Research Groups:

"SURFACTANTS, ENZYMES AND EMULSIONS" (TEP212)

(https://tep212.ugr.es/)

"INTERFACE ENGINEERING AND BIOCHEMICAL TECHNOLOGY" (RNM332)

(https://Rnm332.ugr.es/)

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KEY WORDS:
Detergent, Surfactants, Enzymes, Encapsulation, Nanoparticles, Encapsulation, Ozonation, Environmental assessments, Biodegradation, Toxicity

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1. Introduction.

The research group aims to develop specific formulations for the food industry, containing non-toxic,biodegradable surfactants from natural sources and/or specific enzymes, including nanofluids to treat each type of dirt, formulations with eco-friendly-surfactants that improves the wetting and washing efficiency, as well as the production of biosurfactants from waste using microorganisms and their possible applications. Another important objective of the group is the development of protocols for cleaning and disinfecting using ozone, surfactant solutions, enzymes, nanoparticles, immobilized and encapsulate enzymes. The optimization and application of cleaning protocols, which should be specific to the type of dirt to be treated, and which are necessary in the food industry can be an important challenge for efficient cleaning and better operation of industrial facilities.

The washing efficiency is measured using the BSF method, developed and patented by the research team and modified to incorporate ozone washing bath.

In order to achieve the proposed objectives, it is necessary to characterize both the different soils to be tested and the components of the formulations, especially the surfactant products, analyzing their biodegradability and toxicity, as well as the different enzymes that are incorporated into the formulations, determining their activity and stability due to the presence of the different components of the formulations. The search for microorganisms and more suitable conditions for the production of biosurfactants etc.

The research group develops different standardized methodologies for the determination of surfactant products as well as for their characterization: specific analyzes for anionic and

nonionic surfactants, surface and interfacial tensions, biodegradability and toxicity of surfactants etc.

2. Member of Societies.

- Comité Español de la Detergencia, Tensioactivos y Afines (Spanish Committee of Detergents, Surfactants and Related Products) (CED)
- **"Claudi Mans" Prize** (1st Ed), 52nd CED Conference (6-7 March 2024)

3. General Objectives.

- Development of low environmental impact multifunctional detergent formulations.
- Study of microfibers (MFs): Emerging pollutants from laundry, environmental impact and degradation of textile. Microfibers, and their interactions with washing waters components.
- Extraction of saponins from vegetable wastes

4. Techniques used and/or available in our laboratories:

Topics	Techniques	Some external verifiable results and funding
Detergency and cleaning evaluation (surfactants, enzymes, nanoparticles)	Soiling of different hard surfaces	[Vic17]
	Cleaning evaluation (micromolecular level) using Quartz Crystal Microbalance with Dissipation monitoring (QCM-D)	
	Cleaning evaluation (macromolecular level) milli-manipulation techniques using a Milli-manipulator	[Her20], [Sae24]
	Cleaning evaluation (macromolecular level) BSF device (DOE)	PAT-01, [Vic17], [Avi21], PRO-07
	Cleaning maps methodology	[Her20], [Sae24], PRO-07
	Topographically characterization of surfaces using Confocal Laser Microscopy [CLSM] (CIC-UGR). Visual inspection by optical microscope	[Sae24]
	Food allergenicity assessment by ELISA test	(Writing process)
Surfactant characterization	Critical micellar concentration Foaming of surfactants and detergents (Ross Miles method)	[Rin23], PRO-05
	Surface and interfacial tension tests Emulsions and micro-emulsions, stability, size distribution, Z-potential Rheological behaviour HPLC, TOC	
	Wettability assays (UNE-EN-1772 test)	[Gar14], PRO-05
Enzymes	Activity assays, Stability assays, Shelf-life assays	[Her19], [Vic22], PRO-07
	Immobilization	[Vic19], PRO-09
Disinfection and biofilm removal (outsourced analysis)	In-vitro tests for evaluation of antimicrobial activity (with *L. monocytogenes, E. coli, S. enterica, P. aeruginosa, L. innocua, P. putida*): MVC determination Biofilm removal assays Biofilm ageing *(with L. innocua, P. putida*)	[Med20]
Essential oils	Enzimes stability with essential oils	(Writing process)
Cleaning wih Ozone	Ozone analysis	[Avi21], PRO-07
Encapsulation	Size characterization (Mastersizer, Zetasizer) Stability evaluation (Turbiscan) Zeta potential	[Fer20]
Environmental assessment. Ecotoxicological evaluation	Biodegradation. Aerobic biodegradation (OECD 301F) Anaerobic biodegradation (ISO 11734:1995)	PRO-05, PRO-07
	Environmental assessment (toxicity). Luminescent bacteria *Vibrio fischeri* (UNE-EN ISO 11348-2:2009) Microcrustaceans *Daphnia magna* (UNE-EN ISO 6341:2013)	[Rio 24], [Rio 23], [Lec22], [Rio18], [Rio17a], [Rio17b], [Rio17c], [Rio16], PRO-05, PRO-07
Skin irritation	Zein Method	[Lec23], PRO-05, PRO-07

5. Collaboration with research centres through stays, publications or projects.

	Center	Researcher	Verifiable results
Lodz University of Technology	Univ. Tech. Lodz, **Poland**	Dr. Ledakowicz, Dr. Gmurek	Stay, [Rio17], [PRO20]
UNIVERSITY OF CAMBRIDGE	Univ. Cambridge, **UK**	Dr. Wilson, Dr. Routh	Stay, [Fer20] [Gua19].
UNIVERSITY OF BIRMINGHAM	Univ. Birmingham, **UK**	Dr. Fryer, Dr. Zhang	[Her20]
FURB	Univ. Blumenau, **Brazil**	Dr. Tavares	CON-04
CSIC	CSIC, Barcelona, **Spain**	Dra. Solans	Stay
YNU	Univ. Yokohama, **Japan**	Dr. Aramaki	Stay
uca UNIVERSIDAD DE CÁDIZ	Univ. Cádiz**, Spain**	Dr. Quiroga, Dr. Sales	Stay
	Univ. of Monastir, **Tunisia**	Dr. Mansour, Dr. Mehneni	Stay, [Met21a,b,c]
UNIVERSITÀ DELLA TUSCIA	Univ. Viterbo, **Italy**	Dr. Federici	Stay
dmc-research	DMC Research-DOCMCA SAU, Granada, **Spain**	Dr. Baños	[Med20]
INRAE SayFood	INRAe, UMR SayFood, Univ. Paris-Saclay, **France**	Dr. Ávila-Sierra	[Sae24], [Lec23]
TÉCNICO LISBOA	Center for Biological and Chemical Engineering IST, **Lisbon**		Stay
Swansea University Prifysgol Abertawe	**Swansea Univ.**	Dr. Ojeda-ledo, Dr. Ju-Nam	[Pro20]

6. Collaboration with companies (with verifiable results).

TINO STONE S.A. (Spain)

CON-01

SPB (Spain)

SENSIENT Colors LTD (Spain)

COSENTINO (Spain)

CON-06

BELTEGEUX-CHRISTEYNS Food Higiene (Spain)

CON-03

BETELGEUX
CHRISTEYNS FOOD HYGIENE

CRODA

CRODA

DMC Research-DOMCA SAU) (Spain) [Med20]

dmc-research

PERSAN (Spain) [PRO20]

persán

TEXTIL SANTANDERINA

[PRO20]

7. Most relevant funded projects (more detailed information in https://tep212.ugr.es/investigacion/proyectos, https://rnm332.ugr.es/investigacion/proyectos)

Code	Project Description
PRO-20	**C-ING-122-UGR23**. Unveiling the ecological impact of microfibers released in textile Washing wastewater. Univ. Granada (2024) 15,000 EUR
PRO-19	**PP2023.PP.61**- Development of multifunctional detergents with disinfectant and anti-allergenic properties for food contact surfaces. Univ. Granada (2024) 2,500 EUR
PRO-18	**P20_A231222-** Environmental Assessment of Microfibres Released by Fabrics in Combination with Washing Water Constituents. Univ.Granada (2022-2023) 1,000 EUR
PRO-17	**26102022-** Qsar Modelling of the Skin Irritation of Surfactant-Based Formulations by In Vitro Methods. Univ. Granada (2022-2024)
PRO-16	Environmental Impact Assessment of Washwater in the Presence of Nanoparticles and Microplastics. Univ. Granada (2022)
PRO-15	**PP2022.EI.04-** Valorisation of Plant Residues for their Use as Surfactant, Antibacterial and Antioxidant Agents and their Use in Cleaning Products, Food and Cosmetics. Univ. Granada (2022-2024)
PRO-14	**HORIZON-MSCA-2022-CITIZENS-01 GA: 101061307-** Openresearchers2223 (2022-2023)
PRO-13	**Openresearchers2020 -** Open Researchers 2020 (2020-2021)
PRO-12	**FCT-18-13165-** Project Piiisa (2019-2020)
PRO-11	**P20_00167-** Valorisation of Plastic Waste from the Refuse Fraction of Municipal Solid Waste Treatment Plants by Pyrolysis (Pyromix). Univ. Granada (2021-2022)
PRO-10	**612247-EPP-2019-1-ES-EPPKA2-EUR-UNIV- Arqus European University Alliance** (2019-2022)
PRO-09	**A-TEP-030-UGR18**-Immobilisation of Enzymes for Inclusion in Surfactant Formulations for Cleaning of Mixed Food Dirt. FEDER-Junta Andalucía, Spain (2020-2022) 14,900EUR
PRO-08	**EQC2019-005986-P-**Purchase of a modular nanoparticle characterisation and emulsion stability system (2020) 192,655 EUR
PRO-07	**CTQ2015-69658-R-**Surfactant formulations and CIP cleaning procedures for the food industry, using nanofluids, enzymes and ozone. Ministerio de Economía y Competitividad, Spain (2016-2019) 148,830 EUR
PRO-06	**P10-TEP-6550** (Junta de Andalucía)- **PP2015.08** (University of Granada, Spain)- Development of strategies for the valorisation of oily waste biomass: production and characterization of highly biodegradable surfactants with potential applications. (2011-2015)
PRO-05	**CTM2010-16770-**Ecological surfactant formulations specific for different soils and substrates. Ministerio Ciencia e Innovación, Spain (2011-2014) 125,840 EUR
PRO-04	**CTQ2006-12089-** Performance of ozone for the degradation of surfactants and greasy food soils in washing processes, Plan Nacional Ministerio Educación y Ciencia-Proyectos 2006 (2006-2009) 141,570EUR
PRO-03	**FEDER 1FD1997-0931** – Formulation of specific liquid detergents for the agri-food industry and the hotel and catering sector. FEDER y Fondo Nacional I+D (Spain) (1999-2002) 128,000 EUR
PRO-02	PHB2012-0277- Enzyme preparations for food waste degradation. Ministerio de Educación y Cultura (Spain) (1999-2002) 42,000 EUR
PRO-01	Production of low antigenicity enzymatic hydrolysates of mil proteins. CICYT - ABBOTT LABORATORIES. (1995-1997)

8. Cited and representative papers (full information available at: https://tep212.ugr.es/publicaciones/articulos; https://rnm332.ugr.es/publicaciones/articulos)

Code	Papers
[Avi21]	Avila-Sierra A, Vicaria JM, Lechuga M, Martínez-Gallegos JF, Olivares-Arias V, Medina-Rodríguez AC, Jiménez-Robles R, Jurado-Alameda E. (2021) Insights into the optimisation of the Clean-In-Place technique: Cleaning, disinfection, and reduced environmental impact using ozone-based formulations. Food and Bioprod Proces. 129, 124-133.
[Bur14]	Burgos A., Luzón G., Jurado Alameda E. (2014) Effectiveness of milk soil removal in a bath-substrate-flow (BSF) device for different types of milk. J. Food Eng. 142, 94-99.
[Fer20]	Fernández-Serrano, M., Routh,A.F., Ríos, F., Caparrós-Salvador, F., Ortega, M.A.S. (2020) Calcium alginate as a novel sealing agent for colloidosomes. Langmuir. 36, 8398-8406.
[Gar14]	García Martín, J.F., Herrera-Márquez, O., Vicaria, J.M., Jurado E. (2014) Synergistic effect on wettability of mixtures of amine oxides, alkylpolyglucosides, and ethoxylated fatty alcohols. J. Surfact. Det. 17, 1035-1042.
[Gua19]	Guarnido, I.L., Routh, A.F., Mantle, M.D., Fernandez-Serrano, M., Marr, P.C. (2019) Ionic liquid microcapsules: Formation and application of polystyrene microcapsules with ionic liquid cores. ACS Sustain Chem and Eng. 7, 1870-1874.
[Her19]	Herrera-Márquez, O., Fernández-Serrano, M., Pilamala, M. Jácome, M.B., Luzón, G. (2019) Stability studies of an amylase and a protease for cleaning processes in the food industry. Food Bioprod Proces. 117, 64.
[Her20]	Herrera-Márquez. O., Serrano-Haro M., Vicaria J.M., Jurado-Alameda E., Fraatz-Leál A.R., Zhang Z.J., Fryer P.J., Avila-Sierra A. (2020) Cleaning maps: A multi length-scale strategy to approach the cleaning of complex food deposits. Journal of Cleaner Production. 261, 121254, 1-11.
[Jur11]	Jurado-Alameda, E., Bravo-Rodriguez, V. Altmajer, D., Valle, R.S.C (2011) Effectiveness of Starch Removal in a Bath- Substrate-Flow (BSF) Device Using Surfactants and Alfa-Amylase. Food Hydroc. 25, 647-653.
[Jur14]	Jurado, E., Altmajer, D., García-Román, M., Jiménez, J.L. (2014) Study of heat-denatured whey protein removal from stainless steel surfaces in clean-in-place system. International Dairy Journal. 38, 195-198.
[Jur15]	Jurado-Alameda E, Herrera-Márquez O, Martínez-Gallegos JF, Vicaria JM (2015) Starch-soiled stainless steel cleaning using surfactants and α-amylase. J. Food Eng. 160, 56-64.
[Lec13]	Lechuga, M., Fernández-Arteaga, A., Fernandez Serrano, M., Jurado, E., Burgos, A., Rios, F. (2013) Ozonitation of Anionic and Non-ionic Surfactants in Aqueous Solutions: Impact on Aquatic Toxicity. J. Surfact. Deterg. 16, 779-784.
[Lec23]	Lechuga, M., Fernández-Serrano, M, Ríos, F., Fernández-Arteaga, A., Jiménez, R. (2022) Environmental impact assessment of nanofluids containing mixtures of surfactants and silica nanoparticles. Environ. Sci. Pollut. Res. 29(56), 84125-84136.
[Lec23]	Lechuga, M., Ávila-Sierra, A., Lobato-Guarnido, I., García López, A.I., Ríos, F., Fernández-Serrano, M. (2023) Mitigating the skin irritation potential of mixtures of anionic and non- ionic surfactants by incorporating low-toxicity silica nanoparticles. J. Mol. Liq. 383, 122021.
[Lob23]	Lobato-Guarnido, I., Luzón, G., Ríos, F., Fernández-Serrano, M. (2023) Synthesis and Characterization of Environmentally Friendly Chitosan–Arabic Gum Nanoparticles for Encapsulation of Oregano Essential Oil in Pickering Emulsion. Nanomaterials, 13, 2651.

[Med20]	Medina-Rodríguez A.C., Ávila-Sierra A., Ariza J.J., Guillamón E., Baños-Arjona A., Vicaria J.M., Jurado E. (2020) Clean-in-place disinfection of dual-species biofilm (*Listeria* and *Pseudomonas*) by a green antibacterial product made from citrus extract. Food Control. 118, 107422, 1-7.
[Met21a]	Methneni, N., Ezdini, K., et al. (2021a) Occurrence of textile dyes and metals in tunisian textile dyeing effluent: Effects on oxidative stress status and histological changes in balb/c mice. Internat J Mol Sci. 22, 12568.
[Met21b]	Methneni, N., Morales González, J.A., Jaziri, A., Mansour, H.B., Fernandez-Serrano, M. (2021b) Persistent organic and inorganic pollutants in the effluents from the textile dyeing industries: Ecotoxicology appraisal via a battery of biotests. Environm Res. 196, 110956.
[Met21c]	Methneni, N., Morales González, J.A., Loco, J.V., Anthonissen, R., Maele, J.V., Verschaeve, L., Fernandez-Serrano, M., Mansour, H.B. (2021c) Ecotoxicity profile of heavily contaminated surface water of two rivers in TunisiaEnvironm Toxicol and Pharmac. 82, 103550.
[Rin 23]	Rincón-Romero, J.F., Ríos, F., Reyes-Requena, A., Luzón, G., López-García, A.I. (2023) Surface and thermodynamics properties of commercial fatty-alcohol ethoxylate surfactants. J. Mol. Liq. 376, 121396.
[Rio16]	Lechuga, M., Fernández-Serrano, M., Jurado, E. Nuñez-Olea, J., Ríos, F. (2016) Acute toxicity of anionic and non-ionic surfactants to aquatic organisms. Ecotoxicol. Environ. Saf. 125, 1-8.
[Rio16]	Rios, F., Fernández-Arteaga, A., Lechuga, M., Jurado, E., Fernández-Serrano, M. (2016) Kinetic study of the anaerobic biodegradation of alkylpolyglucosides and the influence of their structural parameters. Env. Sci. Pol. Res. 23, 8286-8293
[Rio17]	Rios, F., Olak-Kucharczyk, Gmurek, M., Ledakowicz, S. (2017) Removal efficiency of anionic surfactants from water during UVC photolysis and advanced oxidation process in H2O2/UVC system. Arc. Env. Prot.43, 20-26.
[Rio17a]	Ríos, F., Lechuga, M., Fernández, M., Fernández-Arteaga, A. (2017) Aerobic biodegradation of amphoteric amine-oxide-based surfactants: effect of molecular structure and initial surfactant concentration. Chemosphere. 171, 324-331.
[Rio17b]	Ríos, F., Lechuga, M., Fernández-Arteaga, A., Jurado, E., Fernández-Serrano, M. (2017) Anaerobic digestion of amine- oxide-based surfactants: biodegradation kinetics and inhibitory effects. Biodegradation. 28(4), 303-312.
[Rio17c]	Ríos, F., Fernández-Arteaga, A., Lechuga, M., Jurado, E., Fernández-Serrano, M. (2017) Ecotoxicological characterization of polyoxyethylene glycerol ester non-ionic surfactants and their mixtures with anionic and non-ionic surfactants. Environ. Sci. Pollut. Res. 24(11), 10121:10130.
[Rio18]	Ríos, F., Fernández-Arteaga, A., Fernández-Serrano, M., Jurado, E., Lechuga, M. (2018) Silica micro/nanoparticles reduce toxicity of surfactants solutions. J. Hazard. Mater. 353, 436-443.
[Rio23]	Ríos, F., Lechuga, M., Lobato-Guarnido, I., Fernández-Serrano, M. (2023) Antagonistic Toxic Effects of Surfactants Mixtures to Bacteria *P. putida* and Marine Microalgae *P. tricornutum*. Toxics. 11(4), 344.
[Rio24]	Ríos, F., Caparrós-Salvador, F., Lechuga, M., Fernández-Serrano, M. (2024) Complete biodegradability assessment of polyoxyethylene glycerol ester non-ionic surfactant: aerobic, anaerobic, combined biodegradation and inhibitory effects. Water Res. 120857.
[Sae24]	Sáenz-Espinar, M.J., Arroyo-Camarena, M., Vicaria, J.M., Luzón, G., Ávila-Sierra, A. (2024) Multi-length scale approach to investigate cleaning of food-derived deposits adhered to hard surfaces: mixtures of starch, whey protein, and lard. Food Bioproc. Technol. (In Press)

[Vic17]	Vicaria JM, Jurado E, Herrera-Márquez O, Olivares-Arias V, Ávila-Sierra A. (2017) Analysis of different protocols for the cleaning of corn starch adhering to stainless steel. J Clean Prod. 168, 87.
[Vic18]	Vicaria J.M., Herrera-Márquez, O., Jurado-Alameda, E. (2018) Cleaning of dried starch adhered to stainless steel using electrocleaning. Optimization of the experimental conditions. Food Control. 84,41-48.
[Vic19]	Vicaria JM, González-Beneded R, Ávila-Sierra A, Jurado E. (2019) Use of α-amylase/silica particle suspensions to optimize cleaning in a simulated cleaning-in-place system. J Food Eng. 247, 64-73.
[Vic22]	Vicaria JM, Herrera-Márquez O, Serrano-Haro M, Vidal A, Jurado E, Jiménez-Pérez JL. (2022) Optimization of surfactants formulations to stabilise proteases and amylases. Chem Eng Sci. 260, 117858.

9. Research projects and contracts with different companies.

Code	Contract description	Company/Centre
CON-06	UGR- 5145- Asesoramiento para la mejora del proceso de limpieza en mezcladoras de la fábrica de Silestone. 4.403 EUR	Cosentino Reserch and Development S.L. + OTRI UGR (2021-2022)
CON-05	**IDI-20120160-**High-performance processes for circuit hygiene in the dairy industry. CDTI, Spain (2012-2014) 454.393 EUR	Beltegeux S.L., Univ. Valencia (Spain), Univ. Castilla La Mancha (Spain)
CON-04	Development of strategies for the valorisation of waste biomass, production and characterization of biosurfactants and study of their technological applications (2013-2014) 338.893 EUR Ministerio de educación y Cultura y Deportes y la Fundacao coordenacao de aperfeicoamento de pessonal de nivel superior (CAPES) (Brazil)	Univ. Blumenau (Brazil), Univ. Região de Joinville (Brazil), Univ. Federal de Santa Catarina (Brazil)
CON-03	**CIP-NANOTEC-**High-performance hygiene processes in CIP systems through the development of (nano)-materials and new chemical technologies (2012-2013) 59.000 EUR	Beltegeux S.L.
CON-02	Formulation of specific enzyme-based and bio-degradable detergents for cleaning and disinfection of hard surfaces (2008-2013) 238.304 EUR	PRODEFUT S.L.
CON-01	Synthesis and characterisation of new cleaning, treatment and protection products for natural stone (2009-2011) 200.000 EUR	TINO STONE GROUP, Univ. Cádiz (Spain)

10. Patents

Code	Patent Description
PAT-07	WO 2017/064345 A1- Household utensil that can be partially heated by microwaves (2017). Titular: University of Granada (Spain)
PAT-06	ES2518790-Procedure and device for cleaning metal surfaces using a direct current (2015). Titular: University of Granada (Spain)
PAT-05	WO 2015/166126 Al- Composition for removing cements and cement-based mortars. (2015) Titular: University of Granada, MOREWITH INVESTMENTS (Spain)
PAT-04	ES2400155B1- Stripping compositions, pre-current compositions of the same, their preparation procedure “in situ”, and their use to strip paint, varnish, and lacquer (2013). Titular: University of Granada. TINO STONE GROUP, S.A. (Spain)
PAT-03	ES2352934-Highly wetting surfactant compositions (2011). Titular: University of Granada (Spain)
PAT-02	WO2009/000958 A1-Detergents for hard surfaces (2008). Titular: University of Granada (Spain)
PAT-01	ES2251269B1-BSF Method (bath - substrate - flow) and device for the evaluation of the detersive and dispersant efficacy of surfactants, detergency builders and of detergent compositions for hard surfaces (2007). Titular: University of Granada (Spain)

11. Equipments and Techniques.

Larger and high-cost equipment will be used through the Scientific Instrumentation Centre of the University of Granada (CIC, http://cic.ugr.es) with reduced costs. Experience in different techniques as SEM, TEM, or Confocal Laser Microscopy [CLSM).

Equipment available in our laboratories:

- Laser diffraction particle size analysis (0.1–1000µm) **Mastersizer 3000E** from Malvern Panalytical
- Nanoparticle Tracking Analysis (10-1000nm) with high sensitivity camera: Nanosight NS300 from Malvern Panalytical
- **Zetasizer** Ultra from Malvern Panalytical
- Static Multiple Light Scattering – **Turbiscan** LAB Expert (Formulation) to detect coalescence, flocculation, creaming, sedimentation.
- Liquid Chromatograph (HPLC) from Shimadzu with IR, UV, fluorescence, and ELSD-LT detectors
- Silverson L5M rotor-stator mixer (Silverson®, Chesham, UK)
- Oxitop® biodegradation reactor aerobic and anaerobic biodegradation tests
- Quartz Crystal Microbalance with Dissipation monitoring (QCM-D)
- Optical microscope, AXIO Lab A1 ZEISS with a MOTICAM color digital camera
- LUMIStox from Dr. Lange, for toxicity tests, Light incubators for toxicity tests
- Milli-manipulator (milli-manipulation techniques)
- Equipment for the determination of Total Organic Carbon (TOC) and Dissolved Organic Carbon (DOC) (Shimadzu)
- Force tensiometer, Krüss K11
- Laminar flow cabinet for microorganism culture
- BSF (Bath-Substrate-Flow) devices for the evaluation of the detersive and dispersing effectiveness of surfactants, detergency builders and hard surface detergent compositions
- Automatic equipment for volumetries (Redox, acid-base) Titrino (Metrohm)
- Pendant drop tensiometer KSV CAM 200
- Ozone Generator and Meter Spectrophotometer ANSEROS
- Generator and in-line ozone meter of the house Spectrophotometer
- Rheometer HAAKE VT 500
- UV Cary 100 Spectrophotometer, Varian