Tecnologie “ad alta intensità di conoscenza e associate ad elevata intensità di R&S, a cicli d’innovazione rapidi, a consistenti spese di investimento e a posti di lavoro altamente qualificati. Rendono possibile l’innovazione nei processi, nei beni e nei servizi in tutti i settori economici e hanno quindi rilevanza sistemica. Sono multidisciplinari, interessano tecnologie di diversi settori e tendono a convergere e a integrarsi. Possono aiutare i leader nelle tecnologie di altri settori a trarre il massimo vantaggio dalle loro attività di ricerca”
• Proprietà foto-opto-elettroniche
• Sostenibilità
• Heritage
• Packaging
• Compositi multifunzione
• Manufacturing
Luminescent gels for energy applications

This research activity was funded by European Commission as part of the Framework 7 integrated project EPHOCELL - “Smart light collecting system for the efficiency enhancement of solar cells”, grant agreement No 227127 (2009-2013)

An increase in the energy conversion efficiency of PV devices could be obtained through a process of energy transfers supported by adaptable molecular systems:

1) down-shifter (DS) – antenna molecules able to absorb UV photons and to transfer the absorbed energy to an emitter, which emits a photon in the absorption band of the photovoltaic material.

2) up-converter (UC) - sensitizer molecules able to absorb IR photons and to emit the absorbed energy in the absorption band of the photovoltaic system.

The main objective is focused on preparation and characterization of gels, based on low and high molecular weight gelators, in which organic molecules and/or organo-metallic complexes are embedded.

The research activity aims to probe the effectiveness of DS and UC mechanisms in gels with the objective to develop new media for DS and UC and to give rise, in the long term, to a new generation of luminescent solar concentrators flexible and adaptable to several geometries.

M. Avella, M. Cocca, M. L. Di Lorenzo, G. Gentile
EnAm Project (supported by CNR and Province of Trento)

1. **Luminescent Nanocomposites for PV applications (patent submitted)**

2. **Green synthesis of luminescent rare-earth nanoparticles**

3. **Nanostructured metal oxides for photocatalytic applications**

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**E. Binetti, A. Longo, G. Carotenuto “HOPV15 International Conference on Hybrid and Organic 10-13 May 2015, Rome (Italy).**

Manuscript in preparation

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**E. Binetti et al. Materials Letters (2015), 139(0), pp 355-358 (doi 10.1016/j.matlet.2014.10.120)**

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ITO/TiO₂ cauliflower-like
Metal or semiconductor nanostructures synthesized by bottom–up approach

Nanostructures

Metal QDs (d < 3 nm)

Polimeric nanocomposites and emission spectra

Nanoparticles, nanoplatelets, etc. (d > 10 nm)

Absorption spectrum of gold nanoparticles

TEM gold QDs

Excitation and emission spectra


A. Longo, G. Carotenuto “New luminescent natural thiol coated gold clusters embedded in polymeric matrix as down-shifting filters”. E-mrs spring meeting 11-15 may 2015 Lille (France).

Eumelanins in Material Science: Challenges and Perspectives

The activities were performed in the framework of the PRIN project n. 2008LMY5WX_003 granted by Italian M.I.U.R.

5,6-Dihydroxyindoles are the building blocks of some of the most enigmatic pigments found in Nature....the Eumelanins

Challenges:

• Understand the basic structural features of the polymer by advanced solid state techniques (NMR, SEM, TEM)
• Prepare novel DHI-derived polymers
• Prepare new hybrid materials with improved physicochemical properties for functional applications

- Light absorption throughout the UV-visible range
- Persistent free radical
- Cation exchanger/metal chelating agents
- Redox system
- Biocompatible and bioavailable

Caratterizzazione STRUTTURALE di polibenzofulveni in collaborazione: Università Siena; ISMAC-CNR Milano


Sintesi e caratterizzazione strutturale di policoniugati: polifluoreni, politiofeni, copolimeri(stirene - 4vinil piridina), etc.

Collaborazioni: ISMAC-CNR Milano; NANOTECCNR Lecce; Dipartimento di Matematica e Fisica ‘E. De Giorgi’, Università del Salento, Lecce; IPCF CNR Bari; Dipartimento di Chimica Università di Bari

5) F. Samperi, S. Battiato, C. Puglisi, U. Giovanella, R. Mendichi, S. Destri
“Combined Techniques for the Characterization of Polyfluorene Copolymers and Correlation whith their Optical Properties”. Macromolecules 2012, 45, 1811-1824


**Metal or semiconductor nanostructures synthesized by top – down approach**

*Fabrication of nanopowder by vibration milling*

- SEM image of Te nanopowder in PMMA

- Photocurrent measurements of Te nanopowder in PMMA

*Fabrication of LDPE supported graphene by shear stress*

- Sem image of graphene-LDPE

- Photocurrent measurements of graphene-LDPE

- Exfoliation by shear stress

- Polyethylene-supported graphene

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GO and rGO for Sensors


Quero, G; Consales, M; Vaiano, P; Cusano, A; Giordano, M; Zuppolini, S; Diodato, L; Borriello, A; Venturelli, A; Costi, MP; ,Reflection-type long period grating biosensor for detection of drug resistant bacteria: the OptoBacteria project,"AISEM Annual Conference, 2015 XVIII",,1-4,2015,IEEE

Ricciardi, A; Severino, R; Quero, G; Carotenuto, B; Consales, M; Crescitelli, A; Esposito, E; Ruvo, M; Sandomenko, A; Borriello, A; ,Lab-on-Fiber biosensing for cancer biomarker detection,International Conference on Optical Fibre Sensors (OFS24),,,963423-963423-4,2015,International Society for Optics and Photonics

Quero, G; Severino, R; Vaiano, P; Consales, M; Ruvo, M; Sandomenko, A; Borriello, A; Giordano, M; Zuppolini, S; Diodato, L; ,"High sensitive reflection type long period fiber grating biosensor for real time detection of thyroglobulin, a differentiated thyroid cancer biomarker: the Smart Health project",International Conference on Optical Fibre Sensors (OFS24),,,96342G-96342G-4,2015,International Society for Optics and Photonics
Advanced polymer-graphene nanocomposites through a fine tailoring of graphene morphology

M. Lavorgna, G.G. Buonocore

H. Xia
State Key Laboratory of Polymer Materials Engineering, Sichuan University, China

- Low electrical percolation
- High barrier properties
- High barrier properties
- Enhanced tensile strength & elongation at break
- Low electrical percolation
- High barrier properties

HAVOH polymer based nanocomposites ……

Biopolymer based nanocomposites ……

Rubber based nanocomposites ……

Joint Laboratory for Graphene-based Multifunctional Polymer Nanocomposites

Electronic packaging

Tires industry

Conductive elastomers

Food packaging

Pharmaceuticals

Hydrogen storage

3D segregated

Layered

Layered/Random
Selective localization of MWCNT in microstructured composites

PS/PLA co-continuous blend with CNTs

A masterbatch of PS with 2wt% of MWCNT was prepared and then melt mixed with different amounts of PLA. This two-step process led to a double percolated morphology (i.e. PS percolates in PLA phase, and MWCNTs percolate in PS phase). SEM micrographs clearly indicated formation of bicontinuous morphology, while TEM images evidenced high selectivity for MWCNT localization in the system. The double percolation led to a very low electrical percolation threshold of about 0.15 v% MWCNT content on the total volume.

V. Ambrogi, C. Carfagna, P. Cerruti, G. Gentile, G. Nasti
COMMON SENSE project will develop prototypes of in-situ new generation sensors and integrate these sensors into different marine platforms in order to reduce significant sampling and monitoring costs

M. Avella, R. Avolio, M. C. Cocca, E. Di Pace, M. E. Errico, G. Gentile, F. De Falco, M. P. Gullo

**Phase 1:** Preparation and characterization of nanocomposite films

**Phase 2:** Preparation of Screen Printed Electrode

**Phase 3:** Field Testing

**IPCB ACTIVITY:** to develop new generation sensors for transversal or reference parameters such as temperature, pressure, pH and pCO2, and integrate them to other commercially available sensors not being developed within the project

The activities are performed in the framework of the European Union’s Seventh Programme for research, technological development and demonstration (OCEAN 2013.2)
Development and characterization of new sustainable and safety materials designed to avoid migration of stabilizers, nanofillers and additives during their life cycle

The activities are supported by the FIRB 2010 project **GREENER** (No. RBFR10DCS7) funded by the Italian Ministry of University and Research (MIUR).

PROBLEM

The cheaper industrial method in polymer based nanocomposite preparation is the melt mixing

- poor additive dispersion
- antagonism between the additives
- migration of the stabilizing molecules

“GREENER” - SOLUTION

Immobilization of functionalized nanoparticles and stabilizing molecules

Application of innovative chemical concepts to develop “green” NCs for different applications, where restrictive regulations on migration of molecules are required.

R. Arrigo; N. Tz. Dintcheva; M. Guenzi; C. Gambarotti; G. Filippone; S. Coiai; S. Carrocio, “Thermo-oxidative resistant nanocomposites containing novel hybrid-nanoparticles based on natural polyphenol and carbon nanotubes”, Polymer Degradation & Stability, 115, 129-137, 2015


Biodegradable semicrystalline polymers: Investigation of their structure for properties optimization

M. L. Di Lorenzo, M. Cocca, M. Malinconico

First discovery of discontinuity in crystallization kinetics of PLA: $\alpha / \alpha'$ polymorphism

$\alpha / \alpha'$ polymorphism affects PLA properties (barrier, mechanical, ...)

D-lactide influences PLA morphology

Selected recent publications

High surface area hyper-crosslinked resins containing MWCNT or GNP

Hyper-crosslinked resins (HCLR) are high surface area polymers based on the post crosslinking of “gel-type” resins, usually realized by suspension polymerization.

The objective of this activity is the realization of HCLR containing carbon nanofillers, such as plain or modified MWCNT or GNP, in order to modulate the specific surface area, the specific pore volume, the pore distribution and the adsorption properties of the material.

RESULTS:

A new synthetic process for the gel-type precursors was set up, based on the bulk polymerization of the starting monomers. This allowed to easily embed MWCNT or GNP within the HCLR.

The specific pore volume and the pore distribution are significantly affected by GNP or MWCNT.

Phenol adsorption increases with GNP or MWCNT.

V. Ambrogi, M. Avella, R. Avolio, C. Carfagna, R. Castaldo, M. Cocca, M.E. Errico, G. Gentile
Organic-Inorganic (O-I) multifunctional hybrid materials by sol-gel processing

G.G. Buonocore, S. Iannace, M. Lavoroga, L. Verdolotti

Modification of epoxy resin by sol-gel approaches for functional and structural applications in buildings

Materials by renewable sources for coatings, composites and foams

- Enhancement of thermal and mechanical properties
- Enhancement of thermal insulating properties
- Enhancement of dimensional stability, fire resistance and mechanical and functional properties of biodegradable materials
- Enhancement of thermal insulating properties

Materials for thermal and acoustical insulation of buildings
Multifunctional Thermosets
Cultural Heritage Restoration

Consolidation of wood statue of Basilica di Santa Patrizia (Naples) with polyurethane foams.

Restoration of charred wood samples from Villa dei Papiri (Herculaneum).

The use of specifically developed epoxy resins (in the right image) enhances mechanical properties of charred wood, preserving permeability through porous structure. A dynamical hygro-thermal equilibrium relaxes internal stresses and prevents fungi and bacterial growth.


Multifunctional nanostructured materials for the conservation of cultural heritage

Maurizio Avella, Roberto Avolio, Giovanna G. Buonocore, Mariacristina Cocca, Maria Emanuela Errico, Gennaro Gentile, Marino Lavorgna, Maria Grazia Raucci

The specific objectives of this research activity include:
1) Realization of efficient multifunctional coatings and gels
2) Realization of specific and compatible materials
3) Realization of highly durable materials
4) Realization of sustainable and safe materials
5) Testing and validating the realized multifunctional materials.

Several nanoparticles have been proposed to prepare active as well as protective coatings/materials for protection/consolidation of lapidei, wooden, metallic and plastic artworks.

Progetto Horizon 2020 NANORESTART NANOmaterials for the REStoration of works of ART (2015-2018)


Materials for active and high barrier packaging: Engineering nanoparticles for Controlling the release of active compounds

G.G. Buonocore, M. Lavorgna

Vanillin as antimicrobial agent or Bezothiazole as anticorrosive agent

Copper ions to form insoluble metal-complex capping the tube ends

Tocopherol as antioxidant

Aminopropyltriethoxysilane to functionalize the particles

Silver as antimicrobial agent

Unfunctionalized: 30% diffusivity reduction

Functionalized: 60% diffusivity reduction

Steady and prolonged release (no initial burst)

Diffusivity reduction
Multiscale/multifunctional thermoplastic hybrid composites

Combining different technologies to produce innovative, high performance structures

Nano Particles

Foams

Interface strength gradation

Si realizzano attraverso la combinazione/integrazione di diverse tecniche di espansione (foaming diretto, sintesi in situ di nano-porosità (aerogel), gas foaming, chemical e physical foaming) con la combinazione di materiali differenti (polimeri organici sintetici, naturali ed inorganici) che interagiscono con meccanismi chimico-fisici che agiscono su scale differenti: da quell’atomica a quella macroscopica.

L’architettura porosa può essere distinta sulla base della matrice di partenza:
- Schiume poliuretaniche: compositi e/o ibridi
- Schiume di origine naturale (Proteine vegetali o animali, polisaccaridi)
- Ceramici espansi compositi o ibridi (geopolimeri, diatomite, silico-aluminati, cementi)

Multifunctional Thermosets
Self Healing Epoxy

The activities were performed in the framework of the FP7 European Project “ALAMSA”

Epoxy resin based on Diels–Alder (D-A) adducts has been synthesized and crosslinked with amine curing agent for the preparation of mendable material. The cured resin can heal multiple time upon heat trigger.

Diels–Alder epoxies are miscible with conventional epoxy and curing agents. Their composition enables the use of processing technologies used for composites manufacturing, like prepregging or liquid infusion of dry fibers.


Multiscale composite for aeronautical components

The activities were performed in the framework of the project “ARCA ” granted to IMAST Scarl by Italian Ministry M.I.U.R.

Loss factor vs T

+15 % @ -40°C


Composite in Fire: experimental and modelling

Fire resistance and Fire Reaction of composite elements surely stand up as fundamental issue for many industrial sector. Enhanced fire performance could be achieved and modelling technique employed to prevent, control and manage fire scenario.

Cone Calorimetry Microcalorimetry

Carbon Oxide (CO) vs Time

Resistance degradation and modelling

Comparison of the three results.

M. Zarrelli, (Royal Institute of Naval Architects) Conference London 2010
M. Zarrelli et al. EXPRESS Polymer Letters Vol.3, No.6 (2009)
M. Zarrelli et al. Polymer Degradation and Stability 94 (2009)
Aeronautical Composites: engine tail fire event

Engine tail pipe fire event: qualification procedure

The wider use of composite materials for primary structures pose the problem of their behavior when exposed accidentally to a local overheating deriving from events like fire. Overheating means that the structure is submitted to a temperature higher than the design maximum service temperature, generally 80°C.
FP7 Project: Scypri

Project acronym: SCYPRI
Project full title: "SMART CYLINDERS FOR FLEXOGRAPHIC PRINTING INDUSTRY"
Grant agreement no: 315335
Call Identifier: FP7-SME-2012

Temperature sensor (FBG) on composite
Temperature sensor (FBG) on tool
Embedded Thermo couples

MAVICYS Software: implementation
Thermo-Mechanical Analysis of Viscoelastic Composite Cylinders
Hybridized COMposite and POwertrain system for Europe 2020 development of innovative technologies for structural composites hybridatization and moto propulsion systems for the sustainable mobility.

Over-injection of resin for the joining of thermoformed structural parts for automotive applications
**Structural and dynamic study of gels**

Relationship between mesoscopic structure and macroscopic properties of physical hydrogels

- **Alginate (left) and Chitosan (right) hydrogel**
- **Mesoscopic schematic structure**
- **Microscopic network structure**

![Mesoscopic schematic structure]

Self correlation: showing a double decay

Aging effect... to be investigated

Force relaxation: displaying aging effect
