

# 15 PhD positions in the EU Horizon 2020 Marie Skłodowska-Curie Project:



**Applications are invited for 15 PhD positions** (“Early Stage Researchers”) to be funded by the Marie-Sklodowska-Curie Innovative Training Network “INNOVEOX – Training of a new generation of researchers in Innovative Electrochemical Oxidation processes for the removal and analysis of micro-pollutants in water streams” within the Horizon 2020 Programme of the European Commission. INNOVEOX is a consortium of high-profile universities, research institutions and companies located in Belgium, Germany, the Netherlands, the United Kingdom, France and Greece (**Figure 1**).

## Key background info

### Number of positions available

15 Phd Positions

### Research Fields

Water treatment/purification – Environmental Engineering - Analytical Chemistry – Chemical Engineering - Clean technologies, Circular Economy, Life Cycle Assessment

### Keywords

wastewater treatment, priority pollutants degradation, electrochemistry, chromatography, mass spectrometry

### Career Stage

Early Stage Researcher (ESR) or 0-4 yrs (Post Graduate)

### Benefits and salary

The successful candidates will receive an attractive salary in accordance with the MSCA regulations for Early Stage Researchers. The exact (net) salary will be confirmed upon appointment and is dependent on local tax regulations and on the country correction factor (to allow for the difference in cost of living in different EU Member States). The salary includes a living allowance, a mobility allowance and a family allowance (if married). The guaranteed PhD funding is for 36 months (i.e. EC funding, additional funding is possible, depending on the local Supervisor, and in accordance with the regular PhD time in the country of origin). In addition to their individual scientific projects, all fellows will benefit from further continuing education, which includes internships and secondments, a variety of training modules as well as transferable skills courses and active participation in workshops and conferences.

**On-line Recruitment Procedure (see Appendix 1 for full description)**

All applications proceed through the on-line recruitment portal on the [innoveox.eu](http://innoveox.eu) website. Candidates apply electronically for one to maximum three positions and indicate their preference. Candidates provide all requested information including a detailed CV ([Europass format](#) obligatory). During the registration, applicants will need to prove that they are eligible, according to the ESR definition, mobility criteria, and English language proficiency. The deadline for the on-line registration is **6 October 2019**. The Innoveox Recruitment Committee selects between 20 and maximum 30 candidates for the Recruitment Event which will take place in Leuven (**21 November 2019**). The selected candidates provide a 20 minute presentation and are examined by the Recruitment Committee. In order to facilitate their travel, selected candidates (from outside Belgium) receive a fixed, lump sum of 250 euro (paid by the prioritised Supervisor). The final decision on who to recruit is communicated the day after the Recruitment Event. The selected ESRs are to start their research as quickly as possible (target: 1 January 2020).

**Applicants need to fully respect three eligibility criteria (to be demonstrated in the Europass cv):**

**Early-stage researchers (ESR)** are those who are, at the time of recruitment by the host, in the first four years (full-time equivalent) of their research careers. This is measured from the date when they obtained the degree which formally entitles them to embark on a doctorate, either in the country in which the degree was obtained or in the country in which the research training is provided, irrespective of whether or not a doctorate was envisaged.

**Conditions of international mobility of researchers:**

Researchers are required to undertake trans-national mobility (i.e. move from one country to another) when taking up the appointment. At the time of selection by the host organisation, researchers must not have resided or carried out their main activity (work, studies, etc.) in the country of their host organisation for more than 12 months in the 3 years immediately prior to their recruitment. Short stays, such as holidays, are not taken into account.

**English language:** Network fellows (ESRs) must demonstrate that their ability to understand and express themselves in both written

and spoken English is sufficiently high for them to derive the full benefit from the network training.

## The 15 available PhD positions

### **ESR1: Secondary oxidation by electrochemically produced sulphate radicals (POSITION FILLED)**

**Host:** University of Leuven (Belgium)

**Main supervisor:** Prof. Raf Dewil (raf.dewil@kuleuven.be)

**Duration:** 36 months

**Required profile:** Chemical Engineer, Environmental Engineer, Bio-Science Engineer or Chemist

**Description:** The use of sulphate radical ( $\text{SO}_4^{\cdot-}$ ) based oxidation processes (SR-AOP) has gained attention as an innovative alternative for typical AOP processes because of some distinct advantages of which the most important are (i) the pH independency of the process (e.g., at neutral pH,  $\text{SO}_4^{\cdot-}$  is more reactive than  $\cdot\text{OH}$ ) (ii) the very fast reaction between  $\text{SO}_4^{\cdot-}$  and the organic molecule (iii) the less significant self-scavenging effect, allowing higher radical concentrations, and (iv) the better selectivity of  $\text{SO}_4^{\cdot-}$  compared to  $\cdot\text{OH}$ , that can be employed to attack specific functional groups responsible for the molecular ecotoxicity characteristics of the pollutant.  $\text{SO}_4^{\cdot-}$  can be generated by applying an activation method (such as UV irradiation) to the radical precursors peroxymonosulphate ( $\text{HSO}_5^-$ ) or persulphate ( $\text{S}_2\text{O}_8^{2-}$ ). eAOPs based on Boron-Doped Diamond (BDD) anodes have recently been demonstrated to form the highly reactive sulphate radicals ( $\text{SO}_4^{\cdot-}$ ) under specific process conditions and in the presence of sulphate ions. This gives rise to an original approach to omit the necessity for dosing of the precursor molecule (and even of any chemical component if sulphate is already present in the water). Also, through the combination of (i) direct electrochemical degradation at the anode's surface, (ii) indirect oxidation via  $\text{OH}^{\cdot}$  produced and (iii) indirect oxidation via  $\text{SO}_4^{\cdot-}$ , the oxidation will take place via different reaction mechanisms, chemically attacking different parts of the organic molecules and hence leading to possibilities for complete mineralisation. The ESR will elucidate the full mechanisms behind the degradation of selected micropollutants via the described combined system, termed SR-eAOP. Specifically, the contribution of both types of radicals to the degradation will be defined via scavenging one of or both radical types. The expected differences in reaction mechanisms and degradation products, compared to a typical BDD, eAOP will further be identified using the analytical tools developed in WP3, and in close collaboration with ESR 9 and ESR 10. The obtained knowledge will further be used to define the most ideal operating conditions for the organics degradation.

### **ESR2: Manipulation of plasma species generation in an AOP**

**Host:** University of Liverpool (UK) (POSITION FILLED)

**Main supervisor:** Prof. James Walsh (J.L.Walsh@liverpool.ac.uk)

**Duration:** 36 months

**Required profile:** Chemical Engineer, Electrotechnical Engineer, Environmental Engineer, Bio-Science Engineer or Chemist

**Description:** Cold plasma generated in air at atmospheric pressure produces an abundance of Reactive Oxygen and Nitrogen Species (ROS and RNS). Recently, it has been shown that such plasmas created in and in-contact with water are capable of rapidly and efficiently degrading micro-pollutants. Critically, the composition of air plasma is extremely complex (75+ chemical species, >750 reactions). Tailoring the electrical properties of the plasma source to enhance the production of ROS whilst simultaneously reducing the

production of undesirable RNS remains a key challenge for any plasma based AOP technology. This ESR will explore the use of nanosecond pulsed excitation as a means to preferentially produce ROS species. Short duration pulses produce energetic electrons, which ultimately lead to an increased production of highly oxidative O and OH species. To achieve this, the ESR will develop an advanced nanosecond-pulsed plasma generator and fully characterize the plasma using advanced plasma diagnostic techniques (optical emission, mass spectroscopy, laser induced fluorescence and FTIR). To complement the experimental measurements, the ESR will have access to an advanced air plasma computational model. The pulse parameters (rise time, duration and repetition rate) will be optimized to maximize ROS production. Finally, the degradation efficiency of the optimized pulsed plasma source will be compared against conventional plasma generation techniques and alternate AOP technologies. For this, the generated degradation products will be identified in close collaboration with ESR 11.

### **ESR3: Enhancing mass transport in a plasma based AOP via liquid spray reactor design.**

**Host:** University of Liverpool (UK)

**Main supervisor:** Prof. James Walsh (J.L.Walsh@liverpool.ac.uk)

**Duration:** 36 months

**Required profile:** Chemical Engineer, Electrotechnical Engineer, Environmental Engineer, Bio-Science Engineer or Chemist

**Description:** In a typical plasma based AOP the degradation efficiency of the process is often limited by the mass transport of highly reactive chemical species from the plasma to the liquid phase. Recently, a large number of plasma reactor configurations have been reported and show an enormous variation in the efficiency of micro-pollutant degradation. Typically, one of the most efficient group of reactors involve spraying the contaminated liquid directly through the plasma region; this is attributed to the direct-contact and large-surface area between the aerosolised liquid and plasma. In this project, the ESR will explore the liquid spray reactor configuration and aim to maximise the degradation efficiency by enhancing the plasma stability and fluid-dynamics properties of the design. Spraying liquid through a plasma has the potential to disrupt the discharge and reduce the efficiency. To overcome this, the ESR will construct a spray-type reactor and investigate its key parameters, such as flow rate, aerosol size and plasma volume to establish the most stable operating conditions. Using a Particle Imaging Velocimetry (PIV) system, the ESR will quantify the velocity profiles of aerosols passing through the reactor, measurements that will be supported by computational fluid dynamics modelling (COMSOL). The characterisation activity will be used to iteratively enhance of the reactor design in terms of mass transport. Ultimately, the optimised reactor configuration will be compared against alternative reactor configurations already available in Liverpool (e.g., surface barrier discharge situated above thin liquid layer), typical BDD electrochemical configurations and those reported in the literature.

### **ESR4: Reactor and process design for industrial implementation of eAOP (POSITION FILLED)**

**Host:** Nijhuis Industries (the Netherlands)

**Main supervisor:** Dr. Nadine Boelee

(Nadine.Boelee@nijhuisindustries.com)

**Academic promoter:** Prof. Raf Dewil (PhD awarded by KU Leuven)

**Duration:** 36 months

**Required profile:** Chemical Engineer, Environmental Engineer, Bio-Science Engineer or Chemist

**Description:** The scale-up of eAOP processes is non-trivial because of various aspects that are not encountered in lab-scale tests. Important issues include mass transfer limitations, electrode fouling and the variability of the wastewater to be treated. Therefore, research is still required to enable the successful application of eAOP on full-scale. This ESR will focus on solving these major limitations via a novel reactor and process design. Mechanistic findings (operating conditions, novel catalysts) that are developed by ESR 1 will be used and integrated in the design. Both synthetic and real wastewater will be used. Synthetic waters will be used to study the system in a controlled environment, while real wastewaters will be tested to determine realistic removal efficiencies of micro-pollutants in wastewater matrices involving different scavengers. Process engineering limitations will be addressed. Moreover, investigation into the mass transfer limitations and electrode form is required to enable scale up of the eAOP.

This research project will lead to a novel reactor concept able to remove organic pollutants at low concentrations, which does not produce toxic byproducts and does not use additional chemicals (making use on the in situ generated molecules). Finally, the novel eAOP reactor will be integrated with other wastewater treatment techniques such as biological processes (in collaboration with ESR 14), chemical coagulation, electrocoagulation and membrane processes. This will lead to a final treatment concept of eAOP in wastewater treatment.

**ESR5: Catalyst evaluation for enhancing anode selectivity in a photo-electrochemical system (POSITION FILLED)**

**Host:** TU Delft (the Netherlands)

**Main supervisor:** Prof. Jan Peter van der Hoek (J.P.vanderHoek@tudelft.nl)

**Co-supervisors:** Prof. Jules van Lier (J.B.vanLier@tudelft.nl) & Dr. Henri Spanjers (H.L.F.M.Spanjers@tudelft.nl)

**Duration:** 36 months

**Required profile:** Chemical Engineer, Environmental Engineer, Bio-Science Engineer or Chemist

**Description:** BiVO<sub>4</sub> has shown to be an effective catalyst in the presence of solar light. BiVO<sub>4</sub> has a bandgap energy of 2.4 eV, and shows good catalytic properties. However, it needs an external bias voltage to reach the required potentials for micro-pollutant degradation. To cover the voltage needs, a solar cell could be coupled with the BiVO<sub>4</sub>. This ESR will design a system that consists of a BiVO<sub>4</sub> photo-anode combined with a thin film silicon solar cell. This solar cell should be specifically designed to work under the transmitted spectrum of the BiVO<sub>4</sub> and tested for the different thicknesses. To optimize the efficiency of the process and the anode selectivity, the ESR will study the complex reactions of the organic compounds in a combined photo-electrochemical system. Over time, adsorption of (natural) organic matter to the BiVO<sub>4</sub> coated surface may drastically increase fouling, and reduce efficiency. In addition, most studies so far have involved simplified models of water containing a single organic pollutant. Therefore, a systematic methodology for degrading mixtures of pollutants will be developed, starting from a rather manageable system to more complex aggregates. Based on this, a complete reaction layout for the mixture can be proposed that is suitable for mathematical modelling based on reaction kinetics of the mixture, being able to predict degradation under changing conditions.

**ESR6: Hybrid photoelectrochemical processes (POSITION FILLED)**

**Host:** Patras University (Greece)

**Main supervisor:** Prof. Dionisios Mantzavinos (mantzavinos@chemeng.upatras.gr)

**Duration:** 36 months

**Required profile:** Chemical Engineer, Environmental Engineer, Bio-Science Engineer or Chemist

**Description:** Integration of AOPs is conceptually advantageous since it increases the rate of reactive oxygen species (ROS) generation and, consequently, the rate of contaminant degradation. The true benefit of process combination arises from the possible synergy of the chosen AOPs, i.e. the performance of the hybrid process being greater than the sum of performances of the individual processes. The simultaneous application of solar photocatalysis on immobilized TiO<sub>2</sub> films and an electric bias in a photoelectrochemical cell is expected to promote the degradation of organic contaminants. The rate of anodic oxidation will be appraised as a function of various process variables including the type of conductive film, the level of applied current, the type and concentration of electrolyte, and the concentration of the contaminant. Moreover, the role of the cathode (which is generally under-estimated) will also be appraised since it may enhance the formation of extra ROS in the system. In this respect, boron-doped diamond will be tested and compared to more conventional cathodes (i.e. zirconium, platinum) for the cathodic oxygen reduction to form H<sub>2</sub>O<sub>2</sub>. Besides the kinetic analyses, major transformation by-products and their ecotoxic and biological properties will be identified. For this purpose, the ESR will closely collaborate with ESR13 in WP4.

**ESR7: Electrochemical modification of catalytic activity for water treatment (POSITION FILLED)**

**Host:** Patras University (Greece)

**Main supervisor:** Prof. Alexandros Katsaounis (alex.katsaounis@chemeng.upatras.gr)

**Duration:** 36 months

**Required profile:** Chemical Engineer, Environmental Engineer, Bio-Science Engineer or Chemist

**Description:** Wet air oxidation (WAO) has been proposed for effective wastewater treatment. It includes a chemical oxidation in the liquid phase via strong oxidants (such as chlorine, hydrogen peroxide and ozone) or via activated oxygen at a temperature above the normal boiling point of water (100°C), but below the critical point (374°C). The system must be maintained under pressure to avoid excessive evaporation of water. In WAO, the organic pollutants are either partially oxidized into biodegradable intermediates or mineralized to carbon dioxide, water and innocuous end products using a gaseous source of oxygen. Application of a proper catalyst, in the WAO process, i.e. catalytic wet air oxidation (CWAO), not only reduces the severity of reaction conditions but also favours the decomposition of even refractory pollutants, resulting in significant reduction of the capital and operational cost. It has been shown that the catalytic activity of conductive catalysts deposited on solid electrolytes can be altered in a very pronounced, reversible and, to some extent, predictable manner by applying electrical currents or potentials between the catalyst and a second electronic conductor (counter electrode) also deposited on the electrolyte (Electrochemical Promotion of Catalysis (EPOC)). The objective of the ESR is the application of EPOC in aqueous phase catalytic processes or, in other words, the combination of the CWAO benefits

with EPOC effect. The novelty of the proposal concerns the development of an effective, low cost and controllable electrocatalytic procedure operating at atmospheric conditions for chemical treatment of toxic compounds.

**ESR8: In-situ production of H<sub>2</sub>O<sub>2</sub> at the cathode surface via catalytic coating**

**Host:** InOpsys (Belgium)

**Main supervisor:** Ir. Kwinten Van Eyck  
(kwinten.vaneyck@inopsys.eu)

**Academic promoter:** Prof. Raf Dewil (PhD awarded by KU Leuven)

**Duration:** 36 months

**Required profile:** Chemical Engineer, Environmental Engineer, Bio-Science Engineer or Chemist

**Objectives:** A typical anodic oxidation process is based on electrochemical oxidation of target pollutants at the anode of the electrochemical system. The process can be improved, however, via the generation of H<sub>2</sub>O<sub>2</sub> from cathodic reduction. The in-situ formation of this oxidant (and precursor for OH\* radicals) at the cathode, results in the presence of an additional possibility for priority pollutant oxidation. The formation of H<sub>2</sub>O<sub>2</sub> is dependent of the process conditions in the system, and very specifically, on the composition of the cathode. In general, carbonaceous cathodes are beneficial for H<sub>2</sub>O<sub>2</sub> generation. In this research, the process will be further developed and optimized. A beneficial catalytic coating for the cathode will be designed, for the production of H<sub>2</sub>O<sub>2</sub>. Furthermore, influential parameters will be determined and an optimization of the process will be carried out.

**ESR9: Evaluation of sample prep methods for the monitoring of eAOP degradation products (POSITION FILLED)**

**Host:** Ineris (France)

**Main supervisor:** Dr. François Lestremau  
(Francois.Lestremau@ineris.fr)

**Academic promoter:** Prof. Deirdre Cabooter (PhD awarded by KU Leuven)

**Duration:** 36 months

**Required profile:** (Analytical) Chemist, Pharmacist, Bio-Science Engineer

**Description:** AOPs tend to produce degradation products that are more polar than the parent pollutants. Current analytical methodologies are not completely suited to analyze a large range of pollutants particularly for polar to very polar substances. Direct injection of the sample can be performed but toxicological level of many of these pollutants (ng/L level) cannot generally be reached. Therefore, there is a current need to develop reliable analytical methodologies that are able to reflect the real composition of waste water pollution at trace levels particularly after degradation treatment. Pre-concentration of contaminants in waste water is particularly challenging due to the complexity of the matrix. As degradation products are expected to be mostly polar, only the dissolved phase will be studied. Enrichment methods based on solid phase extraction (SPE) will be evaluated and compared with large volume direct injections. Since compounds with a large variety in polarity will be considered, multi-mode SPE cartridges will be prepared in-house by combining different SPE sorbents. These sorbents will first be evaluated for a representative test sample to identify the most suitable combination of sorbents and retention/elution strategies. The developed protocol will then be applied to real samples generated in an industrial setting. Analysis will be performed using liquid chromatography coupled to high

resolution mass spectrometry instrument. Data treatment will be particularly studied to produce a methodology suited for the determination and identification of a large range of contaminant with particular focus on generated polar degradation products.

**ESR10: Multidimensional LC separations with MS as a generic method to study the degradation of environmentally relevant micropollutants (POSITION FILLED)**

**Host:** Agilent Technologies (Germany)

**Main supervisor:** Prof. Tom Van de Goor  
([tom\\_vandegoor@agilent.com](mailto:tom_vandegoor@agilent.com))

**Academic promoter:** Prof. Deirdre Cabooter (PhD awarded by KU Leuven)

**Duration:** 36 months

**Required profile:** (Analytical) Chemist, Pharmacist, Bio-Science Engineer

**Objectives:** AOP treatment of micro-pollutants typically results in degradation products with a large variety in physicochemical characteristics, such as polarity, ionizability and molecular size. Before these degradation products can be identified, adequate chromatographic techniques are required to separate all compounds. Due to the broad variety in compound characteristics, this is currently very hard to obtain under a single set of separation conditions. High-end Mass Spectrometry (MS) such as triple-quadrupole MS with multiple reaction monitoring (MRM) is often used to compensate for the inadequate chromatographic resolution. This approach is difficult to optimize, time-consuming and expensive. To analyze all compounds in a single injection run, two-dimensional LC (2D-LC) will be explored to obtain a drastically higher chromatographic resolution. Active Solvent Modulation (ASM) will be used to address the solvent compatibility issue between the two very different dimensions. Different combinations of separation mechanisms will be evaluated in terms of separation capacity, robustness and ease of hyphenation with MS for subsequent identification of the degradation products. Based on the outcome of these experiments, a software solution that can suggest good standard 2D-LC methods for environmentally relevant molecules will be developed in order to expand the use of multidimensional LC techniques in routine environments. Hyphenation with different types of MS such as time-of-flight (TOF) will also be explored for untargeted analysis.

**ESR11: Development of high temperature vacuum GC-EI-MS and of capillary SFC-EI-MS (POSITION FILLED)**

**Host:** Ghent University (Belgium)

**Main supervisor:** Prof. Frédéric Lynen  
([frederic.lynen@ugent.be](mailto:frederic.lynen@ugent.be))

**Duration:** 36 months

**Required profile:** (Analytical) Chemist, Pharmacist, Bio-Science Engineer

**Description:** Today only GC-MS provides the potential of swift solute identification due to the exploitation of the extremely stable electron ionization (EI) process, allowing for the availability of compound libraries containing hundreds of thousands of compounds. As thus far soft ionization sources used in GC have not allowed the construction of comparable libraries. It is therefore highly useful to enhance the applicability range of hard high vacuum ionization sources in GC-MS to the analysis of less volatile solutes. Therefore, in this early stage research project the applicability range of GC will be extended through (I) the improvement of the thermal stability range of polar and apolar GC columns, and (II) the

implementation and further development of vacuum GC also in combination with the former approach. The potential of the recently developed vacuum UV detection will also be explored for the analysis of degradation products from eAOPs in combination with GC. Compounds not amenable to these GC based approaches will be studied in supercritical fluid chromatography in capillary type GC columns with CO<sub>2</sub> and Xenon as mobile phases whereby only density gradients are applied to ensure elution of all solutes on the columns. The avoidance of the usage of organic modifiers in this way will still allow for effective combination with EI-MS. The usage of xenon as mobile phase will additionally allow for identification of alarming functional groups in degradation products from eAOPs by direct hyphenation with infrared spectroscopy.

**ESR12: Combination of retentive and spectroscopic data in artificial intelligence based strategies for functional group flagging in AOP products (POSITION FILLED)**

**Host:** Ghent University (Belgium)

**Main supervisor:** Prof. Frédéric Lynen (frederic.lynen@ugent.be)

**Duration:** 36 months

**Required profile:** (Analytical) Chemist, Pharmacist, Bio-Science Engineer

**Description:** The study of the influence of oxidation processes on e.g. pharmaceutical solutes, and the concomitant assessment of the possible formation of solutes with enhanced toxicity, requires the availability of tools allowing fast structural elucidation and ideally instantaneous flagging of the occurrence of toxic functional groups. Conventional GC-MS and HPLC-MS approaches for solute identification require a one-to-one comparison of compound spectra with spectral libraries whereby the best matching overlays are proposed as tentatively identified structure. Reliable identification of unknown solutes can be obtained in this way providing analyses are performed on two columns and that they are present in the compound libraries. However, this approach does not allocate unknown structures to particular compound classes if the compound spectrum is not present in the reference library, and it fails to take into consideration and combine much of the secondary information such as characteristic isotopic clusters, high resolution data and chromatographic retention. In order to expedite the structural elucidation process in GC-MS and HPLC-MS, the performance and dedicated use of "deep learning" artificial intelligence tools via the construction of neural networks used today in image recognition will be studied for the interpretation of 2D GC-MS and HPLC-MS, or of GCxGC, LCxLC contour plot based, data representations to facilitate structural elucidation and functional group type classification, of unknown oxidation products of representative compounds.

**ESR13: Toxicity assessment of degradation products using zebrafish (POSITION FILLED)**

**Host:** KU Leuven (Belgium)

**Main supervisor:** Prof. Deirdre Cabooter

(deirdre.cabooter@kuleuven.be)

**Duration:** 36 months

**Required profile:** (Analytical) Chemist, Pharmacist, Bio-Science Engineer

**Description:** Zebrafish is a novel and promising small-animal model for toxicity studies. The strength of this in vivo model lies in its high genetic, physiologic and pharmacologic homology to humans. Their high fecundity, optical clarity and small size moreover allow performing tests in a medium- to high-throughput fashion using

microgram-scale quantities of compound. In this way, a unique system is obtained that combines the throughput of in vitro techniques (required to screen the large number of samples that will be generated in this project) with the bio-relevance of the whole animal. To investigate the general toxicity of the degradation products formed during different eAOP treatments, zebrafish larvae with an age of 3 days post-fertilization will be exposed to samples collected before, during and after eAOP treatment via immersion. At this stage, zebrafish are not free-feeding, and hence ethical permission for the use of animals is not required. 10 larvae per sample will be live-screened at 24 and 48h post-treatment for lethality or symptoms of toxicity, including, lethality (as determined by cardiac arrest), edema, impaired circulation, change in heart rate, hemorrhaging, tissue necrosis, loss of posture, impaired motility (diminished or absent touch response), body curvature, swim bladder and jaw defects. This assessment will be carried out through visual observation of treated larvae using a standard light stereomicroscope. When toxicity is observed, a more specific, organ-related assessment of the toxicity will be made using different transgenic zebrafish lines. In this way, compounds will be screened for hepato-, cardio-, and neurotoxicity via high-throughput behavioral and seizure assays, cell imaging and 2D image-based morphometric analysis. Zebrafish will first be exposed to the entire sample obtained before or after eAOP treatment. When toxicity is observed, the compounds responsible for the toxic effects will be identified by separating and purifying these samples using (preparative) chromatography and exposing zebrafish to the obtained fractions separately. Liquid chromatography coupled to tandem mass spectrometry (LC-MS/MS) will be used for the structure elucidation of the toxic compounds.

**ESR14: Combined electrochemical oxidation and biological wastewater treatment (POSITION FILLED)**

**H Host:** KU Leuven (Belgium)

**Main supervisor:** Prof. Lise Appels (lise.appels@kuleuven.be)

**Duration:** 36 months

**Required profile:** Chemical Engineer, Environmental Engineer, Bio-Science Engineer or Chemist

**Description:** In many cases, an eAOP treatment will be followed by a typical aerobic biological treatment to ensure proper wastewater treatment and avoid excessive costs associated with full mineralisation of the organic pollutants via eAOP. In this configuration, only a partial eAOP degradation is aimed at, in which the micropollutants are ideally transformed into biodegradable components, but toxic components may still be present to affect the biological step. This ESR will evaluate the influence of the eAOP treatments developed in WP1 and 2 on subsequent aerobic and anaerobic treatments. In the case of anaerobic treatment, the production of O<sub>2</sub> and H<sub>2</sub> during electrolysis offer an additional benefit for the treatment. Whereas H<sub>2</sub> will end up in the biogas and will contribute to its energetic value, O<sub>2</sub> will create micro-aerobic conditions in the reactor. The latter will result in a more effective biodegradation, and a reduction in the formation of unwanted H<sub>2</sub>S. There will be a close collaboration with ESR 1-8 because the obtained results will, moreover, provide additional guidelines to the optimisation of treatment techniques under scrutiny in WP1 and WP2. The following aims will be targeted: (i) evaluation of the long-term effects on an anaerobic treatment because of the eAOP pre-treatment using continuous pilot-scale experiments (towards process efficiency, COD degradation, biogas production, H<sub>2</sub>S formation), (ii) influence of the treatment of the development of the

anaerobic microbial community in the anaerobic reactor, and (iii) economic and energetic evaluation of the developed process.

**ESR15: Life-cycle assessment and cost analysis of emerging eAOP technologies (POSITION FILLED)**

**Host:** University College London (UK)

**Main supervisor:** Prof. Paola Lettieri (p.lettieri@ucl.ac.uk)

**Duration:** 36 months

**Required profile:** Chemical Engineer or Environmental Engineer

**Objectives:** To develop, apply and test a life-cycle assessment framework for emerging eAOP technologies, compared to traditional routes. The application of the life cycle approach will include the evaluation of direct and indirect burdens of each process step and "hot spot analysis". In addition, all costs associated with the total life cycle will be assessed; both the life cycle assessment and economic cost will be used to devise the best strategy in the application of eAOP technology for the removal of micro-pollutants from wastewater. Both assessments will provide decision support to process developers within the project and decision makers outside the consortium, and will be transferred during the dissemination activities. This ESR will closely interact with and receive information from all other ESRs, following the advancements of their work, in order to highlight and assess the best sustainable routes developed within the project. In particular, a close collaboration is foreseen with ESR4 who will focus on the scale-up of the technology.

## ETN INNOVEOX project abstract and key project information

It has been demonstrated that organic chemical pollutants are still putting half of the European freshwater system at risk. The INNOVEOX R&D training network was built to address and provide a solution for this considerable challenge: to boost innovative electrochemical wastewater treatment techniques to effectively degrade highly hazardous organic micro-pollutants, reducing environmental pollution and improving the European quality of life and health. By setting up a training frame to educate the next generation of highly-qualified ESRs in one of the most promising fields in micro-pollutant degradation, this will enable to generate important innovations, necessary to create a new level of EU excellence and reinforce EU R&D capacity in the field.

The main INNOVEOX R&D objectives are:

1) the exploration of alternative electrochemical oxidation pathways via generation of different oxidative radicals, 2) the development of combined photocatalytic/electrochemical oxidation techniques, 3) the development of novel analytical approaches for the separation and identification of these micro-pollutants and their degradation products, and 4) an assessment of the effects of the developed treatments on the aquatic toxicity, biological wastewater treatment and the environment as a whole via a life cycle assessment.

These objectives combined will ensure a high-quality training with a high-societal impact for the reliable, economic and complete removal of priority pollutants from wastewater. Pushed by an interdisciplinary & intersectoral consortium of 10 leading beneficiaries and 7 partner organisations, the proposal will offer innovative training based on an optimal balance between research and formal training.

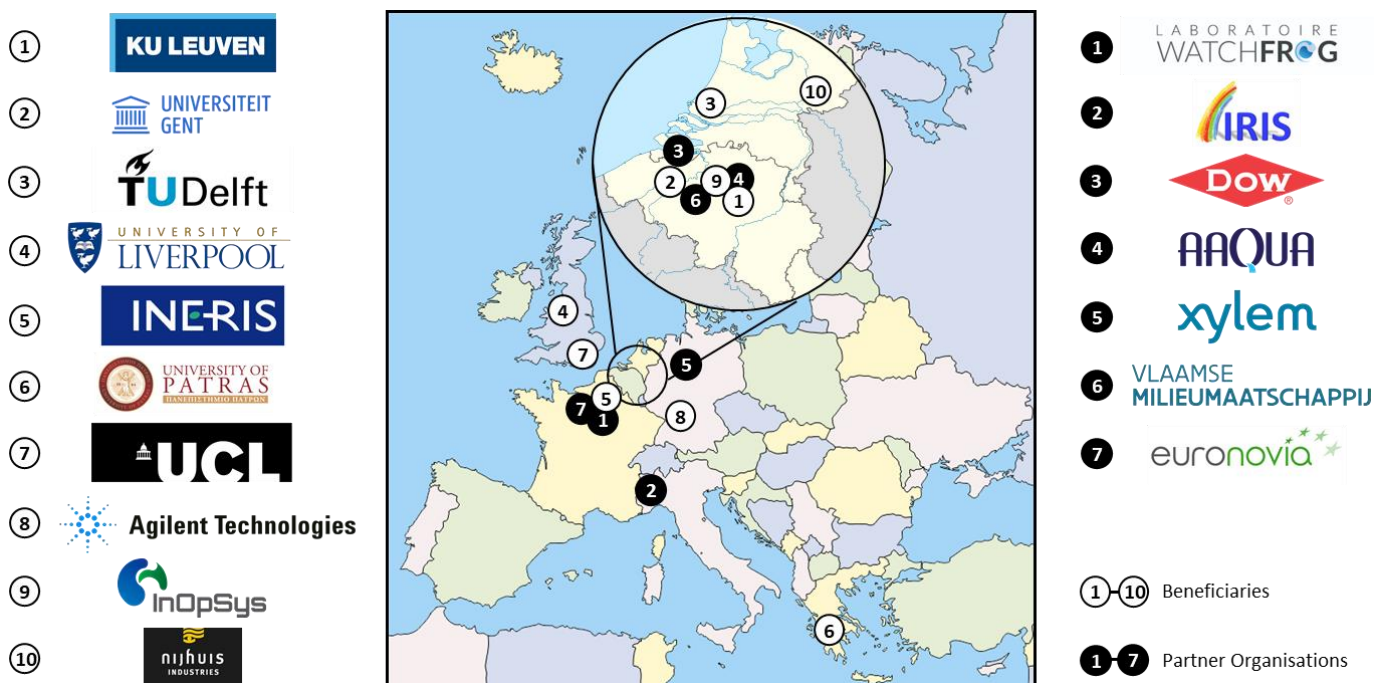


Figure 1: InnovEOX Consortium

## Appendix 1: Recruitment Procedure and Principles

A preliminary INNOVEOX recruitment web page is put on-line (10 August 2019). A special effort is made to promote the vacancies to refugees at the organizations and especially the participation of KU Leuven to the Online Linguistic Support for Refugees, an EU Initiative from which all the ESRs, if refugees, will be able to benefit. To attract the right students, the required profiles are clearly listed for each ESR position (e.g. ESR1: Chemical Engineer, Environmental Engineer, Bio-Science Engineer or Chemist).

Applications are made through an on-line, eligibility-proof form on the INNOVEOX recruitment webpage. The candidates apply for a maximum of three specific ESR positions and list their order of preference. The Supervisors provide the names of their preferred candidates to the SC, which in its turn produces a short list of candidates: 2 per position. As such a maximum of 30 ESRs (from an estimated initial pool of 120-200 candidates) are invited to the Recruitment Event, which coincides with the pre-kick-off meeting (Leuven, M2).

Each candidate gives a presentation and is interviewed by the SC. After a thorough evaluation, the candidates are ranked and a collective decision is made. In this way a complementary team of ESRs can be assembled, as positively experienced from previous ETN recruitment events (e.g. NEW-MINE, all 15 ESRs recruited).

In case not all 15 ESRs can be recruited during the collective Recruitment Event, the recruitment procedure is “decentralised”, meaning that the involved supervisors continue the search for good candidates. The GC is kept informed at all times when new eligible candidates appear. The GC makes an official complaint in case the Code of Conduct for the Recruitment of Researchers is breached. The involved supervisor is then expected to find another candidate. Recruitment problems are also, if still needed, discussed during the RC meeting (M6, M12) in order to deliver specific action plans to target specific networks relevant for the vacant ESR positions.

All details concerning the recruitment-procedure principles are communicated on the on-line application portal, so that potential ESRs know exactly what to expect and are stimulated to apply. All recruitment (pre and final selection) is in line with the European Charter for Researchers, providing the overarching framework for the roles, responsibilities of both researchers and employers. The Code of Conduct for the Recruitment of Researchers functions ensures that the selection procedures are transparent and fair.

The recruitment strategy of INNOVEOX fully complies with the Code of Conduct definition of merit. For example, merit is not just measured by a researcher's grades, but on a range of evaluation criteria, such as teamwork, interdisciplinary knowledge, soft skills and awareness of the policy impact of science.

The SC has members of each gender and considers the promotion of equal opportunities and gender balance as part of the recruitment strategy. Also, in view of the RRI principles, special efforts are made to attract women and ESRs from new EU Member States.

INNOVEOX aims at a participation of 50% female ESRs in the network. Researchers are employed on fixed-term contracts and are

registered as staff candidates for PhD degrees. Therefore, they are entitled to pension contributions, paid holidays, and other benefits as governed by the universities and industrial companies.

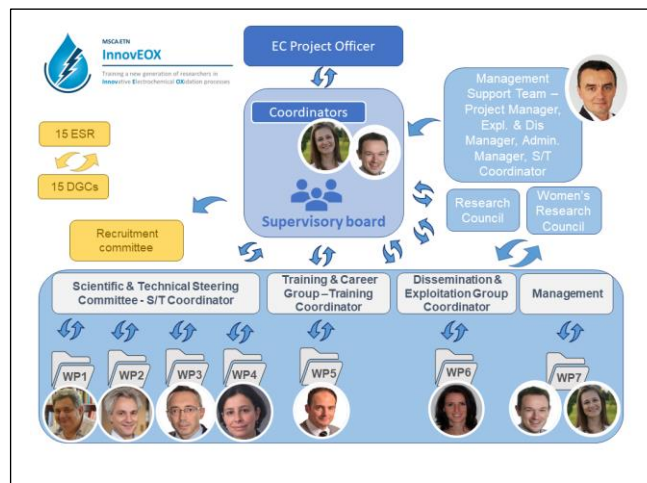


Figure 2: INNOVEOX Governance including SC

**SC** = Selection Committee = This committee involves the General Coordinator (f), the Training and Career officer (m), one representative per Beneficiary, Dr. Hamed Eghbali of Dow as co-chair, and two elected non-academic partners. Its goal is to oversee the recruitment of the 15 ESRs during the collective recruitment event.