The Main Objective of ICTP is the scientific and technological advancement of polymeric materials through research and development. This objective is pursued through the following activities:

- Research projects and contracts.
- Scientific and technical advice.
- Training of specialist staff on polymer science.
- Promotion of the culture of polymer science.
- Transfer of results to the business sector.
## Principal Research Lines at ICTP:

- **Design and development of new elastomeric materials** for advanced applications.

- Development of *components for energy conversion and storage* electrochemical devices.

- Design and development of functional *polymeric nanocomposites* based on graphene, carbon nanotubes and inorganic nanoparticles.

- Development of *nanohybrids and interactive polymers* with stimuli-responsive behavior with applications in sensor field, detection systems, drug release, regenerative medicine and other therapies.

- Preparation and development of application of *polymeric nanomaterials*.

- Design and preparation of *biomaterials* for biomedical field.

- Nanostructured polymer and multicomponent systems.

- Heterogeneous polymer systems and organic-inorganic hybrid materials: control of interphases and surfaces, ionic and molecular transport properties, superhydrophobicity and superlipophobicity, optoelectronic properties, etc.

- **Condensation polymers**: membranes for water purification, gas separation and porous materials as catalyst supports.

- Synthesis and modification of polymers with *photochemical and environmental applications*.

- Synthesis and modification of polymers for *technological and biomedical applications*.

- *Heterogeneous materials based on organic polymers*: blends, composites, interfacial agents from chemical modification of polymers, recycling and waste treatment.

- Synthesis and characterization of nanostructured materials developed from well-defined polymers obtained by conventional/controlled polymerization or physical/chemical modification.

- Design, synthesis and characterization of polymer cholesteric liquid crystals (PCLC), twisted nematic, biocompatibles, optoelectronic and multifunctional.
ICTP is divided into **five research departments** divided in research groups

<table>
<thead>
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<th>Departments</th>
<th>Groups</th>
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| Polymer Physics, Elastomers and Applications Energy | • Energy Applications  
• Elastomers  
• Polymer Physics |
| Polymeric Nanomaterials and Biomaterials          | • Biomaterials  
• Polymeric Nanomaterials |
| Polymeric Physical Chemistry                     | • Nanostructured and multicomponent polymer systems  
• Physical-Chemistry of heterogeneous polymer systems  
• Nanohybrids and Interactive Polymers |
| Applied Macromolecular Chemistry                 | • Polymeric Photochemistry  
• Polymer Functionalization  
• Polycondensation and Polymer Membranes |
| Chemistry and Properties of Polymeric Materials   | • Macromolecular Engineering  
• Polymer Engineering  
• Physical-Chemistry and Modelization of Macromolecules |
Elastomers Group

Elastomers group is the unique research group in Spain specialized in elastomers. Our group specializes in the study of science and technology of elastomeric materials and has extensive experience in both basic research and applied technology in the industrial sector.

Research lines:

The group's main objective is the design and development of new elastomeric materials for advanced applications.

- Study of fundamental concepts about elastomers science and technology.

- NMR experiments application in time domain for the study of crosslinked networks, charge/rubber interactions and chain dynamics in elastomeric compounds. Application of low-field NMR (MQ-NMR experiments).

- Development of elastomeric networks with ionic crosslinks and coordination for advanced applications. Shape memory and temperature elastomers (first elastomer with shape memory effect).

- Development of rubber compounds with advanced properties through the addition of fillers and nanofillers.

- Synthesis and characterization of novel polyurethanes with tailored properties.

- Valuation of recycled elastomers as raw material: regeneration mechanisms/devulcanization optimization and recovery of recycled rubber.

- Knowledge transfer: New technological developments for the degradation and recycling of elastomers.
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Recent publications:

Macromolecules, 46, 5549-5560 (2013) Impact factor 5.521

Study on peroxide vulcanization thermodynamics of ethylene-vinyl acetate copolymer rubber using 2,2,6,6,-tetramethylpiperidinyloxy nitroxide Posadas, P., Fernández-Torres, A., Chamorro, C., Mora-Barrantes, I., Rodríguez, A., González, L., Valentín, J.L.  
Polymer International, 62, 909-918 (2013). Impact factor 2.125

Chain dynamics and strain-induced crystallization of pre- and postvulcanized natural rubber latex using proton multiple quantum NMR and uniaxial deformation by in situ synchrotron X-ray diffraction. Che, J., Toki, S., Valentin, J.L., Brasero, J., Nimpaiboon, A., Rong, L., Hsiao, B.S.  
Macromolecules, 45, 6491-6503 (2012). Impact factor 5.521
Our currently work is focused on the development and characterization of proton exchange hybrid membranes for PEMFC based on perfluorosulfonated ionomers, commercial thermoplastic elastomers and organo-inorganic fillers modified with sulfonic groups. Electrochemical behavior is studied by polarization and durability tests performed on a PEMFC test station. Also analysis the hydrogen diffusion through membranes and determine their proton conductivity at different temperatures and relative humidities.

We also carried out the synthesis, morphological and electrochemistry characterization of polymer gels containing different nature ionic liquids, with application as electrolytes in lithium/lithium ion rechargeable batteries. Study the effect of incorporating interfacial agents in electrochemical behavior both electrolytes as in lithium/lithium ion cells. We also perform the synthesis and characterization of hybrid materials based on graphene modified with electronic conductor polymers to achieve their use as electrodes in supercapacitors.

Energy Applications Group

Energy applications group research activity focuses on development of conducting polymers and their application for electric energy storage and generation devices.

Research lines:

Electrodes and electrolytes development for generation and electric power storage devices:

- Rechargeable batteries lithium/lithium ion
- Electrochemical capacitors
- Polymer membrane fuel cells (PEMFC)
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Recent publications:


Proceedings of the 9th International Symposium on New Materials and Nanomaterials for Electrochemical Systems  
Polymer physics group

The main activity of the group is fundamental and applied research in polymeric materials, with wide experience in the areas of polymer blends, composites, hybrid and nanocomposite materials.

Research lines:

The group undertakes diverse research lines, and a generic list is provided below:

- Graphene: Synthesis, functionalization and new strategies for incorporation into polymeric nanocomposites.


- Polymer nanocomposites based on fullerenes and inorganic nanotubes. IF-WS2, IF-MoS2 in various matrices, dual charges strategies and ITNs in multiphase systems.

- Polymer blends nanocomposites: green and sustainable nanomaterials. Addressed nanofibers location, modification of the interface and Starbon® nanocomposites.

- IR microspectroscopy using synchrotron radiation (MIRAS).

- Chemical functionalization of polymer and nanoparticles.

- "Click" chemistry for the design of new functional materials.

- New materials from bio-derived waste revalorization.
Recent publications:


Biomaterials group

The activity of biomaterials group focuses on the development of bioactive biomedical devices that offer a positive contribution to the health patients as well as in the design and preparation of polymeric systems with a specific therapeutic action (antithrombogenic, antiinflammatory, antitumor, etc.). This activity, called "Therapy with Polymers" fits into the modern development concept of "Nanomedicine".

Research lines

- Development of bioactive biomedical devices.
- Design and preparation of polymeric systems with a specific therapeutic action.
- Development of new systems for controlled and targeted release of bioactive compounds.
Recent publications:


Polymeric nanomaterials group research focuses on the manipulation and the control of materials at "nano" scale, which exhibit very different properties to their corresponding micro scale. Research encompasses both basic and applied science establishing relationships between processing technologies, nanocharge-polymer interactions and properties, in order to design new materials commercially attractive.

The group is divided in two subgroups:

- Polymers and gels nanostructured.
- Polymer nanocomposites.

Research lines:

The group's main objective is the design and development of new elastomeric materials for advanced applications.

- Development of macro, micro and multifunctional nanogels for biomedical applications.

- Manufacture of 1D arranges nanostructured polymers: nanotubes, nanofibers.

- Preparation of new structures by modification of polymeric precursors.

- Characterization of macro-and nanostructured polymers.

- Synthesis and functionalization of nanoparticles (organic, inorganic and carbon nanostructures: carbon nanotubes, graphenes, nanocellulose...).

- Development and processing of polymer nanocomposites both solid state or foamed: elastomeric nanocomposites, polymeric foams; bionanocomposites (from tissue engineering to packaging); high performance thermoplastics (i.e. PEEK, PPS, PA) High performance thermosets (i.e. Epoxies for high performance composites); nanostructured block copolymers; enzymatic polymerization.
Research lines (cont.):

- Development of Shape Memory Polymers: copolymers, composites and shape memory nanocomposites and polymer actuators (dielectric elastomers)
- Production of polymer nanofibres by Electrospinning.
- Development of polymer actuators. Dielectric elastomers.
- Synthesis: Functionalization of nanoparticles; synthesis and functionalization of nanocellulose (i.e. PLA); synthesis of block copolymers PLA-PCL and their PUs; enzymatic polymerization (PLA, PCL, PUs, etc.); self-healing.
- Processing: Chemorheology of thermosets and rheology of thermoplastics; mathematical modelling (composites, nanocomposites); fire retardancy in biopolimers, with IMDEA; availability of special techniques: miniextrusion, calendering three roll mill, electrospinning
- Characterization: Thermal degradation and kinetics; crystallization kinetics; water absorption and kinetics; shape memory behavior.
- Technology transfer.
Recent publications:


Graphene materials with different structures prepared from the same graphite by the Hummers and Brodie methods. *Carbon*, 65, 156-164 (2013). Impact factor 5.868


Nanostructured and multicomponent polymer systems group (NANOMULPOL)

The nanostructured multicomponent polymeric systems group research has focused on two major areas:

- Synthesis and characterization of nanostructured polymer
- Multicomponent systems with the ability to form mesophases and multicomponent polymeric materials

Research lines:

- Development of macro, micro and multifunctional nanogels for biomedical applications: Liquid crystal polymer (backbone and/or lateral, linear and/or crosslinked with shape memory) and polypropylene derivatives
- Manufacture of 1D arranges nanostructured polymers: nanotubes, nanofibers: polymers mixtures with micro and nanocomposites
- Viscoelasticity, polyolefins, nano-structured polymeric materials and their structural, thermal and mechanical characterization.

Environmental sustainability and waste plastics concern is evidenced by our participation and coordination in a network included in the Ibero-American Programme for Science, Technology and Development (CYTED).
Recent publications:


Physical-chemistry of heterogeneous polymer systems group (HEMPOL)

HEMPOL group main research activity focuses on the design and development of new materials with diverse applications in fields as energy, construction and environment. The group specializes in the synthesis of organic-inorganic fillers such MOFs and ad-hoc modification of nanoscale fillers (silica, silicates or cellulose, etc.) using new methods developed in our group. Materials obtained this way were studied by themselves or as part of composites or hybrids with polymeric matrix.

Research lines:

- Surface modification (clays, silica, fibers, cellulose...) and preparation of based polymer composites materials.
- Ionic and molecular transport through polymer based membranes: solid electrolytes (Li⁺ cell) conductivity, gas separation, mechanical and barrier properties ...
- Superhydrophobic surfaces based on polymers coatings (water repellency, transparency and mechanical stability).
- Electronics: conductivity, mechanical properties and processability.
- Synthesis and preparation of materials based on conjugated polymers (optoelectronic properties).
- MOF synthesis (Metal Organic Frameworks) and hybrid membranes

Download a brief summarize:

Electrolytes pseudosolids have also been developed based on polyethylene oxide and modified sepiolites. Such materials behave microscopically as fluids showing high ion Li conductivities although macroscopically maintain the solid character even at high temperatures. As a common link to our previous work, there is our work based on ion and molecular transport properties, which is performed by using dielectric spectroscopy and nuclear magnetic resonance for determination of ionic mobility and conductivity; or by absorption and diffusion methods for the study of molecular transport coefficients, especially gases.
Recent publications:


Nanohybrids and interactive polymers group (NyPI)

Our main research activity focuses on the development of nanohybrid and nanostructured materials for applications as sensors, drug delivery and regenerative medicine.

Research lines:

The group's main objective is the design and development of new elastomeric materials for advanced applications.

- Development of polymers responsive to stimuli (smart)
- Development of photoluminescence nanoparticles.
- Development of noble metals nanoparticles
- Development of NPs hybrids
- Development of biodegradable and biocompatible polymers to facilitate the regeneration of the CNS.
- Design polymer surfaces from scratch (polymer synthesis) with: Control surface functionality and its distribution, micro and nanostructures, modify topography.

Download a brief summarize:
Recent publications:


Polymeric photochemistry group

Photochemistry group is active in the synthesis and structural or surface modification of polymers and multicomponent systems, which contribute to environmental conservation, from the point of view of non-accumulation in the environment by biodegradation microbial, antimicrobial properties preventing the formation of biofilms and later "biofouling", as well as detection sensors and bioremediation of pollutants.

Environmental applications of new materials are studied from a biological (nature, biodiversity and microorganisms concentration) and chemical point of view (polymer structure, additives, degradation, etc.).

Research lines:

The group's main objective is the design and development of new elastomeric materials for advanced applications.

- Controlled structures:
  - Block-copolymers.
  - Hiperbranched polymers.
  - Nanocomposites.

- Fluorescent Probes:
  - Analites/process dynamics detection in polymers.
  - Polymer thin films preparation.

- Environmental degradation:
  - New polymeric materials.
  - Commodities polymers.

Aim 1: Study of environmental degradation process and polymer stabilization. In order to obtain photoselective, photodegradable and bioderadable agricultural thin films, through the incorporation of specific additives. Study of poliolefin films stabilization, through the addition of antioxidizers. Study of polymers degradation through chemiluminiscence.

Aim 2: Fluorescent Probes. Synthesis of novel organic compounds and high fluorescent polymeric structures. Synthesis of "antenna-effect" dendrimers. Evaluation in front of environmental pollutes, organic acids and metallic salts as interest analites. Study of polymer processes detection: crosslinking reactions, adhesives photocure, thermal transitions, molecular compounds absorption. regeneration of the central nervous system (CNS) is other area of group’s work.
Recent publications:


Polymer functionalization group (FUPOL)

Polymer functionalization group is formed by about 10 researchers, three of them with permanent position in CSIC. The group creates and studies new methodologies to chemically modify polymeric materials. The ultimate aim is to provide to the society significant technological and/or biomedical advances.

To achieve that, the group has experience in organic synthesis, polymer chemistry and in the biological evaluation of polymeric materials, and they perform their activities in close collaboration with complementary groups.

Research lines:

- Preparations and functionalization of new polymeric materials for biomedical and technological applications.
- Supercritical CO₂
- Development of new plasticizers for PVC.
- Multifunctional polymers obtained by a bottom-up approach.

Download a brief summarize:

Example of polyvinylpyrrolidone. The aim is to prepare unpublished polyvinylpyrrolidone functionalization routes, a polymer with many applications in biomaterials area. We are tuning up functionalization processes of soluble linear in systems water, also preparation of amphiphilic networks, with applications in angiogenesis, gene therapy, transport properties modulation, etc.

FUPOL Group
Applied Macromolecular Chemistry Department

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Del Prado Abellán, Anselmo
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Recent publications:


Polycondensation and polymeric membranes group

The polycondensation and polymeric membranes group is devoted to the preparation and study of new and special condensation polymers.

In the last fifteen years, a major objective of the group is the preparation of polymer membranes with application in several fields such as: ultrafiltration, reverse osmosis and gas separation.

These investigations, which have always been funded by public and private entities, have led to 13 theses defenses, and more than 100 publications in this area. Recently, thanks to the participation in a consolider project, the group has launched a new research line focused in synthesis of porous polymers designed mainly to anchoring catalysts.

Research lines:

- Polymeric membranes for gas separation.
- Polymeric membranes for water purification.
- Porous polymer for anchoring catalysts.
- Computational modeling.

The group, led by Prof. Javier de Abajo and Prof. Jose G. de la Campa is constituted by two Research Professors, one Senior Researcher, two Tenured Researcher, one Postdoctoral Researcher and eight Ph.D. students.

Due to the multidisciplinary character of our research activity, several collaborations have been established with other groups of excellence not only in Spain but also in Europe and the United States as the Institute of General Organic Chemistry of CSIC, Seoul Hanyang University, Department of Chemical Engineering from Texas University, as well as with the industry through concerted projects (Acciona, Befesa o Porous Fibers).
Recent publications:


Macromolecular engineering group

Macromolecular engineering group performs the synthesis and modification of polymers having well-defined structures and complex nanostructures using conventional/controlled polymerization (classic radical polymerization, ring opening polymerization and chemical modification) and advanced polymerization (living/controlled polymerization, metallocene chemistry, "click" chemistry and physical modification).

Research lines:

- Synthesis and modification of well-defines polymers (controlled polymerization):
  - Polymeric micro-nano particles/fibers
  - Surface/coatings structure-functionality.
  - Hybrid materials and nanocomposites.

Download a brief summarize:

Finally, we have synthesized inorganic nanoparticles, such as iron oxide and titanium for the following use in magnetic systems and hybrid nanocomposites. Aimed to obtain advanced systems, such as those capable of selectively recognizing specific proteins; superhydrophobic, bioactive compounds transport systems, for hyperthermia or antimicrobial systems among others.
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Recent publications:


Polymer engineering group

Polymer engineering group has its origins in the mid-eighties, during the global environmental crisis and the role played in it by the plastic materials, particularly in major solid waste streams. Management has to be effectively combined with knowledge and scientific-technical progress with the rest of the strategic sectors: economic, industrial, social and political.

Research lines:

Study and development of heterogeneous materials based total or partially on organic polymers:

- Blends,
- Composites,
- Interfacial agents from chemical modification of polymers,
- Recycling and waste treatment.
Recent publications:


Physical-chemistry and modelization of macromolecules group

FQMM group's activity focuses on the design, synthesis and characterization of polymer cholesteric liquid crystals (PCLC), twisted nature, biocompatible, optoelectronic, multifunctional and with double thermotropic and lyotropic behavior.

Research lines:

- Structural characterization of PCLC synthesized and their complexes.
- Molecular modeling.

Molecular modeling allows us to design new molecules and also their properties using chemical computational programs: ChemBioOffice, Cerius2, Materials Studio, Discovery Studio, Schrödinger Suite (macromolecule-receptor interaction). With the aid of a computerized laboratory reactor it can be controlled polycondensation and crystallization kinetics of PCLCs.
Recent publications:


Anticarcinogenic polymer nanoparticles with high selectivity
Particles are based on a family of amphiphilic copolymers that are able to form polymer micelles at nanometric scale.

New industrial procedure for characterization of elastomeric latex in real time
A simple and economical procedure for a complete characterization of latex manufacturing process, from quality control of raw material, following with pre-vulcanization up to post-vulcanization.

New smart elastomeric materials with thermal stimuli response
An elastomeric material formed by interpenetrated ionic and covalent networks with shape memory effect which allows to respond to thermal stimuli.

Novel one-step method to create functional wrinkles in polymeric surfaces
A method to produce structured and functional surfaces by sculpting wrinkles on polymeric materials in a controlled manner.

Polymer nanocomposites with high thermal, mechanical and electrical performance for structural applications in aeronautical and aerospace engineering
A polymer nanocomposite with thermal, mechanical and electrical properties drastically improved due to excellent filler dispersion in polymer matrix and to an optimal filler-matrix interface adhesion.
Functionalization of polystyrene surfaces in a low cost and controlled way, maintaining its transparency, for applications in biomedicine and pharmacy
Method to functionalize polystyrene surfaces in a controlled way.

Ionic liquids with low viscosity as electrolytes in electrochemical devices for energy storage
A new family of Ionic Liquids (ILs) with tiazole-like core structure, which possess high ionic conductivity, thermic & electrochemical stability, low viscosity and no inflammability.

Multicomponent hydrogels for in vitro cell manipulation
A new generation of multicomponent hydrogels based on vinylpyrrolidone that can be obtained in a simplistic one step process.

Novel polymeric coating for bioactive agents release in prosthetic meshes that avoids post-operative infections
A multilayer dressing that improves compromised wound and ulcers healing, in particular this dressing is suitable to treat patients with diabetes, elderly patients and/or people with reduced blood flow.

Novel multilayer dressing for compromised wound healing
Polymeric foams based on epoxy resin filled with nanostructured carbon materials. These foams exhibit higher conductivities and permittivities than conventional foams.
Rigid polymer foams with good electrical conductivity
Polymeric foams based on epoxy resin filled with nanostructured carbon materials. These foams exhibit higher conductivities and permittivities than conventional foams.