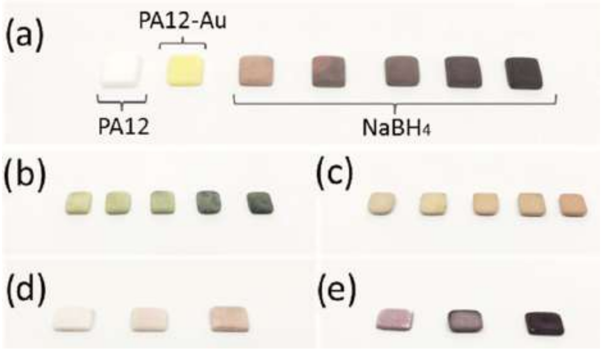
Elmeri Lahtinen, Esa Kukkonen, Virva Kinnunen, Manu Lahtinen, Kimmo Kinnunen, Sari Suvanto, Ari Väisänen, and Matti Haukka

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. [...]



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FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG

FUNCTIONAL PARTICLE SYSTEMS

materials MDPI

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

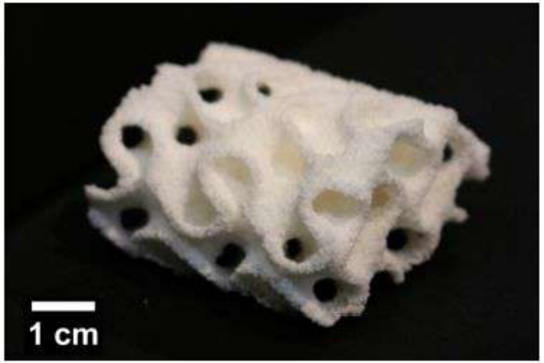
Maximilian A. Dechet, Ina Baumeister and Jochen Schmidt

Institute of Particle Technology, Friedrich-Alexander-Universität Erlangen-Nürnberg, Cauerstraße 4, D-91058 Erlangen, Germany;
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. [...]



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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

Polymers Composites and Hybrids (PCH), IMT Mines Ales, 6, Avenue des Clavières, 30319 Ales, France
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. [...]

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

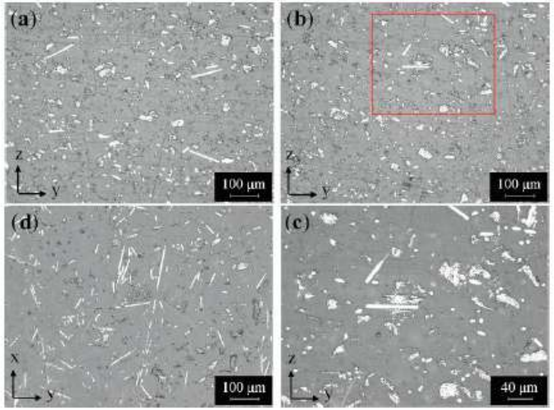
Federico Lupone, Elisa Padovano, Oxana Ostrovskaya, Alessandro Russo, Claudio Badini

OPEN ARTICLE

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

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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UNIVERSITÉ de Picardie Jules Verne · ENERGIE RS2E Réseau sur le stockage électrochimique de l'énergie · JYVÄSKYLÄN YLIOPISTO UNIVERSITY OF JYVÄSKYLÄ · YOUNGSTOWN STATE UNIVERSITY · gemtex ROUBAIX LABORATOIRE DE RECHERCHE TEXTILE · ensait ROUBAIX ECOLE D'INGENIEURS TEXTILE · Université Lille Nord de France

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

OPEN ARTICLE

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
Laboratoire des Technologies Innovantes, LTI-EA 3899, Université de Picardie Jules Verne, 80025 Amiens, France
RS2E, Réseau français sur le stockage électrochimique de l'énergie, FR CNRS 3459, 80039 Amiens Cedex, France
Department of Chemistry, P.O. Box 35, Street Address: Survontie 9 B, FI-40014 University of Jyväskylä, Finland
Electrical & Computer Engineering, Youngstown State University, Youngstown, OH, USA
Université Lille Nord de France, F-59000, Lille, France
ENSAIT, GEMTEX, F-59100 Roubaix, France
Plateforme de Microscopie Électronique (PME) de l'Université de Picardie Jules Verne, Hub de l'Énergie, 15 rue Baudelocque, 80000 Amiens, France

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, LiFePO4 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.

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Politecnico di Torino 1859

ELSEVIER

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

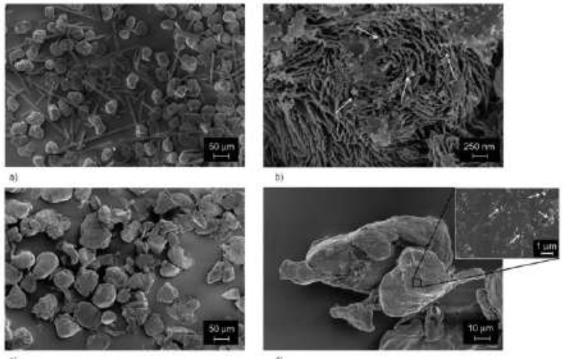
F. Lupone, E. Padovano, M. Pietroluongo, S. Giudice, O. Ostrovskaya, C. Badini

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

OPEN ARTICLE

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.



SNOWWHITE²

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

Technical Chemistry I and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen, Universitaetsstrasse 7, 45141 Essen, Germany
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
Erlangen Graduate School in Advanced Optical Technologies (SAOT), Friedrich-Alexander Universität Erlangen-Nürnberg, Germany
GROC·UJI, Institute of New Imaging Technologies, Universitat Jaume I, Avda. Sos Baynat sn, 12071 Castellón, Spain
Institute of Particle Technology (LFG), Friedrich-Alexander Universität Erlangen-Nürnberg, Cauerstr. 4, 91058 Erlangen, Germany

OPEN ARTICLE

Sintered part (Sharebot Snowwhite)

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.

SNOWWHITE²

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

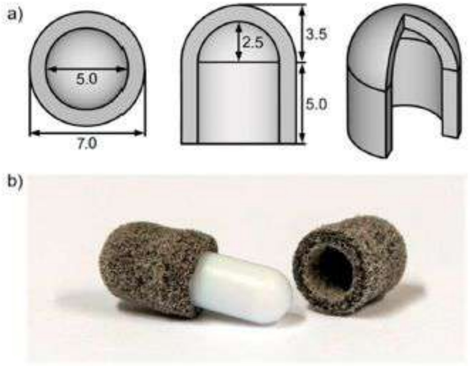
Evgeny Bulatov, Elmeri Lahtinen, Lauri Kivijärvi, Evamarie Hey-Hawkins and Matti Haukka

Department of Chemistry, University of Jyväskylä, P.O. Box 35, 40014 Jyväskylä (Finland)
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.



SNOWWHITE²

Selective Laser Sintering of Solid Oral Dosage Forms with Copovidone and Paracetamol Using a CO_2 Laser

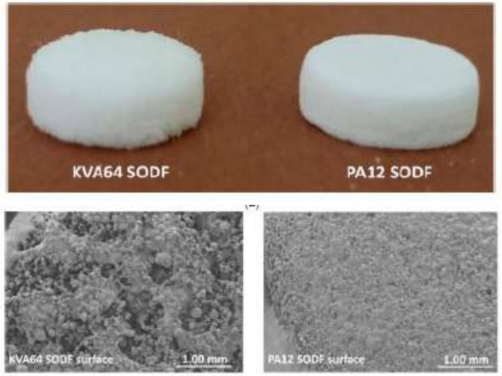
Yanis A. Gueche, Noelia M. Sanchez-Ballester, Bernard Bataille, Adrien Aubert
Laurent Leclercq, Jean-Christophe Rossi and Ian Soulairol

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

OPEN ARTICLE

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 CO_2 laser (= 10.6 m) 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. [...]



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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

SHAREBOT

SNOWWHITE²

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 ✎/s)
HEATED BUILD CHAMBER / MAX T°	up to 190°C (374 °F)
CONNECTIVITY	Ethernet- Sharebox

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MAIN FEATURES

START A
PRINT JOB
IN LESS THAN
15 MINUTES

Watch Video

JUST USE
300g
OF POWDER

Watch Video

AN OPEN SYSTEM
DESIGNED FOR
RESEARCH

Watch Video

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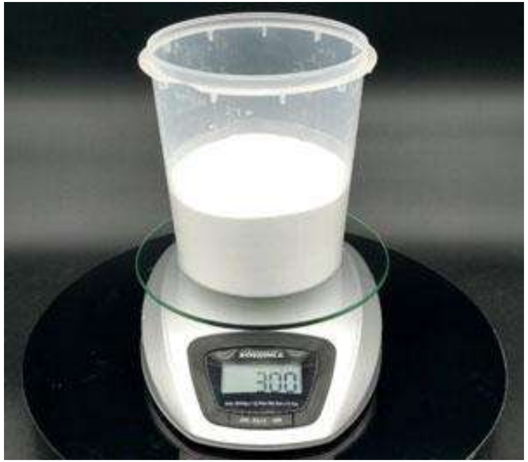
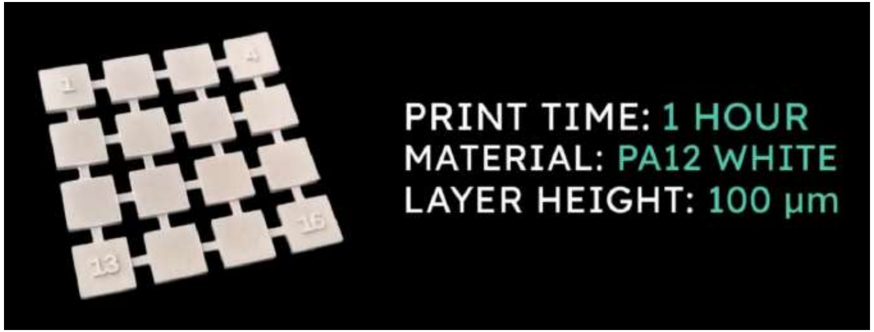


DO YOU HAVE
YOUR OWN POWDER?
USE SNOWWHITE²



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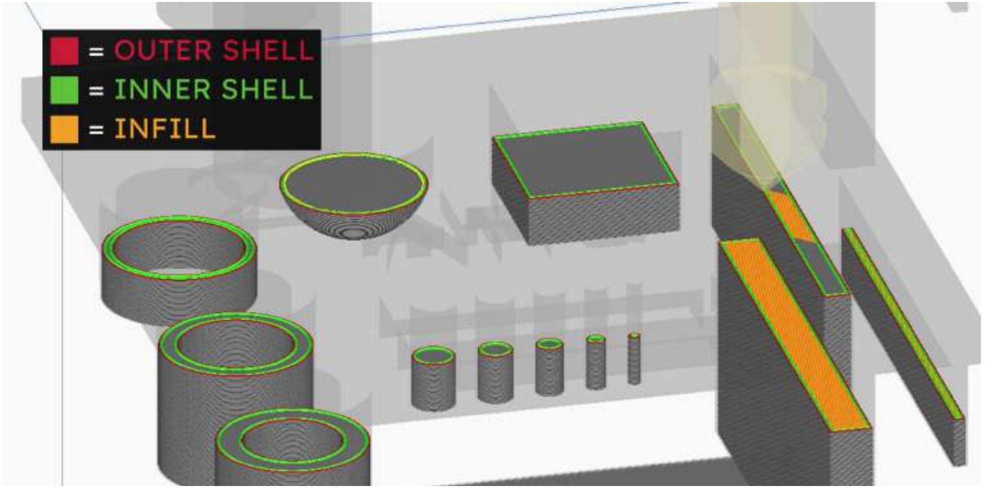
CONTROL LASER PATHS



LOOKING FOR AN OPEN SYSTEM? USE SNOWWHITE²

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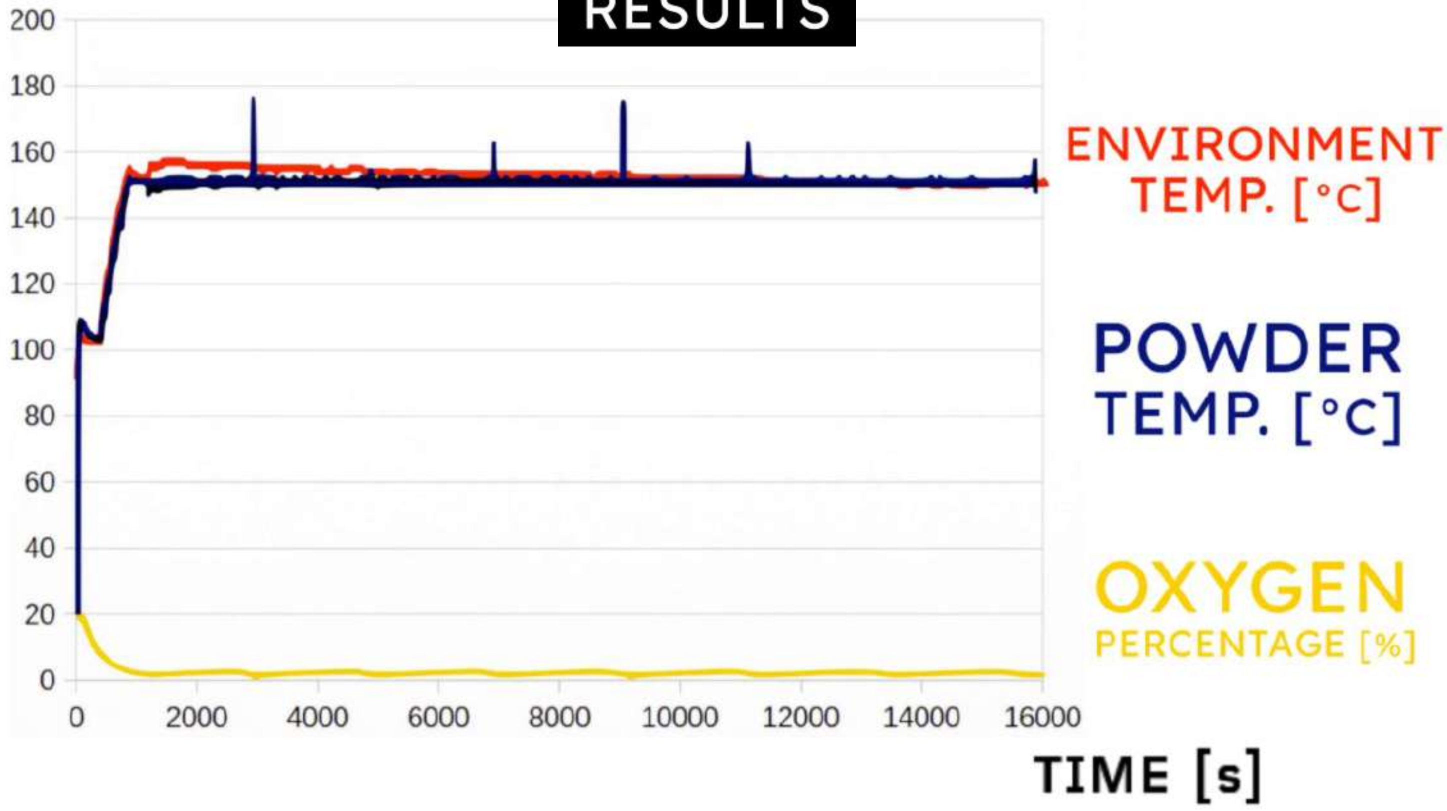
REPEATABLE RESULTS



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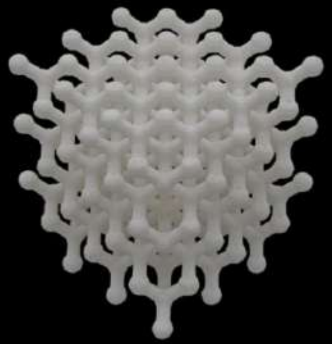
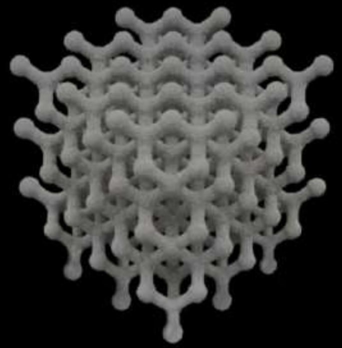
DIFFERENT MATERIALS



PRINT TIME: 4 HOURS
MATERIAL: TPU WHITE
LAYER HEIGHT: 100 µm



PRINT TIME: 4 HOURS
MATERIAL: ALUMIDE
LAYER HEIGHT: 100 µm

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Contact us:

Email: laura.longoni@sharebot.it
Tel: +39 031 692132
Web: https://www.sharebot.it/

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