



Consiglio Nazionale delle Ricerche

Istituto per la Sintesi Organica e la Fotoreattività (CNR-ISOF)

ISOF IN BRIEF



The Institute for Organic Synthesis and Photoreactivity (ISOF) is characterized by a strong and well-established vocation in molecular synthesis and chemical design, advanced functional materials, and photochemistry. ISOF main scientific areas are Molecules and Materials for Life Science, Molecules and Materials for Energy and Clean Technologies, Molecules and Materials for Environment and

Sustainability.

The mission of ISOF is to promote high-level research in synthetic chemistry and light-driven processes for the development of tailored molecules and innovative materials.

Building on its expertise in molecular design, ISOF develops small molecules (such as taxanes, oligothiophenes, rotaxanes, and cyclodextrins) and advanced functional materials (including graphene and modified graphene), biomaterials (such as silk proteins, keratin, carbohydrates, polydopamine, phyto-complexes, polysaccharides), composites (polysulfone and biopolymers based) and nanoparticles (such as polymeric, liposomes, protein-based, cyclodextrins, hydrotalcites). These capabilities enable multidisciplinary research across health and life sciences, energy and clean technologies, and environmental sustainability. Moreover, thanks to its strong synthetic expertise, ISOF is one of the CNR-DSCTM nodes of the National Chemical Compound Collection (Chemoteca Nazionale), the first Italian infrastructure contributing to a European library of synthetic small molecules for societal use.

Research activities range from materials for sensing and removal of emerging contaminants like PFAS in water, biopolymers and composites for biomedical filtration, photoactive molecules for optoelectronics, solar energy conversion and photovoltaics, 2D and molecular materials for astrocytes interfacing, therapeutic molecules and nanosystems as drug delivery platforms, and nutraceutical solutions. The Institute also develops innovative synthetic approaches supported by advanced reactor design, automation, real-time detection, and process control. Numerical modelling and artificial intelligence enable the optimization of chemical and physicochemical processes, leveraging enabling technologies such as catalysis, photochemistry, pharmaceutical chemistry, electrosynthesis, aerosol chemistry, and photo-electrosynthesis.

ISOF holds internationally recognized expertise in light-matter interaction and photoinduced processes on fast and ultrafast timescales, supporting key technologies such as CO₂ reutilization, solar fuels, photocatalysis for environmental remediation, hydrogen production, and sustainable energy.

Leveraging these strengths, ISOF promotes and disseminates research and innovation with high scientific and technological impact through international collaborations and strong partnerships with industry and research institutions.

PATENT



CNR- ISOF - Istituto per la Sintesi Organica e la
Fotoreattività

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Several patents are jointly held with industrial partners and managed under dedicated exploitation agreements. Selected active patents include:

1. Method for the Treatment of a Porous Substrate

Patent Numbers: IT 102018000010402; PCT/IB2019/058300; WO2020/099954

Ownership: CNR Medica S.p.A.

Inventors: M. Melucci, V. Palermo, M. Zambianchi, A. Liscio, A. Kovtun, E. Treossi, M.L. Navacchia, L. Bocchi

2. Method for the Treatment of a Porous Substrate

Patent Numbers: IT 102020000026726; EP 21207308.4

Ownership: CNR Medica S.p.A.

Inventors: M. Melucci, V. Palermo, M. Zambianchi, A. Kovtun, M.L. Navacchia, L. Bocchi

3. Porous Granules of Polysulfone or Derivatives Thereof for the Removal of Organic Molecules from a Fluid

Patent Number: EP 3208241

Inventors: M. Melucci, M.L. Navacchia

4. Modified Membrane

Patent Number: EP 3257573

Inventors: M. Melucci, M. Zambianchi, V. Benfenati, L. Bocchi

5. Graphisulfone®, Figurative trademark with verbal elements

Inventors: M. Melucci, M. Zambianchi, L. Bocchi, G. Palumbo, A. Goldoni

Ownership: CNR-Medica S.p.A.

6. Nanoparticles as delivery vehicles of active ingredients and methods for the production thereof

Inventors: A. Aluigi, G. Varchi, G. Sotgiu, A. Guerrini, M. Ballestri

Ownership: CNR

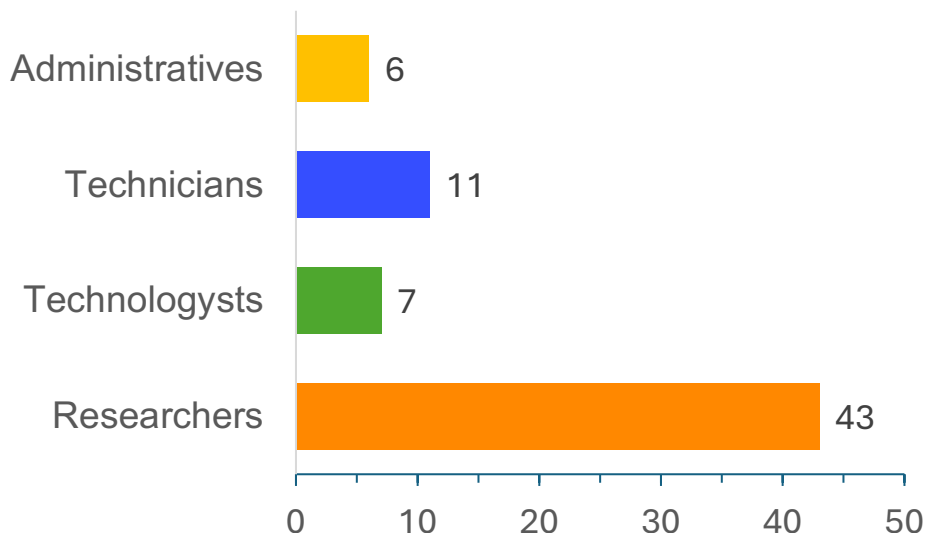
Patent number: EP3638214B1



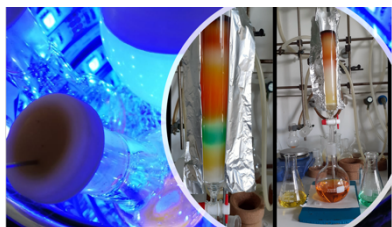
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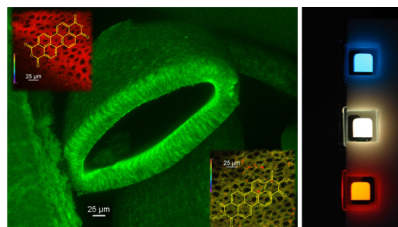
HUMAN RESOURCES



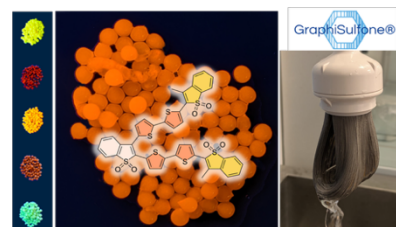
VISUAL SKETCH



Innovative synthetic approaches (i.e. photocatalysis, aerosol chemistry, and electrosynthesis), synthesis of organic small molecules, nanoparticles, and two-dimensional nanomaterials.



Fluorescent molecules, nanomaterials and surfaces functionalization for biomedical and optoelectronic devices. Left: perylene functionalized polymeric hollow fiber membrane; Right: rgb LEDs.

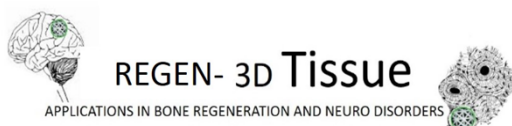


Materials for sensing and removal of emerging contaminants such as PFAS from water. ISOF has developed photocatalysts and composites, including Graphisulfone® a graphene-based drinking water filter.



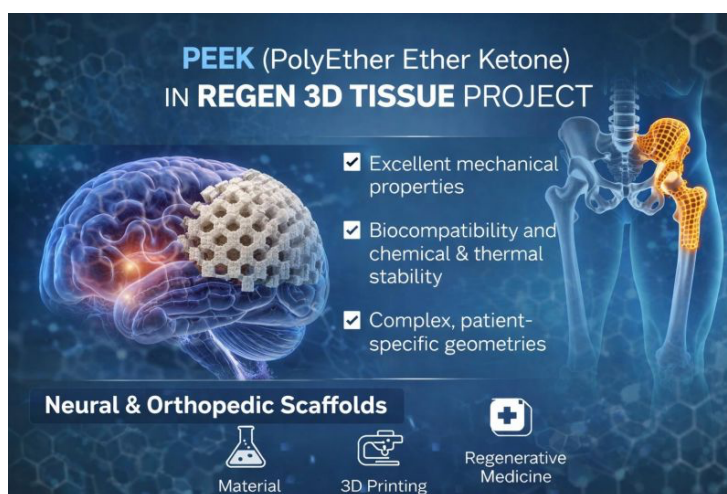
OUR PROJECTS

**Progetto: FISA MUR-Fondo Italiano Scienza Applicata-2023,
Advancing Regenerative Medicine Through Innovative Polymer (REGEN-3D TISSUE)
Project Manager: Emanuela Saracino**



Understanding and developing new polymeric and hybrid materials is a central challenge of our project. By bridging materials science, biology, and 3D engineering, we aim to open new regenerative strategies for patients affected by severe injuries and chronic diseases. In conditions such as trauma, neurodegenerative disorders, and musculoskeletal pathologies, the human body often lacks the intrinsic ability to fully repair complex tissues, as occurs in brain or bone tissue. This is where engineered

materials converge with advanced 3D printing technologies to create soft, biocompatible scaffolds and implants suitable for brain tissue, as well as materials that combine mechanical strength with biological signalling to promote bone and cartilage regeneration. Within the REGEN-3D TISSUE project, we are exploring the potential of 3D printing applied to PEEK based-biomaterials. PEEK is one of the most promising polymer in the biomedical field due to its high biocompatibility, mechanical properties, excellent chemical and thermal resistance and radiolucency, which makes it ideal for medical imaging. Through additive manufacturing, it becomes possible to customize implants and scaffolds from TC, optimize porosity and geometry to improve the integration with biological tissues. The 3D printing of PEEK and its derivatives represents a high-impact clinical solution for the future of regenerative custom-made medicine.



**Project: European Defend Fund (EDF) 2023, Sustainable Water Innovations for Fielded Troops (S.W.I.F.T)
Project Manager: Manuela Melucci**



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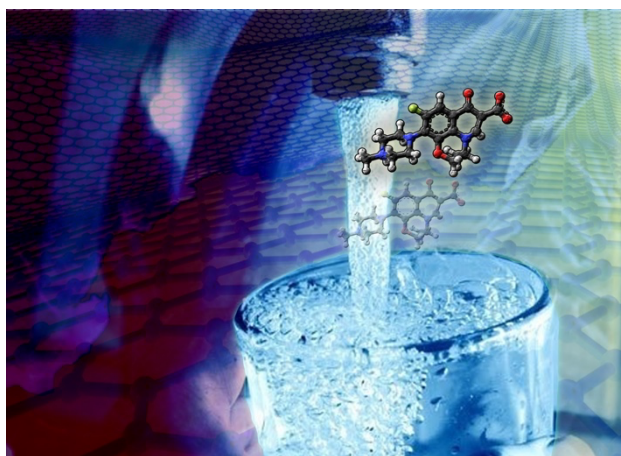


The goal of S.W.I.F.T is to apply a disruptive approach for water management through technological innovations for modular field camps suitable for deployed military units.

In particular, the project aims to develop disruptive approach for water management through technological innovations for modular field camps suitable for deployed military units within expeditionary and European defense contexts.

Specifically, the project concentrates on exploring the potential of emerging water reuse concepts and technologies, including, but not restricted to, graphene-based treatment technologies, and advanced photocatalytic processes, to provide clean

and safe water for military personnel in various often harsh operational environments. The role of ISOF is to develop and validate innovative materials for emerging contaminants adsorption under real operational conditions in a dedicated pilot plant located in Bologna site.



Project: Ricerca e sviluppo di tecnologie per la filiera dell'idrogeno (POR H2), AdP MMES/ENEA with involvement of CNR and RSE, PNRR – Mission 2, Component 2, Investment 3.5 "Ricerca e sviluppo sull'idrogeno"

Project Manager ISOF: Andrea Barbieri



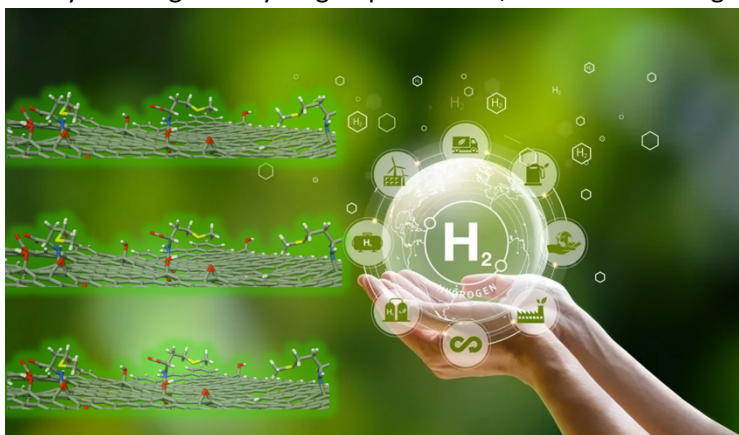


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The Research Operational Plan focuses on four key areas: green hydrogen production; innovative storage, transport, and conversion into e-fuels; fuel cells; and smart integrated management of hydrogen infrastructures. Developed jointly by ENEA, CNR, and RSE, the project promotes interdisciplinary collaboration to strengthen hydrogen as a key energy carrier for national decarbonization and to support the objectives of the PNRR.

ISOF coordinates the activity line LA2.1.12, "Liquid hydrogen carriers obtained from the photochemical and photoelectrochemical



conversion of CO₂ and water" and participates in the activity lines LA1.1.35, "Hydrogen production through photocatalytic and photoelectrocatalytic processes" and LA2.3.6, "Innovative materials for chemical and physical sorption and storage of hydrogen at low temperatures in the solid-state"

ISOF coordinates the activity line LA2.1.12, "Liquid hydrogen carriers obtained from the photochemical and photoelectrochemical conversion of CO₂ and water", studying photoinduced charge transport processes on fast and ultrafast time scales in photoanodes of dye-sensitized photoelectrochemical cells (DS-PEC) for water splitting. These types of studies are essential for understanding the kinetics of charge injection in semiconductor materials, improving the efficiency of photoreduction and photooxidation processes.

EXCELLENCE OF THE INSTITUTE

ISOF publishes an average of 90 articles per year in peer-reviewed international journals, with a citation h-index of 103 (Scopus, June 2021). Beyond scientific communication, ISOF has a strong record of technology transfer and industrial collaboration, with long-term contracts and partnerships with major companies such as ENI, MEDICA, UFI-Hydrogen, HERA, AIRBUS, LEONARDO. Industrial activities are carried out within research projects (e.g., LIFE-REMEMBRANCE, AQUAIM, BICYCLOS) and through direct agreements with industrial partners (e.g., Tetra Pak, UFI-Hydrogen, HERA) focusing on the development and validation of materials for water treatment. ISOF is co-owner of two pilot plants for materials validation in water treatment: one at its Bologna headquarters and a second water living lab at the HERA drinking water plant in Pontelagoscuro (Ferrara). Clean energy technologies, optoelectronics and photocatalysis are key topics in ISOF, supported by individual and collaborative projects (LefkoPhos *d-f*, SupraPhthal).

ISOF also hosts a joint research laboratory with the University of Bologna 'Center for Light Activated Nanostructures (CLAN)', focusing on light-driven processes for energy conversion and medical applications. CNR-ISOF is actively participating to the activities of the Clust-ER Health, chairing the value chain Mat-ER-ials (Materials for Health). Clust-ER Health in Emilia-Romagna is a premier public-private association supporting the competitiveness of the region's health and wellness industries.

In the field of health, ISOF carries out advanced research on the development of molecules and materials for the treatment of cancer and other non-communicable diseases, including cardiovascular and metabolic disorders such as diabetes. This activity integrates chemistry, materials science, biology and photonic



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approaches, with particular attention to innovative therapeutic strategies, including light-activated therapies. ISOF is actively involved in both international and national research programmes in this area, including Marie Skłodowska-Curie Doctoral Networks and national competitive schemes such as PRIN, contributing to multidisciplinary consortia and translational research efforts.

Relying on consolidated experience in the synthesis, characterization, and validation of advanced materials nanostructured interfaces, and their integration into electronic devices, ISOF has pioneered and lead research for validation and applications of advanced materials and devices in basic and applied neuroscience, with particular focus on astrocytes and their interactions with neurons (neuroglial interfaces).

ISOF has also emerging activities that leverage on quantum materials and technologies for probing, sensing and imaging biological systems (supported by AFOSR and ARO) in partnership with Leonardo Quantum Labs. ISOF also plays a key role in promoting and coordinating CNR participation in strategic initiatives such as the Graphene Flagship and the EIT RawMaterials KIC, PNRR-Ecosister, NEST, and the working group on Advanced Materials, Nanomaterials and Biophysics of US-Italy Joint Commission on Science and Technology, involving multiple CNR institutes and departments. Over the past 20 years, ISOF's fundamental and applied research has contributed to the creation of several spin-offs, including Lipinutragen (nutraceuticals), APM (new polymers), Mediteknology (fluorescent dyes), and Kerline (sustainable biomaterials).

An additional strength of ISOF lies in its commitment to science communication and public engagement. ISOF coordinates *ChangeGame – Il linguaggio della ricerca*, a national network involving 20 CNR institutes across 10 regions of Italy. The initiative promotes research topics and scientific challenges in schools and society through innovative educational approaches. ISOF researchers have also conceived and led numerous European educational projects targeting younger generations, and over the past two decades have published books and magazine articles aimed at raising public awareness on major societal challenges such as energy transition, circular economy, critical raw materials, and water pollution.

ISOF Director:

Manuela Melucci