INSTM

Consorzio Interuniversitario Nazionale per la Scienza e Tecnologia dei Materiali

www.instm.it

Advanced Composite Research in the INSTM Consortium

Prof L. Torre

University of Perugia

Department of Civil an Environmental Engineering

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INSTM, a consortium for material science and technology

About INSTM

INSTM:

≡ groups all the Italian Universities (52) where research on Materials is carried out

≡ has about 3000 scientists affiliated

≡ integrates a “critical mass” of knowledge

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What INSTM aims to achieve

INSTM:

≡ promotes and supports the research on Materials Science and Technology

≡ develops and improves exchanges between Universities and Industries

≡ supports technological transfer, spin-off activities and training for enterprises

≡ promotes the public understanding of Materials Science and Technology

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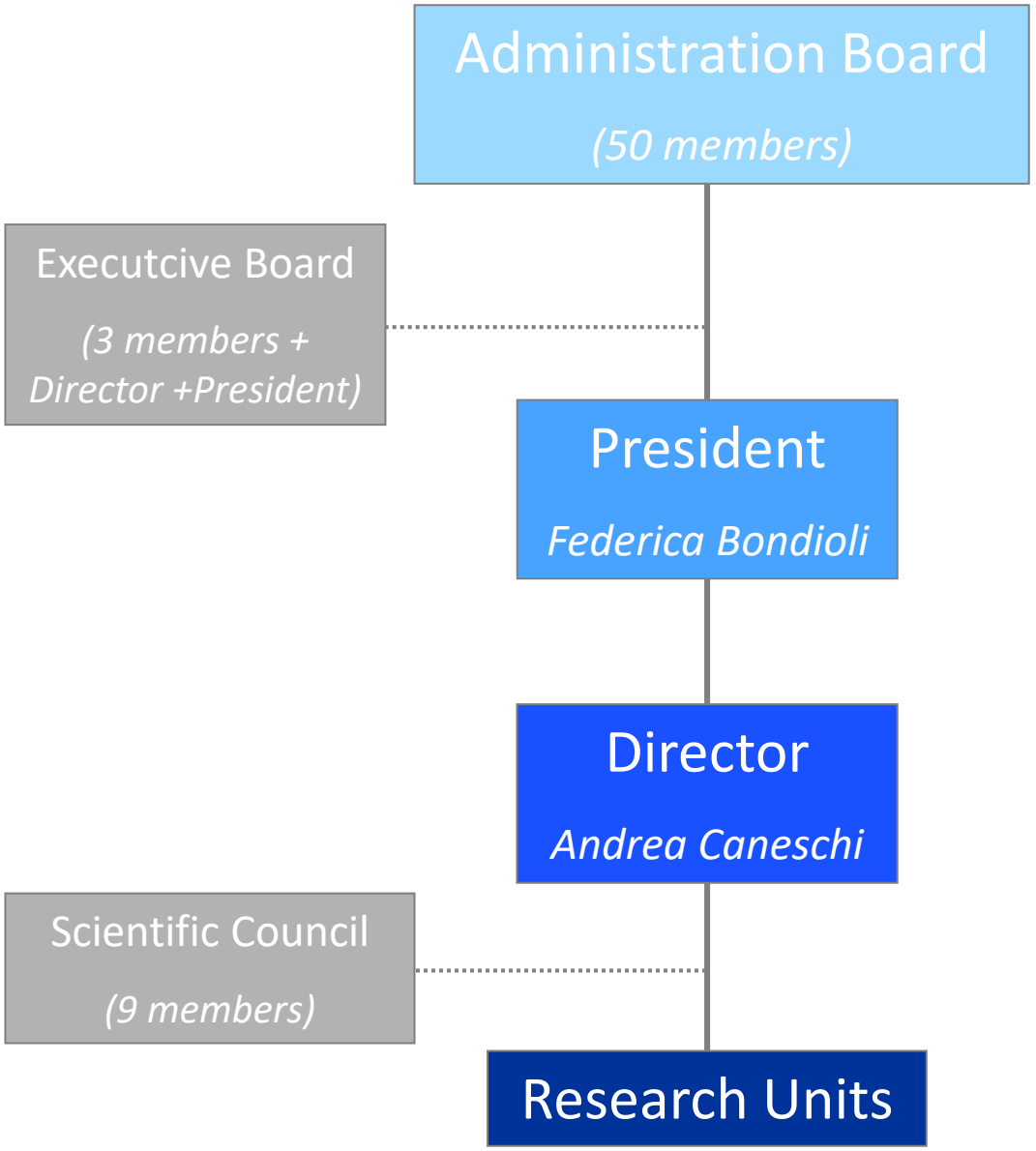
INSTM structure



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INSTM scientific network

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INSTM SCIENTIFIC SECTIONS:

1.Materials and technologies for life and food sciences

2.Materials and technologies for Made in Italy, advanced manufacturing and aerospace

3.Materials and technologies for ecological transition: Energy and Sustainable Mobility.

4.Materials and technologies for green economy and circular economy

5.Materials and technologies for buildings and cultural heritage

INSTM AD HOC COMMITTEE:

- Computational calculus

INSTM Research Centres

1. Technologies for the transformation of polymer and composite materials
Coordinator: Prof. G. Mensitieri, Federico II University, Naples

2. Surfaces and nanostructured interphases
Coordinator: Prof. S. Bordiga, University of Turin

3. CRIMSON - Reference Centre for the modelling and simulation of molecular organisations and nanosystems
Coordinator: Prof. C. Zannoni, University of Bologna

4. Bioactive polymeric materials for biomedical and environmental applications
Coordinator: Prof. D. Puppi, University of Pisa

5. Research centre of nanosized materials for microelectronic and related applications
Coordinator: Prof. M.E. Fragalà, University of Catania

6. LINCE - Laboratory of technology and engineering of ceramic materials
Coordinator: Prof. L. Montanaro, Polytechnic of Turin

7. Reference Centre for controlled porosity materials
Coordinator: Prof. P. Innocenzi, University of Sassari

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INSTM Research Centres

8. NIPLAB - Laboratory of nanocomposites and multifunctional polymeric hybrid materials
Coordinator: Prof. J. M. Kenny, University of Perugia

9. LAMM - Laboratory for molecular magnetism
Coordinator: Prof. R. Sessoli, University of Florence

10. CASPE - Laboratory of catalysts for sustainable production and energy
Coordinator: Prof. S. Perathoner, University of Messina

11. Semi-crystalline polymeric materials
Coordinator: Prof. G. Guerra, University of Salerno

12. LASCAMM - Laboratory of synthesis and characterization of organometallic-based molecular materials
Coordinator: Prof. I. Aiello, University of Calabria

13. SKIES-VILLAGE - Science, Knowledge and Innovation for Earth and Space in a Virtual Italian Laboratory for Large Scale Applications in a Geographically-distributed Environment
Coordinatore: Prof. V. Barone, Scuola Normale di Pisa

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INSTM Research Centres

14. LITS - Laboratory of surface treatments engineering
Coordinator: Prof. T. Valente, La Sapienza University, Rome

15. PREMIO - Centre for the preparation of innovative materials with optimised chemical-physical properties
Coordinator: Prof. L. Malavasi, University of Pavia

16. GISEL - National Centre of Reference for Electrochemical Energy Storage Systems
Coordinator: Prof. C. Gerbaldi, Turin Polytechnic

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INSTM in H2020 - 1

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H2020 projects (INSTM Partner)

AGRIMAX	Agri and food waste valorisation co-ops based on flexible multi-feedstocks biorefinery processing technologies for new high added value applications	H2020-BBI-PPP-2015-2-1
A-LEAF	An Artificial Leaf: a photo-electro-catalytic cell from earth-abundant materials for sustainable solar production of CO_2-based chemicals and fuels	H2020-FETPROACT-2016-2017
ENHANCE	Piezoelectric Energy Harvesters for Self-Powered Automotive Sensors: from Advanced Lead - Free Materials to Smart Systems	H2020-MSCA-ITN-2016
PERFORM	PowerPlatform: Establishment of platform infrastructure for highly selective electrochemical conversions	H2020 Innovation Action
HUC	Development and validation of a powder HIP route for high temperature Astroloy to manufacture Ultrafan® IP Turbine Casings	H2020 Clean Sky2 Innovation action
BIOnTop	Novel packaging films and textiles with tailored end of life and performance based on bio-based copolymers and coatings	H2020-BBI-JTI-2018
SUN2CHEM	Novel photo-assisted systems for direct Solar-driven redUctioN of CO_2 to energy rich CHEMicals	H2020-LC-SC3-2019-NZE-RES-CC
DECADE	DistributEd Chemicals And fuels production from CO_2 in photoelectrocatalytic Devices	H2020-NMBP-ST-IND-2018-2020
ERN-APULIA3	European Researchers' Night Apulia 2021 - Discovering the fascinating world of research	H2020 Coordination and support action

International Coooperation projects (INSTM Partner)

SUMO	Scaling Up Quantum Computation with Molecular spins	ERANET QUANTERA – MIUR
NEXT-LiB	Novel Circular Economic Approaches for Efficient Extraction of Valuables from Spend Li-ion Batteries	ERA-MIN2 Reg, Calabria

INSTM in H2020 - 2

H2020 projects (INSTM Coordinator)

NEWTEAM	Next generation low pressure turbine airfoils by am	H2020 Clean Sky2 Innovation action
ECOFUNCO	Eco sustainable multifunctional biobased coatings with enhanced performance and end of life options	H2020-BBI-JTI-2018
COST ACTION CA 18130	European Network for Chemical Elemental Analysis by Total Reflection X-Ray Fluorescence	COST Open Call Proposal Reference OC-2018-1-22966
COST ACTION CA 20101	Plastics monitoRIng detectiOn RemedIaTion recoverY	COST Open Call Proposal Reference OC-2021
ERN-APULIA2	European Researchers' Night Apulia 2020 - Discovering the fascinating world of research	H2020 Coordination and support action
POLYBIOSKIN	High performance functional bio-based polymers for skin-contact products in biomedical, cosmetic and sanitary industry	H2020-BBI-JTI-2016

International Coooperation projects (INSTM Coordinator)

4NanoEARDRM	NANOfabricated NANOcomposite NANObioactive and NANOfunctional rEplacements of tympAnic membRane as advanced DRUg delivery and regenerative platforMs	EuroNanoMed III JTC2017 - MIUR
NON-ACT	NOvel Natural Antimicrobial CoaTing for food production chain	Manunet III - Regione Toscana

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INSTM in Horizon Europe

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Horizon Europe projects (INSTM Partner)

BEST	Batteries Europe Secretariat	Horizon Europe Coordination and support action
MIRIA	Development of antimicrobial, antiviral, and antifungal nanocoatings for everyday surfaces	Horizon Europe Research and Innovation Action

INSTM is member of Technology Clusters

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INSTM is member of:

≡ Italian Cluster of Circular Bioeconomy SPRING

≡ Lombardy Energy Cleantech Cluster (LE2C)

≡ National Technological Cluster “Made in Italy” (MinIT)

≡ Associazione Fabbrica Intelligente Lombardia (AFIL)

≡ National Cluster “Fabbrica Intelligente” (CFI)

≡ Italian Association for Industrial Research (AIRI)

≡ Batteries European Partnership Association (BEPA)

≡ Bio-based Industry Consortium (BIC)

INSTM Italian and international partners

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Collaboration agreements has been signed between INSTM and:

- Techint Compagnia Tecnica Internazionale SpA
- CNR
- ACEA SpA
- Eni SpA
- MATERIAS Srl
- Rete AIRES
- Nuovo Pignone Tecnologie Srl
- Fondazione Istituto Italiano di Tecnologia (IIT)
- Sincrotrone Trieste SCpA
- Laboratori Nazionali di Legnaro dell'INFN
- Parco Scientifico Tecnologico per l'Ambiente Environment Park Torino SpA
- ECO GV Energy Srl
- Assobiomedica
- Rivista Open Access Polymers
- Kyoto Institute of Technology (KIT)
- CVR Srl
- LMPE Srl
- PA.SE Srl
- Iterchimica Srl

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ADVANCED COMPOSITES AT INSTM

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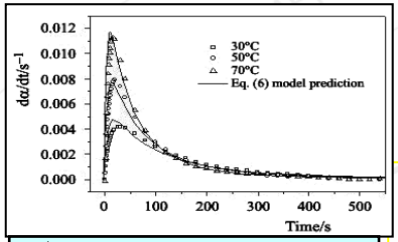
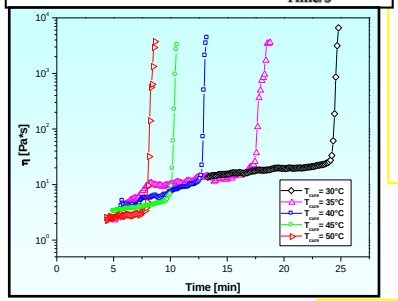
Università del Salento – Dept. of Engineering for Innovation

Composites laboratory of The University of Salento

Director: Prof Alfonso Maffezzoli
alfonso.maffezzoli@unisalento.it



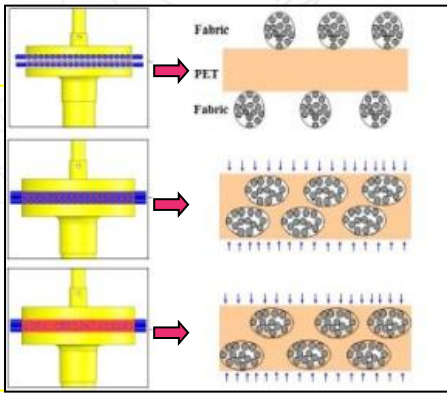


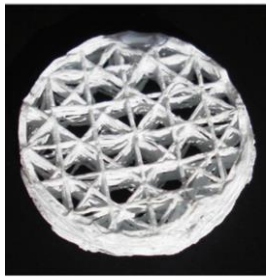
➢ Thermosetting matrix composites

Monitoring and modeling of the curing process

➢ Thermoplastic matrix composites

- Optimization and modeling of the consolidation.
- US and induction Welding





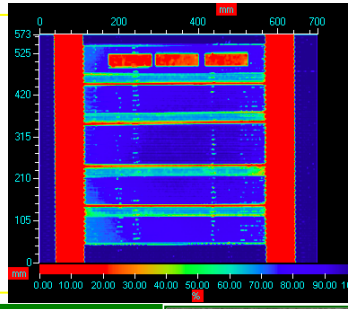
➢3D printing

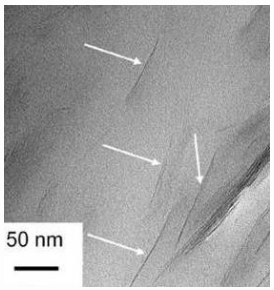
Development of new compounds and production of prototypes

research

➢ Composite Processing

Optimization and modeling of the production process





➢ Nanocomposites grafene and clay based

Synthesis, morphological and physico-mechanical characterization of nanocomposites

➢ Natural based Composites and recycling

- Matrices and fibers of natural origin
- Fibers and matrix recycling

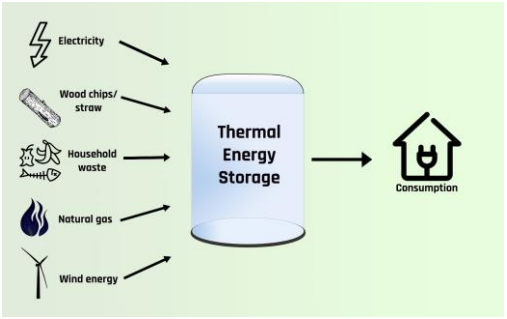
UNIVERSITÀ DI TRENTO
Dipartimento di Ingegneria Industriale

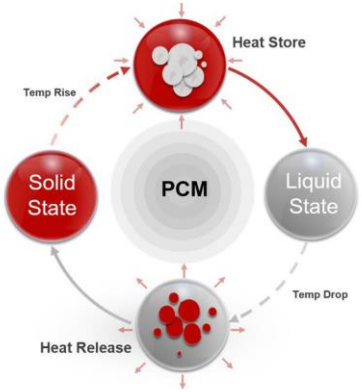
Research lines of the UniTrento's Polymers & Composites Laboratory

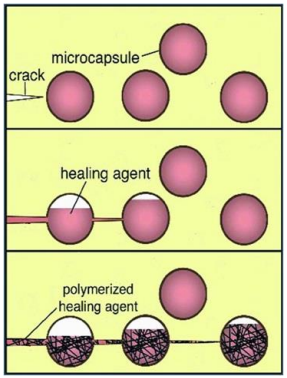
POLYMERS & COMPOSITES LABORATORY

People

- **1 full professor (A. Pegoretti)**
- **2 associate professors (L. Fambri and A. Dorigato)**
- **1 Junior assistant professor (RTDa) (G. Fredi)**
- **3 post-docs**
- **7 PhD students**
- **2 postgraduate researchers**
- **about 20 master's and bachelor's students**







Main research lines:

- **Recycling of polymeric and composite materials**
- **Life cycle assessment of materials and industrial products**
- **Bioderived and biodegradable polymers**
- **Self sensing/self healing structural composites**
- **Multifunctional 3D printed materials**
- **Materials for thermal energy storage (TES) and thermal management**

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Dipartimento di Ingegneria Industriale

POLYMERS & COMPOSITES LABORATORY

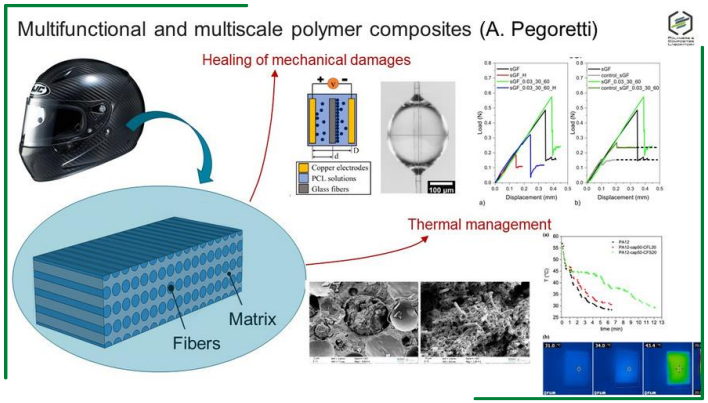
Polymers and Composites

Who
Alessandro Pegoretti

Expertise
Load-bearing composites
Self-healing
Energy storage

Relevant publications

1. Karger-Kocsis J, Mahmood H, Pegoretti A. All-carbon hierarchical fibers and related polymer composites: a review. Composites Science and Technology. 2020; 186: Article 107932.
2. Simonini L, Mahmood H, Dorigato A, Pegoretti A. Evaluation of self-healing capability of a polycaprolactone interphase in epoxy/glass composites. Composites Part A. 2023; 169 107539.
3. Fredi G, Dorigato A, Fambri L, Pegoretti A. Multifunctional structural composites for thermal energy storage. Multifunctional Materials. 2020; 3(4), 042001.
4. Fredi G, Dorigato A, Fambri L, Pegoretti A. Multifunctional epoxy/carbon fiber laminates for thermal energy storage and release. Composites Science and Technology. 2018; 158: 101-111.

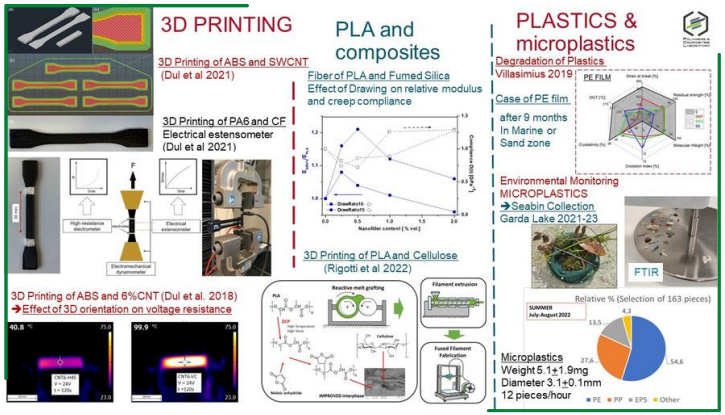


Who
Luca Fambri

Expertise
Additive manufacturing
PLA composites
Microplastics

Relevant publications

1. Fambri L., Dorigato A., Pegoretti A. Role of surface-treated silica nanoparticles on the thermo-mechanical behavior of poly(Lactide). Appl. Sci., 2020, 10; 1-20
2. Dul S., Ecco L. G., Pegoretti A., Fambri L. Graphene/carbon nanotube hybrid nanocomposites: Effect of compression molding and fused filament fabrication on properties. Polymers, 2020, 12; Article 101
3. Residori S., Dul S., Pegoretti A., Fambri L., Pugno N.M.Three Dimensional Printing of Multiscale Carbon Fiber-Reinforced Polymer Composites Containing Graphene or Carbon Nanotubes. Nanomaterials, 2022, 22(12), Article 2064.
4. Dul S., Gutierrez B.J.A., Pegoretti A., Alvarez-Quintana J., Fambri L. 3D printing of ABS Nanocomposites. Comparison of processing and effects of multi-wall and single-wall carbon nanotubes on thermal, mechanical and electrical properties. J.Mater.Sci.Techn., 2022, 21; 52-66.



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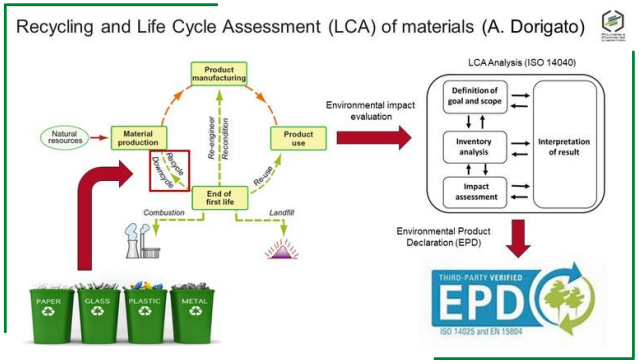
Polymers and Composites

Who
Andrea Dorigato

Expertise
Recycling
LCA
Environmental impact

Relevant publications

1. Dorigato A. Recycling of thermosetting composites for wind blade application. Advanced Industrial and Engineering Polymer Research. 2021;4:116-32.
2. Valentini F, Dorigato A, Rigotti D, Pegoretti A. Evaluation of the role of devulcanized rubber on the thermo-mechanical properties of Ethylene-Propylene Diene Monomers (EPDM) foams. Polymer Engineering and Science. 2021;61:767–79.
3. Siracusa S, Quartinello F, Soccio M, Manfroni M, Lotti N, Dorigato A, et al. On the selective enzymatic recycling of poly(pentamethylene 2,5-furanoate)/poly(lactic acid) blends and multiblock copolymer. ACS Sustainable Chemistry & Engineering. 2023;11:9751-60.
4. Valentini F, Dorigato A. Evaluation of the environmental impact of a plastic sprayer through life cycle assessment: an industrial case study. International Journal of Environmental Science and Technology, in Press.

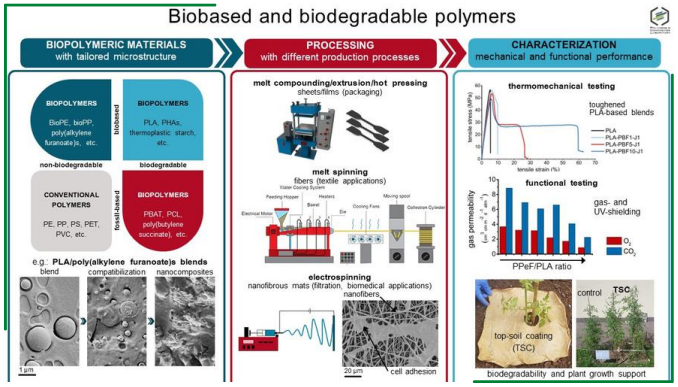


Who
Giulia Fredi

Expertise
Biopolymers
Furanoate polyesters
Sustainable packaging

Relevant publications

- Fredi, G.; Dorigato, A., Recycling of bioplastic waste: a review. Advanced Industrial and Engineering Polymer Research 2021, 4 (3), 159-177.
- Rigotti, D.; Soccio, M.; Dorigato, A.; Gazzano, M.; Siracusa, V.; Fredi, G.; Lotti, N., Novel biobased polylactic acid/poly(pentamethylene 2,5-furanoate) blends for sustainable food packaging. ACS Sustainable Chemistry and Engineering 2021, 9 (41), 13742-13750.
- Fredi, G.; Zonta, E.; Dussin, A.; Bikiaris, D. N.; Papageorgiou, G. Z.; Fambri, L.; Dorigato, A., Toughening effect of 2,5-furandicaboxylate polyesters on polylactide-based renewable fibers. Molecules 2023, 28, 4811.
- Santi, S.; Soccio, M.; Fredi, G.; Lotti, N.; Dorigato, A., Uncharted development of electrospun mats based on bioderived poly(butylene 2,5-furanoate) and poly(pentamethylene 2,5-furanoate). Polymer 2023, 279, 126021.



Polymers & Composites Laboratory

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Dipartimento di Ingegneria Industriale

Polymers & Composites Laboratory

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Prof. Andrea Dorigato
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Università di Catania

Composite Material Laboratory

Director Prof Gianluca Cicala
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Dipartimento di
Ingegneria Civile e Architettura

Università di Catania

Polymers & Composites Group's Research Focus

Hybrid polymer/metal for AM

Polymeric AM for composite's tooling

Recycling of composites

Materials and Technologies for functional AM parts

Novel AM materials formulation for FFF and LCD 3D printing

Università di Catania

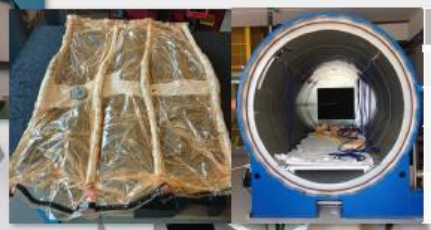
Polymeric AM for composite's tooling

AM for Composites Tooling

Approaches

FDM

Lamination



Curing

Cure Cycle	
Temperature	135 °C
Pressure	5 bar
Dwell time	120 min
Process time	200 min

Dissolution

Work awarded by SAMPE to represent Italy in Zürich, *26-30 Sept 2021*

Composite

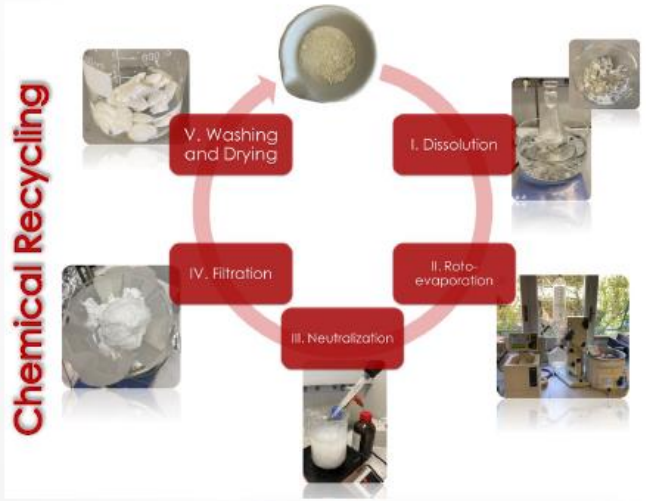
In portnership with:

ACS

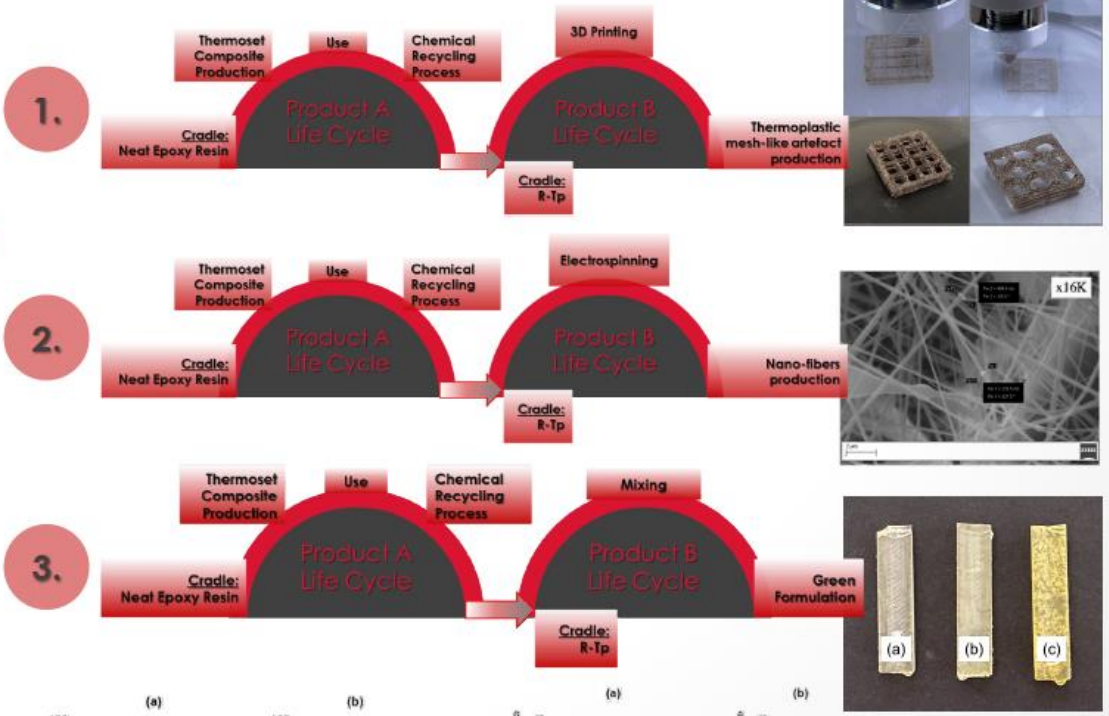
DOI: 10.1002/masy.202100340

Università di Catania

Neat Epoxy Resin Recycling



Re-use Strategy



PLEASE READ

polymers

Chemical Recycling of Fully Recyclable Bio-Epoxy Matrices and Reuse Strategies: A Cradle-to-Cradle Approach

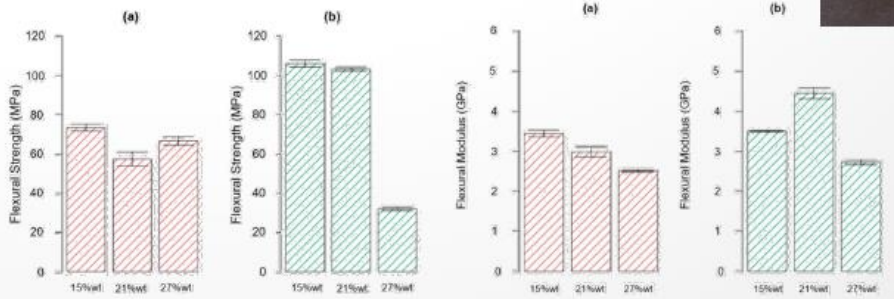
polymers

Chemical Recycling of Fully Recyclable Bio-Epoxy Matrices and Reuse Strategies: A Cradle-to-Cradle Approach

Macromolecular Symposia

Printability of a Recycled Thermoplastic Obtained from a Chemical Recycling Process of a Fully-Recyclable Epoxy Matrix: An Upscaling Re-Use Strategy

Fully-Recyclable Epoxy Fibres Reinforced Composites (FRCs) for Maritime Field: Chemical Recycling and Re-Use Routes



PROGRAMMA DI RICERCA
PON
THALASSA

TecHnology And materials for safe Low consumption And low life cycle cost veSSels And crafts

ReCOMP

Sistemi innovativi di fabbricazione flessibile per materiali compositi ecocompatibili totalmente riciclabili

Università di Catania

Recyclable Fiber-Reinforced Composites

*Study for Innovative production on Pilot plant for Online **Recyclable** Pre-preg.*

In collaboration with

TU Clausthal

Epoxy Resin Chemical Recycling

Carbon Fibers Chemical Recycling

PLEASE READ

RESEARCH ARTICLE

WILEY

Characterization of biobased epoxy resins to manufacture eco-composites showing recycling properties

Lorena Saitta[1] | Vishnu Prasad[2,3] | Claudio Tosto[1] | Neal Murphy[2] | Alojz Ivankovic[2] | Gianluca Cicala[1] | Gennaro Scarselli[1]

PROGRAMMA DI RICERCA PON THALASSA

TecHnology And materials for safe Low consumption And low life cycle cost veSSels And crafts

ReCOMP

Sistemi innovativi di fabbricazione flessibile per materiali compositi ecocompatibili totalmente riciclabili

Università di Catania

Study of Epoxy recycling

Hybrid Biobased Recyclable Epoxy Composites for Mass Production

G. Cicala,[1] S. Mannino,[1] A.D. La Rosa,[1] D.R. Banatao,[2] S.J. Pastine,[2] S.T. Kosinski,[2] F. Scarpa[3]
[1]University of Catania, DICAR, Viale Andrea Doria 6, 95125 Catania, Italy

POLYMER COMPOSITES—2017

materials

MDPI

Article

Innovative Chemical Process for Recycling Thermosets Cured with Recyclamines® by Converting Bio-Epoxy Composites in Reusable Thermoplastic—An LCA Study

Angela D. La Rosa, Ignazio Blanco, Diosdado R. Banatao, Stefan J. Pastine, Anna Björklund and Gianluca Cicala

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

LCA and LCC of a chemical recycling process of waste CF-thermoset composites for the production of novel CF-thermoplastic composites. Open loop and closed loop scenarios

Angela Daniela La Rosa, Sebastiano Greco, Claudio Tosto, Gianluca Cicala

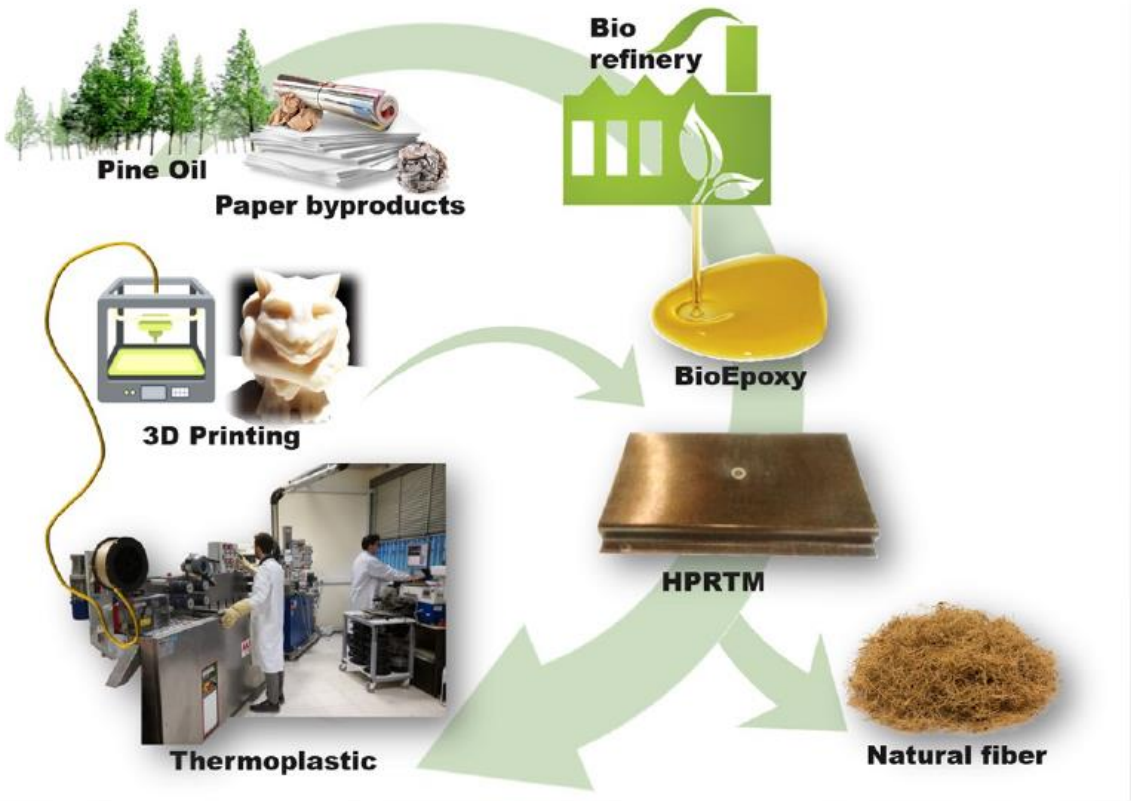
Contents lists available at ScienceDirect

Composites Part B

journal homepage: www.elsevier.com/locate/compositesb

Hybrid composites manufactured by resin infusion with a fully recyclable bioepoxy resin

G. Cicala, E. Pergolizzi, F. Piscopo, D. Carbone, G. Recca



Università degli Studi di Palermo

Polymer Composites and Biocomposites Group

dipartimento di ingegneria unipa

University of Palermo, Department of Engineering

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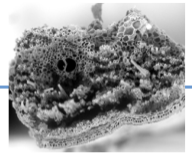
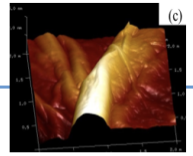
Carmelo Sanfilippo
Marta Balsamo
Maria Clara Citarrella
Erika Di Liberto
Marco Luciano
Vincenzo Titone

Materials

- MATRIX: Thermoplastics, thermosets
- FILLER: nano/microparticles, biomass waste valorization (animal, vegetal)



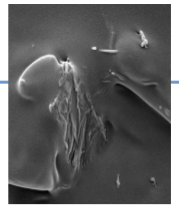


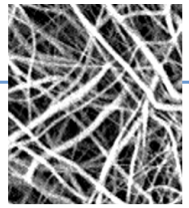
Processing

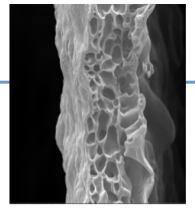
- MELT: Extrusion, batch mixing, FDM, compression molding, injection molding, film blowing
- SOLUTION: Solvent casting, (wet)electrospinning, solution blow spinning

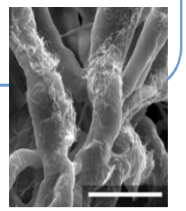
Structure

Laminates, filler inclusion, core-shell composites, etc.
Dense or porous 1D, 2D, 3D structures
Hierarchical/graded structures









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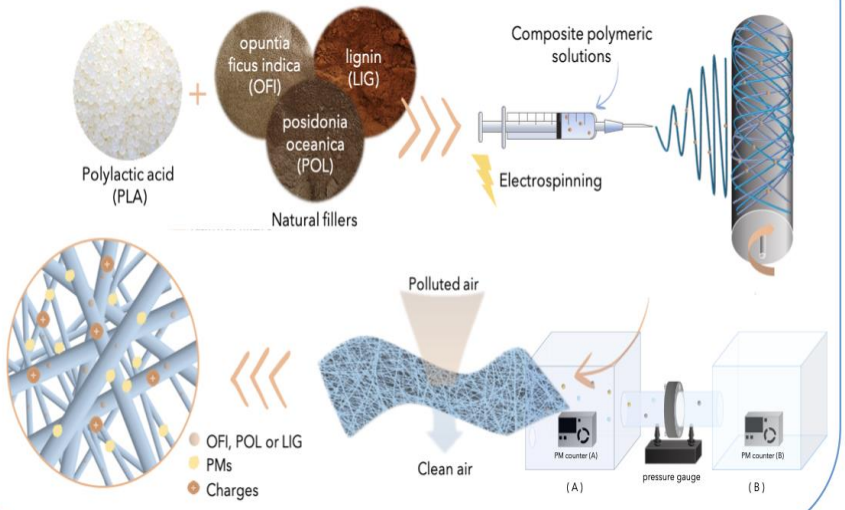
Results and applications

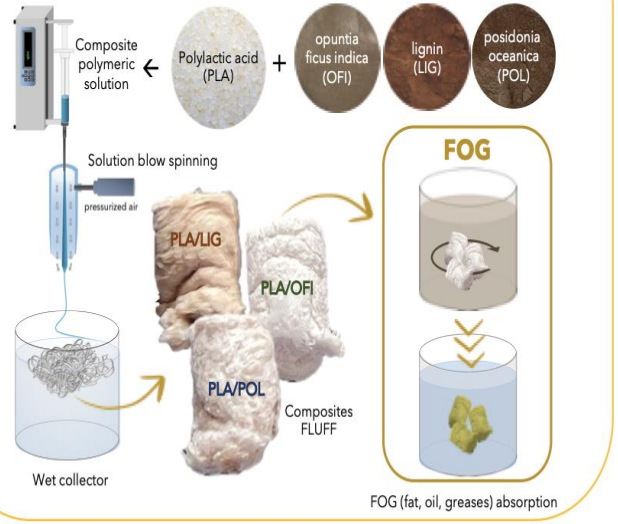
Sustainable Packaging

from waste to resource

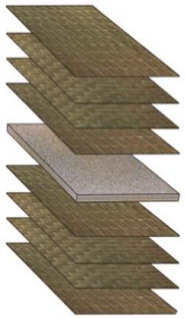
Air Treatment



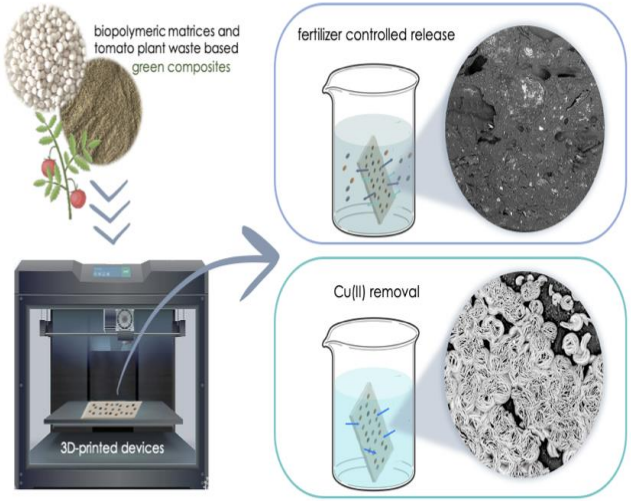
Water Treatment



Structural reinforcement



Release and Removal

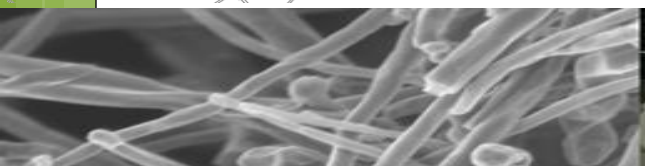


Materials Science and Technology Group

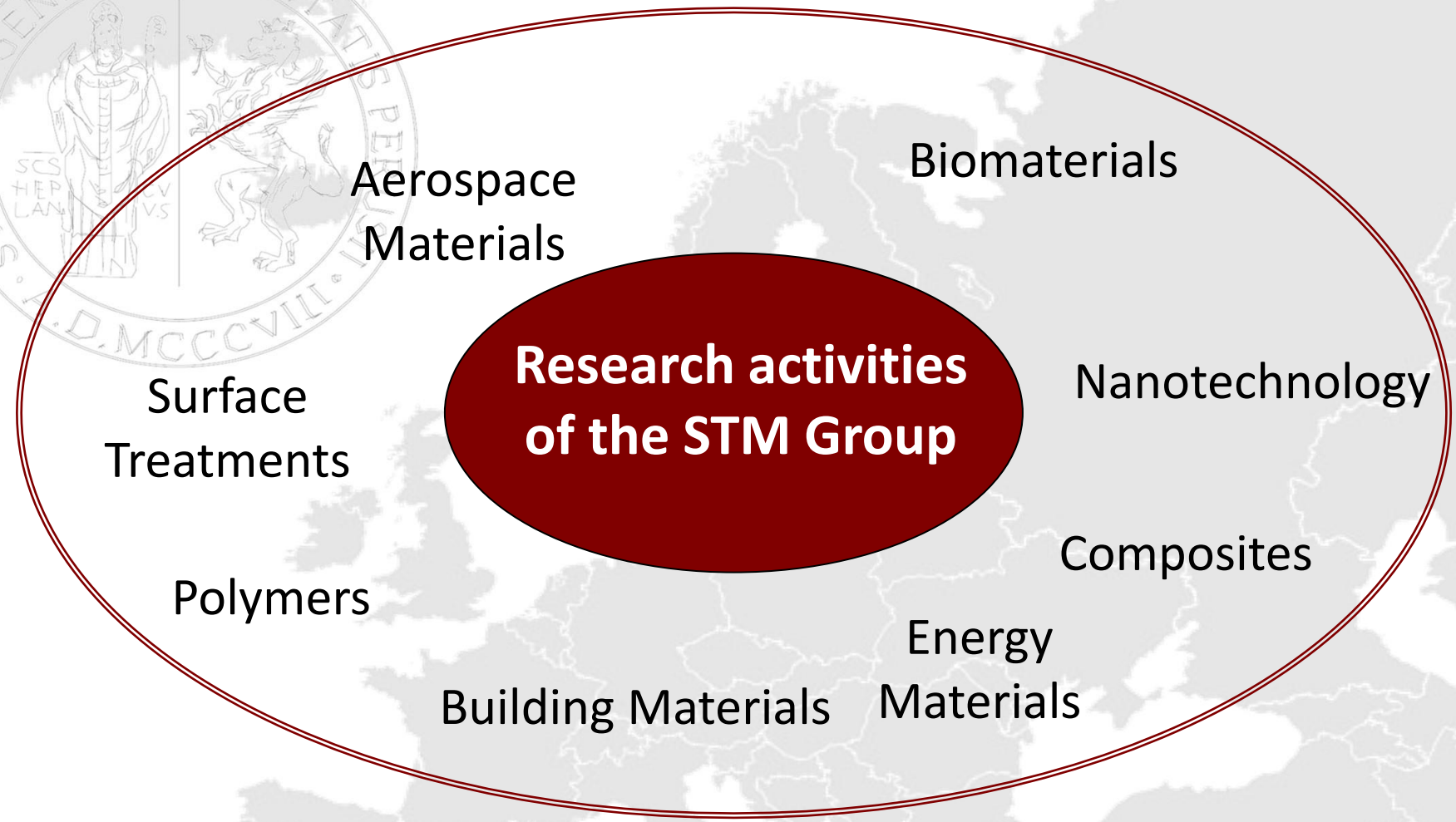
University of Perugia (Terni – ITALY)

Civil and Environmental Engineering Department

Luigi.torre@unipg.it



MISSION AND OBJECTIVES



The Materials Science and Technology group is very active in European research programmes.

The Group is also founder of the ECNP, (European Centre for Nanotechnology of Polymers)

The Group has close collaboration with PUMAS and performs research for many companies and research centres in Italy and abroad.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FECOAM
MATERIALS DESIGN & PROCESSING
Tecnofilm thermoplastic compounds
SOLVAY
Beaulieu International Group
AVIO ADVANCED VISION INTO ORBIT
TERNI ACCIAI SPECIALI TERNI
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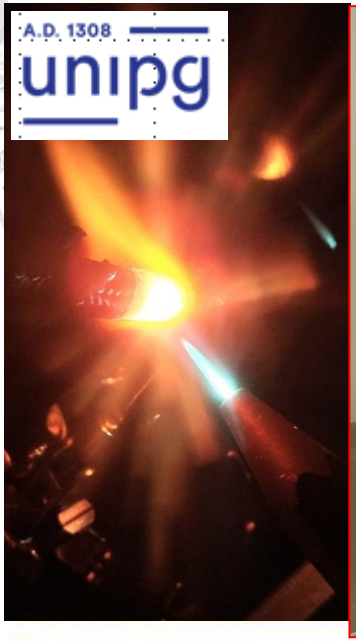
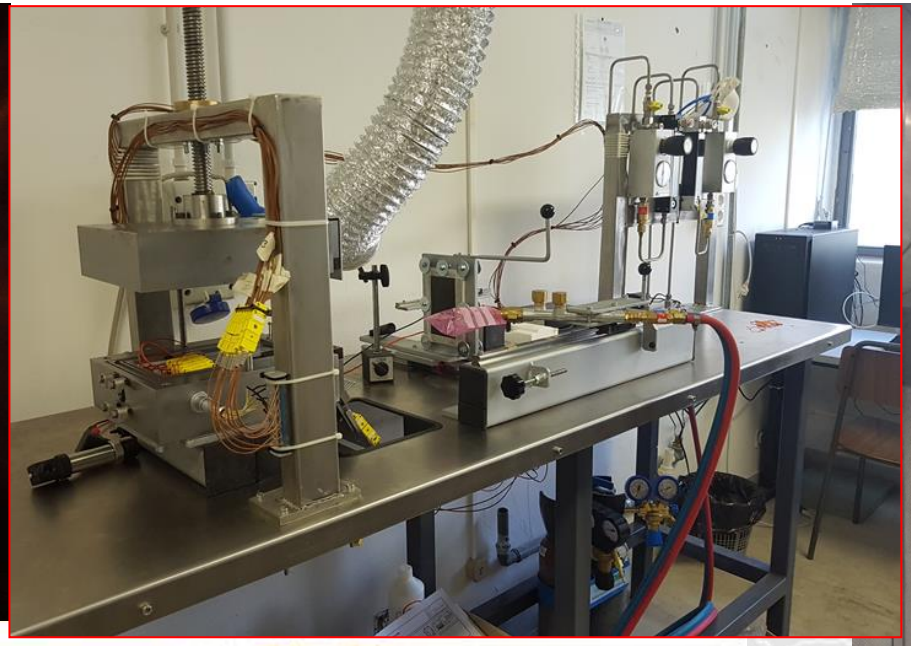
Processing of Fiber Reinforced Composites At UNIPG

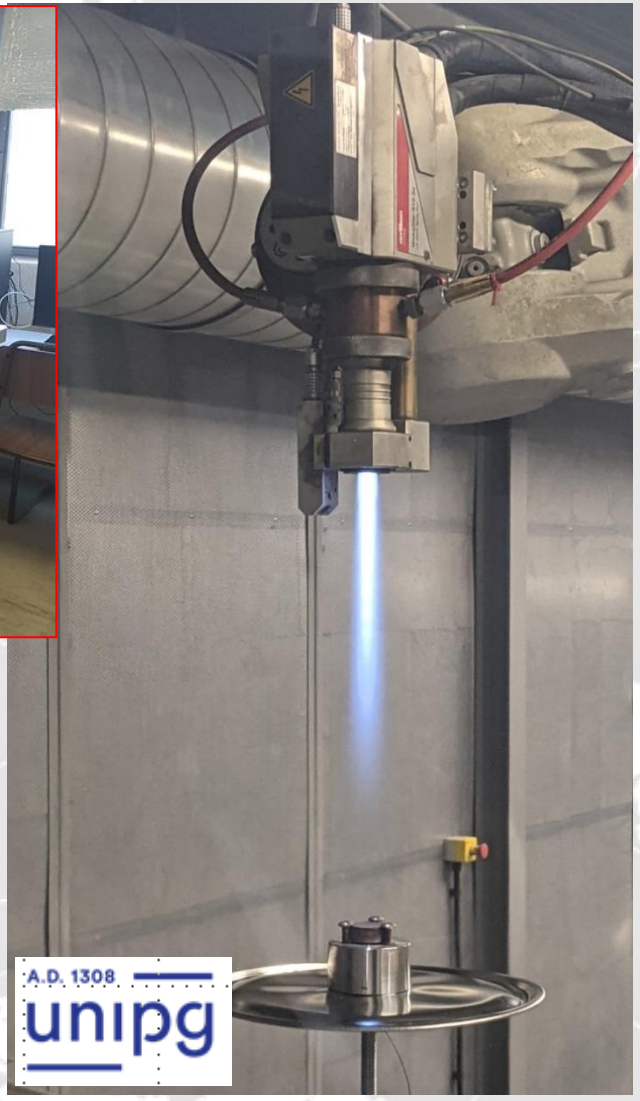
- *Hand Lay Up;- Compression Molding;*
- *Liquid Moulding: RTM, VARTM, L-RTM;*
- *Vacuum infusion;*

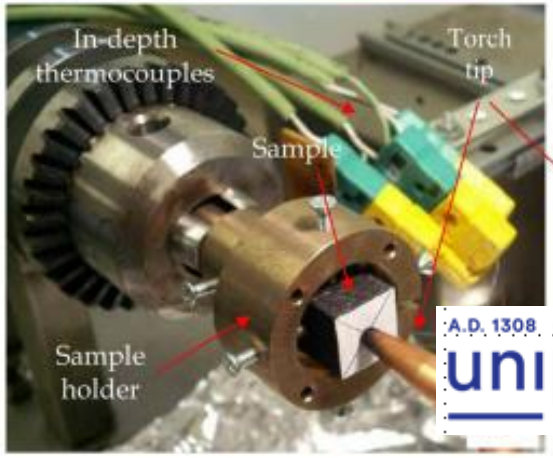
Special molds and manufacturing technologies

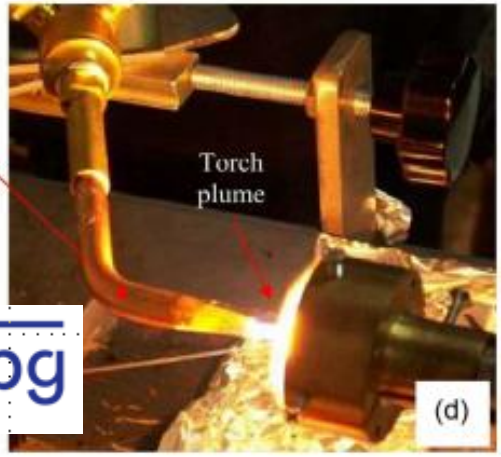
The STM SPACE group







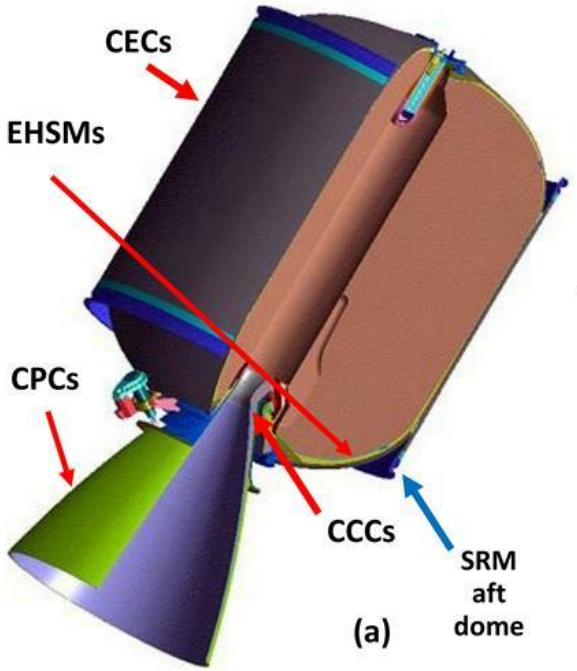

In-depth thermocouples
Torch tip
Sample
Sample holder


Torch plume
(d)

Project Title	*Funding source*	*Period*
Cost effective enabling MatErials and Technologies for Access to Space (**COMETAS**)	Horizon 2020, ERA-NET Cofund On Advanced Manufacturing Technologies, MANUNET III	2018 - 2020
VEGA Generation E	Italian Gov PON Research and Innovation 2014 - 2020 E FSC	2019 - 2021
development of Innovative Testing of High tempERature MAterials for soLid rocket motors (**ITHERMAL**)	POR FESR 2014-2020, Sardinia Region, Aerospace	2019 - 2020
HYbrid ROcket technology for quicK and dedicated accesS to Space (**HYROKSS**)	National Plan for Military Research (PNRM), Italian Ministry of Defense	2019 - 2021

Material for Solid Rocket Motors

1) Structural materials: Carbon/Epoxy Composites (CECs).
2) Thermal Protection System (TPS) materials: Elastomeric Heat Shielding Materials (EHSMs), Carbon/Carbon Composites (CCCs), Carbon/Phenolic Composites (CPCs), Ultra High Temperature Ceramics (UHTCs).
3) Adhesives.



Refractory Metal Throats

Tungsten throat reinforced with tungsten foam

Tungsten is the material of choice when solid rocket propellant flame temperatures exceed the melting point of rhenium. Because tungsten can be used to coat a lighter weight material such as graphite or carbon/carbon, the cost and weight of a monolithic tungsten throat are avoided. With its proficiency in chemical vapor deposition, Ultramet can manufacture tungsten throats as coated parts or freestanding inserts.

Ceramic-lined Throats

Ceramic-lined throat

Next-generation solid rocket propellants will have flame temperatures above the melting point of tungsten, so high temperature ceramics will be required. Ultramet can meet this demand with fiber-reinforced ceramic throats, ceramic-coated carbon/carbon throats, and/or hybrids of the two. Ultramet ceramic composites and coatings can also be used to prevent erosion in the exhaust nozzle.

TaC	7208°F (3987°C)*
HfC	7136°F (3947°C)*

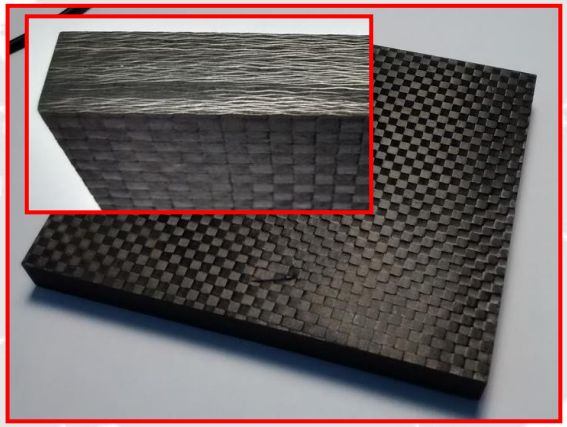
*D.T. Vier, Thermal and Other Properties of Refractories, Technical Report Program R056, Los Alamos Scientific Laboratory for Defense Advanced Research Projects Agency, 1975.

Elastomeric Heat Shielding Materials (EHSMs) are used to protect the Solid Rocket Motor (SRM) case against the high temperatures developed during the combustion process. The state of the art material for insulate SRMs is based on EPDM reinforced with Aramid fibers or pulp (Twaron® or Kevlar®).

State of the art of Carbon/Phenolic Composites (CPCs)

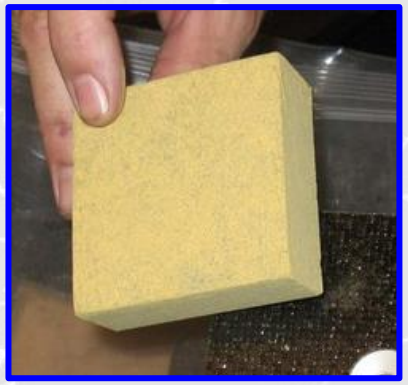
Carbon/Phenolic (~1.5 g/cm^3)

Galileo mission



PICA (~0.3/0.4 g/cm^3)

Stardust mission and SpaceX Dragon capsule

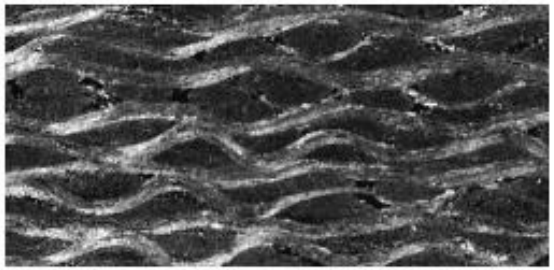


Traditional Carbon/Phenolic Composites (CPCs)

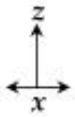
From ex-Rayon to ex-PAN based carbon/phenolic composites

Fiber shape morphology plays a direct role in ply-to-ply fiber intermingling and interlaminar nesting which influences *z*-directional properties by reducing Mode II and Mode I weaknesses.

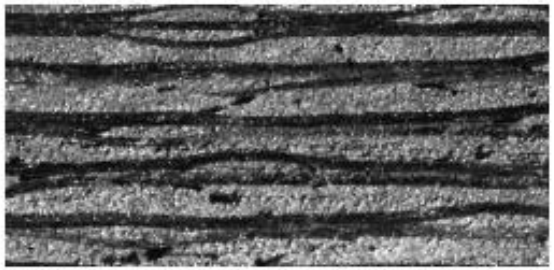
Rayon laminate . . . Natural ply-to-ply intermingling



Side view of carbonized rayon / phenolic matrix substrate (Lee, 1986)



PAN laminate . . . No ply-to-ply intermingling

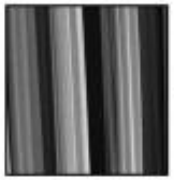


Side view of carbonized PAN / phenolic matrix substrate (Lee, 1986)

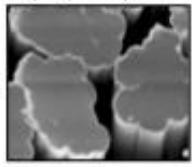
It is apparent which configuration possesses greater interlaminar interactions

Longitudinal and lateral features specific to the fibers/fabrics employed are key factors in mechanical bonding, interlocking and slippage effects along fiber-matrix interfaces as they facilitate 'slip-and-grip' toughness actions during expansion and contraction. Current state-of-the art PAN fibers are smooth, straight, non-interacting structures that exhibit minimal interlocking.

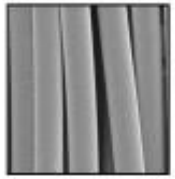
Carbonized rayon filaments (Lee, 1998)



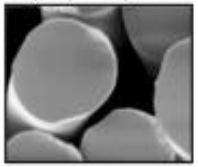
Laterally Crenulated



Carbonized PAN filaments (Lee, 1998)

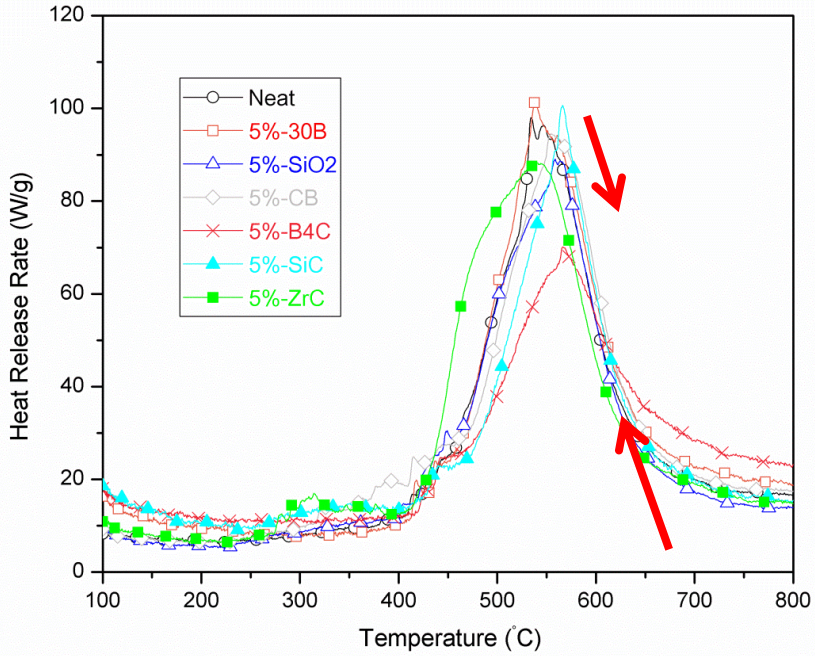


Laterally Smooth



Nanostructured high char yield phenolics for CPCs

Testing of carbon/phenolic composites with improved oxidation resistance and residual structural integrity based on B_4C;



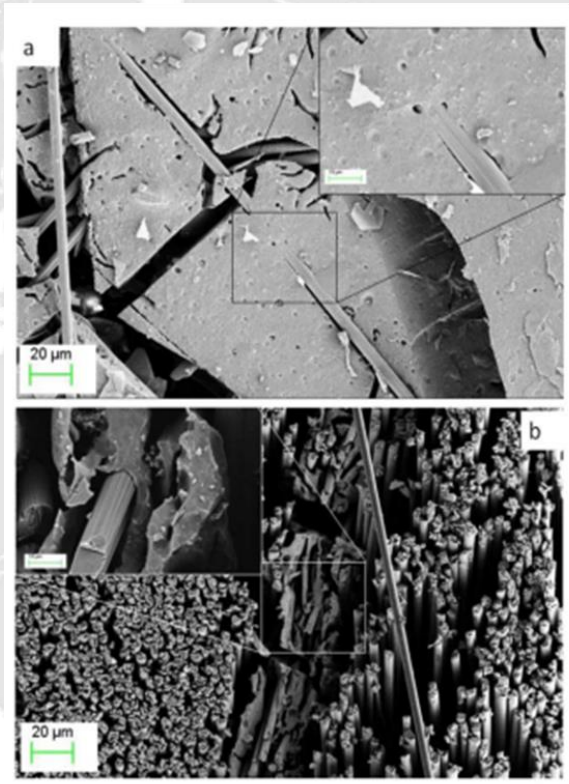
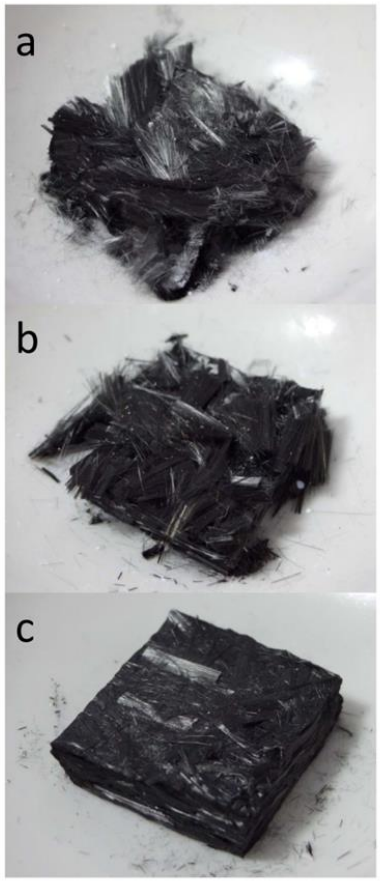


FIG. 7. SEM micrographs of the surface (a) and section (b) of a 5% BC-BMC sample after oxidative isothermal exposure to 700°C for 10 min. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

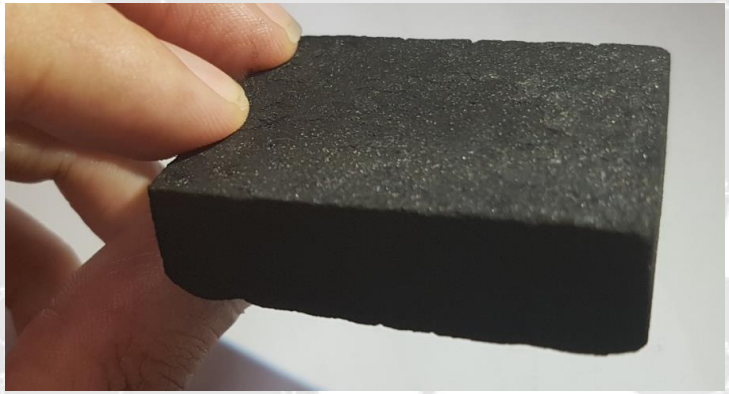


A nanostructured Phenolic Impregnated Carbon Ablator

A A **nanostructured version of PICA (N-PICA)** was produced using an ex-PAN carbon fiber. A nanoclay and Multi Walled Carbon Nanotubes (MWCNTs) were selected as nanophases to control the erosion resistance. A phenolic matrix was used to impregnate the fiber network.

A reliable, scalable, vacuum-driven, processing technique, was identified and applied.

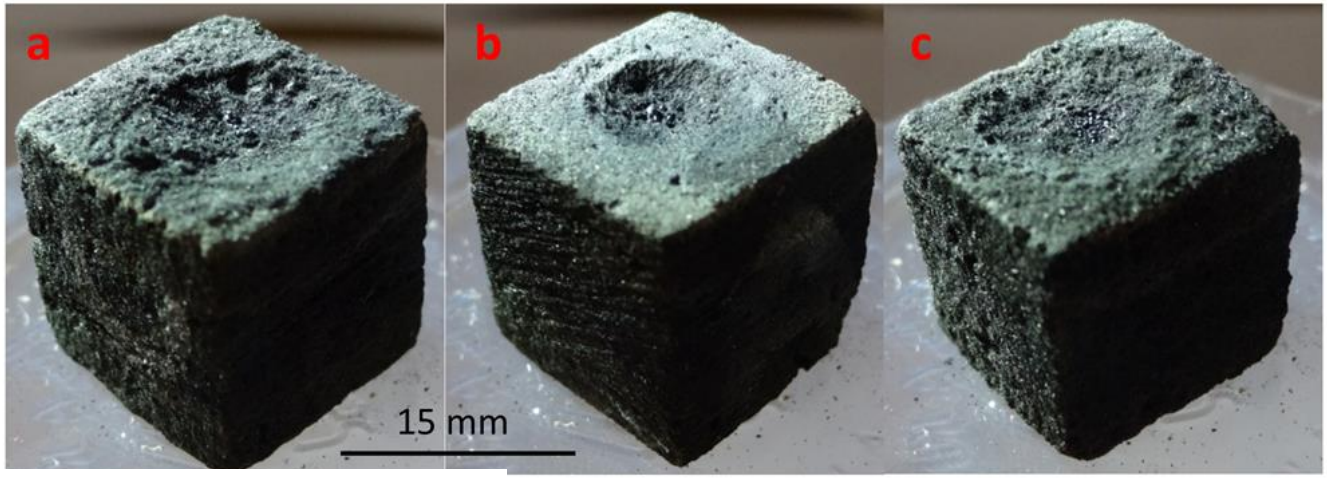
Formulation	Nanoclay/MWCNT ratio	Density (g/cm^3)
PICA 1	1/1	0.36 ± 0.01
PICA 2	2/1	0.47 ± 0.01
PICA 3	1/2	0.29 ± 0.01



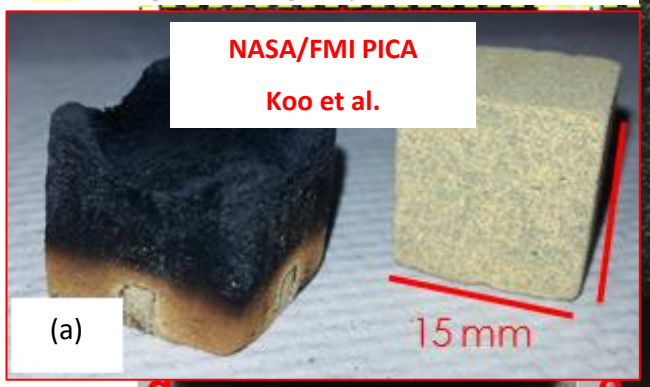
The final densities of the nanostructured formulations were in line with the values of the PICA available in literature.

However, since US PICAs are considered subjected to International Traffic in Arms Regulations (ITAR) by the US, many metrics are not available in literature.

Oxy-Acetylene Torch (OAT) test



For this study, a heat flux of 1000 W/cm^2 was chosen to ensure comparable results with other similar investigations in the past. To produce this heat flux as well as an oxidizing environment, a 3.4:1 oxygen/acetylene ratio and a torch-sample distance of 8 mm were used. The sample was fixed in place by a lathe chuck, which was itself



Formulation	Nanoclay/MWCNT ratio	Density (g/cm^3)
PICA 1	1/1	0.36 ± 0.01
PICA 2	2/1	0.47 ± 0.01
PICA 3	1/2	0.29 ± 0.01

THANK YOU
FOR YOUR
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