



15 PhD positions in the EU Horizon 2020 Marie Skłodowska-Curie Project: MSCA-ETN SOCRATES

(European Training Network for the Sustainable, zero-waste valorisation of critical-metal-containing industrial process residues, Project 721385)

Applications are invited for 15 PhD positions (“Early Stage Researchers”) to be funded by the Marie-Sklodowska-Curie Innovative Training Network “SOCRATES – European Training Network for the Sustainable, zero-waste valorisation of critical-metal-containing industrial process residues” within the Horizon 2020 Programme of the European Commission. SOCRATES is a consortium of high profile universities, research institutions and companies located in Belgium, Germany, Netherlands, Finland, France and UK.

Number of positions available:

15 PhD positions

Research Fields

Chemistry – Chemical Engineering - Metallurgy - Environmental Engineering - Materials Engineering-

Keywords

Critical Metals; Ionometallurgy; Plasma metallurgy; Solvometallurgy; Electrowinning; Extractants; Modelling; Supplementary Cementitious Materials; Geopolymers; Catalysts; LCA; Exergy

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 salary will be confirmed upon appointment and is dependent 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 local Supervisor). 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 www.etn-socrates.eu website. Candidates apply electronically for one to maximum three positions and indicate their preference. Candidates provide all requested information including a detailed CV. 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 **30 July 2016**. The SOCRATES Recruitment Committee selects between 20 and maximum 30 candidates for the Recruitment Event which will take place in Leuven (**12 September 2016**). The selected candidates provide a 15 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 made the day after the Recruitment Event. The selected ESRs are to start their research as quickly as possible (**target: 1 November 2016**).

Applicants need to fully respect three eligibility criteria:

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. See for instance:

<http://www.helsinki.fi/facultyofscience/postgraduate/postapplicant.html>).

The 15 available positions

ESR 1: Biocompatible solvometallurgical leaching methods for low-grade industrial process residues

Objectives: To develop biocompatible solvometallurgical leaching methods for the recovery of valuable metals from low-grade industrial process residues. To use HCl solutions of alcoholic solvents and solutions of organic acids as lixiviants. To use acidic extractants (e.g., DEPHA) in biodiesel as lixiviants. To develop selective solvometallurgical leaching processes. To recover metals from the leachates by non-aqueous solvent extraction or by non-aqueous ion exchange;

Host: KU Leuven (Belgium)

Lead Supervisor: Prof. Koen Binnemans (KU Leuven, Koen.Binnemans@chem.kuleuven.be)

Duration: 36 months

ESR 2: Ionometallurgical leaching of industrial process residues using deep-eutectic solvents

Objectives: To develop a process for the selective leaching of metals from low-grade industrial process residues (tailings, sludges, slags and ashes) using deep-eutectic solvents. To develop an electrocatalytic process for the dissolution of metal oxides and metals in deep-eutectic solvents, with the I₂/I⁻ redox couple and other redox couples. To study the dissolution process by electrochemical methods, with the aim to improve the selectivity. To accelerate the dissolution kinetics by microwave heating..

Host: University of Leicester (UK)

Lead Supervisor: Prof. Andy Abbott (ULEIC, apa1@leicester.ac.uk)

Duration: 36 months

ESR 3: Plasma-driven metal extraction from industrial process residues

Objectives: To study the behaviour of a plasma gas submerged in a liquid bath, from the physical and chemical points of view. To study the effect of plasma on the thermodynamics and kinetics of metal fuming processes. To study the evaporation of lead and zinc from industrial process residues (incl. fayalitic slags), with particular attention on “deep fuming”, which leads to ultra-clean slag. To study the trade-off between (wanted) evaporation of lead and zinc and (unwanted) reduction of metallic iron. To model the reaction rates and equilibrium for the zinc fuming reaction in a plasma reactor. To validate a model on the world’s first large-scale operational plasma fumer. To define optimal use of the identified relevant parameters to achieve metal extraction at the lowest (economic and ecological) cost.

Hosts: Metallo (Belgium) & KU Leuven (Belgium)

Lead Supervisors: Ir. Mathias Chintinne (Metallo, Mathias.Chintinne@metallo.com), Prof. Bart Blanpain (KU Leuven, Bart.Blanpain@kuleuven.be)

Duration: 36 months

ESR 4: Hydrometallurgical process for recovery the critical and valuable metal recovery from complex impure process solutions

Objectives: To develop and optimise hydrometallurgical leaching (atmospheric or autoclave batch leaching or atmospheric continuous leaching) of targeted critical and valuable metals, suitable for electrometallurgical metal recovery. The targeted metals and waste stream are: 1) Au/ Ag from iron-rich hydrometallurgical sludges, 2) germanium leaching from fayalite slags, and 3) copper and noble-metal recovery from copper flotation tailings. To study the leaching mechanism and kinetics. To develop a process flow sheet..

Host: Outotec (Finland) & Aalto University (Finland)

Lead Supervisors: Mika Haapalainen (Outotec, mika.haapalainen@outotec.com) & Prof. Mari Lundström (Aalto U. mari.lundstrom@aalto.fi)

Duration: 36 months

ESR 5: Electrowinning of metals in deep-eutectic solvents

Objectives: To study the electrowinning of metals from deep-eutectic solvents using both cementation and electrolytic techniques. To study how the reduction potentials of metal ions are different in deep-eutectic solvent compared to aqueous solutions. To demonstrate the possibility of selective recovery of dissolved metals from complex mixtures and slurries in deep-eutectic solvents, by tuning the reduction potentials.

Host: University of Leicester (UK)

Lead Supervisor: Prof. Andy Abbott (ULEIC, apa1@leicester.ac.uk)

Duration: 36 months

ESR 6: Selective electrowinning of metals from complex impure solutions

Objectives: To develop and optimise critical and valuable metal recovery by an electrometallurgical method from complex impure process solutions. The target is to gain the most energy-efficient metal recovery with low investment costs in a way that very low concentrations of metals can be recovered from process solutions. The effect of process parameters, such as temperature, solution purity, flow rate, applied electrical potential difference and current will be optimised in order to achieve good recovery kinetics and purity.

Host: Outotec (Finland) & Aalto University (Finland)

Lead Supervisors: Mika Haapalainen (Outotec, mika.haapalainen@outotec.com) & Prof. Mari Lundström (Aalto U. mari.lundstrom@aalto.fi)

Duration: 36 months

ESR 7: Ultrasound- and microwave-assisted non-aqueous solvent extraction in milliflow reactors

Objectives: To investigate the extraction of critical metals in flow reactors. To study the effects of ultrasound and microwaves on solvent extraction with non-aqueous fluids such as ionic liquids. To understand the potential of solvent extraction applied in flow reactors and actuated by alternative energy forms. Proof-of-principle that critical metals can be extracted in continuous flow reactors. Enhanced extraction rates achieved by the application of flow, ultrasound and microwaves, compared to conventional mixer-settler extraction

Host: KU Leuven (Belgium)

Lead Supervisor: Prof. Tom Van Gerven (KU Leuven, Thomas.vangerven@cit.kuleuven.be)

Duration: 36 months

ESR 8: Synthesis of extractants and ionic liquids from renewable chemicals

Objectives: To prepare Guerbet alcohols from bio-alcohols (ethanol, butanol, decanol, dodecanol). To transform the Guerbet alcohols into other derivatives and to use these for the synthesis of extractants and ionic liquids. To characterise the new extractants and ionic liquids. To test the performance of the extractants and ionic liquid diluents in solvent-extraction processes. To investigate the solvent extraction of metal ions by Guerbet carboxylic acids..

Host: KU Leuven (Belgium)

Lead Supervisor: Prof. Wim Dehaen (KU Leuven, Wim.Dehaen@chem.kuleuven.be)

Duration: 36 months

ESR 9: Study of solvent miscibility by computational methods

Objectives: To study the miscibility of solvents and the corresponding substituent effects in systems relevant to metal recovery. To design candidates for switchable liquid mixtures, i.e., where the one-phase and two-phase systems are interconvertible. To characterize the structure and dynamics at relevant liquid-liquid interfaces. To predict suitable solvent pairs for non-aqueous solvent extraction. Goals: Detailed understanding of the structure of the solutions that are potential candidates for metal recovery. Characterisation of the liquid-liquid interface that the desired compounds have to cross during liquid-liquid extraction. Establishing the basic principles for controlling and possibly switching the miscibility of two liquids. Identification of solvent pairs for non-aqueous solvent extraction

Host: University of Bonn (Germany)

Lead Supervisor: Prof. Barbara Kirchner (UBonn, kirchner@thch.uni-bonn.de)

Duration: 36 months

ESR 10: In-silico design of selective metal extractants

Objectives: To develop large-scale methods that describe the dynamics and the energetics of the complex formation between the desired ligands and metals. To understand the coordination and solubility of different metals in solvents. To establish the principles of selective metal recovery. To design solvents and/or solvent mixtures for the selective recovery of the chosen metals. Goals: New theoretical tools for the design of selective ligands for metal coordination, leading to metal complexes with a high solubility in non-polar solvents. New structural leads for the design of extractants. Understanding the mass transfer between the two liquid phases at the molecular level and prediction of the optimised structure of the extractant solvent to achieve high rates for the mass transfer.

Host: University of Bonn (Germany)

Lead Supervisor: Prof. Barbara Kirchner (UBonn, kirchner@thch.uni-bonn.de)

Duration: 36 months

ESR 11: Residual matrix valorisation as supplementary cementitious materials with calcium aluminate binders

Objectives: To broaden the range and increase the hydration potential of by-products derived from the metallurgical industry (residuals arising after metal extraction from tailings, sludges, slags, ashes), valorised as supplementary cementitious materials with calcium aluminate binders, to bring additional performances to and/or lower the environmental footprint or cost of selected existing applications in the construction or building chemistry industries. To define a protocol to evaluate industrial and laboratory-synthesised residuals in terms of hydraulic potential when combined with various types of calcium aluminates, in order to map a wide range of by-products chemistries, and to suggest optimal routes to increase the valorisation potential of actual slags through directed chemistry adjustment.

Hosts: Kerneos (France), KU Leuven (Belgium)

Lead Supervisors: Dr. Hervé Fryda (Kerneos, herve.fryda@kerneos.com), Prof. Yiannis Pontikes (KU Leuven, yiannis.pontikes@kuleuven.be)

Duration: 36 months

ESR 12: Iron-rich inorganic polymers derived from residual matrices

Objectives: To develop Fe-rich inorganic polymers from metal-poor residual matrices. To prepare binary, ternary and quaternary blends aiming to satisfy processing demands (setting times, minimal use of activating solutions, satisfying strength development) and longer-term properties (final strength, durability) while chemically incorporating the heavy metals in the structure.

Host: KU Leuven (Belgium)

Lead Supervisor: Prof. Yiannis Pontikes (KU Leuven, yiannis.pontikes@kuleuven.be)

Duration: 36 months

ESR 13: Valorisation of industrial process residues as heterogeneous catalysts

Objectives: To investigate the use of a residual matrix from 4 low-grade waste families, as potential heterogeneous catalysts for the following 3 chemical reactions: 1) selective catalytic reduction (SCR) of NO_x with NH₃, 2) propane (non-)oxidative dehydrogenation to propylene and 3) propylene epoxidation. To study the influence of impurities and other material components (other than the active phase) on catalytic performance with operando microscopy and spectroscopy techniques.

Host: University of Utrecht (Netherlands)

Lead Supervisor: Prof. Bert Weckhuysen (UU, B.M.Weckhuysen@uu.nl)

Duration: 36 months

ESR 14: Advanced characterisation of metal-containing, low-grade metallurgical residues

Objectives: To carry out a detailed characterisation of low-grade industrial-process residue (Cu flotation tailings, Fe-rich sludges from electro-lytic zinc refining, fayalite slags and incineration bottom ashes) – before and after metal extraction (cf. WP1-2) – with the aim to determine the chemical composition, the mineralogical phase composition, distribution of phases and elements, porosity and oxidation states of the metal ions. Analytical techniques to be used include: EPMA-WDS, ICP-OES, XRD, XRF, SEM-EDX, FIB-SEM, EXAFS, XANES, XRF tomography, micro-computed tomography, N₂-physisorption and FTIR/Raman spectroscopy. Data to be provided to ESR1-13 and ESR15.

Hosts: University of Utrecht (Netherlands), KU Leuven (Belgium)

Lead Supervisor: Prof. Bert Weckhuysen (UU, B.M.Weckhuysen@uu.nl), Prof. Philippe Muchez (KU Leuven, Philippe.Muchez@ees.kuleuven.be)

Duration: 36 months

ESR 15: Development of a comprehensive product-centric sustainability indicator framework

Objectives: To develop a comprehensive product-centric sustainability indicator framework that can be used to evaluate, benchmark, and communicate the sustainability of a copper-production value chain. The indicator framework, together with the suggested data-collection and simulation methods aims at evaluating the whole system, while still enabling a focus on scopes of different width. To develop integrated systems-analysis methods for assessing key economic, environmental, technical, market and policy conditions and measures for the realisation of critical-metal recovery and valorisation flow sheets.

Hosts: Freiberg University (Germany)

Lead Supervisor: Prof. Markus A. Reuter (Freiberg U. m.reuter@hzdr.de)

Duration: 36 months

Public Abstract SOCRATES: Unlike China, Russia or South Africa, the EU-28 Member States are not in the fortunate position of having vast, easily accessible ore deposits containing valuable metals. However, Europe does have large quantities of secondary industrial residues (tailings, sludges, slags and ashes) that contain significant concentrations of both critical and economically important metals. The European Training Network for the Sustainable, zero-waste valorisation of critical-metal-containing industrial process residues (SOCRATES) targets ground-breaking metallurgical processes, incl. plasma-, bio-, solvo-, elec- tro- and ionometallurgy, that can be integrated into environmentally friendly, (near-)zero-waste valorisation flow sheets. By unlocking the potential of these secondary raw materials, SOCRATES contributes to a more diversified and sustainable supply chain for critical metals (cf. Priority area 3 in EC Circular Economy Action Plan; COM(2015)614/2). The SOCRATES consortium brings together all the relevant stakeholders along the value chain, from metal extraction, to metal recovery, and to residual matrix valorisation in added-value applications, such as supplementary cementitious materials, inorganic polymers and catalysts. To maximise applicability, SOCRATES has selected four commonly available and chemically complementary residue families: (1) flotation tailings from primary Cu production, (2) Fe-rich sludges from Zn production, (3) fayalitic slags from non-ferrous metallurgy, and (4) bottom ashes from incineration plants. As a basis for a concerted effort to strengthen the EU's critical-metal supply chain for Ge, In, Ga and Sb, SOCRATES trains 15 early-stage researchers (ESRs) in technological innovation: metal extraction (WP1), metal recovery (WP2), residual matrix valorisation (WP3) and integrated assessment (WP4). By training the ESRs in scientific, technical and soft skills, they are the next generation of highly employable scientists and engineers in the raw-materials sector.

Beneficiaries: *KU Leuven, University of Leicester, Utrecht University, University Bonn, Freiberg University, Outotec, Kerneos, Metallo*

Partner Organisations: *Aalto University, VTT, Boliden Kokkola, Umicore, AVR*

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EURELCO: www.eurelco.org



Appendix 1: Recruitment Procedure SOCRATES - Full description

Initially, the search for the appropriate candidates is based on normal recruitment strategies (i.e., publication on ec.europa.eu/euraxess, Nature and Science ads, etc.; personal contacts). The pre and final selection is made in a collective, fully transparent process, led by the RC. The candidates apply for a maximum of three specific ESR projects and list their order of preference. Applications are made through an on-line, eligibility-proof form on the www.etn-socrates.eu website (e.g. <http://redmud.org/vacancies-for-msca-etn-redmud-project/> which attracted 91 candidates in 4 weeks). The supervisors provide the names of their preferred candidates to the RC, which in its turn produces a short list of candidates. As such a maximum of 30 potential ESRs are invited to the Recruitment Event, which coincides with the pre-kick-off meeting (Leuven, M1, 12 September 2016). Each candidate gives a presentation and is interviewed by the RC. 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 KU Leuven ETN recruitment events (EREAN, REDMUD, DEMETER) where resp. 12, 13 and 13 positions were filled immediately. In order to facilitate their travel, preselected candidates (from outside Belgium) will receive a fixed, lump sum of 250 euro to be paid by the prioritised Supervisor.

In the event that 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. Recruitment problems are also, if still needed, discussed during the RC meeting (M5, M12) in order to deliver specific action plans to target specific networks relevant for the missing 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 as a set of principles and ensures that the selection procedures are transparent and fair. The recruitment strategy of SOCRATES fully complies with the Code of Conduct definition of merit. For example, merit is not just measured on researcher’s grades, but on a range of evaluation criteria, such as team work, interdisciplinary knowledge, soft skills and awareness of the policy impact of science. The RC has members of each gender and considers the promotion of equal opportunities and gender balance as part of the recruitment strategy. In view of the RRI principles, special efforts are made to attract women and ESRs from new EU member states. Among equally qualified applicants, women receive preferential consideration. 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 employment benefits, as governed by the universities and industrial companies.

Recruitment committee: The RC involves the GC (K. Binnemans) and one representative per Beneficiary (A. Abbott, B. Weckhuysen, M. Reuter, B. Kirchner, M. Haapalainen, C. Parr, M. Chintinne). Its goal is to oversee the recruitment of the 15 ESRs during the Recruitment Event. Additionally, it follows up the training progress of the ESRs and looks at their career planning. The RC meets during Workshops 1, 2, 4, 6, 8. During the Recruitment Event additional Supervisors may be present.

Key dates:

- 30-07-2016: Deadline for on-line application for ESR positions
- 10-08-2016: Circulation of communication list “preselected candidates”
- 12-09-2016: Recruitment Event (Novotel, Leuven) for preselected candidates
- 13-09-2016: Circulation of Communication list “recruited¹ SOCRATES ESRs”
- November 2016: Initiation of ESR research work

¹ Human Resources departments of the Beneficiaries get the chance to make a final check and attach conditions to the recruitment.